A. Reference Codes:

Design Code	: ASME Section VIII DIV.I, ED 2007, A08
Material Properties	: ASME Section II Part D, 2007, A 08
Welded and Seamless Pipes	: ASME B36.10, 2004
Pipe Flanges and Flanged Fittings	: ASME B16.5, 2003
Wrought Steel Butt Weld Fittings	: ASME B16.9, 2003

B. Design Data:

Equipment Name	: INLET SEPARATOR (KM-CP01-V-0201)
Medium	: CO_2 / WATER / SAND/H2S
Working Pressure (Max/Nor/Min)	: 1650/ 1050 / 1050 KPa(g)
Working Temperature (Max/Nor/Min)	: 80.7 / 80.6 / 38.7 °C
Design pressure - Internal	: 4500 kPa (g)
Design pressure - External	: FV
Design Temperature (Max/ Min.)	: 120°C / 5°C
Max. Allowable Working Pressure (MAWP)	: 4500 kPa (g)
Min. Design Metal Temperature	: 5° C
Corrosion Allowance	: 3.00 mm
Flange Rating	: 300# / 600# / 900#
Inside Diameter of Shell	: 3500 mm
Shell Length (Tan to Tan)	: 15000 mm
Type	: Horizontal
Closures	: 2:1 Semi-Ellipsoidal Heads
Supports	: Saddle Supports
Radiography	: 100% (RT-1)
Joint Efficiency (Shell / Dish)	: 1
PWHT	: YES, CODE REQUIREMENT
Service	: NON-LETHAL + NON-SOUR
Impact Test	: EXEMPTED AS PER UCS-66

C. Material of Construction:

Shell / Dished Head	: SA 516 Gr.70N
Nozzle Neck (Forged)	: SA 105N
Nozzle Neck (Seamless Pipe)	: SA 106 Gr. B
Flanges	: SA 105N

D. Allowable Stresses: (ASME SEC. II PART D)

	at Design temp. 120°C	at ambient temp.	at Design temp 120°C
Shell / Dished Head	: 20000 psi	137892 kPa	137892 kPa
Nozzles Necks – Forged	: 20000 psi	137892 kPa	137892 kPa
Nozzles Necks – Seamless Pipe	: 17100 psi	117897 kPa	117897 kPa
Flanges (SA 105N)	: 20000 psi	137892 kPa	137892 kPa

The above Allowable Stress Values are calculated from ASME Section II-Part-D with the below conversion factor and found conservative. Hence, the above stress values are acceptable and used in this calculation.

1 Psi = 6.8946 kPa.

E. Additional loadings as per UG-22 other than listed above:

b) Weight of vessel & contents	: Applicable
c) Superimposed static reactions from attachments	: Applicable
d) (1) Attachment of internals,	: Applicable
(2) Vessel Supports (Skirt, Saddle)	: Applicable
e) Cyclic and dynamic reactions	: Not applicable
f) Wind, Snow & Seismic reactions	: Applicable – Wind only
g) Impact reactions from fluid shock	: Not applicable
h) Temperature gradient & different thermal expansion	: Not applicable
i) Abnormal Pressure	: Not Applicable
j) Test Pressure & Coincident Static head	: Applicable

F. Inspection Opening Verification as per UG-46:

According to UG-46 (g)(1), Manholes are provided in the Vessel not less than size NB 400.

Size & Number of Manholes Provided in the vessel are,
Manhole M1 – NB 600 & M2 – NB 500

Hence, the provided manholes are compliance with the UG-46 minimum requirements.

MECHANICAL DESIGN CALCULAIONS C9501-0212-PVD-001, Rev-C
INLET SEPARATOR KM-CP01-V-0201

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2007, Addenda A-08

Analysis Performed by : SPECIAL TECHNICAL SERVICES LLC

Job File : S:\1. WORKSHOP DIVISION\2. JOBS\01. VESSELS\2009

Date of Analysis : Nov 7,2009

PV Elite 2009, January 2009

Note: PVElite performs all calculations internally in Imperial Units to remain compliant with the ASME Code and any built in assumptions in the ASME Code formulas. The customary Imperial database is used for consistency. The finalized results are reflected to show the users set of selected units.

Refer to Code Case 2523 for more information.

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

MECHANICAL DESIGN CALCULAIONS C9501-0212-PVD-001, Rev-C
INLET SEPARATOR KM-CP01-V-0201

Design Internal Pressure (for Hydrotest)	4500.0	kPa
Design Internal Temperature	120	C
Type of Hydrotest	UG99-b Note [34]	
Hydrotest Position	Horizontal	
Projection of Nozzle from Vessel Top	400.00	mm
Projection of Nozzle from Vessel Bottom	300.00	mm
Minimum Design Metal Temperature	5	C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-1	
Miscellaneous Weight Percent	10.	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	
Perform a Corroded Hydrotest	N	
Is this a Heat Exchanger	No	
User Defined Hydro. Press. (Used if > 0)	0.0000	kPa
User defined MAWP	4500.0	kPa
User defined MAPnc	0.0000	kPa

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 98/02/05/IBC-03/STS-1		
Design Wind Speed		46.000	m/sec
Exposure Constant		C	
Importance Factor		1.	
Roughness Factor		1	
Base Elevation		10000.	mm
Percent Wind for Hydrotest		33.	
Using User defined Wind Press. Vs Elev.		N	
Height of Hill or Escarpment	H	0.0000	mm
Distance Upwind of Crest	Lh	0.0000	mm
Distance from Crest to the Vessel	x	0.0000	mm
Height above Local Ground	z	0.0000	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	No Seismic
Design Nozzle for Des. Press. + St. Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Consider Code Case 2168 for Nozzle Des.	N
Material Database Year	Current w/Addenda or Code Year

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Elliptical	
Description		
Distance "FROM" to "TO"	50.000	mm
Inside Diameter	3500.0	mm
Element Thickness	61.500	mm
Internal Corrosion Allowance	3.0000	mm
Nominal Thickness	75.000	mm
External Corrosion Allowance	0.0000	mm
Design Internal Pressure	4500.0	kPa
Design Temperature Internal Pressure	120	C
Design External Pressure	100.00	kPa
Design Temperature External Pressure	120	C
Effective Diameter Multiplier	1.2	
Material Name [Normalized]	SA-516 70	
Allowable Stress, Ambient	137892.	kPa
Allowable Stress, Operating	137892.	kPa
Allowable Stress, Hydrotest	179260.	kPa
Material Density	7833.4	kg/m³
P Number Thickness	31.750	mm
Yield Stress, Operating	235962.	kPa
UCS-66 Chart Curve Designation	D	
External Pressure Chart Name	CS-2	
UNS Number	K02700	
Product Form	Plate	
Efficiency, Longitudinal Seam	1.	
Efficiency, Circumferential Seam	1.	
Elliptical Head Factor	2.	

Element From Node	10	
Detail Type	Liquid	
Detail ID	LIQUID 10	
Dist. from "FROM" Node / Offset dist	0.0000	mm
Height/Length of Liquid	3500.0	mm
Density of Liquid	999.54	kg/m³

Element From Node	10	
Detail Type	Nozzle	
Detail ID	N10	
Dist. from "FROM" Node / Offset dist	900.00	mm
Nozzle Diameter	66.639999	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	180.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	

Element From Node	20	
Element To Node	30	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	14900.	mm
Inside Diameter	3500.0	mm
Element Thickness	65.000	mm
Internal Corrosion Allowance	3.0000	mm
Nominal Thickness	65.000	mm
External Corrosion Allowance	0.0000	mm
Design Internal Pressure	4500.0	kPa
Design Temperature Internal Pressure	120	C
Design External Pressure	100.00	kPa
Design Temperature External Pressure	120	C
Effective Diameter Multiplier	1.2	
Material Name [Normalized]	SA-516 70	
Efficiency, Longitudinal Seam	1.	
Efficiency, Circumferential Seam	1.	

Element From Node	20	
Detail Type	Saddle	
Detail ID	Fixed Saddle	
Dist. from "FROM" Node / Offset dist	550.00	mm
Width of Saddle	300.00	mm
Height of Saddle at Bottom	2050.0	mm
Saddle Contact Angle	120.	
Height of Composite Ring Stiffener	0.0000	mm
Width of Wear Plate	400.00	mm
Thickness of Wear Plate	25.000	mm
Contact Angle, Wear Plate (degrees)	132.	

Element From Node	20	
Detail Type	Saddle	
Detail ID	Sliding Saddle	
Dist. from "FROM" Node / Offset dist	14350.	mm
Width of Saddle	300.00	mm
Height of Saddle at Bottom	2050.0	mm
Saddle Contact Angle	120.	
Height of Composite Ring Stiffener	0.0000	mm
Width of Wear Plate	400.00	mm
Thickness of Wear Plate	25.000	mm
Contact Angle, Wear Plate (degrees)	132.	

Element From Node	20	
Detail Type	Liquid	
Detail ID	Liquid 20	
Dist. from "FROM" Node / Offset dist	0.0000	mm
Height/Length of Liquid	3500.0	mm
Density of Liquid	999.54	kg/m³

Element From Node	20	
Detail Type	Nozzle	
Detail ID	N1	
Dist. from "FROM" Node / Offset dist	1950.0	mm
Nozzle Diameter	477.82001	mm
Nozzle Schedule	None	
Nozzle Class	600	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	4282.2	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	N13	
Dist. from "FROM" Node / Offset dist	3450.0	mm
Nozzle Diameter	66.639999	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	N4	
Dist. from "FROM" Node / Offset dist	11450.	mm
Nozzle Diameter	146.36	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	180.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	M2	
Dist. from "FROM" Node / Offset dist	3950.0	mm
Nozzle Diameter	477.82001	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	270.	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	0.0000	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	M1	
Dist. from "FROM" Node / Offset dist	11400.	mm
Nozzle Diameter	581.46002	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	0.	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	0.0000	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	K4	
Dist. from "FROM" Node / Offset dist	6450.0	mm
Nozzle Diameter	25.	mm
Nozzle Schedule	XXS	
Nozzle Class	600	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N

Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K8B	
Dist. from "FROM" Node / Offset dist	10450.	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	180.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N2	
Dist. from "FROM" Node / Offset dist	13950.	mm
Nozzle Diameter	428.45999	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.0000	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N6	
Dist. from "FROM" Node / Offset dist	4950.0	mm
Nozzle Diameter	92.040001	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N11	
Dist. from "FROM" Node / Offset dist	3950.0	mm
Nozzle Diameter	66.639999	mm
Nozzle Schedule	None	
Nozzle Class	600	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	145.89	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N12	
Dist. from "FROM" Node / Offset dist	4450.0	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	900	
Layout Angle	0.	

Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K5	
Dist. from "FROM" Node / Offset dist	6950.0	mm
Nozzle Diameter	25.	mm
Nozzle Schedule	XXS	
Nozzle Class	600	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N7	
Dist. from "FROM" Node / Offset dist	1450.0	mm
Nozzle Diameter	66.639999	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	180.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N8	
Dist. from "FROM" Node / Offset dist	7950.0	mm
Nozzle Diameter	66.639999	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	180.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N9	
Dist. from "FROM" Node / Offset dist	13085.	mm △C
Nozzle Diameter	66.639999	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	180.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N3	
Dist. from "FROM" Node / Offset dist	13450.	mm
Nozzle Diameter	146.36	mm
Nozzle Schedule	None	

Nozzle Class	300	
Layout Angle	180.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K3A	
Dist. from "FROM" Node / Offset dist	9450.0	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	252.757	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K3B	C
Dist. from "FROM" Node / Offset dist	9450.0	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	211.108	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K6A	
Dist. from "FROM" Node / Offset dist	9950.0	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	252.757	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K6B	C
Dist. from "FROM" Node / Offset dist	9950.0	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	211.108	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K8A	
Dist. from "FROM" Node / Offset dist	10450.	mm

Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	305.57901	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K2A	
Dist. from "FROM" Node / Offset dist	10950.	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	305.57901	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K2B	
Dist. from "FROM" Node / Offset dist	10950.	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	180.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K7A	
Dist. from "FROM" Node / Offset dist	13305.	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	290.98499	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K7B	C
Dist. from "FROM" Node / Offset dist	13305.	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	212.285	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	

Detail ID	K1A	
Dist. from "FROM" Node / Offset dist	13805.	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	290.98499	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K1B	C
Dist. from "FROM" Node / Offset dist	13805.	mm
Nozzle Diameter	50.	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	212.285	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	K9	
Dist. from "FROM" Node / Offset dist	7450.0	mm
Nozzle Diameter	25.	mm
Nozzle Schedule	XXS	
Nozzle Class	600	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N5	
Dist. from "FROM" Node / Offset dist	5450.0	mm
Nozzle Diameter	146.36	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2338.5	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-350 LF2	
Element From Node	20	
Detail Type	Weight	
Detail ID	INLET DEVICE	
Dist. from "FROM" Node / Offset dist	2000.0	mm
Miscellaneous Weight	9806.0	N
Offset from Element Centerline	0.0000	mm
Element From Node	20	
Detail Type	Weight	
Detail ID	GAS BOX	
Dist. from "FROM" Node / Offset dist	14000.	mm
Miscellaneous Weight	4903.0	N
Offset from Element Centerline	0.0000	mm

Element From Node	20	
Detail Type	Weight	
Detail ID	INTERNALS	
Dist. from "FROM" Node / Offset dist	7000.0	mm
Miscellaneous Weight	19612.	N
Offset from Element Centerline	0.0000	mm
Element From Node	20	
Detail Type	Weight	
Detail ID	WEIR	
Dist. from "FROM" Node / Offset dist	12900.	mm
Miscellaneous Weight	4903.0	N
Offset from Element Centerline	0.0000	mm
Element From Node	20	
Detail Type	For./Mom.	
Detail ID	N1	
Dist. from "FROM" Node / Offset dist	1950.0	mm
Force in X Direction	40000.	N
Force in Y Direction	-200000.	N
Force in Z Direction	250000.	N
Moment about X Axis	0.0000	N-m
Moment about Y Axis	0.0000	N-m
Moment about Z Axis	0.0000	N-m
Force/Moment Combination Method	SRSS	
Element From Node	20	
Detail Type	For./Mom.	
Detail ID	N2	
Dist. from "FROM" Node / Offset dist	13950.	mm
Force in X Direction	36000.	N
Force in Y Direction	-36000.	N
Force in Z Direction	36000.	N
Moment about X Axis	0.0000	N-m
Moment about Y Axis	0.0000	N-m
Moment about Z Axis	0.0000	N-m
Force/Moment Combination Method	SRSS	
Element From Node	30	
Element To Node	40	
Element Type	Elliptical	
Description		
Distance "FROM" to "TO"	50.000	mm
Inside Diameter	3500.0	mm
Element Thickness	61.500	mm
Internal Corrosion Allowance	3.0000	mm
Nominal Thickness	75.000	mm
External Corrosion Allowance	0.0000	mm
Design Internal Pressure	4500.0	kPa
Design Temperature Internal Pressure	120	C
Design External Pressure	100.00	kPa
Design Temperature External Pressure	120	C
Effective Diameter Multiplier	1.2	
Material Name [Normalized]	SA-516 70	
Efficiency, Longitudinal Seam	1.	
Efficiency, Circumferential Seam	1.	
Elliptical Head Factor	2.	
Element From Node	30	
Detail Type	Liquid	
Detail ID	Liquid 30	
Dist. from "FROM" Node / Offset dist	0.0000	mm

Height/Length of Liquid	3500.0	mm
Density of Liquid	999.54	kg/m³

XY Coordinate Calculations

From	To	X (Horiz.) mm	Y (Vert.) mm	DX (Horiz.) mm	DY (Vert.) mm
10	20	50.0000	0.00000	50.0000	0.00000
20	30	14950.0	0.00000	14900.0	0.00000
30	40	15000.0	0.00000	50.0000	0.00000

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd kPa	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) kPa
10	20	4534.34	75.0000	3.00000	3500.00	137892.
20	30	4534.34	65.0000	3.00000	3500.00	137892.
30	40	4534.34	75.0000	3.00000	3500.00	137892.

Element Required Thickness and MAWP :

From	To	Design Pressure kPa	M.A.W.P. Corroded kPa	M.A.P. New & Cold kPa	Actual Thickness mm	Required Thickness mm
10	20	4500.00	4562.43	4828.95	61.5000	60.7029
20	30	4500.00	4741.28	5010.05	65.0000	61.8045
30	40	4500.00	4562.43	4828.95	61.5000	60.7029
Minimum			4500.000	4828.942		

MAWP: 4500.000 kPa , limited by: DESIGN (user specified)

Internal Pressure Calculation Results :

ASME Code, Section VIII, Division 1, 2007 A-08

Elliptical Head From 10 To 20 SA-516 70 , UCS-66 Crv. D at 120 C

Thickness Due to Internal Pressure [tr]:
= (P*D*Kcor)/(2*S*E-0.2*P) Appendix 1-4(c)
= (4534.336*3506.0000*0.998)/(2*137892.00*1.00-0.2*4534.336)
= 57.7029 + 3.0000 = 60.7029 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 34.337 kPa
= (2*S*E*t)/(Kcor*D+0.2*t) per Appendix 1-4 (c)
= (2*137892.00*1.00*58.5000)/(0.998*3506.0000+0.2*58.5000)
= 4596.766 - 34.337 = 4562.430 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*D+0.2*t) per Appendix 1-4 (c)
= (2*137892.00*1.00*61.5000)/(1.000*3499.9998+0.2*61.5000)
= 4828.949 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*D+0.2*t))/(2*E*t)
= (4534.336*(0.998*3506.0000+0.2*58.5000))/(2*1.00*58.5000)
= 136019.250 kPa

Required Thickness of Straight Flange:
= (P * R)/(S * E - 0.6 * P) + c per UG-27 (c)(1)
= (4534.336 * 1753.0000) / (137892.00 * 1.00 - 0.6 * 4534.336) + 3.
= 61.805 mm

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 + (3506.000 /(2 * 878.000))^2)/6
= 0.997724

Percent Elongation per UCS-79 (75*tnom/Rf)*(1-Rf/Ro) 9.255 %
Note: Please Check Requirements of UCS-79 as Elongation is > 5%.

MDMT Calculations in the Knuckle Portion:

```
Min Metal Temp. w/o impact per UCS-66                    -16  C
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.99]    -16  C
```

MDMT Calculations in the Straight Flange:

```
Min Metal Temp. w/o impact per UCS-66                    -15  C
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.95]    -17  C
```

Note: Post Weld Heat Treatment is required for this Element.

Cylindrical Shell From 20 To 30 SA-516 70 , UCS-66 Crv. D at 120 C

Thickness Due to Internal Pressure [tr]:
```
  = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
  = (4534.336*1753.0000)/(137892.00*1.00-0.6*4534.336)
  = 58.8045 + 3.0000 = 61.8045 mm
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 34.337 kPa
```
  = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
  = (137892.00*1.00*62.0000)/(1753.0000+0.6*62.0000)
  = 4775.614 - 34.337 = 4741.277  kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
  = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
  = (137892.00*1.00*65.0000)/(1749.9999+0.6*65.0000)
  = 5010.050 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
  = (P*(R+0.6*t))/(E*t)
  = (4534.336*(1753.0000+0.6*62.0000))/(1.00*62.0000)
  = 130925.312 kPa
```

```
Percent Elongation per UCS-79  (50*tnom/Rf)*(1-Rf/Ro)  1.823 %

Min Metal Temp. w/o impact per UCS-66                    -15  C
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.95]    -17  C
```

Note: Post Weld Heat Treatment is required for this Element.

Elliptical Head From 30 To 40 SA-516 70 , UCS-66 Crv. D at 120 C

Thickness Due to Internal Pressure [tr]:
```
  = (P*D*Kcor)/(2*S*E-0.2*P) Appendix 1-4(c)
  = (4534.336*3506.0000*0.998)/(2*137892.00*1.00-0.2*4534.336)
  = 57.7029 + 3.0000 = 60.7029 mm
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 34.337 kPa
```
  = (2*S*E*t)/(Kcor*D+0.2*t) per Appendix 1-4 (c)
  = (2*137892.00*1.00*58.5000)/(0.998*3506.0000+0.2*58.5000)
  = 4596.766 - 34.337 = 4562.430  kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
  = (2*S*E*t)/(K*D+0.2*t) per Appendix 1-4 (c)
  = (2*137892.00*1.00*61.5000)/(1.000*3499.9998+0.2*61.5000)
  = 4828.949 kPa
```

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

```
  = (P*(Kcor*D+0.2*t))/(2*E*t)
  = (4534.336*(0.998*3506.0000+0.2*58.5000))/(2*1.00*58.5000)
  = 136019.250 kPa
```

Required Thickness of Straight Flange:

```
  = (P * R)/(S * E - 0.6 * P) + c    per UG-27 (c)(1)
  = ( 4534.336 * 1753.0000 ) / ( 137892.00 * 1.00 - 0.6 * 4534.336 ) + 3.
  = 61.805 mm
```

Factor K, corroded condition [Kcor]:

```
  = ( 2 + ( Inside Diameter/( 2 * Inside Head Depth ))^2)/6
  = ( 2 + ( 3506.000 /( 2 * 878.000 ))^2)/6
  = 0.997724
```

```
 Percent Elongation per UCS-79  (75*tnom/Rf)*(1-Rf/Ro)  9.255 %
```

Note: Please Check Requirements of UCS-79 as Elongation is > 5%.

MDMT Calculations in the Knuckle Portion:

```
 Min Metal Temp. w/o impact per UCS-66                    -16  C
 Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.99]    -16  C
```

MDMT Calculations in the Straight Flange:

```
 Min Metal Temp. w/o impact per UCS-66                    -15  C
 Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.95]    -17  C
```

Note: Post Weld Heat Treatment is required for this Element.

Minimum Metal Design Temperature Results :

```
 Minimum Metal Temp. w/o impact per UCS-66              -15.  C
 Minimum Metal Temp. at Required thickness              -16.  C
 Minimum Design Metal Temperature ( Entered by User )     5.  C
```

Hydrostatic Test Pressure Results:

```
 Pressure per UG99b     = 1.3 * M.A.W.P. * Sa/S       5850.000  kPa
 Pressure per UG99b[34] = 1.3 * Design Pres * Sa/S     5850.000  kPa
 Pressure per UG99c     = 1.3 * M.A.P. - Head(Hyd)    6236.466  kPa
 Pressure per UG100     = 1.1 * M.A.W.P. * Sa/S       4950.000  kPa
```

UG-99(b) Note 34, Test Pressure Calculation:

```
  = Test Factor * Design Pressure * Stress Ratio
  = 1.3 * 4500.000 * 1.000
  = 5850.000 kPa
```

Horizontal Test performed per: UG-99b (Note 34)

Stresses on Elements due to Hydrostatic Test Pressure:

From	To	Stress	Allowable	Ratio	Pressure
10	20	168028.0	179260.0	0.937	5884.31
20	30	161954.2	179260.0	0.903	5884.31
30	40	168028.0	179260.0	0.937	5884.31

Elements Suitable for Internal Pressure.

External Pressure Calculation Results :
ASME Code, Section VIII, Division 1, 2007 A-08
Required Thickness as per UG-33 (a)(1)(a)

As per clause UG-33 (a) (1) of ASME Sec VIII Div.1, minimum required thickness shall be greater of (a) and (b).
Proposed 2:1 Ellipsoidal heads formed from SA 516 Gr. 70 Plate material.

Min. thickness required, tmin $= \frac{PD}{2SE - 0.2P} + CA$

Where, External Pressure = 103.42 kPa
Design Pressure = 1.67 * 103.42 = 172.71 kPa
Static Head Pressure = 34.337 kPa
Total Design Pressure (P) = 172.71 + 34.337 = 207.05 kPa
D = 3500 + 2 * 3 (CA) = 3506 mm
S = 137892 kPa
E = 1.0 (Full Radiography)

Minimum Thickness (t) $= \frac{207.05 \times 3506}{2 \times 137892 \times 1.0 - (0.2 \times 207.05)} + 3$
$= 2.63 + 3 = 5.63$ mm

Minimum Required Thickness (t) as per UG-33 (a)(1)(a) = 5.63 mm

Required Thickness as per UG-33 (a)(1)(b)
Elliptical Head From 10 to 20 Ext. Chart: CS-2 at 120 C

Elastic Modulus from Chart: CS-2 at 149 C : 0.19994E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
58.500	3623.00	61.93	0.0022426	106249.29

EMAP = B/(K0*D/t) = 0.1E+06/(0.9000 *61.9316) = 1906.2117 kPa

Results for Required Thickness (Tca):

Tca	OD	D/t	Factor A	B
9.224	3623.00	392.77	0.0003536	35351.71

EMAP = B/(K0*D/t) = 35351.7070/(0.9000 *392.7663) = 100.0078 kPa

Cylindrical Shell From 20 to 30 Ext. Chart: CS-2 at 120 C

Elastic Modulus from Chart: CS-2 at 149 C : 0.19994E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
62.000	3630.00	15583.33	58.55	4.2929	0.0006853	68514.88

EMAP = (4*B)/(3*(D/t)) = (4*68514.8828)/(3*58.5484) = 1560.3024 kPa

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
20.708	3630.00	15583.33	175.30	4.2929	0.0001315	13147.99

EMAP = (4*B)/(3*(D/t)) = (4*13147.9863)/(3*175.2964) = 100.0058 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
62.000	3630.00	0.10E+30	58.55	.5000E+02	0.0003209	32080.42

EMAP = (4*B)/(3*(D/t)) = (4*32080.4160)/(3*58.5484) = 730.5733 kPa

Required Thickness as per UG-33 (a)(1)(a)

As per clause UG-33 (a) (1) of ASME Sec VIII Div.1, minimum required thickness shall be greater of (a) and (b).
Proposed 2:1 Ellipsoidal heads formed from SA 516 Gr. 70 Plate material.

Min. thickness required, tmin $= \frac{PD}{2SE - 0.2P} + CA$

Where, External Pressure = 103.42 kPa
Design Pressure = 1.67 * 103.42 = 172.71 kPa
Static Head Pressure = 34.337 kPa
Total Design Pressure (P) = 172.71 + 34.337 = 207.05 kPa
D = 3500 + 2 * 3 (CA) = 3506 mm
S = 137892 kPa
E = 1.0 (Full Radiography)

Minimum Thickness (t) $= \frac{207.05 \times 3506}{2 \times 137892 \times 1.0 - (0.2 \times 207.05)} + 3$

= 2.63 + 3 = 5.63 mm

Minimum Required Thickness (t) as per UG-33 (a)(1)(a) = 5.63 mm

Elliptical Head From 30 to 40 Ext. Chart: CS-2 at 120 C

Elastic Modulus from Chart: CS-2 at 149 C : 0.19994E+09 kPa
Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
58.500	3623.00	61.93	0.0022426	106249.29

EMAP = B/(K0*D/t) = 0.1E+06/(0.9000 *61.9316) = 1906.2117 kPa

Results for Required Thickness (Tca):

Tca	OD	D/t	Factor A	B
9.224	3623.00	392.77	0.0003536	35351.71

EMAP = B/(K0*D/t) = 35351.7070/(0.9000 *392.7663) = 100.0078 kPa

External Pressure Calculations

From	To	Section Length mm	Outside Diameter mm	Corroded Thickness mm	Factor A	Factor B kPa
10	20	No Calc	3623.00	58.5000	0.0022426	106249.
20	30	15583.3	3630.00	62.0000	0.00068534	68514.9
30	40	No Calc	3623.00	58.5000	0.0022426	106249.

External Pressure Calculations

From	To	External Actual T. mm	External Required T. mm	External Des. Press. kPa	External M.A.W.P. kPa
10	20	61.5000	12.2243	100.000	1906.21
20	30	65.0000	23.7078	100.000	1560.30
30	40	61.5000	12.2243	100.000	1906.21
Minimum					1560.302

External Pressure Calculations

From	To	Actual Len. Bet. Stiff. mm	Allow. Len. Bet. Stiff. mm	Ring Inertia Required mm**4	Ring Inertia Available mm**4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	15583.3	101.0E+27	No Calc	No Calc
30	40	No Calc	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

Element and Detail Weights

From	To	Element Metal Wgt. kgm	Element ID Volume m³	Corroded Metal Wgt. kgm	Corroded ID Volume m³	Extra due Misc % kgm
10	20	9316.88	6.09447	8944.20	6.12504	931.688
20	30	84970.3	143.380	81116.8	143.872	8497.03
30	40	9316.88	6.09447	8944.20	6.12504	931.688
Total		103604	155	99005	156	10360

Weight of Details

From	Type	Weight of Detail kgm	X Offset, Dtl. Cent. mm	Y Offset, Dtl. Cent. mm	Description
10	Liqd	6090.75	-291.667	0.00000	LIQUID 10
10	Nozl	262.327	-72.9167	900.000	N10
20	Sadl	1276.55	550.000	1855.00	Fixed Saddle
20	Sadl	1276.55	14350.0	1855.00	Sliding Saddle
20	Liqd	143293.	7450.00	0.00000	Liquid 20
20	Nozl	480.366	1950.00	1988.91	N1
20	Nozl	262.327	3450.00	1783.32	N13
20	Nozl	262.327	11450.0	1823.18	N4
20	Nozl	682.353	3950.00	1988.91	M2
20	Nozl	1000.02	11400.0	2040.73	M1
20	Nozl	262.327	6450.00	1757.61	K4
20	Nozl	262.327	10450.0	1771.42	K8B
20	Nozl	324.548	13950.0	1964.23	N2
20	Nozl	262.327	4950.00	1796.02	N6
20	Nozl	16.3654	3950.00	1783.32	N11
20	Nozl	262.327	4450.00	1771.42	N12
20	Nozl	262.327	6950.00	1757.61	K5
20	Nozl	262.327	1450.00	1783.32	N7
20	Nozl	262.327	7950.00	1783.32	N8
20	Nozl	262.327	13085.0	1783.32	N9
20	Nozl	262.327	13450.0	1823.18	N3
20	Nozl	262.327	9450.00	1771.42	K3A
20	Nozl	262.327	9450.00	1771.42	K3B
20	Nozl	262.327	9950.00	1771.42	K6A
20	Nozl	262.327	9950.00	1771.42	K6B
20	Nozl	262.327	10450.0	1771.42	K8A
20	Nozl	262.327	10950.0	1771.42	K2A
20	Nozl	262.327	10950.0	1771.42	K2B
20	Nozl	262.327	13304.8	1771.42	K7A
20	Nozl	262.327	13304.8	1771.42	K7B
20	Nozl	262.327	13804.8	1771.42	K1A
20	Nozl	262.327	13804.8	1771.42	K1B
20	Nozl	262.327	7450.00	1757.61	K9
20	Nozl	262.327	5450.00	1823.18	N5
20	Wght	1000.00	2000.00	0.00000	INLET DEVICE
20	Wght	500.000	14000.0	0.00000	GAS BOX
20	Wght	2000.00	7000.00	0.00000	INTERNALS
20	Wght	500.000	12900.0	0.00000	WEIR
20	Forc	0.00000	1950.00	0.00000	N1
20	Forc	0.00000	13950.0	0.00000	N2
30	Liqd	6090.75	341.667	0.00000	Liquid 30

Total Weight of Each Detail Type

Total Weight of Saddles	2553.1
Total Weight of Liquid	155474.5

Total Weight of Nozzles	9061.8
Total Weight of Weights	4000.0
Sum of the Detail Weights	171089.5 kgm

Weight Summary

Fabricated Wt.	- Bare Weight W/O Removable Internals	129579.3 kgm
Shop Test Wt.	- Fabricated Weight + Water (Full)	285053.8 kgm
Shipping Wt.	- Fab. Wt + Rem. Intls.+ Shipping App.	129579.3 kgm
Erected Wt.	- Fab. Wt + Rem. Intls.+ Insul. (etc)	129579.3 kgm
Ope. Wt. no Liq	- Fab. Wt + Intls. + Details + Wghts.	129579.3 kgm
Operating Wt.	- Empty Wt. + Operating Liquid (No CA)	285053.8 kgm
Oper. Wt. + CA	- Corr Wt. + Operating Liquid	279995.1 kgm
Field Test Wt.	- Empty Weight + Water (Full)	285053.8 kgm

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

Outside Surface Areas of Elements

From	To	Surface Area mm²
10	20	15.01E+06
20	30	169.9E+06
30	40	15.01E+06
Total		199948768.000 mm²

Nozzle Flange MAWP Results :

Nozzle Description	Flange Rating Operating kPa	Ambient kPa	Temperature C	Class	Grade|Group
N10	4605.63	5102.00	120	300	GR 1.1
N1	9211.25	10204.01	120	600	GR 1.1
N13	4605.63	5102.00	120	300	GR 1.1
N4	4605.63	5102.00	120	300	GR 1.1
M2	4605.63	5102.00	120	300	GR 1.1
M1	4605.63	5102.00	120	300	GR 1.1
K4	9211.25	10204.01	120	600	GR 1.1
K8B	4605.63	5102.00	120	300	GR 1.1
N2	4605.63	5102.00	120	300	GR 1.1
N6	4605.63	5102.00	120	300	GR 1.1
N11	9211.25	10204.01	120	600	GR 1.1
N12	13798.95	15306.01	120	900	GR 1.1
K5	9211.25	10204.01	120	600	GR 1.1
N7	4605.63	5102.00	120	300	GR 1.1
N8	4605.63	5102.00	120	300	GR 1.1
N9	4605.63	5102.00	120	300	GR 1.1
N3	4605.63	5102.00	120	300	GR 1.1
K3A	4605.63	5102.00	120	300	GR 1.1
K3B	4605.63	5102.00	120	300	GR 1.1
K6A	4605.63	5102.00	120	300	GR 1.1
K6B	4605.63	5102.00	120	300	GR 1.1
K8A	4605.63	5102.00	120	300	GR 1.1
K2A	4605.63	5102.00	120	300	GR 1.1
K2B	4605.63	5102.00	120	300	GR 1.1
K7A	4605.63	5102.00	120	300	GR 1.1
K7B	4605.63	5102.00	120	300	GR 1.1
K1A	4605.63	5102.00	120	300	GR 1.1
K1B	4605.63	5102.00	120	300	GR 1.1
K9	9211.25	10204.01	120	600	GR 1.1
N5	4605.63	5102.00	120	300	GR 1.1
Minimum Rating	4605.627	5102.004	kPa		

Note: ANSI Ratings are per ANSI/ASME B16.5 2003 Edition

Wind Analysis Results

Wind Load Results per ASCE-7 98/02/05:

Note: Per Section 1609 of IBC 2003/06 these results are also applicable for the determination of Wind Loads on structures (1609.1.1).

User Entered Importance Factor is		1.000	
Gust Effect Factor (Ope)(G or Gf)	Dynamic	0.887	
User entered Beta Value (Operating Case)		0.0100	
Shape Factor (Cf)		0.557	
User Entered Basic Wind Speed		46.0	m/sec

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 = 3 (C) thus from Table C6-2:
Alpha = 9.500 : Zg = 274320.000 mm

Effective Height [z]
= Centroid Hgt. + Vessel Base Elevation
= 2050.000 + 10000.000 = 12050.000 mm
= 39.534 ft. Imperial Units

Compute [Kz]
Because z (39.534 ft.) > 15 ft.
$= 2.01 * (z / Zg)^{2 / Alpha}$
$= 2.01 * (39.534 / 900.000)^{2 / 9.500}$
= 1.041

Type of Hill: No Hill

Directionality Factor for round structures [Kd]:
= 0.95 per [6-6 ASCE-7 98][6-4 ASCE-7 02/05]

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

Topographical Factor [Kzt]
$= (1 + K1 * K2 * K3)^2$
$= (1 + 0.000 * 0.000 * 0.000)^2$
= 1.0000

Basic Wind Pressure, Imperial Units [qz]:
$= 0.00256 * Kz * Kzt * Kd * I * Vr(mph)^2$
$= 0.00256 * 1.041 * 1.000 * 0.950 * 1.000 * (102.901)^2$
$= 26.808$ psf [1283.529] N/m^2

Force on the first element [F]:
= qz * Gh * Cf * WindArea
= 1283.529 * 0.887 * 0.557 * 2882188
= 1828.583 N

Element	Hgt (z) mm	K1	K2	K3	Kz	Kzt	qz N/m^2
Node 10 to 20	12050.0	0.000	0.000	0.000	1.041	1.000	1283.529
Node 20 to 30	12050.0	0.000	0.000	0.000	1.041	1.000	1283.529
Node 30 to 40	12050.0	0.000	0.000	0.000	1.041	1.000	1283.529

Platform Load Calculations

ID	Wind Area mm²	Elevation mm	Pressure N/m²	Force N	Cf

Wind Loads on Masses/Equipment/Piping

ID	Wind Area mm²	Elevation mm	Pressure N/m²	Force N
INLET DEVICE	0.00	12000.00	1283.53	0.00
GAS BOX	0.00	24000.00	1283.53	0.00
INTERNALS	0.00	17000.00	1283.53	0.00
WEIR	0.00	22900.00	1283.53	0.00

Wind Load Calculation

From	To	Wind Height mm	Wind Diameter mm	Wind Area mm²	Height Factor N/m²	Element Wind Load N
10	20	12050.0	4347.60	2.882E+06	1283.53	1828.58
20	30	12050.0	4356.00	64.90E+06	1283.53	41178.1
30	40	12050.0	4347.60	2.882E+06	1283.53	1828.58

Shop/Field Installation Options :

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

Center of Gravity of Saddles	7500.0 mm
Center of Gravity of Liquid	7500.0 mm
Center of Gravity of Nozzles	8648.9 mm
Center of Gravity of Added Weights (Empty)	7412.5 mm
Center of Gravity of Added Weights (Operating)	7412.5 mm
Center of Gravity of Bare Shell New and Cold	7500.0 mm
Center of Gravity of Bare Shell Corroded	7500.0 mm
Vessel CG in the Operating Condition	7535.9 mm
Vessel CG in the Fabricated (Shop/Empty) Condition	7577.6 mm

Horizontal Vessel Analysis: Stresses for the Left Saddle

Horizontal Vessel Stress Calculations : Operating Case

Shell Allowable Stress used in Calculation	137892.00	kPa
Shell Comp. Yield Stress used in Calculation	235962.00	kPa
Head Allowable Stress used in Calculation	137892.00	kPa
Saddle Force Q, Operating Case	2018459.12	N

Horizontal Vessel Analysis Results:	Actual	Allowable	
Long. Stress at Top of Saddles	62900.25	137892.00	kPa
Long. Stress at Bottom of Saddles	63012.16	137892.00	kPa
Long. Stress at Top of Midspan	52766.13	137892.00	kPa
Long. Stress at Bottom of Midspan	73146.28	137892.00	kPa
Tangential Shear in Shell	16341.55	110313.60	kPa
Tangential Shear in Head	17319.25	110313.60	kPa
Circ. Stress at Horn of Saddle	-15930.70	-206838.00	kPa
Circ. Stress at Tip of Wear Plate	-18659.64	-206838.00	kPa
Addl. Stress in Head as Stiffener	7894.03	34473.00	kPa
Circ. Compressive Stress in Shell	-44097.44	-117981.00	kPa

Note: The Longitudinal Stress from the Zick Analysis is combined with the Longitudinal Pressure Stress to get the total stress.

Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:
= Ftr * (Ft/Num of Saddles + Z Force Load) * B / E
= 3.00 * (44835.3 /2 + 225681) * 2050.0000 / 3148.8682
= 484557.5 N

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:
= Max(Fl, Friction Load, Sum of X Forces) * B / Ls
= Max(15939.69 , 613560 , 76000) * 2050.0000 / 13800.0010
= 91144.9 N

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:
= Max(Fl, Friction Force, Sum of X Forces) * B / Ls
= Max(0.00 , 613560 , 76000) * 2050.0000 / 13800.0010
= 91144.9 N

Saddle Reaction Force due to Earthquake Ft [Fst]:
= Ftr * (Ft/Num of Saddles + Z Force Load) * B / E
= 3.00 * (0 /2 + 225681) * 2050.0000 / 3148.8682
= 440774.0 N

Load Combination Results for Q + Wind or Seismic [Q]:
= Saddle Load + Max(Fwl, Fwt, Fsl, Fst)
= 1533901 + Max(91144 , 484557 , 91144 , 440773)
= 2018459.1 N

Summary of Loads at the base of this Saddle:

Vertical Load (including sadddle weight)	2030977.00	N
Transverse Shear Load Saddle	248098.80	N
Longitudinal Shear Load Saddle	613560.69	N

Formulas and Substitutions for Horizontal Analysis:

Intermediate Term [MFract1]:
= 1 - (1- a/L + (R^2-$H2^2$)/(2a*L))/(1+(4H)/3L)

```
  = 1-(1-600.00/15000.00+(1753.000²-875.000²)/(2*600.00*15000.00))/
    (1+(4*72.92)/(2*15000.00))
  = -0.0097
```

Bending Moment over the Saddle (+-) [M1]:

```
  = Q * a( MFract1 )
  = 2018459 * 600.000 ( -0.0097 )
  = -11702.47 N-m
```

Intermediate Term [MFract2]:

```
  = (1+2(R²-H²)/(L²))/(1+(4H)/( 3L))-4a/L
  = (1+2(1752²-875²)/(15000²))/(1+(4*875)/(3*15000))-
    4*600.00/15000.00
  = 0.7869
```

Moment at Mid-Span [M2]:

```
  = QL/4 * MFract2
  = 2018459 * 15000.001 /4 * 0.7869
  = 5958371.50 N-m
```

Longitudinal Bending (+-) at Midspan:

```
  = ( 0.25 * Q * L * K.2 / ( pi * R² * ( Ts - Ca )))
  = ( 0.25 * 2018459 * 15000.00 * 0.7869 ) /
    ( 3.141 * 1753.0000 * 1753.0000 * ( 65.0000 - 3.0000 )))
  = 9950.80 kPa
```

Compute the area ratio [K]:

```
  = pi * (sin(delta)/Delta - cos(delta) ) / (delta + sin(delta) * cos(delta) -
    (delta + sin(delta) * cos(delta) - 2 * sin(delta) * sin(delta)/delta)
  = Pi * (sin(1.396 ) / 1.396 - cos(1.396 )) / ( 1.396 + sin(1.396 ) *
    cos(1.396 ) - 2 * sin(1.396 ) * sin(1.396 )/ 1.396 )
  = 9.3799
```

Intermediate Product [K.1]:

```
  = K * MFract1 * 4 * A / L
  = 9.380 * -0.010 * 4 * 600.000 / 15000.001
  = -0.0145
```

Longitudinal Bending (+-) at Saddle:

```
  = ( 0.25 * Q * L * K.1 / ( pi * R² * ( Ts - Ca )))
  = ( 0.25 * 2018459 * 15000.00 * -0.0145 ) /
    ( 3.141 * 1753.0000 * 1753.0000 * ( 65.0000 - 3.0000 )))
  = -183.32 kPa
```

Tangential Shear in Shell near Saddle:

```
  = K3 * Q / ( R * t )
  = 0.8799 * 2018459 / ( 1753.0000 * 62.0000 )
  = 16341.55 kPa
```

Tangential Shear in Head used as Stiffener:

```
  = K4 * Q / ( R * Th )
  = 0 * 2018459 / ( 1753.00 * ( 58.5000 - 0.0000 )
  = 17319.25 kPa
```

Circumferential Stress at Tip of the Wear Plate:

```
  = -Q/(4t(b+x1+x2)) - 3*Q*K7,1/(2t²)
  = -2018459 /( 4 * 62.0000 (300.00 + 257.1469 + 257.1469 ))
    -3 * 2018459 * 0.0110 / ( 2 * 3843.9998 )
  = -18659.64 kPa
```

Note: Wear Plate is considered as A < R/2 and WearPlate extension > R/10)

Equivalent Membrane Thickness [Tem]:

= Corroded Thickness + Wearplate Thickness
= 62.000 + 25.000
= 87.000 mm

Equivalent Bending Thickness squared [Teb]:
= Corroded Thickness^2 + Wearplate Thickness^2
= 62.000 ^2 + 25.000 ^2
= 4469.000 mm^2

Circumferential Stress at Horn of Saddle:
= $-Q/(4t(b+x1+x2)) - 3*Q*K7/(2t^2)$
= -2018459 /(4 * 87.0000 (300.00 + 257.1469 + 257.1469))
-3 * 2018459 * 0.0130 / (2 * 4469.0000)
= -15930.70 kPa

Parameter [K4]:
= $(3/8)*(\sin(alpha)^2/(pi-alpha+\sin(alpha*\cos(alpha)))$
= $(3/8)*(\sin(114.0)^2/(pi-114.0+\sin(114.0*\cos(114.0)))$
= 0.4011

Additional Tension in Head used as Stiffener:
= K4 * Q/(R * th)
= 0.4011 * 2018459 /(1753.0000 * 58.5000)
= 7894.03 kPa

Circumferential Compression at Bottom of Shell:
= (Q*(K.9/(TEM9 * WPDWTH)))
= (2018459 *(0.7603 /(87.0000 * 400.000)))
= -44097.44 kPa

Free Un-Restrained Thermal Expansion between the Saddles [Exp]:
= Alpha * Ls * (Design Temperature - Ambient Temperature)
= 0.109E-04 * 13800.001 * (120.0 - 21.1)
= 14.903 mm

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	2300.0000	mm
Baseplate Thickness	Bpthk	40.0000	mm
Baseplate Width	Bpwid	300.0000	mm
Number of Ribs (inc. outside ribs)	Nribs	6	
Rib Thickness	Ribtk	25.0000	mm
Web Thickness	Webtk	30.0000	mm
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Ay²	Io
Shell	31.	56686.	1757273.	54475408.	18158470.
Wearplate	74.	10000.	745000.	55502452.	520833.
Web	154.	3990.	612465.	94013288.	5881586.
BasePlate	240.	12000.	2880000.	691199296.	1599998.
Totals	499.	82676.	5994738.	895190400.	26160886.

Value C1 = Sumof(Ay)/Sumof(A) = 73. mm
Value I = Sumof(Ay²) + Sumof(Io) - C1*Sumof(Ay) = 486681664. mm**4
Value As = Sumof(A) - Ashell = 25990. mm²

K1 = $(1+\cos(beta)-.5*\sin(beta)^2)/(pi-beta+\sin(beta)*\cos(beta))$ = 0.2035

Fh = K1 * Q = 0.2035 * 2018459 = 0.4E+06 N

Tension Stress, St = (Fh/As) = 15806.5146 kPa
Allowed Stress, Sa = 0.6 * Yield Str = 148923.5938 kPa

```
d  = B - R*Sin(theta) / theta        =        563.2806  mm
Bending Moment, M  = Fh * d          =     231489.6406  N-m

Bending Stress, Sb = ( M * C1 / I  ) =      34475.5664  kPa
Allowed Stress, Sa = 2/3 * Yield Str =     165470.6719  kPa
```

Minimum Thickness of Baseplate per Moss :

```
= ( 3 * ( Q + Saddle_Wt ) * BasePlateWidth / ( 4 * BasePlateLength *
  AllStress ))½
= ( 3 * (2018459 + 12517 ) * 300.00 / ( 4 * 2300.000 * 165470.672 ))½
= 34.652 mm
```

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

```
= ( Bplen - Clearance ) / ( Nribs - 1)
= ( 2300.0000 - 25.4 ) / ( 6 - 1 ) = 454.9200 mm
```

Baseplate Pressure Area [Ap]:

```
= e * Bpwid / 2
= 454.9200 * 300.0000 / 2 = 68238.0000 mm²
```

Axial Load [P]:

```
= Ap * Bp
= 68238.0 * 2.93 = 199616.8 N
```

Area of the Rib and Web [Ar]:

```
= ( Bpwid - Clearance - Webtk ) * Ribtk + e/2 * Webtk
= ( 300.000 - 25.4 - 30.000 ) * 25.000 + 454.9200 /2 * 30.000
= 12938.801 mm²
```

Compressive Stress [Sc]:

```
= P/Ar
= 199616.8 / 12938.8008 = 15428.1855 kPa
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	Y	A	AY	Ay²	Io
Rib	150.0	6432.5	964874.9	0.0	49404356.0
Web	150.0	6823.8	1023570.0	0.0	1023569.1
Values	150.0	13256.3	1988444.9	0.0	50427924.0

Bending Moment [Rm]:

```
= Fl /( 2 * Bplen ) * e * rl / 2
= 613560 /( 2 * 2300.00 ) * 454.920 * 1105.50 / 2
= 33553.621 N-m

KL/R < Cc ( 17.7080 < 126.0991 ) per AISC E2-1
Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
Sca = ( 1-( 17.71 )²/(2 * 126.10² )) * 248206 /
      ( 5/3+3*(17.71 )/(8* 126.10 )-( 17.71³)/(8*126.10³)
Sca = 142967.58 kPa
```

AISC Unity Check on Outside Ribs (must be <= 1.0)

```
Check = Sc/Sca + (Rm/Z)/Sba
Check = 15428.19 / 142967.58 + (33553.62 /336186.156) / 165470.67
Check = 0.71
```

Check of Inside Ribs

Inertia of Saddle, Inner Ribs - Axial Direction

	Y	A	AY	Ay²	Io

Rib	137.3	6115.0	839589.4	0.0	43137992.0
Web	137.3	13647.6	1873815.5	0.0	1023569.1
Values	137.3	19762.6	2713404.8	0.0	44161564.0

KL/R < Cc (6.4354 < 126.0991) per AISC E2-1
Sca = $(1-(Klr)^2/(2*Cc^2))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr^3)/(8*Cc^3)$
Sca = $(1-(6.44)^2/(2 * 126.10^2)) * 248206 /$
$(5/3+3*(6.44)/(8* 126.10)-(6.44^3)/(8*126.10^3)$
Sca = 147042.69 kPa

AISC Unity Check on Inside Ribs (must be <= 1.0)
Check = Sc/Sca + (Rm/Z)/Sba
Check = 20202.02 / 147042.69 + (18466.60 /321642.844) / 165470.67
Check = 0.48

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	6	
Total Number of Bolts in Tension/Baseplate	Nbt	3	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	172365.00	kPa
Bolt Corrosion Allowance	Bca	0.0000	mm
Distance from Bolts to Edge	Edgedis	150.0124	mm
Nominal Bolt Diameter	Bnd	36.0000	mm
Thread Series	Series	TEMA Metric	
BasePlate Allowable Stress	S	114449.67	kPa
Area Available in a Single Bolt	BltArea	738.0151	mm²
Saddle Load QO (Weight)	QO	1546419.5	N
Saddle Load QL (Wind/Seismic contribution)	QL	91144.9	N
Maximum Transverse Force	Ft	248098.8	N
Maximum Longitudinal Force	Fl	613560.7	N
Saddle Bolted to Steel Foundation		No	

Bolt Area Calculation per Dennis R. Moss

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

Bolt Area due to Shear Load [Bltarears]:
= Fl / (Stba * Nbolts)
= 613560 / (172365.00 * 6.00)
= 593.2925 mm²

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:
= B * Ft + Sum of X Moments
= 2050.00 * 248098.80 + 0.00
= 508808.75 N-m

Eccentricity (e):
= Rmom / QO
= 508808 / 1546419
= 328.89 mm < Bplen/6 --> No Uplift in Transverse direction

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

Required of a Single Bolt [Bltarear]
= max[Bltarearl, Bltarears, Bltareart]
= max[0.0000 , 593.2925 , 0.0000]
= 593.2925 mm²

Zick Analysis: Stresses for the Right Saddle

Shell Allowable Stress used in Calculation	137892.00	kPa
Shell Comp. Yield Stress used in Calculation	235962.00	kPa
Head Allowable Stress used in Calculation	137892.00	kPa
Saddle Force Q, Operating Case	1584284.12	N

Horizontal Vessel Analysis Results:	Actual	Allowable	
Long. Stress at Top of Saddles	62860.82	137892.00	kPa
Long. Stress at Bottom of Saddles	63051.60	137892.00	kPa
Long. Stress at Top of Midspan	54906.57	137892.00	kPa
Long. Stress at Bottom of Midspan	71005.84	137892.00	kPa
Tangential Shear in Shell	12826.45	110313.60	kPa
Tangential Shear in Head	13593.84	110313.60	kPa
Circ. Stress at Horn of Saddle	-12503.97	-206838.00	kPa
Circ. Stress at Tip of Wear Plate	-14645.91	-206838.00	kPa
Addl. Stress in Head as Stiffener	6196.01	34473.00	kPa
Circ. Compressive Stress in Shell	-34611.98	-117981.00	kPa

Note: The Longitudinal Stress from the Zick Analysis is combined with the Longitudinal Pressure Stress to get the total stress.

Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:
= Ftr * (Ft/Num of Saddles + Z Force Load) * B / E
= 3.00 * (44835.3 /2 + 60318) * 2050.0000 / 3148.8682
= 161591.2 N

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:
= Max(Fl, Friction Load, Sum of X Forces) * B / Ls
= Max(15939.69 , 569077 , 76000) * 2050.0000 / 13800.0010
= 84536.8 N

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:
= Max(Fl, Friction Force, Sum of X Forces) * B / Ls
= Max(0.00 , 569077 , 76000) * 2050.0000 / 13800.0010
= 84536.8 N

Saddle Reaction Force due to Earthquake Ft [Fst]:
= Ftr * (Ft/Num of Saddles + Z Force Load) * B / E
= 3.00 * (0 /2 + 60318) * 2050.0000 / 3148.8682
= 117807.7 N

Load Combination Results for Q + Wind or Seismic [Q]:
= Saddle Load + Max(Fwl, Fwt, Fsl, Fst)
= 1422693 + Max(84536 , 161591 , 84536 , 117807)
= 1584284.1 N

Summary of Loads at the base of this Saddle:

Vertical Load (including sadddle weight)	1596802.00	N
Transverse Shear Load Saddle	82736.48	N
Longitudinal Shear Load Saddle	569077.19	N

Formulas and Substitutions for Horizontal Analysis:

Intermediate Term [MFract1]:
= 1 - (1- a/L + (R^2-$H2^2$)/(2a*L))/(1+(4H)/3L)

```
  = 1-(1-600.00/15000.00+(1753.000²-875.000²)/(2*600.00*15000.00))/
    (1+(4*72.92)/(2*15000.00))
  = -0.0097
```

Bending Moment over the Saddle (+-) [M1]:

```
  = Q * a( MFract1 )
  = 1584284 * 600.000 ( -0.0097 )
  = -9185.25 N-m
```

Intermediate Term [MFract2]:

```
  = (1+2(R²-H²)/(L²))/(1+(4H)/( 3L))-4a/L
  = (1+2(1752²-875²)/(15000²))/(1+(4*875)/(3*15000))-
    4*600.00/15000.00
  = 0.7869
```

Moment at Mid-Span [M2]:

```
  = QL/4 * MFract2
  = 1584284 * 15000.001 /4 * 0.7869
  = 4676712.50 N-m
```

Longitudinal Bending (+-) at Midspan:

```
  = ( 0.25 * Q * L * K.2 / ( pi * R² * ( Ts - Ca )))
  = ( 0.25 * 1584284 * 15000.00 * 0.7869 ) /
    ( 3.141 * 1753.0000 * 1753.0000 * ( 65.0000 - 3.0000 )))
  = 7810.36 kPa
```

Compute the area ratio [K]:

```
  = pi * (sin(delta)/Delta - cos(delta) ) / (delta + sin(delta) * cos(delta) -
    (delta + sin(delta) * cos(delta) - 2 * sin(delta) * sin(delta)/delta)
  = Pi * (sin(1.396 ) / 1.396 - cos(1.396 )) / ( 1.396 + sin(1.396 ) *
    cos(1.396 ) - 2 * sin(1.396 ) * sin(1.396 )/ 1.396 )
  = 9.3799
```

Intermediate Product [K.1]:

```
  = K * MFract1 * 4 * A / L
  = 9.380 * -0.010 * 4 * 600.000 / 15000.001
  = -0.0145
```

Longitudinal Bending (+-) at Saddle:

```
  = ( 0.25 * Q * L * K.1 / ( pi * R² * ( Ts - Ca )))
  = ( 0.25 * 1584284 * 15000.00 * -0.0145 ) /
    ( 3.141 * 1753.0000 * 1753.0000 * ( 65.0000 - 3.0000 )))
  = -143.89 kPa
```

Tangential Shear in Shell near Saddle:

```
  = K3 * Q / ( R * t )
  = 0.8799 * 1584284 / ( 1753.0000 * 62.0000 )
  = 12826.45 kPa
```

Tangential Shear in Head used as Stiffener:

```
  = K4 * Q / ( R * Th )
  = 0 * 1584284 / ( 1753.00 * ( 58.5000 - 0.0000 )
  = 13593.84 kPa
```

Circumferential Stress at Tip of the Wear Plate:

```
  = -Q/(4t(b+x1+x2)) - 3*Q*K7,1/(2t²)
  = -1584284 /( 4 * 62.0000 (300.00 + 257.1469 + 257.1469 ))
    -3 * 1584284 * 0.0110 / ( 2 * 3843.9998 )
  = -14645.91 kPa
```

Note: Wear Plate is considered as A < R/2 and WearPlate extension > R/10)

Equivalent Membrane Thickness [Tem]:

```
  = Corroded Thickness + Wearplate Thickness
  = 62.000 + 25.000
  = 87.000 mm
```

Equivalent Bending Thickness squared [Teb]:

```
  = Corroded Thickness^2 + Wearplate Thickness^2
  = 62.000 ^2 + 25.000 ^2
  = 4469.000 mm^2
```

Circumferential Stress at Horn of Saddle:

```
  = -Q/(4t(b+x1+x2)) - 3*Q*K7/(2t^2)
  = -1584284 /( 4 * 87.0000 (300.00 + 257.1469 + 257.1469 ))
    -3 * 1584284 * 0.0130 / ( 2 * 4469.0000 )
  = -12503.97 kPa
```

```
 Parameter [K4]:
  = (3/8)*(sin(alpha)²/(pi-alpha+sin(alpha*cos(alpha)))
  = (3/8)*(sin(114.0 )²/(pi-114.0 +sin(114.0 *cos(114.0 )))
  = 0.4011
```

Additional Tension in Head used as Stiffener:

```
  = K4 * Q/( R * th )
  = 0.4011 * 1584284 /( 1753.0000 * 58.5000 )
  = 6196.01 kPa
```

Circumferential Compression at Bottom of Shell:

```
  = (Q*( K.9/( TEM9 * WPDWTH ) ) )
  = ( 1584284 *( 0.7603 /( 87.0000 * 400.000 ) ) )
  = -34611.98 kPa
```

Results for Vessel Ribs, Web and Base

Baseplate Length	Bplen	2300.0000	mm
Baseplate Thickness	Bpthk	40.0000	mm
Baseplate Width	Bpwid	300.0000	mm
Number of Ribs (inc. outside ribs)	Nribs	6	
Rib Thickness	Ribtk	25.0000	mm
Web Thickness	Webtk	30.0000	mm
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Ay²	Io
Shell	31.	56686.	1757273.	54475408.	18158470.
Wearplate	74.	10000.	745000.	55502452.	520833.
Web	154.	3990.	612465.	94013288.	5881586.
BasePlate	240.	12000.	2880000.	691199296.	1599998.
Totals	499.	82676.	5994738.	895190400.	26160886.

```
 Value  C1 = Sumof(Ay)/Sumof(A)                      =          73.  mm
 Value   I = Sumof(Ay² ) + Sumof(Io) - C1*Sumof(Ay) =   486681664.  mm**4
 Value  As = Sumof(A) - Ashell                      =       25990.  mm²

 K1 = (1+Cos(beta)-.5*Sin(beta)² )/(pi-beta+Sin(beta)*Cos(beta)) =   0.2035

 Fh = K1 * Q = 0.2035 * 1584284 = 0.3E+06 N

 Tension Stress, St = ( Fh/As )       =      12406.4990  kPa
 Allowed Stress, Sa = 0.6 * Yield Str =     148923.5938  kPa

 d  = B - R*Sin(theta) / theta        =        563.2806  mm
 Bending Moment, M  = Fh * d          =     181695.7188  N-m
```

```
Bending Stress, Sb = ( M * C1 / I  ) =      27059.7988  kPa
Allowed Stress, Sa = 2/3 * Yield Str =     165470.6719  kPa
```

Minimum Thickness of Baseplate per Moss :

```
= ( 3 * ( Q + Saddle_Wt ) * BasePlateWidth / ( 4 * BasePlateLength *
  AllStress ))½
= ( 3 * (1584284 + 12517 ) * 300.00 / ( 4 * 2300.000 * 165470.672 ))½
= 30.725 mm
```

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

```
= ( Bplen - Clearance ) / ( Nribs - 1)
= ( 2300.0000 - 25.4 ) / ( 6 - 1 ) = 454.9200 mm
```

Baseplate Pressure Area [Ap]:

```
= e * Bpwid / 2
= 454.9200 * 300.0000 / 2 = 68238.0000 mm²
```

Axial Load [P]:

```
= Ap * Bp
= 68238.0 * 2.30 = 156678.8 N
```

Area of the Rib and Web [Ar]:

```
= ( Bpwid - Clearance - Webtk ) * Ribtk + e/2 * Webtk
= ( 300.000 - 25.4 - 30.000 ) * 25.000 + 454.9200 /2 * 30.000
= 12938.801 mm²
```

Compressive Stress [Sc]:

```
= P/Ar
= 156678.8 / 12938.8008 = 12109.5488 kPa
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	Y	A	AY	Ay²	Io
Rib	150.0	6432.5	964874.9	0.0	49404356.0
Web	150.0	6823.8	1023570.0	0.0	1023569.1
Values	150.0	13256.3	1988444.9	0.0	50427924.0

Bending Moment [Rm]:

```
= Fl /( 2 * Bplen ) * e * rl / 2
= 569077 /( 2 * 2300.00 ) * 454.920 * 1105.50 / 2
= 31120.971 N-m

KL/R < Cc ( 17.7080 < 126.0991 ) per AISC E2-1
Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
Sca = ( 1-( 17.71 )²/(2 * 126.10² )) * 248206 /
      ( 5/3+3*(17.71 )/(8* 126.10 )-( 17.71³)/(8*126.10³)
Sca = 142967.58 kPa
```

AISC Unity Check on Outside Ribs (must be <= 1.0)

```
Check = Sc/Sca + (Rm/Z)/Sba
Check = 12109.55 / 142967.58 + (31120.97 /336186.156) / 165470.67
Check = 0.64
```

Check of Inside Ribs

Inertia of Saddle, Inner Ribs - Axial Direction

	Y	A	AY	Ay²	Io
Rib	137.3	6115.0	839589.4	0.0	43137992.0
Web	137.3	13647.6	1873815.5	0.0	1023569.1
Values	137.3	19762.6	2713404.8	0.0	44161564.0

KL/R < Cc (6.4354 < 126.0991) per AISC E2-1
Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
Sca = (1-(6.44)²/(2 * 126.10²)) * 248206 /
(5/3+3*(6.44)/(8* 126.10)-(6.44³)/(8*126.10³)
Sca = 147042.69 kPa

AISC Unity Check on Inside Ribs (must be <= 1.0)
Check = Sc/Sca + (Rm/Z)/Sba
Check = 15856.52 / 147042.69 + (17127.76 /321642.844) / 165470.67
Check = 0.43

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	6	
Total Number of Bolts in Tension/Baseplate	Nbt	3	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	172365.00	kPa
Bolt Corrosion Allowance	Bca	0.0000	mm
Distance from Bolts to Edge	Edgedis	150.0124	mm
Nominal Bolt Diameter	Bnd	36.0000	mm
Thread Series	Series	TEMA Metric	
BasePlate Allowable Stress	S	114449.67	kPa
Area Available in a Single Bolt	BltArea	738.0151	mm²
Saddle Load QO (Weight)	QO	1435210.9	N
Saddle Load QL (Wind/Seismic contribution)	QL	84536.8	N
Maximum Transverse Force	Ft	248098.8	N
Maximum Longitudinal Force	Fl	613560.7	N
Saddle Bolted to Steel Foundation		No	

Bolt Area Calculation per Dennis R. Moss

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

Bolt Area due to Shear Load [Bltarears]:
= Fl / (Stba * Nbolts)
= 613560 / (172365.00 * 6.00)
= 593.2925 mm²

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:
= B * Ft + Sum of X Moments
= 2050.00 * 248098.80 + 0.00
= 508808.75 N-m

Eccentricity (e):
= Rmom / QO
= 508808 / 1435210
= 354.37 mm < Bplen/6 --> No Uplift in Transverse direction

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

Required of a Single Bolt [Bltarear]
= max[Bltarearl, Bltarears, Bltareart]
= max[0.0000 , 593.2925 , 0.0000]
= 593.2925 mm²

Horizontal Vessel Analysis: Stresses for the Left Saddle

Horizontal Vessel Stress Calculations : Test Case

Shell Allowable Stress used in Calculation	137892.00	kPa
Shell Comp. Yield Stress used in Calculation	261994.80	kPa
Head Allowable Stress used in Calculation	137892.00	kPa
Saddle Force Q, Test Case, no Ext. Forces	1573177.50	N

Horizontal Vessel Analysis Results:	Actual	Allowable	
Long. Stress at Top of Saddles	77709.07	137892.00	kPa
Long. Stress at Bottom of Saddles	77450.91	137892.00	kPa
Long. Stress at Top of Midspan	70157.77	137892.00	kPa
Long. Stress at Bottom of Midspan	85002.21	137892.00	kPa
Tangential Shear in Shell	12169.52	110313.60	kPa
Tangential Shear in Head	12862.09	110313.60	kPa
Circ. Stress at Horn of Saddle	-11615.05	-206838.00	kPa
Circ. Stress at Tip of Wear Plate	-13244.77	-206838.00	kPa
Addl. Stress in Head as Stiffener	5862.48	34473.00	kPa
Circ. Compressive Stress in Shell	-33223.69	-130997.40	kPa
Hydrostatic Test Pressure at top of Vessel	5850.000		kPa

Note: The Longitudinal Stress from the Zick Analysis is combined with the Longitudinal Pressure Stress to get the total stress.

Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:
= Ftr * (Ft/Num of Saddles + Z Force Load) * B / E
= 3.00 * (14795.6 /2 + 0) * 2050.0000 / 3143.6721
= 14472.4 N

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:
= Max(Fl, Friction Load, Sum of X Forces) * B / Ls
= Max(5260.10 , 0.00 , 0) * 2050.0000 / 13800.0010
= 781.4 N

Load Combination Results for Q + Wind or Seismic [Q]:
= Saddle Load + Max(Fwl, Fwt, Fsl, Fst)
= 1558705 + Max(781 , 14472 , 0 , 0)
= 1573177.5 N

Summary of Loads at the base of this Saddle:

Vertical Load (including sadddle weight)	1585695.38	N
Transverse Shear Load Saddle	7397.82	N
Longitudinal Shear Load Saddle	5260.10	N

Formulas and Substitutions for Horizontal Analysis:

Intermediate Term [MFract1]:
= 1 - (1- a/L + (R²-H2²)/(2a*L))/(1+(4H)/3L)
= 1-(1-600.00/15000.00+(1750.000²-875.000²)/(2*600.00*15000.00))/
(1+(4*72.92)/(2*15000.00))
= -0.0091

Bending Moment over the Saddle (+-) [M1]:
= Q * a(MFract1)
= 1573177 * 600.000 (-0.0091)
= -8609.34 N-m

Intermediate Term [MFract2]:
= (1+2(R²-H²)/(L²))/(1+(4H)/(3L))-4a/L
= (1+2(1750²-875²)/(15000²))/(1+(4*875)/(3*15000))-
4*600.00/15000.00
= 0.7868

Moment at Mid-Span [M2]:
= QL/4 * MFract2
= 1573177 * 15000.001 /4 * 0.7868
= 4643415.00 N-m

Longitudinal Bending (+-) at Midspan:
= (0.25 * Q * L * K.2 / (pi * R² * (Ts - Ca)))
= (0.25 * 1573177 * 15000.00 * 0.7868) /
(3.141 * 1749.9999 * 1749.9999 * (65.0000 - 0.0000)))
= 7422.22 kPa

Compute the area ratio [K]:
= pi * (sin(delta)/Delta - cos(delta)) / (delta + sin(delta) * cos(delta) -
(delta + sin(delta) * cos(delta) - 2 * sin(delta) * sin(delta)/delta)
= Pi * (sin(1.396) / 1.396 - cos(1.396)) / (1.396 + sin(1.396) *
cos(1.396) - 2 * sin(1.396) * sin(1.396)/ 1.396)
= 9.3799

Intermediate Product [K.1]:
= K * MFract1 * 4 * A / L
= 9.380 * -0.009 * 4 * 600.000 / 15000.001
= -0.0137

Longitudinal Bending (+-) at Saddle:
= (0.25 * Q * L * K.1 / (pi * R² * (Ts - Ca)))
= (0.25 * 1573177 * 15000.00 * -0.0137) /
(3.141 * 1749.9999 * 1749.9999 * (65.0000 - 0.0000)))
= -129.08 kPa

Tangential Shear in Shell near Saddle:
= K3 * Q / (R * t)
= 0.8799 * 1573177 / (1749.9999 * 65.0000)
= 12169.52 kPa

Tangential Shear in Head used as Stiffener:
= K4 * Q / (R * Th)
= 0 * 1573177 / (1750.00 * (61.5000 - 0.0000)
= 12862.09 kPa

Circumferential Stress at Tip of the Wear Plate:
= -Q/(4t(b+x1+x2)) - 3*Q*K7,1/(2t^2)
= -1573177 /(4 * 65.0000 (300.00 + 263.0694 + 263.0694))
-3 * 1573177 * 0.0106 / (2 * 4224.9995)
= -13244.77 kPa

Note: Wear Plate is considered as A < R/2 and WearPlate extension > R/10)

Equivalent Membrane Thickness [Tem]:
= Corroded Thickness + Wearplate Thickness
= 65.000 + 25.000
= 90.000 mm

Equivalent Bending Thickness squared [Teb]:
= Corroded Thickness^2 + Wearplate Thickness^2
= 65.000 ^2 + 25.000 ^2
= 4850.000 mm^2

Circumferential Stress at Horn of Saddle:

```
= -Q/(4t(b+x1+x2)) - 3*Q*K7/(2t²)
= -1573177 /( 4 * 90.0000 (300.00 + 263.0694 + 263.0694 ))
  -3 * 1573177 * 0.0130 / ( 2 * 4849.9995 )
= -11615.05 kPa
```

```
Parameter [K4]:
 = (3/8)*(sin(alpha)²/(pi-alpha+sin(alpha*cos(alpha)))
 = (3/8)*(sin(114.0 )²/(pi-114.0 +sin(114.0 *cos(114.0 )))
 = 0.4011
```

Additional Tension in Head used as Stiffener:

```
= K4 * Q/( R * th )
= 0.4011 * 1573177 /( 1749.9999 * 61.5000 )
= 5862.48 kPa
```

Circumferential Compression at Bottom of Shell:

```
= (Q*( K.9/( TEM9 * WPDWTH ) ) )
= ( 1573177 *( 0.7603 /( 90.0000 * 400.000 ) ) )
= -33223.69 kPa
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	2300.0000	mm
Baseplate Thickness	Bpthk	40.0000	mm
Baseplate Width	Bpwid	300.0000	mm
Number of Ribs (inc. outside ribs)	Nribs	6	
Rib Thickness	Ribtk	25.0000	mm
Web Thickness	Webtk	30.0000	mm
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Ay²	Io
Shell	32.	60199.	1956468.	63585148.	21195048.
Wearplate	78.	10000.	775000.	60062440.	520833.
Web	155.	3900.	604500.	93697400.	5492494.
BasePlate	240.	12000.	2880000.	691199296.	1599998.
Totals	505.	86099.	6215968.	908544256.	28808376.

```
Value  C1 = Sumof(Ay)/Sumof(A)                      =          72.  mm
Value   I = Sumof(Ay² ) + Sumof(Io) - C1*Sumof(Ay) =   488587680.  mm**4
Value  As = Sumof(A) - Ashell                      =       25900.  mm²

K1 = (1+Cos(beta)-.5*Sin(beta)² )/(pi-beta+Sin(beta)*Cos(beta)) =   0.2035

Fh = K1 * Q = 0.2035 * 1573177 = 0.3E+06 N

Tension Stress, St = ( Fh/As )       =      12362.3359  kPa
Allowed Stress, Sa = 0.6 * Yield Str =     148923.5938  kPa

d  = B - R*Sin(theta) / theta        =        562.7616  mm
Bending Moment, M  = Fh * d          =     180255.7031  N-m

Bending Stress, Sb = ( M * C1 / I  ) =      26625.1699  kPa
Allowed Stress, Sa = 2/3 * Yield Str =     165470.6719  kPa
```

Minimum Thickness of Baseplate per Moss :

```
= ( 3 * ( Q + Saddle_Wt ) * BasePlateWidth / ( 4 * BasePlateLength *
  AllStress ))½
= ( 3 * (1573177 + 12517 ) * 300.00 / ( 4 * 2300.000 * 165470.672 ))½
= 30.618 mm
```

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:
= (Bplen - Clearance) / (Nribs - 1)
= (2300.0000 - 25.4) / (6 - 1) = 454.9200 mm

Baseplate Pressure Area [Ap]:
= e * Bpwid / 2
= 454.9200 * 300.0000 / 2 = 68238.0000 mm²

Axial Load [P]:
= Ap * Bp
= 68238.0 * 2.28 = 155580.4 N

Area of the Rib and Web [Ar]:
= (Bpwid - Clearance - Webtk) * Ribtk + e/2 * Webtk
= (300.000 - 25.4 - 30.000) * 25.000 + 454.9200 /2 * 30.000
= 12938.801 mm²

Compressive Stress [Sc]:
= P/Ar
= 155580.4 / 12938.8008 = 12024.6543 kPa

Check of Outside Ribs:
Inertia of Saddle, Outer Ribs - Longitudinal Direction

	Y	A	AY	Ay²	Io
Rib	150.0	6432.5	964874.9	0.0	49404356.0
Web	150.0	6823.8	1023570.0	0.0	1023569.1
Values	150.0	13256.3	1988444.9	0.0	50427924.0

Bending Moment [Rm]:
= Fl /(2 * Bplen) * e * rl / 2
= 5260.1 /(2 * 2300.00) * 454.920 * 1102.50 / 2
= 286.877 N-m

KL/R < Cc (17.6600 < 126.0991) per AISC E2-1
Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
Sca = (1-(17.66)²/(2 * 126.10²)) * 248206 /
(5/3+3*(17.66)/(8* 126.10)-(17.66³)/(8*126.10³)
Sca = 142986.95 kPa

AISC Unity Check on Outside Ribs (must be <= 1.0)
Check = Sc/Sca + (Rm/Z)/Sba
Check = 12024.65 / 142986.95 + (286.88 /336186.156) / 165470.67
Check = 0.09

Check of Inside Ribs
Inertia of Saddle, Inner Ribs - Axial Direction

	Y	A	AY	Ay²	Io
Rib	137.3	6115.0	839589.4	0.0	43137992.0
Web	137.3	13647.6	1873815.5	0.0	1023569.1
Values	137.3	19762.6	2713404.8	0.0	44161564.0

KL/R < Cc (6.3719 < 126.0991) per AISC E2-1
Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
Sca = (1-(6.37)²/(2 * 126.10²)) * 248206 /
(5/3+3*(6.37)/(8* 126.10)-(6.37³)/(8*126.10³)
Sca = 147062.86 kPa

AISC Unity Check on Inside Ribs (must be <= 1.0)
Check = Sc/Sca + (Rm/Z)/Sba

```
Check = 15745.36 / 147062.86 + ( 156.75 /321642.844) / 165470.67
Check = 0.11
```

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	6	
Total Number of Bolts in Tension/Baseplate	Nbt	3	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	172365.00	kPa
Bolt Corrosion Allowance	Bca	0.0000	mm
Distance from Bolts to Edge	Edgedis	150.0124	mm
Nominal Bolt Diameter	Bnd	36.0000	mm
Thread Series	Series	TEMA Metric	
BasePlate Allowable Stress	S	114449.67	kPa
Area Available in a Single Bolt	BltArea	738.0151	mm²
Saddle Load QO (Weight)	QO	1571222.9	N
Saddle Load QL (Wind/Seismic contribution)	QL	781.4	N
Maximum Transverse Force	Ft	7397.8	N
Maximum Longitudinal Force	Fl	5260.1	N
Saddle Bolted to Steel Foundation		No	

Bolt Area Calculation per Dennis R. Moss

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

Bolt Area due to Shear Load [Bltarears]:
= Fl / (Stba * Nbolts)
= 5260.10 / (172365.00 * 6.00)
= 5.0863 mm²

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:
= B * Ft + Sum of X Moments
= 2050.00 * 7397.82 + 0.00
= 15171.68 N-m

Eccentricity (e):
= Rmom / QO
= 15171.68 / 1571222
= 9.65 mm < Bplen/6 --> No Uplift in Transverse direction

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

Required of a Single Bolt [Bltarear]
= max[Bltarearl, Bltarears, Bltareart]
= max[0.0000 , 5.0863 , 0.0000]
= 5.0863 mm²

Zick Analysis: Stresses for the Right Saddle

Shell Allowable Stress used in Calculation		137892.00	kPa
Shell Comp. Yield Stress used in Calculation		261994.80	kPa
Head Allowable Stress used in Calculation		137892.00	kPa
Saddle Force Q, Test Case, no Ext. Forces		1461968.38	N

Horizontal Vessel Analysis Results:	Actual	Allowable	
Long. Stress at Top of Saddles	77699.95	137892.00	kPa

Long. Stress at Bottom of Saddles	77460.04	137892.00	kPa
Long. Stress at Top of Midspan	70682.45	137892.00	kPa
Long. Stress at Bottom of Midspan	84477.52	137892.00	kPa
Tangential Shear in Shell	11309.24	110313.60	kPa
Tangential Shear in Head	11952.86	110313.60	kPa
Circ. Stress at Horn of Saddle	-10793.98	-206838.00	kPa
Circ. Stress at Tip of Wear Plate	-12308.49	-206838.00	kPa
Addl. Stress in Head as Stiffener	5448.06	34473.00	kPa
Circ. Compressive Stress in Shell	-30875.08	-130997.40	kPa
Hydrostatic Test Pressure at top of Vessel		5850.000	kPa

Note: The Longitudinal Stress from the Zick Analysis is combined with the Longitudinal Pressure Stress to get the total stress.

Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:
= Ftr * (Ft/Num of Saddles + Z Force Load) * B / E
= 3.00 * (14795.6 /2 + 0) * 2050.0000 / 3143.6721
= 14472.4 N

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:
= Max(Fl, Friction Load, Sum of X Forces) * B / Ls
= Max(5260.10 , 0.00 , 0) * 2050.0000 / 13800.0010
= 781.4 N

Load Combination Results for Q + Wind or Seismic [Q]:
= Saddle Load + Max(Fwl, Fwt, Fsl, Fst)
= 1447496 + Max(781 , 14472 , 0 , 0)
= 1461968.4 N

Summary of Loads at the base of this Saddle:

Vertical Load (including sadddle weight)	1474486.12	N
Transverse Shear Load Saddle	7397.82	N
Longitudinal Shear Load Saddle	5260.10	N

Formulas and Substitutions for Horizontal Analysis:

Intermediate Term [MFract1]:
= 1 - (1- a/L + (R²-H2²)/(2a*L))/(1+(4H)/3L)
= 1-(1-600.00/15000.00+(1750.000²-875.000²)/(2*600.00*15000.00))/
(1+(4*72.92)/(2*15000.00))
= -0.0091

Bending Moment over the Saddle (+-) [M1]:
= Q * a(MFract1)
= 1461968 * 600.000 (-0.0091)
= -8000.74 N-m

Intermediate Term [MFract2]:
= (1+2(R²-H²)/(L²))/(1+(4H)/(3L))-4a/L
= (1+2(1750²-875²)/(15000²))/(1+(4*875)/(3*15000))-
4*600.00/15000.00
= 0.7868

Moment at Mid-Span [M2]:
= QL/4 * MFract2
= 1461968 * 15000.001 /4 * 0.7868
= 4315168.50 N-m

Longitudinal Bending (+-) at Midspan:

```
  = ( 0.25 * Q * L * K.2 / ( pi * R² * ( Ts - Ca )))
  = ( 0.25 * 1461968 * 15000.00 * 0.7868 ) /
    ( 3.141 * 1749.9999 * 1749.9999 * ( 65.0000 - 0.0000 )))
  = 6897.54 kPa
```

Compute the area ratio [K]:

```
  = pi * (sin(delta)/Delta - cos(delta) ) / (delta + sin(delta) * cos(delta) -
    (delta + sin(delta) * cos(delta) - 2 * sin(delta) * sin(delta)/delta)
  = Pi * (sin(1.396 ) / 1.396 - cos(1.396 )) / ( 1.396 + sin(1.396 ) *
    cos(1.396 ) - 2 * sin(1.396 ) * sin(1.396 )/ 1.396 )
  = 9.3799
```

Intermediate Product [K.1]:

```
  = K * MFract1 * 4 * A / L
  = 9.380 * -0.009 * 4 * 600.000 / 15000.001
  = -0.0137
```

Longitudinal Bending (+-) at Saddle:

```
  = ( 0.25 * Q * L * K.1 / ( pi * R² * ( Ts - Ca )))
  = ( 0.25 * 1461968 * 15000.00 * -0.0137 ) /
    ( 3.141 * 1749.9999 * 1749.9999 * ( 65.0000 - 0.0000 )))
  = -119.96 kPa
```

Tangential Shear in Shell near Saddle:

```
  = K3 * Q / ( R * t )
  = 0.8799 * 1461968 / ( 1749.9999 * 65.0000 )
  = 11309.24 kPa
```

Tangential Shear in Head used as Stiffener:

```
  = K4 * Q / ( R * Th )
  = 0 * 1461968 / ( 1750.00 * ( 61.5000 - 0.0000 )
  = 11952.86 kPa
```

Circumferential Stress at Tip of the Wear Plate:

```
  = -Q/(4t(b+x1+x2)) - 3*Q*K7,1/(2t^2)
  = -1461968 /( 4 * 65.0000 (300.00 + 263.0694 + 263.0694 ))
    -3 * 1461968 * 0.0106 / ( 2 * 4224.9995 )
  = -12308.49 kPa
```

Note: Wear Plate is considered as A < R/2 and WearPlate extension > R/10)

Equivalent Membrane Thickness [Tem]:

```
  = Corroded Thickness + Wearplate Thickness
  = 65.000 + 25.000
  = 90.000 mm
```

Equivalent Bending Thickness squared [Teb]:

```
  = Corroded Thickness^2 + Wearplate Thickness^2
  = 65.000 ^2 + 25.000 ^2
  = 4850.000 mm^2
```

Circumferential Stress at Horn of Saddle:

```
  = -Q/(4t(b+x1+x2)) - 3*Q*K7/(2t^2)
  = -1461968 /( 4 * 90.0000 (300.00 + 263.0694 + 263.0694 ))
    -3 * 1461968 * 0.0130 / ( 2 * 4849.9995 )
  = -10793.98 kPa
```

```
 Parameter [K4]:
  = (3/8)*(sin(alpha)²/(pi-alpha+sin(alpha*cos(alpha)))
  = (3/8)*(sin(114.0 )²/(pi-114.0 +sin(114.0 *cos(114.0 )))
  = 0.4011
```

Additional Tension in Head used as Stiffener:

```
= K4 * Q/( R * th )
= 0.4011 * 1461968 /( 1749.9999 * 61.5000 )
= 5448.06 kPa
```

Circumferential Compression at Bottom of Shell:

```
= (Q*( K.9/( TEM9 * WPDWTH ) ) )
= ( 1461968 *( 0.7603 /( 90.0000 * 400.000 ) ) )
= -30875.08 kPa
```

Results for Vessel Ribs, Web and Base

Baseplate Length	Bplen	2300.0000	mm
Baseplate Thickness	Bpthk	40.0000	mm
Baseplate Width	Bpwid	300.0000	mm
Number of Ribs (inc. outside ribs)	Nribs	6	
Rib Thickness	Ribtk	25.0000	mm
Web Thickness	Webtk	30.0000	mm
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Ay²	Io
Shell	32.	60199.	1956468.	63585148.	21195048.
Wearplate	78.	10000.	775000.	60062440.	520833.
Web	155.	3900.	604500.	93697400.	5492494.
BasePlate	240.	12000.	2880000.	691199296.	1599998.
Totals	505.	86099.	6215968.	908544256.	28808376.

Value C1 = Sumof(Ay)/Sumof(A)	=	72.	mm
Value I = Sumof(Ay²) + Sumof(Io) - C1*Sumof(Ay)	=	488587680.	mm**4
Value As = Sumof(A) - Ashell	=	25900.	mm²

K1 = (1+Cos(beta)-.5*Sin(beta)²)/(pi-beta+Sin(beta)*Cos(beta)) = 0.2035

Fh = K1 * Q = 0.2035 * 1461968 = 0.3E+06 N

Tension Stress, St = (Fh/As)	=	11488.4326	kPa
Allowed Stress, Sa = 0.6 * Yield Str	=	148923.5938	kPa
d = B - R*Sin(theta) / theta	=	562.7616	mm
Bending Moment, M = Fh * d	=	167513.2812	N-m
Bending Stress, Sb = (M * C1 / I)	=	24743.0137	kPa
Allowed Stress, Sa = 2/3 * Yield Str	=	165470.6719	kPa

Minimum Thickness of Baseplate per Moss :

```
= ( 3 * ( Q + Saddle_Wt ) * BasePlateWidth / ( 4 * BasePlateLength *
  AllStress ))½
= ( 3 * (1461968 + 12517 ) * 300.00 / ( 4 * 2300.000 * 165470.672 ))½
= 29.525 mm
```

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

```
= ( Bplen - Clearance ) / ( Nribs - 1)
= ( 2300.0000 - 25.4 ) / ( 6 - 1 ) = 454.9200 mm
```

Baseplate Pressure Area [Ap]:

```
= e * Bpwid / 2
= 454.9200 * 300.0000 / 2 = 68238.0000 mm²
```

Axial Load [P]:

```
= Ap * Bp
```

= 68238.0 * 2.12 = 144582.3 N

Area of the Rib and Web [Ar]:
= (Bpwid - Clearance - Webtk) * Ribtk + e/2 * Webtk
= (300.000 - 25.4 - 30.000) * 25.000 + 454.9200 /2 * 30.000
= 12938.801 mm²

Compressive Stress [Sc]:
= P/Ar
= 144582.3 / 12938.8008 = 11174.6221 kPa

Check of Outside Ribs:
Inertia of Saddle, Outer Ribs - Longitudinal Direction

	Y	A	AY	Ay²	Io
Rib	150.0	6432.5	964874.9	0.0	49404356.0
Web	150.0	6823.8	1023570.0	0.0	1023569.1
Values	150.0	13256.3	1988444.9	0.0	50427924.0

Bending Moment [Rm]:
= Fl /(2 * Bplen) * e * rl / 2
= 5260.1 /(2 * 2300.00) * 454.920 * 1102.50 / 2
= 286.877 N-m

KL/R < Cc (17.6600 < 126.0991) per AISC E2-1
Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
Sca = (1-(17.66)²/(2 * 126.10²)) * 248206 /
(5/3+3*(17.66)/(8* 126.10)-(17.66³)/(8*126.10³)
Sca = 142986.95 kPa

AISC Unity Check on Outside Ribs (must be <= 1.0)
Check = Sc/Sca + (Rm/Z)/Sba
Check = 11174.62 / 142986.95 + (286.88 /336186.156) / 165470.67
Check = 0.08

Check of Inside Ribs
Inertia of Saddle, Inner Ribs - Axial Direction

	Y	A	AY	Ay²	Io
Rib	137.3	6115.0	839589.4	0.0	43137992.0
Web	137.3	13647.6	1873815.5	0.0	1023569.1
Values	137.3	19762.6	2713404.8	0.0	44161564.0

KL/R < Cc (6.3719 < 126.0991) per AISC E2-1
Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
Sca = (1-(6.37)²/(2 * 126.10²)) * 248206 /
(5/3+3*(6.37)/(8* 126.10)-(6.37³)/(8*126.10³)
Sca = 147062.86 kPa

AISC Unity Check on Inside Ribs (must be <= 1.0)
Check = Sc/Sca + (Rm/Z)/Sba
Check = 14632.31 / 147062.86 + (156.75 /321642.844) / 165470.67
Check = 0.10

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	6	
Total Number of Bolts in Tension/Baseplate	Nbt	3	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	172365.00	kPa
Bolt Corrosion Allowance	Bca	0.0000	mm
Distance from Bolts to Edge	Edgedis	150.0124	mm
Nominal Bolt Diameter	Bnd	36.0000	mm

Thread Series	Series	TEMA Metric	
BasePlate Allowable Stress	S	114449.67	kPa
Area Available in a Single Bolt	BltArea	738.0151	mm²
Saddle Load QO (Weight)	QO	1460013.8	N
Saddle Load QL (Wind/Seismic contribution)	QL	781.4	N
Maximum Transverse Force	Ft	7397.8	N
Maximum Longitudinal Force	Fl	5260.1	N
Saddle Bolted to Steel Foundation		No	

Bolt Area Calculation per Dennis R. Moss

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

Bolt Area due to Shear Load [Bltarears]:
= Fl / (Stba * Nbolts)
= 5260.10 / (172365.00 * 6.00)
= 5.0863 mm²

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:
= B * Ft + Sum of X Moments
= 2050.00 * 7397.82 + 0.00
= 15171.68 N-m

Eccentricity (e):
= Rmom / QO
= 15171.68 / 1460013
= 10.39 mm < Bplen/6 --> No Uplift in Transverse direction

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

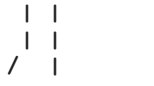
Required of a Single Bolt [Bltarear]
= max[Bltarearl, Bltarears, Bltareart]
= max[0.0000 , 5.0863 , 0.0000]
= 5.0863 mm²

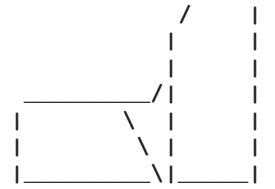
INPUT VALUES, Nozzle Description: N10 From : 10

Pressure for Nozzle Reinforcement Calculations	P	4525.976	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Elliptical Head	D	3500.00	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	61.5000	mm
Head Internal Corrosion Allowance	cas	3.0000	mm
Head External Corrosion Allowance	caext	0.0000	mm
Distance from Head Centerline	L1	900.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		180.00	deg
Nozzle Diameter	Dia	66.6400	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	11.1300	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	83.0000	mm
Height of Beveled Transition	L`	14.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		30.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	119.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	16.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	61.5000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch





Hub Nozzle

NOZZLE CALCULATION, Description: N10

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	66.640	mm.
Actual Nozzle Thickness Used in Calculation	11.130	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Elliptical Head, Tr [Int. Press]
= (P*K1*D))/(2*S*E-0.2*P) per UG-37(a)(3)
= (4525.98*0.899*3505.9998)/(2 *137892.00*1.00-0.2*4525.98)
= 51.8700 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4525.98*36.32)/(137892*1.00-0.6*4525.98)
= 1.2161 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3166 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):
= 2.5 * Corroded Hub Thickness
= 2.5 * 27.000 Note: less than the hub height, use (e-2)
= 67.5000 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	246.8165	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	67.5000	mm

Note: Hub Height was >= 2.5 times Hub Thickness, using sketch UG-40 (e-2).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	3932.602	349.678	NA	mm²
Area in Shell	A1	1133.737	8426.142	NA	mm²
Area in Nozzle Wall	A2	933.381	1054.805	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	256.000	256.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	2547.450	2547.450	NA	mm²
TOTAL AREA AVAILABLE	Atot	4870.568	12284.397	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	73.36	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)

= (75.8166*51.8700+2*(30.0000-3.0000)*51.8700*(1-1.0000))
= 3932.602 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (246.817-75.817)*(1.00*(61.5000-3.000)-51.870)-2*(30.000-3.000)
(1.00(61.5000-3.0000)-51.8700)*(1-1.0000)
= 1133.737 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(67.50 ,119.00)) * (11.13 - 3.00 - 1.22) * 1.0000)
= 933.381 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 16.0000² * 1.0000 + (0.0000)² * 1.0000
= 256.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(67.5 ,119.0 ,83.0)) * (30.0 - 11.1) * 1.000)
= 2547.450 mm²

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
Shell is governing, tg = 30.000 , tr = 51.870 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 1.921

Minimum Temp. w/o impact per UCS-66 -30 C

Governing MDMT of the all the sub-joints of this Junction : -30 C

Weld Size Calculations, Description: N10

Intermediate Calc. for nozzle/shell Welds Tmin 19.0000 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	11.3120 = 0.7 * Wo mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (3932.6016 - 1133.7367 + 2 * (30.0000 - 3.0000) * 1.0000 *
(1.00 * (61.5000 - 3.0000) - 51.8700)) * 137892
= 435297.72 N

Weld Load [W1]:
= ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
= (3480.8313 + 256.0000 - 0.0000 * 1.00) * 137892
= 515265.25 N

Weld Load [W2]:
= ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
= (3480.8313 + 0.0000 + 256.0000 + 3159.0000) * 137892
= 950854.31 N

Weld Load [W3]:
= ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
= (3480.8313 + 0.0000 + 256.0000 + 2547.4502 + 0.1E+06) * 0
= 2055147.25 N

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
= (pi/2) * Dlo * Wo * 0.49 * Snw
= (3.1416 / 2.0) * 132.1780 * 16.0000 * 0.49 * 137892
= 224451. N

Shear, Nozzle Wall [Snw]:
= (pi *(Dlr + Dlo)/4) * (Thk - Can) * 0.7 * Sn
= (3.1416 * 51.9986) * (30.0000 - 3.0000) * 0.7 * 137892
= 425727. N

Tension, Nozzle Groove Weld [Tngw]:
= (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
= (3.1416 / 2.0) * 132.1780 * (61.5000 - 3.0000) * 0.74 * 137892
= 1239350. N

Strength of Failure Paths:

PATH11 = (SONW + SNW) = (224451 + 425726) = 650178 N
PATH22 = (Sonw + Tpgw + Tngw + Sinw)
= (224451 + 0 + 1239349 + 0) = 1463801 N
PATH33 = (Sonw + Tngw + Sinw)
= (224451 + 1239349 + 0) = 1463801 N

Summary of Failure Path Calculations:
Path 1-1 = 650178 N , must exceed W = 435297 N or W1 = 515265 N
Path 2-2 = 1463801 N , must exceed W = 435297 N or W2 = 950854 N
Path 3-3 = 1463801 N , must exceed W = 435297 N or W3 = 2055147 N

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4525.976 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in the Latitudinal direction.

NOZZLE CALCULATION, Description: N10

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation 66.640 mm.
Actual Nozzle Thickness Used in Calculation 11.130 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Elliptical Head, Tr [Int. Press]
= (P*K1*D))/(2*S*E-0.2*P) per UG-37(a)(3)
= (4525.98*0.899*3505.9998)/(2 *137892.00*1.00-0.2*4525.98)
= 51.8700 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4525.98*36.32)/(137892*1.00-0.6*4525.98)
= 1.2161 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3166 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):
= 2.5 * Corroded Hub Thickness
= 2.5 * 27.000 Note: less than the hub height, use (e-2)
= 67.5000 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	243.6400	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	67.5000	mm

Note: Hub Height was >= 2.5 times Hub Thickness, using sketch UG-40 (e-2).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	3767.834	335.027	NA	mm²
Area in Shell	A1	1133.737	8426.143	NA	mm²
Area in Nozzle Wall	A2	933.381	1054.805	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	256.000	256.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	2547.450	2547.450	NA	mm²
TOTAL AREA AVAILABLE	Atot	4870.568	12284.397	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (72.6400*51.8700+2*(30.0000-3.0000)*51.8700*(1-1.0000))
= 3767.834 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (243.640-72.640)*(1.00*(61.5000-3.000)-51.870)-2*(30.000-3.000)
(1.00(61.5000-3.0000)-51.8700)*(1-1.0000)
= 1133.737 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(67.50 ,119.00)) * (11.13 - 3.00 - 1.22) * 1.0000)
= 933.381 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 16.0000² * 1.0000 + (0.0000)² * 1.0000
= 256.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(67.5 ,119.0 ,83.0)) * (30.0 - 11.1) * 1.000)
= 2547.450 mm²

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
Wall Thickness per UG45(a), tra = 4.2161 mm

```
 Wall Thickness per UG16(b),   tr16b = 4.5875 mm
 Wall Thickness per UG45(b)(1), trb1 = 60.5961 mm
 Wall Thickness per UG45(b)(2), trb2 = 4.2685 mm
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 60.5961 mm
 Std. Wall Pipe per UG45(b)(4), trb4 = 7.8006 mm
 Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 7.8006 mm

 Final Required Thickness,      tr45 = Max(tra, trb) = 7.8006 mm
 Available Nozzle Neck Thickness     = 11.1300 mm --> OK
```

Weld Size Calculations, Description: N10

```
 Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
 Nozzle Weld          6.0000 = Min per Code11.3120 = 0.7 * Wo mm
```

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

Weld Load [W]:

```
  = (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
  = (3767.8342 - 1133.7368 + 2 * ( 30.0000 - 3.0000 ) * 1.0000 *
    (1.00 * ( 61.5000 - 3.0000 ) - 51.8700 ) ) * 137892
  = 412578.22 N
```

Weld Load [W1]:

```
  = ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
  = ( 3480.8313 + 256.0000 - 0.0000 * 1.00 ) * 137892
  = 515265.25 N
```

Weld Load [W2]:

```
   = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 3480.8313 + 0.0000 + 256.0000 + 3159.0000 ) * 137892
  = 950854.31 N
```

Weld Load [W3]:

```
  = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 3480.8313 + 0.0000 + 256.0000 + 2547.4502 + 0.1E+06 ) * 0
  = 2055147.25 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.1416 / 2.0 ) * 126.6400 * 16.0000 * 0.49 * 137892
  = 215047. N
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.1416 * 49.8200 ) * ( 30.0000 - 3.0000 ) * 0.7 * 137892
  = 407890. N
```

Tension, Nozzle Groove Weld [Tngw]:

```
  = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.1416 / 2.0 ) * 126.6400 * ( 61.5000 - 3.0000 ) * 0.74 * 137892
  = 1187424. N
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 215047 + 407889 ) = 622937 N
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 215047 + 0 + 1187423 + 0 ) = 1402471 N
  PATH33 = ( Sonw + Tngw + Sinw )
```

= (215047 + 1187423 + 0) = 1402471 N

Summary of Failure Path Calculations:

Path 1-1 = 622937 N , must exceed W = 412578 N or W1 = 515265 N
Path 2-2 = 1402471 N , must exceed W = 412578 N or W2 = 950854 N
Path 3-3 = 1402471 N , must exceed W = 412578 N or W3 = 2055147 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 4525.976 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 19.2765 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 202.3129 mm

Input Echo, WRC107 Item 1, Description: N10 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Spherical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	6300.000	mm
Vessel Thickness	Tv	61.500	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
WRC107 Attachment Classification	Holsol	Hollow	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	66.640	mm
Nozzle Thickness	Tn	30.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4525.976	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)		P	8000.0	N
Longitudinal Shear	(SUS)	(Vl)	V1	8000.0	N
Circumferential Shear	(SUS)	(Vc)	V2	8000.0	N
Circumferential Moment	(SUS)	(Mc)	M1	8000.0	N-m
Longitudinal Moment	(SUS)	(Ml)	M2	8000.0	N-m
Torsional Moment	(SUS)		Mt	8000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load			P	8000.0	N
Circumferential Shear		(VC)	V2	8000.0	N
Longitudinal Shear		(VL)	V1	8000.0	N

```
 Circumferential Moment                 (MC)  M1       8000.0  N-m
 Longitudinal Moment                    (ML)  M2       8000.0  N-m
 Torsional Moment                             MT       8000.0  N-m

 Dimensionless Param: U =   0.15 TAU =   5.00 (  1.85) RHO =   2.17
```

Dimensionless Loads for Spherical Shells at Attachment Junction:

Curves read for 1979	Figure	Value	Location
N(x) * T / P	SP 3	0.15708	(A,B,C,D)
M(x) / P	SP 3	0.12424	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / MC	SM 3	0.49180	(A,B,C,D)
M(x) * SQRT(Rm * T) / MC	SM 3	0.44703	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / ML	SM 3	0.49180	(A,B,C,D)
M(x) * SQRT(Rm * T) / ML	SM 3	0.44703	(A,B,C,D)
N(y) * T / P	SP 3	0.22301	(A,B,C,D)
M(y) / P	SP 3	0.14318	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / MC	SM 3	0.08918	(A,B,C,D)
M(y) * SQRT(Rm * T) / MC	SM 3	0.83977	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / ML	SM 3	0.08918	(A,B,C,D)
M(y) * SQRT(Rm * T) / ML	SM 3	0.83977	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Memb. P	-367	-367	-367	-367	-367	-367	-367	-367
Rad. Bend. P	-1742	1742	-1742	1742	-1742	1742	-1742	1742
Rad. Memb. MC	0	0	0	0	-2663	-2663	2663	2663
Rad. Bend. MC	0	0	0	0	-14526	14526	14526	-14526
Rad. Memb. ML	-2663	-2663	2663	2663	0	0	0	0
Rad. Bend. ML	-14526	14526	14526	-14526	0	0	0	0
Tot. Rad. Str.	-19299	13238	15079	-10487	-19299	13238	15079	-10487
Tang. Memb. P	-521	-521	-521	-521	-521	-521	-521	-521
Tang. Bend. P	-2008	2008	-2008	2008	-2008	2008	-2008	2008
Tang. Memb. MC	0	0	0	0	-482	-482	482	482
Tang. Bend. MC	0	0	0	0	-27288	27288	27288	-27288
Tang. Memb. ML	-482	-482	482	482	0	0	0	0
Tang. Bend. ML	-27288	27288	27288	-27288	0	0	0	0
Tot. Tang. Str.	-30301	28292	25241	-25318	-30301	28292	25241	-25318
Shear VC	687	687	-687	-687	0	0	0	0
Shear VL	0	0	0	0	-687	-687	687	687
Shear MT	5426	5426	5426	5426	5426	5426	5426	5426
Tot. Shear	6113	6113	4738	4738	4738	4738	6113	6113
Str. Int.	33024	30462	27108	26703	32061	29660	28110	27514

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Pm (SUS)	121997	121997	121997	121997	121997	121997	121997	121997
Rad. Pl (SUS)	-3030	-3030	2296	2296	-3030	-3030	2296	2296
Rad. Q (SUS)	-16268	16268	12783	-12783	-16268	16268	12783	-12783
Long. Pm (SUS)	121997	121997	121997	121997	121997	121997	121997	121997
Long. Pl (SUS)	-1004	-1004	-38	-38	-1004	-1004	-38	-38
Long. Q (SUS)	-29297	29297	25280	-25280	-29297	29297	25280	-25280
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	687	687	-687	-687	-687	-687	687	687
Shear Q (SUS)	5426	5426	5426	5426	5426	5426	5426	5426
Pm (SUS)	121997	121997	121997	121997	121997	121997	121997	121997
Pm+Pl (SUS)	121204	121204	124480	124480	121204	121204	124480	124480
Pm+Pl+Q (Total)	105420	152459	149106	112894	104457	151657	150107	113705

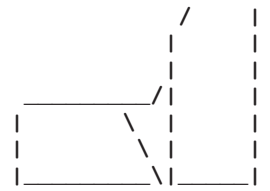
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	121997	137892	Passed
Pm+Pl (SUS)	124480	206838	Passed
Pm+Pl+Q (TOTAL)	152459	413676	Passed

INPUT VALUES, Nozzle Description: N1 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		1999.9999	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	477.8200	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	15.0900	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	82.0000	mm
Height of Beveled Transition	L`	35.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		75.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	137.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	30.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	95.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	30.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		600	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: N1

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	477.820	mm.
Actual Nozzle Thickness Used in Calculation	15.090	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*241.91)/(137892*1.00-0.6*4500.00)
= 8.0522 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.9329 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):

Height value from sketch (e-1) [te]:
= (Hub Thickness - Neck Thickness) / cos(30)
= 59.910 / 0.5773
= 103.7672 mm

Note: Hub Height was < 2.5 times Hub Thickness, use sketch UG-40 (e-1).

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)		Dl	967.6401	mm
Normal to Vessel Wall (Thickness Limit), no pad		Tlnp	133.9922	mm

Note: Hub Height was < 2.5 times Hub Thickness, using sketch UG-40 (e-1).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	28231.064	5009.420	NA	mm²
Area in Shell	A1	1765.777	19978.002	NA	mm²
Area in Nozzle Wall	A2	1082.064	2989.938	NA	mm²
Area in Inward Nozzle	A3	12696.000	12696.000	NA	mm²
Area in Welds	A4	1563.439	1563.439	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	11922.090	11922.090	NA	mm²
TOTAL AREA AVAILABLE	Atot	29029.369	49149.469	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (483.8200*58.3503+2*(75.0000-3.0000)*58.3503*(1-1.0000))
= 28231.064 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (967.640-483.820)*(1.00*(65.0000-3.000)-58.350)-2*(75.000-3.000)
(1.00(65.0000-3.0000)-58.3503)*(1-1.0000)
= 1765.777 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(133.99 ,137.00)) * (15.09 - 3.00 - 8.05) * 1.0000)
= 1082.064 mm²

Area Available in Nozzle Penetration [A3]:
= 2*(tn-can-can)*(min(h-can,Tl, 2.5*tn-can-can))*fr2
= 2 * (69.0000) * (92.0000) * 1.0000
= 12696.000 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 30.0000² * 1.0000 + (25.7573)² * 1.0000
= 1563.439 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(134.0 ,137.0 ,82.0)) * (75.0 - 15.1) * 1.000)
= 11922.090 mm² Includes Bevel Area of 2096.850 mm²

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
Wall Thickness per UG45(a), tra = 11.0522 mm
Wall Thickness per UG16(b), tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 11.3344 mm
Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 11.3344 mm

Final Required Thickness, tr45 = Max(tra, trb) = 11.3344 mm
Available Nozzle Neck Thickness = 15.0900 mm --> OK

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
Shell is governing, tg = 65.000 , tr = 58.350 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.941

Minimum Temp. w/o impact per UCS-66 -15 C
Minimum Temp. at required thickness -18 C

Governing MDMT of the all the sub-joints of this Junction : -18 C

Weld Size Calculations, Description: N1

Intermediate Calc. for nozzle/shell Welds Tmin 19.0000 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	21.2100 = 0.7 * Wo mm

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

Weld Load [W]:
```
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (28231.0645 - 1765.7767 + 2 * ( 75.0000 - 3.0000 ) * 1.0000 *
  (1.00 * ( 65.0000 - 3.0000 ) - 58.3503 ) ) * 137892
= 3721720.25 N
```

Weld Load [W1]:
```
= ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
= ( 13004.1533 + 1563.4395 - 26.1197 * 1.00 ) * 137892
= 1917219.75 N
```

Weld Load [W2]:
```
= ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
= ( 13004.1533 + 12696.0000 + 1563.4395 + 8928.0000 ) * 137892
= 4990396.50 N
```

Weld Load [W3]:
```
= ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
= ( 13004.1533 + 12696.0000 + 1563.4395 + 0.0000 + 8928.0000 ) * 137892
= 4990396.50 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.1416 / 2.0 ) * 627.8200 * 30.0000 * 0.49 * 137892
= 1998940. N
```

Shear, Inward Nozzle Weld [Sinw]:
```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.1416 / 2.0 ) * 627.8200 * 25.7573 * 0.49 * 137892
= 1716244. N
```

Shear, Nozzle Wall [Snw]:
```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.1416 * 277.9100 ) * ( 75.0000 - 3.0000 ) * 0.7 * 137892
= 6067530. N
```

Tension, Nozzle Groove Weld [Tngw]:
```
= (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
= ( 3.1416 / 2.0 ) * 627.8200 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
= 6238868. N
```

Strength of Failure Paths:

```
PATH11 = ( SONW + SNW ) = ( 1998939 + 6067530 ) = 8066470 N
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 1998939 + 0 + 6238868 + 1716244 ) = 9954052 N
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 1998939 + 6238868 + 1716244 ) = 9954052 N
```

Summary of Failure Path Calculations:
```
Path 1-1 = 8066470 N  , must exceed W = 3721720 N   or W1 = 1917219 N
Path 2-2 = 9954052 N  , must exceed W = 3721720 N   or W2 = 4990396 N
Path 3-3 = 9954052 N  , must exceed W = 3721720 N   or W3 = 4990396 N
```

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 4499.993 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 28.3843 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 296.9999 mm

Input Echo, WRC107 Item 1, Description: N1 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	477.820	mm
Nozzle Thickness	Tn	75.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	200000.0	N
Longitudinal Shear	(SUS)	Vl	40000.0	N
Circumferential Shear	(SUS)	Vc	250000.0	N
Circumferential Moment	(SUS)	Mc	380000.0	N-m
Longitudinal Moment	(SUS)	Ml	40000.0	N-m
Torsional Moment	(SUS)	Mt	120000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	200000.0	N
Circumferential Shear	VC	250000.0	N
Longitudinal Shear	VL	40000.0	N
Circumferential Moment	MC	380000.0	N-m
Longitudinal Moment	ML	40000.0	N-m
Torsional Moment	MT	120000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location

N(PHI) / (P/Rm)	0.154	4C	4.624	(A,B)
N(PHI) / (P/Rm)	0.154	3C	3.648	(C,D)
M(PHI) / (P)	0.154	2C1	0.065	(A,B)
M(PHI) / (P)	0.154	1C	0.097	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.154	3A	1.040	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.154	1A	0.090	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.154	3B	3.169	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.154	1B	0.038	(A,B,C,D)
N(x) / (P/Rm)	0.154	3C	3.648	(A,B)
N(x) / (P/Rm)	0.154	4C	4.624	(C,D)
M(x) / (P)	0.154	1C1	0.102	(A,B)
M(x) / (P)	0.154	2C	0.065	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.154	4A	1.643	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.154	2A	0.047	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.154	4B	1.014	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.154	2B	0.062	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		-8361	-8361	-8361	-8361	-6596	-6596	-6596	-6596
Circ. Bend. P		-20174	20174	-20174	20174	-30291	30291	-30291	30291
Circ. Memb. MC		0	0	0	0	-13001	-13001	13001	13001
Circ. Bend. MC		0	0	0	0	-194955	194955	194955	-194955
Circ. Memb. ML		-4170	-4170	4170	4170	0	0	0	0
Circ. Bend. ML		-8719	8719	8719	-8719	0	0	0	0
Tot. Circ. Str.		-41426	16362	-15646	7263	-244844	205649	171069	-158258
Long. Memb. P		-6596	-6596	-6596	-6596	-8361	-8361	-8361	-8361
Long. Bend. P		-31807	31807	-31807	31807	-20208	20208	-20208	20208
Long. Memb. MC		0	0	0	0	-20547	-20547	20547	20547
Long. Bend. MC		0	0	0	0	-101587	101587	101587	-101587
Long. Memb. ML		-1334	-1334	1334	1334	0	0	0	0
Long. Bend. ML		-14014	14014	14014	-14014	0	0	0	0
Tot. Long. Str.		-53752	37890	-23054	12531	-150705	92887	93564	-69193
Shear VC		4088	4088	-4088	-4088	0	0	0	0
Shear VL		0	0	0	0	-654	-654	654	654
Shear MT		3124	3124	3124	3124	3124	3124	3124	3124
Tot. Shear		7213	7213	-963	-963	2470	2470	3779	3779
Str. Int.		57077	40084	23177	12702	244909	205703	171253	158418

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)

Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-12532	-12532	-4191	-4191	-19597	-19597	6405	6405
Circ. Q (SUS)	-28894	28894	-11455	11455	-225246	225246	164664	-164664
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-7931	-7931	-5261	-5261	-28909	-28909	12185	12185
Long. Q (SUS)	-45821	45821	-17792	17792	-121796	121796	81378	-81378
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	4088	4088	-4088	-4088	-654	-654	654	654
Shear Q (SUS)	3124	3124	3124	3124	3124	3124	3124	3124
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Pm+Pl (SUS)	112778	117257	121093	125576	105431	109930	131436	135935
Pm+Pl+Q (Total)	84285	147002	109389	136802	120013	335206	296194	29365

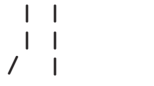
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	135935	206838	Passed
Pm+Pl+Q (TOTAL)	335206	413676	Passed

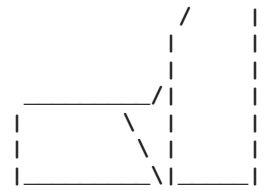
INPUT VALUES, Nozzle Description: N13 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		3500.0002	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	66.6400	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	11.1300	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	119.0000	mm
Height of Beveled Transition	L`	11.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		30.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	156.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	16.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch





Hub Nozzle

NOZZLE CALCULATION, Description: N13

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	66.640	mm.
Actual Nozzle Thickness Used in Calculation	11.130	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*36.32)/(137892*1.00-0.6*4500.00)
= 1.2089 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3534 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):
= 2.5 * Corroded Hub Thickness
= 2.5 * 27.000 Note: less than the hub height, use (e-2)
= 67.5000 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	250.6400	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	67.5000	mm

Note: Hub Height was >= 2.5 times Hub Thickness, using sketch UG-40 (e-2).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	4238.569	752.107	NA	mm²
Area in Shell	A1	649.639	7350.015	NA	mm²
Area in Nozzle Wall	A2	934.342	1049.841	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	256.000	256.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	2547.450	2547.450	NA	mm²
TOTAL AREA AVAILABLE	Atot	4387.431	11203.306	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)

```
  = (72.6400*58.3503+2*(30.0000-3.0000)*58.3503*(1-1.0000))
  = 4238.569 mm²
```

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
```
  = (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
  = (250.640-72.640)*(1.00*(65.0000-3.000)-58.350)-2*(30.000-3.000)
    *(1.00*(65.0000-3.0000)-58.3503)*(1-1.0000)
  = 649.639 mm²
```

Area Available in Nozzle Wall, no Pad [A2np]:
```
  = ( 2 * min(Tlnp,ho) ) * ( tn - can - trn ) * fr2
  = ( 2 * min(67.50 ,156.00 ) ) * ( 11.13 - 3.00 - 1.21 ) * 1.0000 )
  = 934.342 mm²
```

Area Available in Welds, no Pad [A4np]:
```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
  = 16.0000² * 1.0000 + ( 0.0000 )² * 1.0000
  = 256.000 mm²
```

Area Available in the Hub Section [A6]:
```
  = ( 2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
  = ( 2 * min(67.5 ,156.0 ,119.0 )) * (30.0 - 11.1 ) * 1.000 )
  = 2547.450 mm²
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
 Wall Thickness per UG45(a),     tra = 4.2089 mm
 Wall Thickness per UG16(b),   tr16b = 4.5875 mm
 Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
 Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
 Std. Wall Pipe per UG45(b)(4), trb4 = 7.8006 mm
 Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 7.8006 mm

 Final Required Thickness,      tr45 = Max(tra, trb) = 7.8006 mm
 Available Nozzle Neck Thickness     = 11.1300 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
```
 Shell is governing, tg = 30.000 , tr = 58.350 , c = 3.000 mm , E* = 1.00
 Stress Ratio = tr * (E*) / (tg - c) = 2.161

 Minimum Temp. w/o impact per UCS-66              -30  C
```

Governing MDMT of the all the sub-joints of this Junction : -30 C

Weld Size Calculations, Description: N13

```
 Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:
```
                      Required Thickness    Actual Thickness
 Nozzle Weld          6.0000 = Min per Code11.3120 = 0.7 * Wo mm
```

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
```
  = (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
  = (4238.5693 - 649.6388 + 2 * ( 30.0000 - 3.0000 ) * 1.0000 *
    (1.00 * ( 65.0000 - 3.0000 ) - 58.3503 ) ) * 137892
```

```
  = 522046.62 N
```

Weld Load [W1]:
```
  = ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
  = ( 3481.7922 + 256.0000 - 0.0000 * 1.00 ) * 137892
  = 515397.75 N
```

Weld Load [W2]:
```
   = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 3481.7922 + 0.0000 + 256.0000 + 3348.0000 ) * 137892
  = 977047.75 N
```

Weld Load [W3]:
```
  = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 3481.7922 + 0.0000 + 256.0000 + 2547.4502 + 0.1E+06 ) * 0
  = 4990396.50 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.1416 / 2.0 ) * 126.6400 * 16.0000 * 0.49 * 137892
  = 215047. N
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.1416 * 49.8200 ) * ( 30.0000 - 3.0000 ) * 0.7 * 137892
  = 407890. N
```

Tension, Nozzle Groove Weld [Tngw]:
```
  = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.1416 / 2.0 ) * 126.6400 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
  = 1258466. N
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 215047 + 407889 ) = 622937 N
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 215047 + 0 + 1258466 + 0 ) = 1473513 N
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 215047 + 1258466 + 0 ) = 1473513 N
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 622937 N  , must exceed W = 522046 N   or W1 = 515397 N
 Path 2-2 = 1473513 N  , must exceed W = 522046 N   or W2 = 977047 N
 Path 3-3 = 1473513 N  , must exceed W = 522046 N   or W3 = 4990396 N
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case     4499.993  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
 Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 1.1459 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 222.1458 mm

Input Echo, WRC107 Item 1, Description: N13 :

```
 Diameter Basis for Vessel                Vbasis      ID
 Cylindrical or Spherical Vessel          Cylsph      Cylindrical
 Internal Corrosion Allowance               Cas       3.0000  mm
 Vessel Diameter                             Dv     3500.000  mm
```

Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	66.640	mm
Nozzle Thickness	Tn	30.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.031	4C		5.604	(A,B)
N(PHI) / (P/Rm)	0.031	3C		5.710	(C,D)
M(PHI) / (P)	0.031	2C1		0.206	(A,B)
M(PHI) / (P)	0.031	1C		0.247	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.031	3A		0.156	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.031	1A		0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.031	3B		0.638	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.031	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.031	3C		5.710	(A,B)
N(x) / (P/Rm)	0.031	4C		5.604	(C,D)
M(x) / (P)	0.031	1C1		0.253	(A,B)
M(x) / (P)	0.031	2C		0.202	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.031	4A		0.194	(A,B,C,D)

M(x) / (MC/(Rm * Beta))	0.031	2A !	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.031	4B	0.151	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.031	2B	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-405	-405	-405	-405	-412	-412	-412	-412
Circ. Bend. P	-2570	2570	-2570	2570	-3087	3087	-3087	3087
Circ. Memb. MC	0	0	0	0	-203	-203	203	203
Circ. Bend. MC	0	0	0	0	-23608	23608	23608	-23608
Circ. Memb. ML	-831	-831	831	831	0	0	0	0
Circ. Bend. ML	-14364	14364	14364	-14364	0	0	0	0
Tot. Circ. Str.	-18171	15696	12220	-11367	-27311	26079	20311	-20730
Long. Memb. P	-412	-412	-412	-412	-405	-405	-405	-405
Long. Bend. P	-3164	3164	-3164	3164	-2523	2523	-2523	2523
Long. Memb. MC	0	0	0	0	-253	-253	253	253
Long. Bend. MC	0	0	0	0	-14210	14210	14210	-14210
Long. Memb. ML	-197	-197	197	197	0	0	0	0
Long. Bend. ML	-24141	24141	24141	-24141	0	0	0	0
Tot. Long. Str.	-27915	26695	20760	-21192	-17392	16075	11534	-11839
Shear VC	648	648	-648	-648	0	0	0	0
Shear VL	0	0	0	0	-648	-648	648	648
Shear MT	5120	5120	5120	5120	5120	5120	5120	5120
Tot. Shear	5768	5768	4471	4471	4471	4471	5768	5768
Str. Int.	30594	29166	22673	22922	29029	27786	23171	23568

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-1237	-1237	426	426	-616	-616	-209	-209
Circ. Q (SUS)	-16934	16934	11794	-11794	-26695	26695	20521	-20521
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-610	-610	-215	-215	-658	-658	-152	-152
Long. Q (SUS)	-27305	27305	20976	-20976	-16733	16733	11686	-11686
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	648	648	-648	-648	-648	-648	648	648

Shear Q (SUS)	5120	5120	5120	5120	5120	5120	5120	5120
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Pm+Pl (SUS)	123792	128292	125456	129955	124413	128913	124820	129319
Pm+Pl+Q (Total)	107309	145808	137611	118414	98088	155860	145798	109359

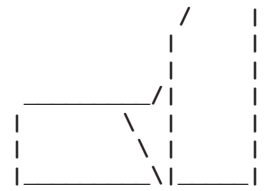
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	129955	206838	Passed
Pm+Pl+Q (TOTAL)	155860	413676	Passed

INPUT VALUES, Nozzle Description: N4 **From : 20**

Pressure for Nozzle Reinforcement Calculations	P	4534.307	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		11500.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		180.00	deg
Nozzle Diameter	Dia	146.3600	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	10.9700	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	87.0000	mm
Height of Beveled Transition	L`	24.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		52.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	137.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	20.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: N4

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	146.360	mm.
Actual Nozzle Thickness Used in Calculation	10.970	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*1752.9999)/(137892*1.00-0.6*4534.31)
= 58.8041 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*76.18)/(137892*1.00-0.6*4534.31)
= 2.5554 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.4893 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):

Height value from sketch (e-1) [te]:
= (Hub Thickness - Neck Thickness) / cos(30)
= 41.030 / 0.5773
= 71.0661 mm

Note: Hub Height was < 2.5 times Hub Thickness, use sketch UG-40 (e-1).

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)		Dl	304.7200	mm
Normal to Vessel Wall (Thickness Limit), no pad		Tlnp	90.9911	mm

Note: Hub Height was < 2.5 times Hub Thickness, using sketch UG-40 (e-1).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	8959.400	1577.519	NA	mm²
Area in Shell	A1	486.920	6291.282	NA	mm²
Area in Nozzle Wall	A2	985.352	1361.352	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	400.000	400.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub + Bevel	A6	7439.497	7439.497	NA	mm²
TOTAL AREA AVAILABLE	Atot	9311.769	15492.131	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (152.3600*58.8041+2*(52.0000-3.0000)*58.8041*(1-1.0000))
= 8959.400 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (304.720-152.360)*(1.00*(65.0000-3.000)-58.804)-2*(52.000-3.000)
(1.00(65.0000-3.0000)-58.8041)*(1-1.0000)
= 486.920 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(90.99 ,137.00)) * (10.97 - 3.00 - 2.56) * 1.0000)
= 985.352 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 20.0000² * 1.0000 + (0.0000)² * 1.0000
= 400.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(91.0 ,137.0 ,87.0)) * (52.0 - 11.0) * 1.000)
= 7439.497 mm² Includes Bevel Area of 300.277 mm²

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

```
Wall Thickness per UG45(a),     tra = 5.5554 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.8041 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.8041 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 10.1564 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 10.1564 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 10.1564 mm
Available Nozzle Neck Thickness     = 10.9700 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D

```
Shell is governing, tg = 52.000 , tr = 58.804 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 1.200

Minimum Temp. w/o impact per UCS-66              -19  C
```

Governing MDMT of the all the sub-joints of this Junction : -19 C

Weld Size Calculations, Description: N4

```
Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	14.1400 = 0.7 * Wo mm

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

Weld Load [W]:
```
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (8959.4004 - 486.9197 + 2 * ( 52.0000 - 3.0000 ) * 1.0000 *
  (1.00 * ( 65.0000 - 3.0000 ) - 58.8041 ) ) * 137892
= 1211441.38 N
```

Weld Load [W1]:
```
= ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
= ( 8424.8486 + 400.0000 - 0.0000 * 1.00 ) * 137892
= 1216843.25 N
```

Weld Load [W2]:
```
= ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
= ( 8424.8486 + 0.0000 + 400.0000 + 6076.0000 ) * 137892
= 2054652.38 N
```

Weld Load [W3]:
```
= ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
= ( 8424.8486 + 0.0000 + 400.0000 + 0.0000 + 6076.0000 ) * 137892
= 2054652.38 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.1416 / 2.0 ) * 250.3600 * 20.0000 * 0.49 * 137892
= 531420. N
```

Shear, Nozzle Wall [Snw]:
```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.1416 * 100.6800 ) * ( 52.0000 - 3.0000 ) * 0.7 * 137892
= 1495941. N
```

Tension, Nozzle Groove Weld [Tngw]:
```
= (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
= ( 3.1416 / 2.0 ) * 250.3600 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
= 2487916. N
```

Strength of Failure Paths:

```
PATH11 = ( SONW + SNW ) = ( 531420 + 1495941 ) = 2027361 N
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 531420 + 0 + 2487915 + 0 ) = 3019335 N
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 531420 + 2487915 + 0 ) = 3019335 N
```

Summary of Failure Path Calculations:
```
Path 1-1 = 2027361 N  , must exceed W = 1211441 N   or W1 = 1216843 N
Path 2-2 = 3019335 N  , must exceed W = 1211441 N   or W2 = 2054652 N
Path 3-3 = 3019335 N  , must exceed W = 1211441 N   or W3 = 2054652 N
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
Converged Max. Allow. Pressure in Operating case     4568.607  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 4.4829 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 206.4828 mm

Input Echo, WRC107 Item 1, Description: N4 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	146.360	mm
Nozzle Thickness	Tn	52.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4534.307	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	12000.0	N
Longitudinal Shear	(SUS)	Vl	12000.0	N
Circumferential Shear	(SUS)	Vc	12000.0	N
Circumferential Moment	(SUS)	Mc	12000.0	N-m
Longitudinal Moment	(SUS)	Ml	12000.0	N-m
Torsional Moment	(SUS)	Mt	12000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	12000.0	N
Circumferential Shear	VC	12000.0	N
Longitudinal Shear	VL	12000.0	N
Circumferential Moment	MC	12000.0	N-m
Longitudinal Moment	ML	12000.0	N-m
Torsional Moment	MT	12000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.061	4C	5.415	(A,B)
N(PHI) / (P/Rm)	0.061	3C	5.275	(C,D)
M(PHI) / (P)	0.061	2C1	0.147	(A,B)
M(PHI) / (P)	0.061	1C	0.185	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.061	3A	0.427	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.061	1A	0.103	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.061	3B	1.582	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.061	1B	0.057	(A,B,C,D)
N(x) / (P/Rm)	0.061	3C	5.275	(A,B)

N(x) / (P/Rm)	0.061	4C	5.415	(C,D)
M(x) / (P)	0.061	1C1	0.189	(A,B)
M(x) / (P)	0.061	2C	0.147	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.061	4A	0.538	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.061	2A	0.061	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.061	4B	0.422	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.061	2B	0.096	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-587	-587	-587	-587	-572	-572	-572	-572
Circ. Bend. P	-2758	2758	-2758	2758	-3456	3456	-3456	3456
Circ. Memb. MC	0	0	0	0	-422	-422	422	422
Circ. Bend. MC	0	0	0	0	-17660	17660	17660	-17660
Circ. Memb. ML	-1566	-1566	1566	1566	0	0	0	0
Circ. Bend. ML	-9727	9727	9727	-9727	0	0	0	0
Tot. Circ. Str.	-14639	10332	7948	-5991	-22112	20122	14054	-14353
Long. Memb. P	-572	-572	-572	-572	-587	-587	-587	-587
Long. Bend. P	-3533	3533	-3533	3533	-2749	2749	-2749	2749
Long. Memb. MC	0	0	0	0	-532	-532	532	532
Long. Bend. MC	0	0	0	0	-10506	10506	10506	-10506
Long. Memb. ML	-417	-417	417	417	0	0	0	0
Long. Bend. ML	-16344	16344	16344	-16344	0	0	0	0
Tot. Long. Str.	-20867	18888	12655	-12965	-14375	12135	7702	-7812
Shear VC	492	492	-492	-492	0	0	0	0
Shear VL	0	0	0	0	-492	-492	492	492
Shear MT	1965	1965	1965	1965	1965	1965	1965	1965
Tot. Shear	2457	2457	1472	1472	1472	1472	2457	2457
Str. Int.	21720	19543	13078	13263	22383	20385	14893	15173

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Circ. Pl (SUS)	-2153	-2153	978	978	-994	-994	-149	-149
Circ. Q (SUS)	-12485	12485	6969	-6969	-21117	21117	14203	-14203
Long. Pm (SUS)	62988	62988	62988	62988	62988	62988	62988	62988
Long. Pl (SUS)	-989	-989	-154	-154	-1119	-1119	-55	-55
Long. Q (SUS)	-19878	19878	12810	-12810	-13255	13255	7757	-7757
Shear Pm (SUS)	0	0	0	0	0	0	0	0

Shear Pl (SUS)	492	492	-492	-492	-492	-492	492	492
Shear Q (SUS)	1965	1965	1965	1965	1965	1965	1965	1965
Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Pm+Pl (SUS)	123826	128360	126958	131492	124985	129519	125830	130364
Pm+Pl+Q (Total)	111423	140945	133961	124548	103903	150661	140117	116256

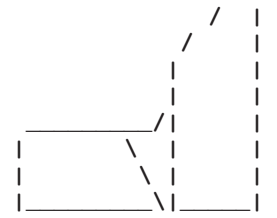
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130510	137892	Passed
Pm+Pl (SUS)	131492	206838	Passed
Pm+Pl+Q (TOTAL)	150661	413676	Passed

INPUT VALUES, Nozzle Description: M2 **From : 20**

Pressure for Nozzle Reinforcement Calculations	P	4517.153	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		3999.9998	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		270.00	deg
Nozzle Diameter	Dia	477.8200	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	15.0900	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	149.0000	mm
Height of Beveled Transition	L`	47.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		96.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	223.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	30.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
This is a Manway or Access Opening.			
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: M2

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	477.820	mm.
Actual Nozzle Thickness Used in Calculation	15.090	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4517.15*1752.9999)/(137892*1.00-0.6*4517.15)
= 58.5772 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4517.15*241.91)/(137892*1.00-0.6*4517.15)
= 8.0835 mm

Required Nozzle thickness under External Pressure per UG-28 : 1.1447 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):

Height value from sketch (e-1) [te]:
= (Hub Thickness - Neck Thickness) / cos(30)
= 80.910 / 0.5773
= 140.1403 mm

Note: Hub Height was < 2.5 times Hub Thickness, use sketch UG-40 (e-1).

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	967.6401	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	155.0000	mm

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	28340.834	5009.420	NA	mm²
Area in Shell	A1	1656.007	19978.002	NA	mm²
Area in Nozzle Wall	A2	1242.008	3393.052	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	900.000	900.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub + Bevel	A6	25020.127	25020.127	NA	mm²
TOTAL AREA AVAILABLE	Atot	28818.141	49291.184	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (483.8200*58.5772+2*(96.0000-3.0000)*58.5772*(1-1.0000))
= 28340.834 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (967.640-483.820)*(1.00*(65.0000-3.000)-58.577)-2*(96.000-3.000)
(1.00(65.0000-3.0000)-58.5772)*(1-1.0000)
= 1656.007 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(155.00 ,223.00)) * (15.09 - 3.00 - 8.08) * 1.0000)
= 1242.008 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 30.0000² * 1.0000 + (0.0000)² * 1.0000
= 900.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(155.0 ,223.0 ,149.0)) * (96.0 - 15.1) * 1.000)
= 25020.127 mm² Includes Bevel Area of 908.946 mm²

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
Shell is governing, tg = 65.000 , tr = 58.577 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.945

Minimum Temp. w/o impact per UCS-66	-15 C
Minimum Temp. at required thickness	-18 C

Governing MDMT of the all the sub-joints of this Junction : -18 C

Weld Size Calculations, Description: M2

Intermediate Calc. for nozzle/shell Welds Tmin 19.0000 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	21.2100 = 0.7 * Wo mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (28340.8340 - 1656.0067 + 2 * (96.0000 - 3.0000) * 1.0000 *
(1.00 * (65.0000 - 3.0000) - 58.5772)) * 137892
= 3767309.50 N

Weld Load [W1]:
= ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
= (26262.1348 + 900.0000 - 0.0000 * 1.00) * 137892
= 3745340.00 N

Weld Load [W2]:

```
  = ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
  = ( 26262.1348 + 0.0000 + 900.0000 + 11531.9990 ) * 137892
  = 5335467.50 N
```

Weld Load [W3]:

```
  = ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
  = ( 26262.1348 + 0.0000 + 900.0000 + 0.0000 + 11531.9990 ) * 137892
  = 5335467.50 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.1416 / 2.0 ) * 669.8200 * 30.0000 * 0.49 * 137892
  = 2132665. N
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.1416 * 288.4100 ) * ( 96.0000 - 3.0000 ) * 0.7 * 137892
  = 8133333. N
```

Tension, Nozzle Groove Weld [Tngw]:

```
  = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.1416 / 2.0 ) * 669.8200 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
  = 6656237. N
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 2132665 + 8133333 ) = 10265998 N
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 2132665 + 0 + 6656237 + 0 ) = 8788902 N
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 2132665 + 6656237 + 0 ) = 8788902 N
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 10265998 N  , must exceed W = 3767309 N   or W1 = 3745340 N
 Path 2-2 = 8788902 N  , must exceed W = 3767309 N   or W2 = 5335467 N
 Path 3-3 = 8788902 N  , must exceed W = 3767309 N   or W3 = 5335467 N
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case     4534.300  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
 Nozzle is O.K. for the External Pressure              100.000  kPa
```

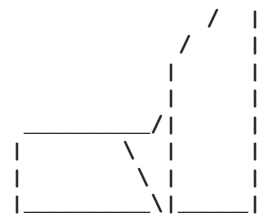
The Drop for this Nozzle is : 32.3459 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 320.3458 mm

INPUT VALUES, Nozzle Description: M1 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		11450.0010	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	581.4600	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	14.2700	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	128.0000	mm
Height of Beveled Transition	L`	62.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		120.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	216.7000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	30.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
This is a Manway or Access Opening.			
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: M1

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	581.460	mm.
Actual Nozzle Thickness Used in Calculation	14.270	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*293.73)/(137892*1.00-0.6*4500.00)
= 9.7771 mm

Required Nozzle thickness under External Pressure per UG-28 : 1.2582 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):

Height value from sketch (e-1) [te]:
= (Hub Thickness - Neck Thickness) / cos(30)
= 105.730 / 0.5773
= 183.1298 mm

Note: Hub Height was < 2.5 times Hub Thickness, use sketch UG-40 (e-1).

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	1174.9202	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	155.0000	mm

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	34278.496	6082.498	NA	mm²
Area in Shell	A1	2144.027	24257.527	NA	mm²
Area in Nozzle Wall	A2	462.800	3103.655	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	900.000	900.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub + Bevel	A6	31533.119	31533.119	NA	mm²
TOTAL AREA AVAILABLE	Atot	35039.945	59794.301	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (587.4601*58.3503+2*(120.0000-3.0000)*58.3503*(1-1.0000))
= 34278.496 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (1174.920-587.460)*(1.00*(65.0000-3.000)-58.350)-2*(120.000-3.000)
(1.00(65.0000-3.0000)-58.3503)*(1-1.0000)
= 2144.027 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(155.00 ,216.70)) * (14.27 - 3.00 - 9.78) * 1.0000)
= 462.800 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 30.0000² * 1.0000 + (0.0000)² * 1.0000
= 900.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(155.0 ,216.7 ,128.0)) * (120.0 - 14.3) * 1.000)
= 31533.119 mm² Includes Bevel Area of 4466.238 mm²

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
Shell is governing, tg = 65.000 , tr = 58.350 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.941

Minimum Temp. w/o impact per UCS-66	-15 C
Minimum Temp. at required thickness	-18 C

Governing MDMT of the all the sub-joints of this Junction : -18 C

Weld Size Calculations, Description: M1

Intermediate Calc. for nozzle/shell Welds Tmin 19.0000 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	21.2100 = 0.7 * Wo mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (34278.4961 - 2144.0271 + 2 * (120.0000 - 3.0000) * 1.0000 *
(1.00 * (65.0000 - 3.0000) - 58.3503)) * 137892
= 4548726.00 N

Weld Load [W1]:
= ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
= (31995.9199 + 900.0000 - 0.0000 * 1.00) * 137892
= 4535961.50 N

Weld Load [W2]:

```
  = ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
  = ( 31995.9199 + 0.0000 + 900.0000 + 14508.0000 ) * 137892
  = 6536445.00 N
```

Weld Load [W3]:

```
  = ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
  = ( 31995.9199 + 0.0000 + 900.0000 + 0.0000 + 14508.0000 ) * 137892
  = 6536445.00 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.1416 / 2.0 ) * 821.4600 * 30.0000 * 0.49 * 137892
  = 2615478. N
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.1416 * 352.2300 ) * ( 120.0000 - 3.0000 ) * 0.7 * 137892
  = 12496475. N
```

Tension, Nozzle Groove Weld [Tngw]:

```
  = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.1416 / 2.0 ) * 821.4600 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
  = 8163137. N
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 2615477 + 12496475 ) = 15111952 N
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 2615477 + 0 + 8163137 + 0 ) = 10778615 N
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 2615477 + 8163137 + 0 ) = 10778615 N
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 15111952 N  , must exceed W = 4548726 N   or W1 = 4535961 N
 Path 2-2 = 10778615 N  , must exceed W = 4548726 N   or W2 = 6536445 N
 Path 3-3 = 10778615 N  , must exceed W = 4548726 N   or W3 = 6536445 N
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case     4499.993  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
 Nozzle is O.K. for the External Pressure              100.000  kPa
```

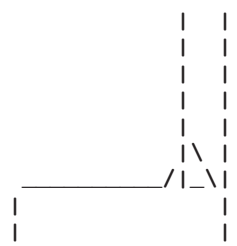
The Drop for this Nozzle is : 48.8825 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 330.5824 mm

INPUT VALUES, Nozzle Description: K4 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		6500.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	25.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	XXS	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	215.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	8.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		600	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



|_____|

Abutting Nozzle No Pad

NOZZLE CALCULATION, Description: K4

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    33.401  mm.
Actual Nozzle Thickness Used in Calculation            9.093  mm
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm

Reqd thk per App. 1 of Nozzle Wall, Trn [Int. Press]
= Ro * ($Z^{½}$ - 1) / $Z^{½}$ per Appendix 1-2 (a)(1)
= 16.701*($1.0794^{½}$-1)/$1.0794^{½}$
= 0.6257 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2243 mm

UG-40, Limits of Reinforcement : [Int. Press]

```
Parallel to Vessel Wall (Diameter Limit)            Dl   157.4010  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    15.2330  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for K4 .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 3.6257 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 5.9559 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 5.9559 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 5.9559 mm
Available Nozzle Neck Thickness     = .875 * 9.0932 = 7.9565 mm --> OK
```

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B

```
Nozzle, tg = 7.957 , tr = 0.626 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.126

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

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

```
Nozzle is governing, tg = 7.957 , tr = 0.626 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.126

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

Minimum Temp. w/o impact per UG-20(f)	-29	C

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)	-48	C

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4500.00/10204.01 = 0.441

Weld Size Calculations, Description: K4

Intermediate Calc. for nozzle/shell Welds	Tmin	6.0932	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	4.2652 = 0.7 * TMIN	5.6560 = 0.7 * Wo	mm

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

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case	4500.000	kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure	100.000	kPa

The Drop for this Nozzle is : 0.0796 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 280.0796 mm

Input Echo, WRC107 Item 1, Description: K4 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	33.401	mm
Nozzle Thickness	Tn	9.093	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N

Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979
Include Pressure Stress Indices per Div. 2		No
Compute Pressure Stress per WRC-368		No

Error/Warning Messages for WRC107 Analysis 1
Warning - The ratio Ro/Rm, 0.0094 , must be > 0.0571 and < 0.571.

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.008	4C	5.752	(A,B)
N(PHI) / (P/Rm)	0.008	3C	5.977	(C,D)
M(PHI) / (P)	0.008	2C1 !	0.269	(A,B)
M(PHI) / (P)	0.008	1C !	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.008	3A !	0.018	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.008	1A !	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.008	3B !	0.105	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.008	1B !	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.008	3C	5.977	(A,B)
N(x) / (P/Rm)	0.008	4C	5.752	(C,D)
M(x) / (P)	0.008	1C1 !	0.292	(A,B)
M(x) / (P)	0.008	2C !	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.008	4A !	0.023	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.008	2A !	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.008	4B	0.019	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.008	2B !	0.107	(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

Type of Stress	Load	Stress Values at (kPa) Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-416	-416	-416	-416	-432	-432	-432	-432
Circ. Bend.	P	-3364	3364	-3364	3364	-3577	3577	-3577	3577
Circ. Memb.	MC	0	0	0	0	-89	-89	89	89

Circ. Bend. MC	0	0	0	0	-89547	89547	89547	-89547
Circ. Memb. ML	-518	-518	518	518	0	0	0	0
Circ. Bend. ML	-54461	54461	54461	-54461	0	0	0	0
Tot. Circ. Str.	-58761	56892	51199	-50994	-93646	92602	85626	-86312
Long. Memb. P	-432	-432	-432	-432	-416	-416	-416	-416
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-113	-113	113	113
Long. Bend. MC	0	0	0	0	-53878	53878	53878	-53878
Long. Memb. ML	-94	-94	94	94	0	0	0	0
Long. Bend. ML	-91708	91708	91708	-91708	0	0	0	0
Tot. Long. Str.	-95881	94828	87723	-88400	-57679	56619	50304	-50909
Shear VC	2459	2459	-2459	-2459	0	0	0	0
Shear VL	0	0	0	0	-2459	-2459	2459	2459
Shear MT	73602	73602	73602	73602	73602	73602	73602	73602
Tot. Shear	76062	76062	71143	71143	71143	71143	76062	76062
Str. Int.	156588	156783	146899	147121	149044	147994	156171	156189

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-934	-934	102	102	-521	-521	-342	-342
Circ. Q (SUS)	-57826	57826	51097	-51097	-93124	93124	85969	-85969
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-526	-526	-338	-338	-529	-529	-302	-302
Long. Q (SUS)	-95354	95354	88061	-88061	-57149	57149	50607	-50607
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	2459	2459	-2459	-2459	-2459	-2459	2459	2459
Shear Q (SUS)	73602	73602	73602	73602	73602	73602	73602	73602
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Pm+Pl (SUS)	124185	128679	125221	129715	124598	129091	124777	129270
Pm+Pl+Q (Total)	181847	249316	235549	176489	144741	258454	252167	155373

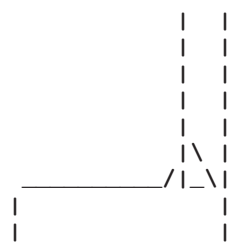
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	129715	206838	Passed
Pm+Pl+Q (TOTAL)	258454	413676	Passed

INPUT VALUES, Nozzle Description: K8B From : 20

Pressure for Nozzle Reinforcement Calculations	P	4534.307	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		10500.0010	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		180.00	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	54.6481	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



|_____|

Abutting Nozzle No Pad

NOZZLE CALCULATION, Description: K8B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    60.325  mm.
Actual Nozzle Thickness Used in Calculation            8.738  mm
```

Nozzle input data check completed without errors.

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

```
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*1752.9999)/(137892*1.00-0.6*4534.31)
= 58.8041 mm
```

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

```
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4534.31*30.1625)/(117897*1.00+0.4*4534.31)
= 1.1425 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.1832 mm

UG-40, Limits of Reinforcement : [Int. Press]

```
Parallel to Vessel Wall (Diameter Limit)            Dl   184.3250  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    14.3440  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for K8B .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 4.1425 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.8041 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.8041 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness     = .875 * 8.7376 = 7.6454 mm --> OK
```

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B

```
Nozzle, tg = 7.645 , tr = 1.142 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.246

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

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

```
Nozzle is governing, tg = 7.645 , tr = 1.142 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.246

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

Minimum Temp. w/o impact per UG-20(f)	-29	C

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)	-35	C

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4534.31/5102.00 = 0.889

Weld Size Calculations, Description: K8B

Intermediate Calc. for nozzle/shell Welds	Tmin	5.7376	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo	mm

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

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case	4534.307	kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure	100.000	kPa

The Drop for this Nozzle is : 0.2599 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 119.9079 mm

Input Echo, WRC107 Item 1, Description: K8B :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	60.325	mm
Nozzle Thickness	Tn	8.738	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4534.307	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N

Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0
Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0

Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831
Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62988	62988	62988	62988	62988	62988	62988	62988
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Pm+Pl (SUS)	124941	129474	126243	130776	125450	129982	125707	130240
Pm+Pl+Q (Total)	97873	173043	161769	108676	80963	187974	178127	94094

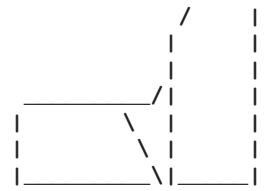
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130510	137892	Passed
Pm+Pl (SUS)	130776	206838	Passed
Pm+Pl+Q (TOTAL)	187974	413676	Passed

INPUT VALUES, Nozzle Description: N2 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		14000.0010	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	428.4600	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	14.2700	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	96.0000	mm
Height of Beveled Transition	L`	53.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		106.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	176.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	30.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: N2

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	428.460	mm.
Actual Nozzle Thickness Used in Calculation	14.270	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*217.23)/(137892*1.00-0.6*4500.00)
= 7.2307 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.9750 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):

Height value from sketch (e-1) [te]:
= (Hub Thickness - Neck Thickness) / cos(30)
= 91.730 / 0.5773
= 158.8811 mm

Note: Hub Height was < 2.5 times Hub Thickness, use sketch UG-40 (e-1).

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	868.9200	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	155.0000	mm

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	25350.891	4498.352	NA	mm²
Area in Shell	A1	1585.630	17939.816	NA	mm²
Area in Nozzle Wall	A2	1252.178	3191.435	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	900.000	900.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	22473.850	22473.850	NA	mm²
TOTAL AREA AVAILABLE	Atot	26211.656	44505.102	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (434.4600*58.3503+2*(106.0000-3.0000)*58.3503*(1-1.0000))
= 25350.891 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (868.920-434.460)*(1.00*(65.0000-3.000)-58.350)-2*(106.000-3.000)
(1.00(65.0000-3.0000)-58.3503)*(1-1.0000)
= 1585.630 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(155.00 ,176.00)) * (14.27 - 3.00 - 7.23) * 1.0000)
= 1252.178 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 30.0000² * 1.0000 + (0.0000)² * 1.0000
= 900.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(155.0 ,176.0 ,96.0)) * (106.0 - 14.3) * 1.000)
= 22473.850 mm² Includes Bevel Area of 4861.689 mm²

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

```
Wall Thickness per UG45(a),     tra = 10.2307 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 11.3344 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 11.3344 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 11.3344 mm
Available Nozzle Neck Thickness     = 14.2700 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D

```
Shell is governing, tg = 65.000 , tr = 58.350 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.941

Minimum Temp. w/o impact per UCS-66              -15  C
Minimum Temp. at required thickness              -18  C
```

Governing MDMT of the all the sub-joints of this Junction : -18 C

Weld Size Calculations, Description: N2

```
Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	21.2100 = 0.7 * Wo mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:

```
  = (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
  = (25350.8906 - 1585.6295 + 2 * ( 106.0000 - 3.0000 ) * 1.0000 *
    (1.00 * ( 65.0000 - 3.0000 ) - 58.3503 ) ) * 137892
  = 3380619.25 N
```

Weld Load [W1]:

```
  = ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
  = ( 23726.0273 + 900.0000 - 0.0000 * 1.00 ) * 137892
  = 3395640.50 N
```

Weld Load [W2]:

```
  = ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
  = ( 23726.0273 + 0.0000 + 900.0000 + 12771.9990 ) * 137892
  = 5156749.50 N
```

Weld Load [W3]:

```
  = ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
  = ( 23726.0273 + 0.0000 + 900.0000 + 0.0000 + 12771.9990 ) * 137892
  = 5156749.50 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.1416 / 2.0 ) * 640.4600 * 30.0000 * 0.49 * 137892
  = 2039185. N
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.1416 * 268.7300 ) * ( 106.0000 - 3.0000 ) * 0.7 * 137892
  = 8393221. N
```

Tension, Nozzle Groove Weld [Tngw]:

```
  = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.1416 / 2.0 ) * 640.4600 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
  = 6364476. N
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 2039184 + 8393221 ) = 10432406 N
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 2039184 + 0 + 6364476 + 0 ) = 8403661 N
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 2039184 + 6364476 + 0 ) = 8403661 N
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 10432406 N  , must exceed W = 3380619 N   or W1 = 3395640 N
 Path 2-2 = 8403661 N  , must exceed W = 3380619 N   or W2 = 5156749 N
 Path 3-3 = 8403661 N  , must exceed W = 3380619 N   or W3 = 5156749 N
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case     4499.993  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
 Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 29.5488 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 270.5487 mm

Input Echo, WRC107 Item 1, Description: N2 :

```
 Diameter Basis for Vessel                Vbasis      ID
```

Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	428.460	mm
Nozzle Thickness	Tn	106.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	36000.0	N
Longitudinal Shear	(SUS)	Vl	36000.0	N
Circumferential Shear	(SUS)	Vc	36000.0	N
Circumferential Moment	(SUS)	Mc	60000.0	N-m
Longitudinal Moment	(SUS)	Ml	36000.0	N-m
Torsional Moment	(SUS)	Mt	60000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	36000.0	N
Circumferential Shear	VC	36000.0	N
Longitudinal Shear	VL	36000.0	N
Circumferential Moment	MC	60000.0	N-m
Longitudinal Moment	ML	36000.0	N-m
Torsional Moment	MT	60000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.157	4C	4.592	(A,B)
N(PHI) / (P/Rm)	0.157	3C	3.591	(C,D)
M(PHI) / (P)	0.157	2C1	0.063	(A,B)
M(PHI) / (P)	0.157	1C	0.095	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.157	3A	1.051	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.157	1A	0.090	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.157	3B	3.172	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.157	1B	0.038	(A,B,C,D)
N(x) / (P/Rm)	0.157	3C	3.591	(A,B)
N(x) / (P/Rm)	0.157	4C	4.592	(C,D)

M(x) / (P)	0.157	1C1	0.100	(A,B)
M(x) / (P)	0.157	2C	0.063	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.157	4A	1.670	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.157	2A	0.047	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.157	4B	1.026	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.157	2B	0.061	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-1494	-1494	-1494	-1494	-1168	-1168	-1168	-1168
Circ. Bend. P	-3537	3537	-3537	3537	-5350	5350	-5350	5350
Circ. Memb. MC	0	0	0	0	-2034	-2034	2034	2034
Circ. Bend. MC	0	0	0	0	-30036	30036	30036	-30036
Circ. Memb. ML	-3682	-3682	3682	3682	0	0	0	0
Circ. Bend. ML	-7578	7578	7578	-7578	0	0	0	0
Tot. Circ. Str.	-16293	5938	6228	-1852	-38590	32183	25551	-23819
Long. Memb. P	-1168	-1168	-1168	-1168	-1494	-1494	-1494	-1494
Long. Bend. P	-5621	5621	-5621	5621	-3541	3541	-3541	3541
Long. Memb. MC	0	0	0	0	-3231	-3231	3231	3231
Long. Bend. MC	0	0	0	0	-15576	15576	15576	-15576
Long. Memb. ML	-1191	-1191	1191	1191	0	0	0	0
Long. Bend. ML	-12176	12176	12176	-12176	0	0	0	0
Tot. Long. Str.	-20158	15438	6577	-6532	-23845	14392	13771	-10297
Shear VC	577	577	-577	-577	0	0	0	0
Shear VL	0	0	0	0	-577	-577	577	577
Shear MT	1501	1501	1501	1501	1501	1501	1501	1501
Tot. Shear	2078	2078	924	924	924	924	2078	2078
Str. Int.	21063	15873	7343	6708	38648	32231	25907	24131

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-5177	-5177	2187	2187	-3203	-3203	866	866
Circ. Q (SUS)	-11115	11115	4040	-4040	-35386	35386	24685	-24685
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-2359	-2359	22	22	-4726	-4726	1736	1736
Long. Q (SUS)	-17798	17798	6555	-6555	-19118	19118	12034	-12034
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	577	577	-577	-577	-577	-577	577	577

Shear Q (SUS)	1501	1501	1501	1501	1501	1501	1501	1501
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Pm+Pl (SUS)	119851	124350	127216	131715	121824	126324	125894	130394
Pm+Pl+Q (Total)	108795	135536	131265	127682	86450	161716	150633	105784

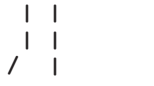
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	131715	206838	Passed
Pm+Pl+Q (TOTAL)	161716	413676	Passed

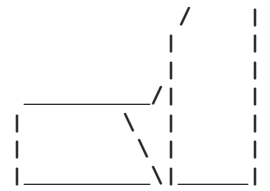
INPUT VALUES, Nozzle Description: N6 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		5000.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	92.0400	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	11.1300	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	110.0000	mm
Height of Beveled Transition	L`	14.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		35.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	131.3000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	20.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch





Hub Nozzle

NOZZLE CALCULATION, Description: N6

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	92.040	mm.
Actual Nozzle Thickness Used in Calculation	11.130	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*49.02)/(137892*1.00-0.6*4500.00)
= 1.6317 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3825 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):
= 2.5 * Corroded Hub Thickness
= 2.5 * 32.000 Note: less than the hub height, use (e-2)
= 80.0000 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	286.0400	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	80.0000	mm

Note: Hub Height was >= 2.5 times Hub Thickness, using sketch UG-40 (e-2).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	5720.667	1015.096	NA	mm²
Area in Shell	A1	686.135	7762.936	NA	mm²
Area in Nozzle Wall	A2	1039.731	1239.596	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	400.000	400.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	3819.200	3819.200	NA	mm²
TOTAL AREA AVAILABLE	Atot	5945.067	13221.732	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)

```
  = (98.0400*58.3503+2*(35.0000-3.0000)*58.3503*(1-1.0000))
  = 5720.667 mm²
```

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
```
  = (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
  = (286.040-98.040)*(1.00*(65.0000-3.000)-58.350)-2*(35.000-3.000)
    *(1.00*(65.0000-3.0000)-58.3503)*(1-1.0000)
  = 686.135 mm²
```

Area Available in Nozzle Wall, no Pad [A2np]:
```
  = ( 2 * min(Tlnp,ho) ) * ( tn - can - trn ) * fr2
  = ( 2 * min(80.00 ,131.30 ) ) * ( 11.13 - 3.00 - 1.63 ) * 1.0000 )
  = 1039.731 mm²
```

Area Available in Welds, no Pad [A4np]:
```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
  = 20.0000² * 1.0000 + ( 0.0000 )² * 1.0000
  = 400.000 mm²
```

Area Available in the Hub Section [A6]:
```
  = ( 2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
  = ( 2 * min(80.0 ,131.3 ,110.0 )) * (35.0 - 11.1 ) * 1.000 )
  = 3819.200 mm²
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
 Wall Thickness per UG45(a),     tra = 4.6317 mm
 Wall Thickness per UG16(b),   tr16b = 4.5875 mm
 Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
 Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
 Std. Wall Pipe per UG45(b)(4), trb4 = 8.2673 mm
 Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 8.2673 mm

 Final Required Thickness,      tr45 = Max(tra, trb) = 8.2673 mm
 Available Nozzle Neck Thickness     = 11.1300 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
```
 Shell is governing, tg = 35.000 , tr = 58.350 , c = 3.000 mm , E* = 1.00
 Stress Ratio = tr * (E*) / (tg - c) = 1.823

 Minimum Temp. w/o impact per UCS-66              -27  C
```

Governing MDMT of the all the sub-joints of this Junction : -27 C

Weld Size Calculations, Description: N6

```
 Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:
```
                      Required Thickness    Actual Thickness
 Nozzle Weld          6.0000 = Min per Code14.1400 = 0.7 * Wo mm
```

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
```
  = (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
  = (5720.6675 - 686.1353 + 2 * ( 35.0000 - 3.0000 ) * 1.0000 *
    (1.00 * ( 65.0000 - 3.0000 ) - 58.3503 ) ) * 137892
```

```
  = 726410.69 N
```

Weld Load [W1]:
```
  = ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
  = ( 4858.9316 + 400.0000 - 0.0000 * 1.00 ) * 137892
  = 725145.00 N
```

Weld Load [W2]:
```
   = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 4858.9316 + 0.0000 + 400.0000 + 3968.0000 ) * 137892
  = 1272285.75 N
```

Weld Load [W3]:
```
  = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 4858.9316 + 0.0000 + 400.0000 + 3819.2000 + 0.1E+06 ) * 0
  = 5156749.50 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.1416 / 2.0 ) * 162.0400 * 20.0000 * 0.49 * 137892
  = 343950. N
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.1416 * 65.0200 ) * ( 35.0000 - 3.0000 ) * 0.7 * 137892
  = 630917. N
```

Tension, Nozzle Groove Weld [Tngw]:
```
  = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.1416 / 2.0 ) * 162.0400 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
  = 1610248. N
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 343950 + 630916 ) = 974867 N
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 343950 + 0 + 1610248 + 0 ) = 1954198 N
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 343950 + 1610248 + 0 ) = 1954198 N
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 974867 N  , must exceed W = 726410 N   or W1 = 725145 N
 Path 2-2 = 1954198 N  , must exceed W = 726410 N   or W2 = 1272285 N
 Path 3-3 = 1954198 N  , must exceed W = 726410 N   or W3 = 5156749 N
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case     4499.993  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
 Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 1.8766 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 198.1765 mm

Input Echo, WRC107 Item 1, Description: N6 :

```
 Diameter Basis for Vessel                Vbasis      ID
 Cylindrical or Spherical Vessel          Cylsph      Cylindrical
 Internal Corrosion Allowance               Cas       3.0000  mm
 Vessel Diameter                             Dv     3500.000  mm
```

Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	92.040	mm
Nozzle Thickness	Tn	35.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.040	4C	5.549	(A,B)
N(PHI) / (P/Rm)	0.040	3C	5.607	(C,D)
M(PHI) / (P)	0.040	2C1	0.184	(A,B)
M(PHI) / (P)	0.040	1C	0.224	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.040	3A	0.228	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.040	1A	0.104	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.040	3B	0.915	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.040	1B	0.062	(A,B,C,D)
N(x) / (P/Rm)	0.040	3C	5.607	(A,B)
N(x) / (P/Rm)	0.040	4C	5.549	(C,D)
M(x) / (P)	0.040	1C1	0.230	(A,B)
M(x) / (P)	0.040	2C	0.183	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.040	4A	0.287	(A,B,C,D)

M(x) / (MC/(Rm * Beta))	0.040	2A	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.040	4B	0.228	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.040	2B	0.104	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-401	-401	-401	-401	-405	-405	-405	-405
Circ. Bend. P	-2301	2301	-2301	2301	-2799	2799	-2799	2799
Circ. Memb. MC	0	0	0	0	-232	-232	232	232
Circ. Bend. MC	0	0	0	0	-18383	18383	18383	-18383
Circ. Memb. ML	-933	-933	933	933	0	0	0	0
Circ. Bend. ML	-10927	10927	10927	-10927	0	0	0	0
Tot. Circ. Str.	-14563	11894	9157	-8094	-21821	20544	15411	-15756
Long. Memb. P	-405	-405	-405	-405	-401	-401	-401	-401
Long. Bend. P	-2869	2869	-2869	2869	-2283	2283	-2283	2283
Long. Memb. MC	0	0	0	0	-292	-292	292	292
Long. Bend. MC	0	0	0	0	-11049	11049	11049	-11049
Long. Memb. ML	-232	-232	232	232	0	0	0	0
Long. Bend. ML	-18260	18260	18260	-18260	0	0	0	0
Tot. Long. Str.	-21768	20492	15217	-15564	-14026	12639	8656	-8874
Shear VC	506	506	-506	-506	0	0	0	0
Shear VL	0	0	0	0	-506	-506	506	506
Shear MT	3127	3127	3127	3127	3127	3127	3127	3127
Tot. Shear	3634	3634	2620	2620	2620	2620	3634	3634
Str. Int.	23283	21822	16193	16391	22620	21334	16995	17320

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-1334	-1334	531	531	-638	-638	-172	-172
Circ. Q (SUS)	-13228	13228	8626	-8626	-21183	21183	15583	-15583
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-637	-637	-173	-173	-693	-693	-109	-109
Long. Q (SUS)	-21130	21130	15390	-15390	-13332	13332	8765	-8765
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	506	506	-506	-506	-506	-506	506	506
Shear Q (SUS)	3127	3127	3127	3127	3127	3127	3127	3127
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523

Pm+Pl (SUS)	123692	128192	125559	130058	124388	128888	124854	129354
Pm+Pl+Q (Total)	110648	141642	134302	121520	103326	150159	140624	113985

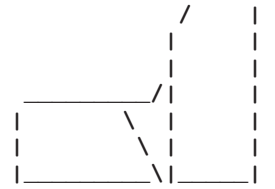
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	130058	206838	Passed
Pm+Pl+Q (TOTAL)	150159	413676	Passed

INPUT VALUES, Nozzle Description: N11 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		3999.9998	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	66.6400	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	11.1300	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	116.0000	mm
Height of Beveled Transition	L`	11.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		30.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	146.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	16.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		600	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: N11

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	66.640	mm.
Actual Nozzle Thickness Used in Calculation	11.130	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*36.32)/(137892*1.00-0.6*4500.00)
= 1.2089 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3440 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):
= 2.5 * Corroded Hub Thickness
= 2.5 * 27.000 Note: less than the hub height, use (e-2)
= 67.5000 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	250.6400	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	67.5000	mm

Note: Hub Height was >= 2.5 times Hub Thickness, using sketch UG-40 (e-2).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	4238.569	752.107	NA	mm²
Area in Shell	A1	649.639	7350.015	NA	mm²
Area in Nozzle Wall	A2	934.342	1051.105	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	256.000	256.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	2547.450	2547.450	NA	mm²
TOTAL AREA AVAILABLE	Atot	4387.431	11204.570	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)

= (72.6400*58.3503+2*(30.0000-3.0000)*58.3503*(1-1.0000))
= 4238.569 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (250.640-72.640)*(1.00*(65.0000-3.000)-58.350)-2*(30.000-3.000)
(1.00(65.0000-3.0000)-58.3503)*(1-1.0000)
= 649.639 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(67.50 ,146.00)) * (11.13 - 3.00 - 1.21) * 1.0000)
= 934.342 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 16.0000² * 1.0000 + (0.0000)² * 1.0000
= 256.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(67.5 ,146.0 ,116.0)) * (30.0 - 11.1) * 1.000)
= 2547.450 mm²

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

```
Wall Thickness per UG45(a),     tra = 4.2089 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 7.8006 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 7.8006 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 7.8006 mm
Available Nozzle Neck Thickness     = 11.1300 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D

```
Shell is governing, tg = 30.000 , tr = 58.350 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 2.161

Minimum Temp. w/o impact per UCS-66              -30  C
```

Governing MDMT of the all the sub-joints of this Junction : -30 C

Weld Size Calculations, Description: N11

```
Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:

```
                     Required Thickness    Actual Thickness
Nozzle Weld          6.0000 = Min per Code11.3120 = 0.7 * Wo mm
```

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (4238.5693 - 649.6388 + 2 * (30.0000 - 3.0000) * 1.0000 *
(1.00 * (65.0000 - 3.0000) - 58.3503)) * 137892

= 522046.62 N

Weld Load [W1]:
= ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
= (3481.7922 + 256.0000 - 0.0000 * 1.00) * 137892
= 515397.75 N

Weld Load [W2]:
= ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
= (3481.7922 + 0.0000 + 256.0000 + 3348.0000) * 137892
= 977047.75 N

Weld Load [W3]:
= ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
= (3481.7922 + 0.0000 + 256.0000 + 2547.4502 + 0.1E+06) * 0
= 5156749.50 N

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
= (pi/2) * Dlo * Wo * 0.49 * Snw
= (3.1416 / 2.0) * 126.6400 * 16.0000 * 0.49 * 137892
= 215047. N

Shear, Nozzle Wall [Snw]:
= (pi *(Dlr + Dlo)/4) * (Thk - Can) * 0.7 * Sn
= (3.1416 * 49.8200) * (30.0000 - 3.0000) * 0.7 * 137892
= 407890. N

Tension, Nozzle Groove Weld [Tngw]:
= (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
= (3.1416 / 2.0) * 126.6400 * (65.0000 - 3.0000) * 0.74 * 137892
= 1258466. N

Strength of Failure Paths:

PATH11 = (SONW + SNW) = (215047 + 407889) = 622937 N
PATH22 = (Sonw + Tpgw + Tngw + Sinw)
= (215047 + 0 + 1258466 + 0) = 1473513 N
PATH33 = (Sonw + Tngw + Sinw)
= (215047 + 1258466 + 0) = 1473513 N

Summary of Failure Path Calculations:
Path 1-1 = 622937 N , must exceed W = 522046 N or W1 = 515397 N
Path 2-2 = 1473513 N , must exceed W = 522046 N or W2 = 977047 N
Path 3-3 = 1473513 N , must exceed W = 522046 N or W3 = 5156749 N

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4499.993 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 1.1459 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 212.1458 mm

Input Echo, WRC107 Item 1, Description: N11 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm

Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	66.640	mm
Nozzle Thickness	Tn	30.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.031	4C		5.604	(A,B)
N(PHI) / (P/Rm)	0.031	3C		5.710	(C,D)
M(PHI) / (P)	0.031	2C1		0.206	(A,B)
M(PHI) / (P)	0.031	1C		0.247	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.031	3A		0.156	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.031	1A		0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.031	3B		0.638	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.031	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.031	3C		5.710	(A,B)
N(x) / (P/Rm)	0.031	4C		5.604	(C,D)
M(x) / (P)	0.031	1C1		0.253	(A,B)
M(x) / (P)	0.031	2C		0.202	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.031	4A		0.194	(A,B,C,D)

M(x) / (MC/(Rm * Beta))	0.031	2A !	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.031	4B	0.151	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.031	2B	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-405	-405	-405	-405	-412	-412	-412	-412
Circ. Bend. P	-2570	2570	-2570	2570	-3087	3087	-3087	3087
Circ. Memb. MC	0	0	0	0	-203	-203	203	203
Circ. Bend. MC	0	0	0	0	-23608	23608	23608	-23608
Circ. Memb. ML	-831	-831	831	831	0	0	0	0
Circ. Bend. ML	-14364	14364	14364	-14364	0	0	0	0
Tot. Circ. Str.	-18171	15696	12220	-11367	-27311	26079	20311	-20730
Long. Memb. P	-412	-412	-412	-412	-405	-405	-405	-405
Long. Bend. P	-3164	3164	-3164	3164	-2523	2523	-2523	2523
Long. Memb. MC	0	0	0	0	-253	-253	253	253
Long. Bend. MC	0	0	0	0	-14210	14210	14210	-14210
Long. Memb. ML	-197	-197	197	197	0	0	0	0
Long. Bend. ML	-24141	24141	24141	-24141	0	0	0	0
Tot. Long. Str.	-27915	26695	20760	-21192	-17392	16075	11534	-11839
Shear VC	648	648	-648	-648	0	0	0	0
Shear VL	0	0	0	0	-648	-648	648	648
Shear MT	5120	5120	5120	5120	5120	5120	5120	5120
Tot. Shear	5768	5768	4471	4471	4471	4471	5768	5768
Str. Int.	30594	29166	22673	22922	29029	27786	23171	23568

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-1237	-1237	426	426	-616	-616	-209	-209
Circ. Q (SUS)	-16934	16934	11794	-11794	-26695	26695	20521	-20521
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-610	-610	-215	-215	-658	-658	-152	-152
Long. Q (SUS)	-27305	27305	20976	-20976	-16733	16733	11686	-11686
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	648	648	-648	-648	-648	-648	648	648

Shear Q (SUS)	5120	5120	5120	5120	5120	5120	5120	5120
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Pm+Pl (SUS)	123792	128292	125456	129955	124413	128913	124820	129319
Pm+Pl+Q (Total)	107309	145808	137611	118414	98088	155860	145798	109359

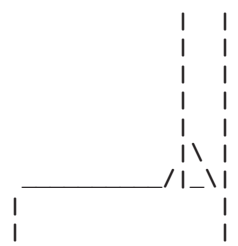
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	129955	206838	Passed
Pm+Pl+Q (TOTAL)	155860	413676	Passed

INPUT VALUES, Nozzle Description: N12 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		4500.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		RTJWn	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	54.6481	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		900	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



|_____|

Abutting Nozzle No Pad

NOZZLE CALCULATION, Description: N12

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    60.325  mm.
Actual Nozzle Thickness Used in Calculation            8.738  mm
```

Nozzle input data check completed without errors.

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

```
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm
```

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

```
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4500.00*30.1625)/(117897*1.00+0.4*4500.00)
= 1.1340 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.1832 mm

UG-40, Limits of Reinforcement : [Int. Press]

```
Parallel to Vessel Wall (Diameter Limit)            Dl   184.3250  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    14.3440  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for N12 .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 4.1340 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness     = .875 * 8.7376 = 7.6454 mm --> OK
```

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B

```
Nozzle, tg = 7.645 , tr = 1.134 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.244

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

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

```
Nozzle is governing, tg = 7.645 , tr = 1.134 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.244

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

Minimum Temp. w/o impact per UG-20(f)	-29	C

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)	-104	C

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4500.00/15306.01 = 0.294

Weld Size Calculations, Description: N12

Intermediate Calc. for nozzle/shell Welds	Tmin	5.7376	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo	mm

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

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case		4500.000	kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure		100.000	kPa

The Drop for this Nozzle is : 0.2599 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 119.9079 mm

Input Echo, WRC107 Item 1, Description: N12 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	60.325	mm
Nozzle Thickness	Tn	8.738	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N

Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Load	Stress Values at (kPa) Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend.	P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb.	MC	0	0	0	0	-128	-128	128	128
Circ. Bend.	MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb.	ML	-651	-651	651	651	0	0	0	0
Circ. Bend.	ML	-30154	30154	30154	-30154	0	0	0	0

Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831
Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Pm+Pl (SUS)	123988	128486	125290	129788	124497	128995	124754	129252
Pm+Pl+Q (Total)	96951	172134	160884	107714	80079	187013	177206	93182

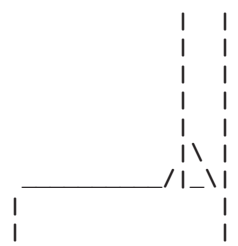
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	129788	206838	Passed
Pm+Pl+Q (TOTAL)	187013	413676	Passed

INPUT VALUES, Nozzle Description: K5 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		7000.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	25.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	XXS	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	215.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	8.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		600	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



|_____|

Abutting Nozzle No Pad

NOZZLE CALCULATION, Description: K5

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    33.401  mm.
Actual Nozzle Thickness Used in Calculation            9.093  mm
```

Nozzle input data check completed without errors.

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

```
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm
```

Reqd thk per App. 1 of Nozzle Wall, Trn [Int. Press]

```
= Ro * ( Z^½ - 1 ) / Z^½  per Appendix 1-2 (a)(1)
= 16.701*(1.0794^½-1)/1.0794^½
= 0.6257 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2243 mm

UG-40, Limits of Reinforcement : [Int. Press]

```
Parallel to Vessel Wall (Diameter Limit)            Dl   157.4010  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    15.2330  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for K5 .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 3.6257 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 5.9559 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 5.9559 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 5.9559 mm
Available Nozzle Neck Thickness     = .875 * 9.0932 = 7.9565 mm --> OK
```

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B

```
Nozzle, tg = 7.957 , tr = 0.626 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.126

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

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

```
Nozzle is governing, tg = 7.957 , tr = 0.626 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.126

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

Minimum Temp. w/o impact per UG-20(f) -29 C

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)	-48	C

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4500.00/10204.01 = 0.441

Weld Size Calculations, Description: K5

Intermediate Calc. for nozzle/shell Welds Tmin 6.0932 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	4.2652 = 0.7 * TMIN	5.6560 = 0.7 * Wo	mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4500.000 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 0.0796 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 280.0796 mm

Input Echo, WRC107 Item 1, Description: K5 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	33.401	mm
Nozzle Thickness	Tn	9.093	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N

Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No

Error/Warning Messages for WRC107 Analysis 1
Warning - The ratio Ro/Rm, 0.0094 , must be > 0.0571 and < 0.571.

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.008	4C		5.752	(A,B)
N(PHI) / (P/Rm)	0.008	3C		5.977	(C,D)
M(PHI) / (P)	0.008	2C1	!	0.269	(A,B)
M(PHI) / (P)	0.008	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.008	3A	!	0.018	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.008	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.008	3B	!	0.105	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.008	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.008	3C		5.977	(A,B)
N(x) / (P/Rm)	0.008	4C		5.752	(C,D)
M(x) / (P)	0.008	1C1	!	0.292	(A,B)
M(x) / (P)	0.008	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.008	4A	!	0.023	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.008	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.008	4B		0.019	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.008	2B	!	0.107	(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

Type of		Stress Values at (kPa)							
Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-416	-416	-416	-416	-432	-432	-432	-432
Circ. Bend.	P	-3364	3364	-3364	3364	-3577	3577	-3577	3577
Circ. Memb.	MC	0	0	0	0	-89	-89	89	89

Circ. Bend. MC	0	0	0	0	-89547	89547	89547	-89547
Circ. Memb. ML	-518	-518	518	518	0	0	0	0
Circ. Bend. ML	-54461	54461	54461	-54461	0	0	0	0
Tot. Circ. Str.	-58761	56892	51199	-50994	-93646	92602	85626	-86312
Long. Memb. P	-432	-432	-432	-432	-416	-416	-416	-416
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-113	-113	113	113
Long. Bend. MC	0	0	0	0	-53878	53878	53878	-53878
Long. Memb. ML	-94	-94	94	94	0	0	0	0
Long. Bend. ML	-91708	91708	91708	-91708	0	0	0	0
Tot. Long. Str.	-95881	94828	87723	-88400	-57679	56619	50304	-50909
Shear VC	2459	2459	-2459	-2459	0	0	0	0
Shear VL	0	0	0	0	-2459	-2459	2459	2459
Shear MT	73602	73602	73602	73602	73602	73602	73602	73602
Tot. Shear	76062	76062	71143	71143	71143	71143	76062	76062
Str. Int.	156588	156783	146899	147121	149044	147994	156171	156189

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-934	-934	102	102	-521	-521	-342	-342
Circ. Q (SUS)	-57826	57826	51097	-51097	-93124	93124	85969	-85969
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-526	-526	-338	-338	-529	-529	-302	-302
Long. Q (SUS)	-95354	95354	88061	-88061	-57149	57149	50607	-50607
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	2459	2459	-2459	-2459	-2459	-2459	2459	2459
Shear Q (SUS)	73602	73602	73602	73602	73602	73602	73602	73602
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Pm+Pl (SUS)	124185	128679	125221	129715	124598	129091	124777	129270
Pm+Pl+Q (Total)	181847	249316	235549	176489	144741	258454	252167	155373

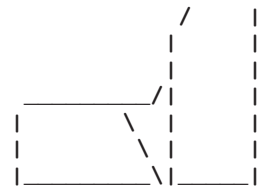
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	129715	206838	Passed
Pm+Pl+Q (TOTAL)	258454	413676	Passed

INPUT VALUES, Nozzle Description: N7 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4534.307	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		1500.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		180.00	deg
Nozzle Diameter	Dia	66.6400	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	11.1300	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	119.0000	mm
Height of Beveled Transition	L`	14.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		30.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	156.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	16.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: N7

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	66.640	mm.
Actual Nozzle Thickness Used in Calculation	11.130	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*1752.9999)/(137892*1.00-0.6*4534.31)
= 58.8041 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*36.32)/(137892*1.00-0.6*4534.31)
= 1.2183 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3534 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):
= 2.5 * Corroded Hub Thickness
= 2.5 * 27.000 Note: less than the hub height, use (e-2)
= 67.5000 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	250.6400	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	67.5000	mm

Note: Hub Height was >= 2.5 times Hub Thickness, using sketch UG-40 (e-2).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	4271.534	752.107	NA	mm²
Area in Shell	A1	568.861	7350.015	NA	mm²
Area in Nozzle Wall	A2	933.073	1049.841	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	256.000	256.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	2547.450	2547.450	NA	mm²
TOTAL AREA AVAILABLE	Atot	4305.384	11203.306	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)

= (72.6400*58.8041+2*(30.0000-3.0000)*58.8041*(1-1.0000))
= 4271.534 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (250.640-72.640)*(1.00*(65.0000-3.000)-58.804)-2*(30.000-3.000)
(1.00(65.0000-3.0000)-58.8041)*(1-1.0000)
= 568.861 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(67.50 ,156.00)) * (11.13 - 3.00 - 1.22) * 1.0000)
= 933.073 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 16.0000² * 1.0000 + (0.0000)² * 1.0000
= 256.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(67.5 ,156.0 ,119.0)) * (30.0 - 11.1) * 1.000)
= 2547.450 mm²

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

```
Wall Thickness per UG45(a),     tra = 4.2183 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.8041 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.8041 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 7.8006 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 7.8006 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 7.8006 mm
Available Nozzle Neck Thickness     = 11.1300 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D

```
Shell is governing, tg = 30.000 , tr = 58.804 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 2.178

Minimum Temp. w/o impact per UCS-66              -30  C
```

Governing MDMT of the all the sub-joints of this Junction : -30 C

Weld Size Calculations, Description: N7

```
Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:

```
                     Required Thickness    Actual Thickness
Nozzle Weld          6.0000 = Min per Code11.3120 = 0.7 * Wo mm
```

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (4271.5337 - 568.8613 + 2 * (30.0000 - 3.0000) * 1.0000 *
(1.00 * (65.0000 - 3.0000) - 58.8041)) * 137892

```
  = 534351.31 N
```

Weld Load [W1]:
```
  = ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
  = ( 3480.5229 + 256.0000 - 0.0000 * 1.00 ) * 137892
  = 515222.72 N
```

Weld Load [W2]:
```
   = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 3480.5229 + 0.0000 + 256.0000 + 3348.0000 ) * 137892
  = 976872.69 N
```

Weld Load [W3]:
```
  = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 3480.5229 + 0.0000 + 256.0000 + 2547.4502 + 0.1E+06 ) * 0
  = 5156749.50 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.1416 / 2.0 ) * 126.6400 * 16.0000 * 0.49 * 137892
  = 215047. N
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.1416 * 49.8200 ) * ( 30.0000 - 3.0000 ) * 0.7 * 137892
  = 407890. N
```

Tension, Nozzle Groove Weld [Tngw]:
```
  = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.1416 / 2.0 ) * 126.6400 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
  = 1258466. N
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 215047 + 407889 ) = 622937 N
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 215047 + 0 + 1258466 + 0 ) = 1473513 N
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 215047 + 1258466 + 0 ) = 1473513 N
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 622937 N  , must exceed W = 534351 N   or W1 = 515222 N
 Path 2-2 = 1473513 N  , must exceed W = 534351 N   or W2 = 976872 N
 Path 3-3 = 1473513 N  , must exceed W = 534351 N   or W3 = 5156749 N
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case     4568.607  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
 Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 1.1459 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 222.1458 mm

Input Echo, WRC107 Item 1, Description: N7 :

```
 Diameter Basis for Vessel                Vbasis      ID
 Cylindrical or Spherical Vessel          Cylsph      Cylindrical
 Internal Corrosion Allowance               Cas       3.0000  mm
 Vessel Diameter                             Dv     3500.000  mm
```

Vessel Thickness		Tv	65.000	mm
Design Temperature			120.00	C
Vessel Material			SA-516 70	
Vessel Cold S.I. Allowable		Smc	137892.00	kPa
Vessel Hot S.I. Allowable		Smh	137892.00	kPa
Attachment Type		Type	Round	
Diameter Basis for Nozzle		Nbasis	ID	
Corrosion Allowance for Nozzle		Can	3.0000	mm
Nozzle Diameter		Dn	66.640	mm
Nozzle Thickness		Tn	30.000	mm
Nozzle Material			SA-350 LF2	
Nozzle Cold S.I. Allowable		SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable		SNmh	137892.00	kPa
Design Internal Pressure		Dp	4534.307	kPa
Include Pressure Thrust			No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2			No
Compute Pressure Stress per WRC-368			No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.031	4C		5.604	(A,B)
N(PHI) / (P/Rm)	0.031	3C		5.710	(C,D)
M(PHI) / (P)	0.031	2C1		0.206	(A,B)
M(PHI) / (P)	0.031	1C		0.247	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.031	3A		0.156	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.031	1A		0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.031	3B		0.638	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.031	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.031	3C		5.710	(A,B)
N(x) / (P/Rm)	0.031	4C		5.604	(C,D)
M(x) / (P)	0.031	1C1		0.253	(A,B)
M(x) / (P)	0.031	2C		0.202	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.031	4A		0.194	(A,B,C,D)

M(x) / (MC/(Rm * Beta))	0.031	2A !	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.031	4B	0.151	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.031	2B	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-405	-405	-405	-405	-412	-412	-412	-412
Circ. Bend. P	-2570	2570	-2570	2570	-3087	3087	-3087	3087
Circ. Memb. MC	0	0	0	0	-203	-203	203	203
Circ. Bend. MC	0	0	0	0	-23608	23608	23608	-23608
Circ. Memb. ML	-831	-831	831	831	0	0	0	0
Circ. Bend. ML	-14364	14364	14364	-14364	0	0	0	0
Tot. Circ. Str.	-18171	15696	12220	-11367	-27311	26079	20311	-20730
Long. Memb. P	-412	-412	-412	-412	-405	-405	-405	-405
Long. Bend. P	-3164	3164	-3164	3164	-2523	2523	-2523	2523
Long. Memb. MC	0	0	0	0	-253	-253	253	253
Long. Bend. MC	0	0	0	0	-14210	14210	14210	-14210
Long. Memb. ML	-197	-197	197	197	0	0	0	0
Long. Bend. ML	-24141	24141	24141	-24141	0	0	0	0
Tot. Long. Str.	-27915	26695	20760	-21192	-17392	16075	11534	-11839
Shear VC	648	648	-648	-648	0	0	0	0
Shear VL	0	0	0	0	-648	-648	648	648
Shear MT	5120	5120	5120	5120	5120	5120	5120	5120
Tot. Shear	5768	5768	4471	4471	4471	4471	5768	5768
Str. Int.	30594	29166	22673	22922	29029	27786	23171	23568

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Circ. Pl (SUS)	-1237	-1237	426	426	-616	-616	-209	-209
Circ. Q (SUS)	-16934	16934	11794	-11794	-26695	26695	20521	-20521
Long. Pm (SUS)	62988	62988	62988	62988	62988	62988	62988	62988
Long. Pl (SUS)	-610	-610	-215	-215	-658	-658	-152	-152
Long. Q (SUS)	-27305	27305	20976	-20976	-16733	16733	11686	-11686
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	648	648	-648	-648	-648	-648	648	648

Shear Q (SUS)	5120	5120	5120	5120	5120	5120	5120	5120
Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Pm+Pl (SUS)	124745	129279	126409	130943	125366	129900	125773	130307
Pm+Pl+Q (Total)	108259	146790	138561	119400	99038	156846	146748	110341

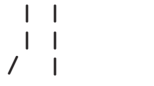
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130510	137892	Passed
Pm+Pl (SUS)	130943	206838	Passed
Pm+Pl+Q (TOTAL)	156846	413676	Passed

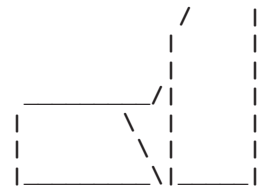
INPUT VALUES, Nozzle Description: N8 **From : 20**

Pressure for Nozzle Reinforcement Calculations	P	4534.307	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		7999.9995	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		180.00	deg
Nozzle Diameter	Dia	66.6400	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	11.1300	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	119.0000	mm
Height of Beveled Transition	L`	14.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		30.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	156.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	16.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch





Hub Nozzle

NOZZLE CALCULATION, Description: N8

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	66.640	mm.
Actual Nozzle Thickness Used in Calculation	11.130	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*1752.9999)/(137892*1.00-0.6*4534.31)
= 58.8041 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*36.32)/(137892*1.00-0.6*4534.31)
= 1.2183 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3534 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):
= 2.5 * Corroded Hub Thickness
= 2.5 * 27.000 Note: less than the hub height, use (e-2)
= 67.5000 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	250.6400	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	67.5000	mm

Note: Hub Height was >= 2.5 times Hub Thickness, using sketch UG-40 (e-2).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	4271.534	752.107	NA	mm²
Area in Shell	A1	568.861	7350.015	NA	mm²
Area in Nozzle Wall	A2	933.073	1049.841	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	256.000	256.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	2547.450	2547.450	NA	mm²
TOTAL AREA AVAILABLE	Atot	4305.384	11203.306	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)

```
  = (72.6400*58.8041+2*(30.0000-3.0000)*58.8041*(1-1.0000))
  = 4271.534 mm²
```

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
```
  = (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
  = (250.640-72.640)*(1.00*(65.0000-3.000)-58.804)-2*(30.000-3.000)
    *(1.00*(65.0000-3.0000)-58.8041)*(1-1.0000)
  = 568.861 mm²
```

Area Available in Nozzle Wall, no Pad [A2np]:
```
  = ( 2 * min(Tlnp,ho) ) * ( tn - can - trn ) * fr2
  = ( 2 * min(67.50 ,156.00 ) ) * ( 11.13 - 3.00 - 1.22 ) * 1.0000 )
  = 933.073 mm²
```

Area Available in Welds, no Pad [A4np]:
```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
  = 16.0000² * 1.0000 + ( 0.0000 )² * 1.0000
  = 256.000 mm²
```

Area Available in the Hub Section [A6]:
```
  = ( 2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
  = ( 2 * min(67.5 ,156.0 ,119.0 )) * (30.0 - 11.1 ) * 1.000 )
  = 2547.450 mm²
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
 Wall Thickness per UG45(a),     tra = 4.2183 mm
 Wall Thickness per UG16(b),   tr16b = 4.5875 mm
 Wall Thickness per UG45(b)(1), trb1 = 61.8041 mm
 Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.8041 mm
 Std. Wall Pipe per UG45(b)(4), trb4 = 7.8006 mm
 Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 7.8006 mm

 Final Required Thickness,      tr45 = Max(tra, trb) = 7.8006 mm
 Available Nozzle Neck Thickness     = 11.1300 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
```
 Shell is governing, tg = 30.000 , tr = 58.804 , c = 3.000 mm , E* = 1.00
 Stress Ratio = tr * (E*) / (tg - c) = 2.178

 Minimum Temp. w/o impact per UCS-66              -30  C
```

Governing MDMT of the all the sub-joints of this Junction : -30 C

Weld Size Calculations, Description: N8

```
 Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:
```
                     Required Thickness    Actual Thickness
 Nozzle Weld          6.0000 = Min per Code11.3120 = 0.7 * Wo mm
```

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
```
  = (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
  = (4271.5337 - 568.8613 + 2 * ( 30.0000 - 3.0000 ) * 1.0000 *
    (1.00 * ( 65.0000 - 3.0000 ) - 58.8041 ) ) * 137892
```

= 534351.31 N

Weld Load [W1]:
= ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
= (3480.5229 + 256.0000 - 0.0000 * 1.00) * 137892
= 515222.72 N

Weld Load [W2]:
= ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
= (3480.5229 + 0.0000 + 256.0000 + 3348.0000) * 137892
= 976872.69 N

Weld Load [W3]:
= ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
= (3480.5229 + 0.0000 + 256.0000 + 2547.4502 + 0.1E+06) * 0
= 5156749.50 N

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
= (pi/2) * Dlo * Wo * 0.49 * Snw
= (3.1416 / 2.0) * 126.6400 * 16.0000 * 0.49 * 137892
= 215047. N

Shear, Nozzle Wall [Snw]:
= (pi *(Dlr + Dlo)/4) * (Thk - Can) * 0.7 * Sn
= (3.1416 * 49.8200) * (30.0000 - 3.0000) * 0.7 * 137892
= 407890. N

Tension, Nozzle Groove Weld [Tngw]:
= (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
= (3.1416 / 2.0) * 126.6400 * (65.0000 - 3.0000) * 0.74 * 137892
= 1258466. N

Strength of Failure Paths:

PATH11 = (SONW + SNW) = (215047 + 407889) = 622937 N
PATH22 = (Sonw + Tpgw + Tngw + Sinw)
= (215047 + 0 + 1258466 + 0) = 1473513 N
PATH33 = (Sonw + Tngw + Sinw)
= (215047 + 1258466 + 0) = 1473513 N

Summary of Failure Path Calculations:
Path 1-1 = 622937 N , must exceed W = 534351 N or W1 = 515222 N
Path 2-2 = 1473513 N , must exceed W = 534351 N or W2 = 976872 N
Path 3-3 = 1473513 N , must exceed W = 534351 N or W3 = 5156749 N

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4568.607 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 1.1459 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 222.1458 mm

Input Echo, WRC107 Item 1, Description: N8 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm

Vessel Thickness		Tv	65.000	mm
Design Temperature			120.00	C
Vessel Material			SA-516 70	
Vessel Cold S.I. Allowable		Smc	137892.00	kPa
Vessel Hot S.I. Allowable		Smh	137892.00	kPa
Attachment Type		Type	Round	
Diameter Basis for Nozzle		Nbasis	ID	
Corrosion Allowance for Nozzle		Can	3.0000	mm
Nozzle Diameter		Dn	66.640	mm
Nozzle Thickness		Tn	30.000	mm
Nozzle Material			SA-350 LF2	
Nozzle Cold S.I. Allowable		SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable		SNmh	137892.00	kPa
Design Internal Pressure		Dp	4534.307	kPa
Include Pressure Thrust			No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2			No
Compute Pressure Stress per WRC-368			No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.031	4C		5.604	(A,B)
N(PHI) / (P/Rm)	0.031	3C		5.710	(C,D)
M(PHI) / (P)	0.031	2C1		0.206	(A,B)
M(PHI) / (P)	0.031	1C		0.247	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.031	3A		0.156	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.031	1A		0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.031	3B		0.638	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.031	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.031	3C		5.710	(A,B)
N(x) / (P/Rm)	0.031	4C		5.604	(C,D)
M(x) / (P)	0.031	1C1		0.253	(A,B)
M(x) / (P)	0.031	2C		0.202	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.031	4A		0.194	(A,B,C,D)

M(x) / (MC/(Rm * Beta))	0.031	2A !	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.031	4B	0.151	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.031	2B	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-405	-405	-405	-405	-412	-412	-412	-412
Circ. Bend. P	-2570	2570	-2570	2570	-3087	3087	-3087	3087
Circ. Memb. MC	0	0	0	0	-203	-203	203	203
Circ. Bend. MC	0	0	0	0	-23608	23608	23608	-23608
Circ. Memb. ML	-831	-831	831	831	0	0	0	0
Circ. Bend. ML	-14364	14364	14364	-14364	0	0	0	0
Tot. Circ. Str.	-18171	15696	12220	-11367	-27311	26079	20311	-20730
Long. Memb. P	-412	-412	-412	-412	-405	-405	-405	-405
Long. Bend. P	-3164	3164	-3164	3164	-2523	2523	-2523	2523
Long. Memb. MC	0	0	0	0	-253	-253	253	253
Long. Bend. MC	0	0	0	0	-14210	14210	14210	-14210
Long. Memb. ML	-197	-197	197	197	0	0	0	0
Long. Bend. ML	-24141	24141	24141	-24141	0	0	0	0
Tot. Long. Str.	-27915	26695	20760	-21192	-17392	16075	11534	-11839
Shear VC	648	648	-648	-648	0	0	0	0
Shear VL	0	0	0	0	-648	-648	648	648
Shear MT	5120	5120	5120	5120	5120	5120	5120	5120
Tot. Shear	5768	5768	4471	4471	4471	4471	5768	5768
Str. Int.	30594	29166	22673	22922	29029	27786	23171	23568

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Circ. Pl (SUS)	-1237	-1237	426	426	-616	-616	-209	-209
Circ. Q (SUS)	-16934	16934	11794	-11794	-26695	26695	20521	-20521
Long. Pm (SUS)	62988	62988	62988	62988	62988	62988	62988	62988
Long. Pl (SUS)	-610	-610	-215	-215	-658	-658	-152	-152
Long. Q (SUS)	-27305	27305	20976	-20976	-16733	16733	11686	-11686
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	648	648	-648	-648	-648	-648	648	648

Shear Q (SUS)	5120	5120	5120	5120	5120	5120	5120	5120
Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Pm+Pl (SUS)	124745	129279	126409	130943	125366	129900	125773	130307
Pm+Pl+Q (Total)	108259	146790	138561	119400	99038	156846	146748	110341

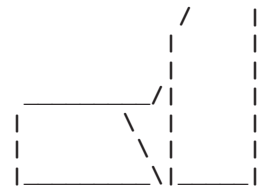
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130510	137892	Passed
Pm+Pl (SUS)	130943	206838	Passed
Pm+Pl+Q (TOTAL)	156846	413676	Passed

INPUT VALUES, Nozzle Description: N9 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4534.307	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		13135.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		180.00	deg
Nozzle Diameter	Dia	66.6400	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	11.1300	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	119.0000	mm
Height of Beveled Transition	L`	14.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		30.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	156.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	16.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: N9

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	66.640	mm.
Actual Nozzle Thickness Used in Calculation	11.130	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*1752.9999)/(137892*1.00-0.6*4534.31)
= 58.8041 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*36.32)/(137892*1.00-0.6*4534.31)
= 1.2183 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3534 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):
= 2.5 * Corroded Hub Thickness
= 2.5 * 27.000 Note: less than the hub height, use (e-2)
= 67.5000 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	250.6400	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	67.5000	mm

Note: Hub Height was >= 2.5 times Hub Thickness, using sketch UG-40 (e-2).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	4271.534	752.107	NA	mm²
Area in Shell	A1	568.861	7350.015	NA	mm²
Area in Nozzle Wall	A2	933.073	1049.841	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	256.000	256.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub	A6	2547.450	2547.450	NA	mm²
TOTAL AREA AVAILABLE	Atot	4305.384	11203.306	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)

= (72.6400*58.8041+2*(30.0000-3.0000)*58.8041*(1-1.0000))
= 4271.534 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (250.640-72.640)*(1.00*(65.0000-3.000)-58.804)-2*(30.000-3.000)
(1.00(65.0000-3.0000)-58.8041)*(1-1.0000)
= 568.861 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(67.50 ,156.00)) * (11.13 - 3.00 - 1.22) * 1.0000)
= 933.073 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 16.0000² * 1.0000 + (0.0000)² * 1.0000
= 256.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(67.5 ,156.0 ,119.0)) * (30.0 - 11.1) * 1.000)
= 2547.450 mm²

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

```
Wall Thickness per UG45(a),     tra = 4.2183 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.8041 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.8041 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 7.8006 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 7.8006 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 7.8006 mm
Available Nozzle Neck Thickness     = 11.1300 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D

```
Shell is governing, tg = 30.000 , tr = 58.804 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 2.178

Minimum Temp. w/o impact per UCS-66              -30  C
```

Governing MDMT of the all the sub-joints of this Junction : -30 C

Weld Size Calculations, Description: N9

```
Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:

```
                     Required Thickness    Actual Thickness
Nozzle Weld          6.0000 = Min per Code11.3120 = 0.7 * Wo mm
```

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (4271.5337 - 568.8613 + 2 * (30.0000 - 3.0000) * 1.0000 *
(1.00 * (65.0000 - 3.0000) - 58.8041)) * 137892

```
  = 534351.31 N
```

Weld Load [W1]:
```
  = ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
  = ( 3480.5229 + 256.0000 - 0.0000 * 1.00 ) * 137892
  = 515222.72 N
```

Weld Load [W2]:
```
   = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 3480.5229 + 0.0000 + 256.0000 + 3348.0000 ) * 137892
  = 976872.69 N
```

Weld Load [W3]:
```
  = ((A2+A6)+A3+A4+(2*(Hubtk-Can)*(T-Ca)*Fr1))*S
  = ( 3480.5229 + 0.0000 + 256.0000 + 2547.4502 + 0.1E+06 ) * 0
  = 5156749.50 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.1416 / 2.0 ) * 126.6400 * 16.0000 * 0.49 * 137892
  = 215047. N
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.1416 * 49.8200 ) * ( 30.0000 - 3.0000 ) * 0.7 * 137892
  = 407890. N
```

Tension, Nozzle Groove Weld [Tngw]:
```
  = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.1416 / 2.0 ) * 126.6400 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
  = 1258466. N
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 215047 + 407889 ) = 622937 N
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 215047 + 0 + 1258466 + 0 ) = 1473513 N
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 215047 + 1258466 + 0 ) = 1473513 N
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 622937 N  , must exceed W = 534351 N   or W1 = 515222 N
 Path 2-2 = 1473513 N  , must exceed W = 534351 N   or W2 = 976872 N
 Path 3-3 = 1473513 N  , must exceed W = 534351 N   or W3 = 5156749 N
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case     4568.607  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
 Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 1.1459 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 222.1458 mm

Input Echo, WRC107 Item 1, Description: N9 :

```
 Diameter Basis for Vessel                Vbasis      ID
 Cylindrical or Spherical Vessel          Cylsph      Cylindrical
 Internal Corrosion Allowance                Cas      3.0000  mm
 Vessel Diameter                              Dv    3500.000  mm
```

Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	66.640	mm
Nozzle Thickness	Tn	30.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4534.307	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.031	4C		5.604	(A,B)
N(PHI) / (P/Rm)	0.031	3C		5.710	(C,D)
M(PHI) / (P)	0.031	2C1		0.206	(A,B)
M(PHI) / (P)	0.031	1C		0.247	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.031	3A		0.156	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.031	1A		0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.031	3B		0.638	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.031	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.031	3C		5.710	(A,B)
N(x) / (P/Rm)	0.031	4C		5.604	(C,D)
M(x) / (P)	0.031	1C1		0.253	(A,B)
M(x) / (P)	0.031	2C		0.202	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.031	4A		0.194	(A,B,C,D)

M(x) / (MC/(Rm * Beta))	0.031	2A !	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.031	4B	0.151	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.031	2B	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-405	-405	-405	-405	-412	-412	-412	-412
Circ. Bend. P	-2570	2570	-2570	2570	-3087	3087	-3087	3087
Circ. Memb. MC	0	0	0	0	-203	-203	203	203
Circ. Bend. MC	0	0	0	0	-23608	23608	23608	-23608
Circ. Memb. ML	-831	-831	831	831	0	0	0	0
Circ. Bend. ML	-14364	14364	14364	-14364	0	0	0	0
Tot. Circ. Str.	-18171	15696	12220	-11367	-27311	26079	20311	-20730
Long. Memb. P	-412	-412	-412	-412	-405	-405	-405	-405
Long. Bend. P	-3164	3164	-3164	3164	-2523	2523	-2523	2523
Long. Memb. MC	0	0	0	0	-253	-253	253	253
Long. Bend. MC	0	0	0	0	-14210	14210	14210	-14210
Long. Memb. ML	-197	-197	197	197	0	0	0	0
Long. Bend. ML	-24141	24141	24141	-24141	0	0	0	0
Tot. Long. Str.	-27915	26695	20760	-21192	-17392	16075	11534	-11839
Shear VC	648	648	-648	-648	0	0	0	0
Shear VL	0	0	0	0	-648	-648	648	648
Shear MT	5120	5120	5120	5120	5120	5120	5120	5120
Tot. Shear	5768	5768	4471	4471	4471	4471	5768	5768
Str. Int.	30594	29166	22673	22922	29029	27786	23171	23568

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Circ. Pl (SUS)	-1237	-1237	426	426	-616	-616	-209	-209
Circ. Q (SUS)	-16934	16934	11794	-11794	-26695	26695	20521	-20521
Long. Pm (SUS)	62988	62988	62988	62988	62988	62988	62988	62988
Long. Pl (SUS)	-610	-610	-215	-215	-658	-658	-152	-152
Long. Q (SUS)	-27305	27305	20976	-20976	-16733	16733	11686	-11686
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	648	648	-648	-648	-648	-648	648	648

Shear Q (SUS)	5120	5120	5120	5120	5120	5120	5120	5120
Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Pm+Pl (SUS)	124745	129279	126409	130943	125366	129900	125773	130307
Pm+Pl+Q (Total)	108259	146790	138561	119400	99038	156846	146748	110341

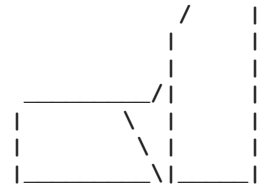
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130510	137892	Passed
Pm+Pl (SUS)	130943	206838	Passed
Pm+Pl+Q (TOTAL)	156846	413676	Passed

INPUT VALUES, Nozzle Description: N3 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4534.307	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		13500.0010	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		180.00	deg
Nozzle Diameter	Dia	146.3600	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	10.9700	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	87.0000	mm
Height of Beveled Transition	L`	24.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		52.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	137.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	20.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: N3

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	146.360	mm.
Actual Nozzle Thickness Used in Calculation	10.970	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*1752.9999)/(137892*1.00-0.6*4534.31)
= 58.8041 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*76.18)/(137892*1.00-0.6*4534.31)
= 2.5554 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.4893 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):

Height value from sketch (e-1) [te]:
= (Hub Thickness - Neck Thickness) / cos(30)
= 41.030 / 0.5773
= 71.0661 mm

Note: Hub Height was < 2.5 times Hub Thickness, use sketch UG-40 (e-1).

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	304.7200	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	90.9911	mm

Note: Hub Height was < 2.5 times Hub Thickness, using sketch UG-40 (e-1).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	8959.400	1577.519	NA	mm²
Area in Shell	A1	486.920	6291.282	NA	mm²
Area in Nozzle Wall	A2	985.352	1361.352	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	400.000	400.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub + Bevel	A6	7439.497	7439.497	NA	mm²
TOTAL AREA AVAILABLE	Atot	9311.769	15492.131	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (152.3600*58.8041+2*(52.0000-3.0000)*58.8041*(1-1.0000))
= 8959.400 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (304.720-152.360)*(1.00*(65.0000-3.000)-58.804)-2*(52.000-3.000)
(1.00(65.0000-3.0000)-58.8041)*(1-1.0000)
= 486.920 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(90.99 ,137.00)) * (10.97 - 3.00 - 2.56) * 1.0000)
= 985.352 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 20.0000² * 1.0000 + (0.0000)² * 1.0000
= 400.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(91.0 ,137.0 ,87.0)) * (52.0 - 11.0) * 1.000)
= 7439.497 mm² Includes Bevel Area of 300.277 mm²

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

```
Wall Thickness per UG45(a),     tra = 5.5554 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.8041 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.8041 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 10.1564 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 10.1564 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 10.1564 mm
Available Nozzle Neck Thickness     = 10.9700 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D

```
Shell is governing, tg = 52.000 , tr = 58.804 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 1.200

Minimum Temp. w/o impact per UCS-66              -19  C
```

Governing MDMT of the all the sub-joints of this Junction : -19 C

Weld Size Calculations, Description: N3

```
Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	14.1400 = 0.7 * Wo mm

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

Weld Load [W]:
```
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (8959.4004 - 486.9197 + 2 * ( 52.0000 - 3.0000 ) * 1.0000 *
  (1.00 * ( 65.0000 - 3.0000 ) - 58.8041 ) ) * 137892
= 1211441.38 N
```

Weld Load [W1]:
```
= ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
= ( 8424.8486 + 400.0000 - 0.0000 * 1.00 ) * 137892
= 1216843.25 N
```

Weld Load [W2]:
```
= ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
= ( 8424.8486 + 0.0000 + 400.0000 + 6076.0000 ) * 137892
= 2054652.38 N
```

Weld Load [W3]:
```
= ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
= ( 8424.8486 + 0.0000 + 400.0000 + 0.0000 + 6076.0000 ) * 137892
= 2054652.38 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.1416 / 2.0 ) * 250.3600 * 20.0000 * 0.49 * 137892
= 531420. N
```

Shear, Nozzle Wall [Snw]:
```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.1416 * 100.6800 ) * ( 52.0000 - 3.0000 ) * 0.7 * 137892
= 1495941. N
```

Tension, Nozzle Groove Weld [Tngw]:
```
= (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
= ( 3.1416 / 2.0 ) * 250.3600 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
= 2487916. N
```

Strength of Failure Paths:

```
PATH11 = ( SONW + SNW ) = ( 531420 + 1495941 ) = 2027361 N
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 531420 + 0 + 2487915 + 0 ) = 3019335 N
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 531420 + 2487915 + 0 ) = 3019335 N
```

Summary of Failure Path Calculations:
```
Path 1-1 = 2027361 N  , must exceed W = 1211441 N   or W1 = 1216843 N
Path 2-2 = 3019335 N  , must exceed W = 1211441 N   or W2 = 2054652 N
Path 3-3 = 3019335 N  , must exceed W = 1211441 N   or W3 = 2054652 N
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
Converged Max. Allow. Pressure in Operating case     4568.607  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 4.4829 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 206.4828 mm

Input Echo, WRC107 Item 1, Description: N3 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	146.360	mm
Nozzle Thickness	Tn	52.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4534.307	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	12000.0	N
Longitudinal Shear	(SUS)	Vl	12000.0	N
Circumferential Shear	(SUS)	Vc	12000.0	N
Circumferential Moment	(SUS)	Mc	12000.0	N-m
Longitudinal Moment	(SUS)	Ml	12000.0	N-m
Torsional Moment	(SUS)	Mt	12000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	12000.0	N
Circumferential Shear	VC	12000.0	N
Longitudinal Shear	VL	12000.0	N
Circumferential Moment	MC	12000.0	N-m
Longitudinal Moment	ML	12000.0	N-m
Torsional Moment	MT	12000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.061	4C	5.415	(A,B)
N(PHI) / (P/Rm)	0.061	3C	5.275	(C,D)
M(PHI) / (P)	0.061	2C1	0.147	(A,B)
M(PHI) / (P)	0.061	1C	0.185	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.061	3A	0.427	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.061	1A	0.103	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.061	3B	1.582	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.061	1B	0.057	(A,B,C,D)
N(x) / (P/Rm)	0.061	3C	5.275	(A,B)

N(x) / (P/Rm)	0.061	4C	5.415	(C,D)
M(x) / (P)	0.061	1C1	0.189	(A,B)
M(x) / (P)	0.061	2C	0.147	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.061	4A	0.538	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.061	2A	0.061	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.061	4B	0.422	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.061	2B	0.096	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-587	-587	-587	-587	-572	-572	-572	-572
Circ. Bend. P	-2758	2758	-2758	2758	-3456	3456	-3456	3456
Circ. Memb. MC	0	0	0	0	-422	-422	422	422
Circ. Bend. MC	0	0	0	0	-17660	17660	17660	-17660
Circ. Memb. ML	-1566	-1566	1566	1566	0	0	0	0
Circ. Bend. ML	-9727	9727	9727	-9727	0	0	0	0
Tot. Circ. Str.	-14639	10332	7948	-5991	-22112	20122	14054	-14353
Long. Memb. P	-572	-572	-572	-572	-587	-587	-587	-587
Long. Bend. P	-3533	3533	-3533	3533	-2749	2749	-2749	2749
Long. Memb. MC	0	0	0	0	-532	-532	532	532
Long. Bend. MC	0	0	0	0	-10506	10506	10506	-10506
Long. Memb. ML	-417	-417	417	417	0	0	0	0
Long. Bend. ML	-16344	16344	16344	-16344	0	0	0	0
Tot. Long. Str.	-20867	18888	12655	-12965	-14375	12135	7702	-7812
Shear VC	492	492	-492	-492	0	0	0	0
Shear VL	0	0	0	0	-492	-492	492	492
Shear MT	1965	1965	1965	1965	1965	1965	1965	1965
Tot. Shear	2457	2457	1472	1472	1472	1472	2457	2457
Str. Int.	21720	19543	13078	13263	22383	20385	14893	15173

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Circ. Pl (SUS)	-2153	-2153	978	978	-994	-994	-149	-149
Circ. Q (SUS)	-12485	12485	6969	-6969	-21117	21117	14203	-14203
Long. Pm (SUS)	62988	62988	62988	62988	62988	62988	62988	62988
Long. Pl (SUS)	-989	-989	-154	-154	-1119	-1119	-55	-55
Long. Q (SUS)	-19878	19878	12810	-12810	-13255	13255	7757	-7757
Shear Pm (SUS)	0	0	0	0	0	0	0	0

Shear Pl (SUS)	492	492	-492	-492	-492	-492	492	492
Shear Q (SUS)	1965	1965	1965	1965	1965	1965	1965	1965
Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Pm+Pl (SUS)	123826	128360	126958	131492	124985	129519	125830	130364
Pm+Pl+Q (Total)	111423	140945	133961	124548	103903	150661	140117	116256

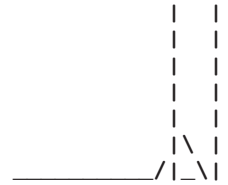
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130510	137892	Passed
Pm+Pl (SUS)	131492	206838	Passed
Pm+Pl+Q (TOTAL)	150661	413676	Passed

INPUT VALUES, Nozzle Description: K3A From : 20

Pressure for Nozzle Reinforcement Calculations	P	4522.238	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	538.0000	mm
Distance from Bottom/Left Tangent		9500.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		252.76	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	144.2180	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Abutting Nozzle No Pad

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K3A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    60.325  mm.
Actual Nozzle Thickness Used in Calculation            8.738  mm
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
  = (4522.24*1752.9999)/(137892*1.00-0.6*4522.24)
  = 58.6445 mm
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
  = (4522.24*30.1625)/(117897*1.00+0.4*4522.24)
  = 1.1395 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2718 mm

UG-40, Limits of Reinforcement : [Int. Press]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   186.7175  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    14.3440  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for K3A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B
```
Nozzle, tg = 7.645 , tr = 1.139 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.245

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B
```
Nozzle is governing, tg = 7.645 , tr = 1.139 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.245

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
Minimum Temp. w/o impact per UG-20(f)            -29  C
```

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)      -35  C
```

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4522.24/5102.00 = 0.886

Weld Size Calculations, Description: K3A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4522.238 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K3A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 60.325 mm.
Actual Nozzle Thickness Used in Calculation 8.738 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4522.24*1752.9999)/(137892*1.00-0.6*4522.24)
= 58.6445 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4522.24*30.1625)/(117897*1.00+0.4*4522.24)
= 1.1395 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2718 mm

UG-40, Limits of Reinforcement : [Int. Press]
Parallel to Vessel Wall (Diameter Limit) Dl 184.3250 mm
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 14.3440 mm

Note: Taking a UG-36(c)(3)(a) exemption for K3A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
Wall Thickness per UG45(a), tra = 4.1395 mm
Wall Thickness per UG16(b), tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.6445 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.6445 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm

Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness, tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness = .875 * 8.7376 = 7.6454 mm --> OK

Weld Size Calculations, Description: K3A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4522.238 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 10.0482 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 222.4469 mm

Input Echo, WRC107 Item 1, Description: K3A :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	60.325	mm
Nozzle Thickness	Tn	8.738	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4522.238	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control No

WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0
Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831

Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125641	130163	125641	130163	125641	130163	125641	130163
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62820	62820	62820	62820	62820	62820	62820	62820
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125641	130163	125641	130163	125641	130163	125641	130163
Pm+Pl (SUS)	124606	129126	125908	130428	125115	129635	125372	129892
Pm+Pl+Q (Total)	97548	172723	161457	108337	80652	187636	177803	93773

Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130163	137892	Passed
Pm+Pl (SUS)	130428	206838	Passed
Pm+Pl+Q (TOTAL)	187636	413676	Passed

INPUT VALUES, Nozzle Description: K3B From : 20

Pressure for Nozzle Reinforcement Calculations	P	4531.840	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	1554.0000	mm
Distance from Bottom/Left Tangent		9500.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		211.11	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	223.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		18.5900	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	243.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		F-4	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K3B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation	60.325	mm.
Actual Nozzle Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4531.84*1752.9999)/(137892*1.00-0.6*4531.84)
= 58.7715 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4531.84*30.1625)/(137892*1.00+0.4*4531.84)
= 0.9784 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3354 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	235.3576	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	155.0000	mm

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	2935.121	1034.172	NA	mm²
Area in Shell	A1	4418.421	5594.070	NA	mm²
Area in Nozzle Wall	A2	1475.342	1674.675	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	81.000	81.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub + Bevel	A6	1992.792	1992.792	NA	mm²
TOTAL AREA AVAILABLE	Atot	7967.554	9342.537	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	29.28	Degs.

The area available without a pad is Sufficient.

Note: The value of tr in the following equation has been multiplied by
the F correction factor of 0.5.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (99.8824*29.3858+2*(8.7376-3.0000)*29.3858*(1-1.0000))
= 2935.121 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (235.358-99.882)*(1.00*(65.0000-3.000)-29.386)-2*(8.738-3.000)
(1.00(65.0000-3.0000)-29.3858)*(1-1.0000)
= 4418.421 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(155.00 ,243.00)) * (8.74 - 3.00 - 0.98) * 1.0000)
= 1475.342 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2

= 9.0000² * 1.0000 + (0.0000)² * 1.0000
= 81.000 mm²

Area Available in the Hub Section [A6]:
= ((Hubtk - tn) * h - atrap) * fr
= ((18.5900 - 8.7376) * 223.0000 - 204.2937) * 1.0000
= 1992.792 mm²

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
Shell is governing, tg = 18.590 , tr = 58.772 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 3.770

Minimum Temp. w/o impact per UCS-66 -42 C

Governing MDMT of the all the sub-joints of this Junction : -42 C

Weld Size Calculations, Description: K3B

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4563.674 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K3B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 60.325 mm.
Actual Nozzle Thickness Used in Calculation 8.738 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4531.84*1752.9999)/(137892*1.00-0.6*4531.84)
= 58.7715 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4531.84*30.1625)/(137892*1.00+0.4*4531.84)
= 0.9784 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3354 mm

UG-40, Limits of Reinforcement : [Int. Press]
Parallel to Vessel Wall (Diameter Limit) Dl 184.3250 mm
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 155.0000 mm

Note: Taking a UG-36(c)(3)(a) exemption for K3B .

This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 3.9784 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.7715 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.7715 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness     = .875 * 8.7376 = 7.6454 mm --> OK
```

Weld Size Calculations, Description: K3B

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

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case     4531.840  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 61.1340 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 437.1225 mm

Input Echo, WRC107 Item 1, Description: K3B :

```
Diameter Basis for Vessel                Vbasis      ID
Cylindrical or Spherical Vessel          Cylsph      Cylindrical
Internal Corrosion Allowance                Cas      3.0000  mm
Vessel Diameter                              Dv    3500.000  mm
Vessel Thickness                             Tv      65.000  mm

Design Temperature                                   120.00  C
Vessel Material                                  SA-516 70
Vessel Cold S.I. Allowable                  Smc   137892.00  kPa
Vessel Hot  S.I. Allowable                  Smh   137892.00  kPa

Attachment Type                            Type      Round

Diameter Basis for Nozzle                Nbasis      OD
Corrosion Allowance for Nozzle              Can      3.0000  mm
Nozzle Diameter                              Dn      60.325  mm
Nozzle Thickness                             Tn       8.738  mm
Nozzle Material                                  SA-350 LF2
Nozzle Cold S.I. Allowable                 SNmc   137892.00  kPa
Nozzle Hot  S.I. Allowable                 SNmh   137892.00  kPa

Design Internal Pressure                     Dp    4531.840  kPa
Include Pressure Thrust                                 No
```

External Forces and Moments in WRC 107 Convention:

```
Radial Load            (SUS)                 P      8000.0  N
```

Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979
Include Pressure Stress Indices per Div. 2		No
Compute Pressure Stress per WRC-368		No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0

Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831
Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125907	130439	125907	130439	125907	130439	125907	130439
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62953	62953	62953	62953	62953	62953	62953	62953
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125907	130439	125907	130439	125907	130439	125907	130439
Pm+Pl (SUS)	124873	129403	126175	130705	125381	129911	125639	130169
Pm+Pl+Q (Total)	97806	172978	161705	108607	80900	187905	178060	94029

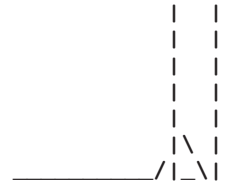
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130439	137892	Passed
Pm+Pl (SUS)	130705	206838	Passed
Pm+Pl+Q (TOTAL)	187905	413676	Passed

INPUT VALUES, Nozzle Description: K6A **From : 20**

Pressure for Nozzle Reinforcement Calculations	P	4522.238	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	538.0000	mm
Distance from Bottom/Left Tangent		10000.0010	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		252.76	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	144.2180	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Abutting Nozzle No Pad

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K6A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    60.325  mm.
Actual Nozzle Thickness Used in Calculation            8.738  mm
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
  = (4522.24*1752.9999)/(137892*1.00-0.6*4522.24)
  = 58.6445 mm
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
  = (4522.24*30.1625)/(117897*1.00+0.4*4522.24)
  = 1.1395 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2718 mm

UG-40, Limits of Reinforcement : [Int. Press]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   186.7175  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    14.3440  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for K6A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B
```
Nozzle, tg = 7.645 , tr = 1.139 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.245

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B
```
Nozzle is governing, tg = 7.645 , tr = 1.139 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.245

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
Minimum Temp. w/o impact per UG-20(f)            -29  C
```

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)      -35  C
```

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4522.24/5102.00 = 0.886

Weld Size Calculations, Description: K6A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4522.238 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K6A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 60.325 mm.
Actual Nozzle Thickness Used in Calculation 8.738 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4522.24*1752.9999)/(137892*1.00-0.6*4522.24)
= 58.6445 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4522.24*30.1625)/(117897*1.00+0.4*4522.24)
= 1.1395 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2718 mm

UG-40, Limits of Reinforcement : [Int. Press]
Parallel to Vessel Wall (Diameter Limit) Dl 184.3250 mm
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 14.3440 mm

Note: Taking a UG-36(c)(3)(a) exemption for K6A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
Wall Thickness per UG45(a), tra = 4.1395 mm
Wall Thickness per UG16(b), tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.6445 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.6445 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm

Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness, tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness = .875 * 8.7376 = 7.6454 mm --> OK

Weld Size Calculations, Description: K6A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4522.238 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 10.0482 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 222.4469 mm

Input Echo, WRC107 Item 1, Description: K6A :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	60.325	mm
Nozzle Thickness	Tn	8.738	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4522.238	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control No

WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0
Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831

Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125641	130163	125641	130163	125641	130163	125641	130163
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62820	62820	62820	62820	62820	62820	62820	62820
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125641	130163	125641	130163	125641	130163	125641	130163
Pm+Pl (SUS)	124606	129126	125908	130428	125115	129635	125372	129892
Pm+Pl+Q (Total)	97548	172723	161457	108337	80652	187636	177803	93773

Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130163	137892	Passed
Pm+Pl (SUS)	130428	206838	Passed
Pm+Pl+Q (TOTAL)	187636	413676	Passed

INPUT VALUES, Nozzle Description: K6B From : 20

Pressure for Nozzle Reinforcement Calculations	P	4531.840	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	1554.0000	mm
Distance from Bottom/Left Tangent		10000.0010	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		211.11	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	223.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		18.5900	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	243.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		F-4	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K6B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation	60.325	mm.
Actual Nozzle Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4531.84*1752.9999)/(137892*1.00-0.6*4531.84)
= 58.7715 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4531.84*30.1625)/(137892*1.00+0.4*4531.84)
= 0.9784 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3354 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	235.3576	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	155.0000	mm

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	2935.121	1034.172	NA	mm²
Area in Shell	A1	4418.421	5594.070	NA	mm²
Area in Nozzle Wall	A2	1475.342	1674.675	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	81.000	81.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub + Bevel	A6	1992.792	1992.792	NA	mm²
TOTAL AREA AVAILABLE	Atot	7967.554	9342.537	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	29.28	Degs.

The area available without a pad is Sufficient.

Note: The value of tr in the following equation has been multiplied by
the F correction factor of 0.5.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (99.8824*29.3858+2*(8.7376-3.0000)*29.3858*(1-1.0000))
= 2935.121 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (235.358-99.882)*(1.00*(65.0000-3.000)-29.386)-2*(8.738-3.000)
(1.00(65.0000-3.0000)-29.3858)*(1-1.0000)
= 4418.421 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(155.00 ,243.00)) * (8.74 - 3.00 - 0.98) * 1.0000)
= 1475.342 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2

= 9.0000² * 1.0000 + (0.0000)² * 1.0000
= 81.000 mm²

Area Available in the Hub Section [A6]:
= ((Hubtk - tn) * h - atrap) * fr
= ((18.5900 - 8.7376) * 223.0000 - 204.2937) * 1.0000
= 1992.792 mm²

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
Shell is governing, tg = 18.590 , tr = 58.772 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 3.770

Minimum Temp. w/o impact per UCS-66 -42 C

Governing MDMT of the all the sub-joints of this Junction : -42 C

Weld Size Calculations, Description: K6B

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4563.674 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K6B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 60.325 mm.
Actual Nozzle Thickness Used in Calculation 8.738 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4531.84*1752.9999)/(137892*1.00-0.6*4531.84)
= 58.7715 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4531.84*30.1625)/(137892*1.00+0.4*4531.84)
= 0.9784 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3354 mm

UG-40, Limits of Reinforcement : [Int. Press]
Parallel to Vessel Wall (Diameter Limit) Dl 184.3250 mm
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 155.0000 mm

Note: Taking a UG-36(c)(3)(a) exemption for K6B .

This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 3.9784 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.7715 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.7715 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness     = .875 * 8.7376 = 7.6454 mm --> OK
```

Weld Size Calculations, Description: K6B

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

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case     4531.840  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 61.1340 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 437.1225 mm

Input Echo, WRC107 Item 1, Description: K6B :

```
Diameter Basis for Vessel                Vbasis      ID
Cylindrical or Spherical Vessel          Cylsph      Cylindrical
Internal Corrosion Allowance                Cas      3.0000  mm
Vessel Diameter                              Dv    3500.000  mm
Vessel Thickness                             Tv      65.000  mm

Design Temperature                                   120.00  C
Vessel Material                                  SA-516 70
Vessel Cold S.I. Allowable                  Smc   137892.00  kPa
Vessel Hot  S.I. Allowable                  Smh   137892.00  kPa

Attachment Type                            Type      Round

Diameter Basis for Nozzle                Nbasis      OD
Corrosion Allowance for Nozzle              Can      3.0000  mm
Nozzle Diameter                              Dn      60.325  mm
Nozzle Thickness                             Tn       8.738  mm
Nozzle Material                                  SA-350 LF2
Nozzle Cold S.I. Allowable                 SNmc   137892.00  kPa
Nozzle Hot  S.I. Allowable                 SNmh   137892.00  kPa

Design Internal Pressure                     Dp    4531.840  kPa
Include Pressure Thrust                                 No
```

External Forces and Moments in WRC 107 Convention:

```
Radial Load            (SUS)                 P      8000.0  N
```

Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0

Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831
Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125907	130439	125907	130439	125907	130439	125907	130439
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62953	62953	62953	62953	62953	62953	62953	62953
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125907	130439	125907	130439	125907	130439	125907	130439
Pm+Pl (SUS)	124873	129403	126175	130705	125381	129911	125639	130169
Pm+Pl+Q (Total)	97806	172978	161705	108607	80900	187905	178060	94029

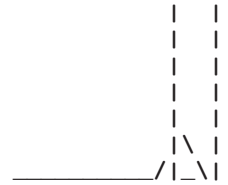
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130439	137892	Passed
Pm+Pl (SUS)	130705	206838	Passed
Pm+Pl+Q (TOTAL)	187905	413676	Passed

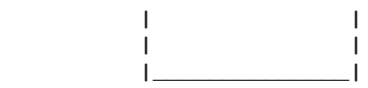
INPUT VALUES, Nozzle Description: K8A **From : 20**

Pressure for Nozzle Reinforcement Calculations	P	4507.173	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	1056.0000	mm
Distance from Bottom/Left Tangent		10500.0010	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		305.58	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	151.4750	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch





Abutting Nozzle No Pad

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K8A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation	60.325	mm.
Actual Nozzle Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4507.17*1752.9999)/(137892*1.00-0.6*4507.17)
= 58.4452 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4507.17*30.1625)/(117897*1.00+0.4*4507.17)
= 1.1357 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2772 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	196.1239	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	14.3440	mm

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	1772.312	627.950	NA	mm²
Area in Shell	A1	4440.524	5594.071	NA	mm²
Area in Nozzle Wall	A2	112.876	133.934	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	69.255	69.255	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
TOTAL AREA AVAILABLE	Atot	4622.655	5797.260	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	53.65	Degs.

The area available without a pad is Sufficient.

Note: The value of tr in the following equation has been multiplied by
the F correction factor of 0.5.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (60.6487*29.2226+2*(8.7376-3.0000)*29.2226*(1-1.0000))
= 1772.312 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (196.124-60.649)*(1.00*(65.0000-3.000)-29.223)-2*(8.738-3.000)
(1.00(65.0000-3.0000)-29.2226)*(1-1.0000)

= 4440.524 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(14.34 ,151.48)) * (8.74 - 3.00 - 1.14) * 0.8550)
= 112.876 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 9.0000² * 0.8550 + (0.0000)² * 0.8550
= 69.255 mm²

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B
Nozzle, tg = 7.645 , tr = 1.136 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.244

Minimum Temp. w/o impact per UCS-66	-46 C
Minimum Temp. at required thickness	-104 C

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B
Nozzle is governing, tg = 7.645 , tr = 1.136 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.244

Minimum Temp. w/o impact per UCS-66	-46 C
Minimum Temp. at required thickness	-104 C
Minimum Temp. w/o impact per UG-20(f)	-29 C

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)	-35 C

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4507.17/5102.00 = 0.883

Weld Size Calculations, Description: K8A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
= (Ar - A1)* S
= (1772.3118 - 4440.5239) * 137892
= 0.00 N

Weld Load [W1]:
= (A2+A5+A4-(Wi-Can/.707)²*Ffr2)*S
= (112.8758 + 0.0000 + 69.2550 - 0.0000 * 0.86) * 137892
= 25113.70 N

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
= (pi/2) * Dlo * Wo * 0.49 * Snw
= (3.1416 / 2.0) * 74.8955 * 9.0000 * 0.49 * 117897

= 61166. N

Shear, Nozzle Groove Weld [Sngw]:
= (pi/2) * (Dlr+Wgnva) * (Wgnva-Can) * 0.60 * Sng
= (3.14 /2)*(60.649 +6.350)*(6.350 -3.0000)*0.6*117897
= 24939. N

Strength of Failure Paths:

PATH11 = (SONW + SNGW)= (61165 + 24938) = 86104 N

Summary of Failure Path Calculations:
Path 1-1 = 86104 N , must exceed W = 0 N or W1 = 25113 N

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4514.339 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K8A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 60.325 mm.
Actual Nozzle Thickness Used in Calculation 8.738 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4507.17*1752.9999)/(137892*1.00-0.6*4507.17)
= 58.4452 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4507.17*30.1625)/(117897*1.00+0.4*4507.17)
= 1.1357 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2772 mm

UG-40, Limits of Reinforcement : [Int. Press]
Parallel to Vessel Wall (Diameter Limit) Dl 184.3250 mm
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 14.3440 mm

Note: Taking a UG-36(c)(3)(a) exemption for K8A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
Wall Thickness per UG45(a), tra = 4.1357 mm
Wall Thickness per UG16(b), tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.4452 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.4452 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm

Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness, tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness = .875 * 8.7376 = 7.6454 mm --> OK

Weld Size Calculations, Description: K8A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4507.173 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 23.3462 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 255.5150 mm

Input Echo, WRC107 Item 1, Description: K8A :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	60.325	mm
Nozzle Thickness	Tn	8.738	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4507.173	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control No

WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0
Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831

Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125222	129729	125222	129729	125222	129729	125222	129729
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62611	62611	62611	62611	62611	62611	62611	62611
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125222	129729	125222	129729	125222	129729	125222	129729
Pm+Pl (SUS)	124188	128693	125490	129995	124696	129201	124954	129459
Pm+Pl+Q (Total)	97144	172324	161069	107915	80264	187214	177398	93373

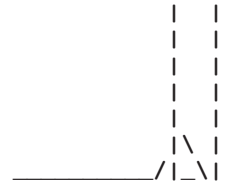
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129729	137892	Passed
Pm+Pl (SUS)	129995	206838	Passed
Pm+Pl+Q (TOTAL)	187214	413676	Passed

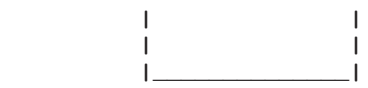
INPUT VALUES, Nozzle Description: K2A From : 20

Pressure for Nozzle Reinforcement Calculations	P	4507.173	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	1056.0000	mm
Distance from Bottom/Left Tangent		11000.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		305.58	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	151.4750	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch





Abutting Nozzle No Pad

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K2A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation	60.325	mm.
Actual Nozzle Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4507.17*1752.9999)/(137892*1.00-0.6*4507.17)
= 58.4452 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4507.17*30.1625)/(117897*1.00+0.4*4507.17)
= 1.1357 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2772 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	196.1239	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	14.3440	mm

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	1772.312	627.950	NA	mm²
Area in Shell	A1	4440.524	5594.071	NA	mm²
Area in Nozzle Wall	A2	112.876	133.934	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	69.255	69.255	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
TOTAL AREA AVAILABLE	Atot	4622.655	5797.260	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	53.65	Degs.

The area available without a pad is Sufficient.

Note: The value of tr in the following equation has been multiplied by
the F correction factor of 0.5.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (60.6487*29.2226+2*(8.7376-3.0000)*29.2226*(1-1.0000))
= 1772.312 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (196.124-60.649)*(1.00*(65.0000-3.000)-29.223)-2*(8.738-3.000)
(1.00(65.0000-3.0000)-29.2226)*(1-1.0000)

= 4440.524 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(14.34 ,151.48)) * (8.74 - 3.00 - 1.14) * 0.8550)
= 112.876 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 9.0000² * 0.8550 + (0.0000)² * 0.8550
= 69.255 mm²

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B
Nozzle, tg = 7.645 , tr = 1.136 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.244

Minimum Temp. w/o impact per UCS-66	-46 C
Minimum Temp. at required thickness	-104 C

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B
Nozzle is governing, tg = 7.645 , tr = 1.136 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.244

Minimum Temp. w/o impact per UCS-66	-46 C
Minimum Temp. at required thickness	-104 C
Minimum Temp. w/o impact per UG-20(f)	-29 C

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)	-35 C

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4507.17/5102.00 = 0.883

Weld Size Calculations, Description: K2A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)
Weld Load [W]:
= (Ar - A1)* S
= (1772.3118 - 4440.5239) * 137892
= 0.00 N

Weld Load [W1]:
= (A2+A5+A4-(Wi-Can/.707)²*Ffr2)*S
= (112.8758 + 0.0000 + 69.2550 - 0.0000 * 0.86) * 137892
= 25113.70 N

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
= (pi/2) * Dlo * Wo * 0.49 * Snw
= (3.1416 / 2.0) * 74.8955 * 9.0000 * 0.49 * 117897

= 61166. N

Shear, Nozzle Groove Weld [Sngw]:
= (pi/2) * (Dlr+Wgnva) * (Wgnva-Can) * 0.60 * Sng
= (3.14 /2)*(60.649 +6.350)*(6.350 -3.0000)*0.6*117897
= 24939. N

Strength of Failure Paths:

PATH11 = (SONW + SNGW)= (61165 + 24938) = 86104 N

Summary of Failure Path Calculations:
Path 1-1 = 86104 N , must exceed W = 0 N or W1 = 25113 N

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4514.339 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K2A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 60.325 mm.
Actual Nozzle Thickness Used in Calculation 8.738 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4507.17*1752.9999)/(137892*1.00-0.6*4507.17)
= 58.4452 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4507.17*30.1625)/(117897*1.00+0.4*4507.17)
= 1.1357 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2772 mm

UG-40, Limits of Reinforcement : [Int. Press]
Parallel to Vessel Wall (Diameter Limit) Dl 184.3250 mm
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 14.3440 mm

Note: Taking a UG-36(c)(3)(a) exemption for K2A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
Wall Thickness per UG45(a), tra = 4.1357 mm
Wall Thickness per UG16(b), tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.4452 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.4452 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm

Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness, tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness = .875 * 8.7376 = 7.6454 mm --> OK

Weld Size Calculations, Description: K2A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo	mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4507.173 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 23.3462 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 255.5150 mm

Input Echo, WRC107 Item 1, Description: K2A :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	60.325	mm
Nozzle Thickness	Tn	8.738	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4507.173	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control No

WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0
Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831

Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125222	129729	125222	129729	125222	129729	125222	129729
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62611	62611	62611	62611	62611	62611	62611	62611
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125222	129729	125222	129729	125222	129729	125222	129729
Pm+Pl (SUS)	124188	128693	125490	129995	124696	129201	124954	129459
Pm+Pl+Q (Total)	97144	172324	161069	107915	80264	187214	177398	93373

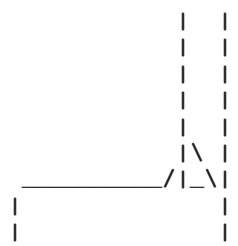
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129729	137892	Passed
Pm+Pl (SUS)	129995	206838	Passed
Pm+Pl+Q (TOTAL)	187214	413676	Passed

INPUT VALUES, Nozzle Description: K2B From : 20

Pressure for Nozzle Reinforcement Calculations	P	4534.307	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		11000.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		180.00	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	54.6481	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



|_____|

Abutting Nozzle No Pad

NOZZLE CALCULATION, Description: K2B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    60.325  mm.
Actual Nozzle Thickness Used in Calculation            8.738  mm
```

Nozzle input data check completed without errors.

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

```
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4534.31*1752.9999)/(137892*1.00-0.6*4534.31)
= 58.8041 mm
```

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

```
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4534.31*30.1625)/(117897*1.00+0.4*4534.31)
= 1.1425 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.1832 mm

UG-40, Limits of Reinforcement : [Int. Press]

```
Parallel to Vessel Wall (Diameter Limit)            Dl   184.3250  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    14.3440  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for K2B .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 4.1425 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.8041 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.8041 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness     = .875 * 8.7376 = 7.6454 mm --> OK
```

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B

```
Nozzle, tg = 7.645 , tr = 1.142 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.246

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

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

```
Nozzle is governing, tg = 7.645 , tr = 1.142 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.246

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

```
 Minimum Temp. w/o impact per UG-20(f)            -29  C
```

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)     -35  C
```

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

```
  Stress ratio: P/Ambient Rating = 4534.31/5102.00 = 0.889
```

Weld Size Calculations, Description: K2B

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

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
 Nozzle Weld          4.0163 = 0.7 * TMIN   6.3630 = 0.7 * Wo mm
```

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

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case     4534.307  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
 Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 0.2599 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 119.9079 mm

Input Echo, WRC107 Item 1, Description: K2B :

```
 Diameter Basis for Vessel                Vbasis      ID
 Cylindrical or Spherical Vessel          Cylsph      Cylindrical
 Internal Corrosion Allowance                Cas      3.0000  mm
 Vessel Diameter                              Dv    3500.000  mm
 Vessel Thickness                             Tv      65.000  mm

 Design Temperature                                   120.00  C
 Vessel Material                                  SA-516 70
 Vessel Cold S.I. Allowable                  Smc   137892.00  kPa
 Vessel Hot  S.I. Allowable                  Smh   137892.00  kPa

 Attachment Type                           Type      Round

 Diameter Basis for Nozzle                Nbasis      OD
 Corrosion Allowance for Nozzle              Can      3.0000  mm
 Nozzle Diameter                              Dn      60.325  mm
 Nozzle Thickness                             Tn       8.738  mm
 Nozzle Material                                   SA-106 B
 Nozzle Cold S.I. Allowable                 SNmc   117897.66  kPa
 Nozzle Hot  S.I. Allowable                 SNmh   117897.66  kPa

 Design Internal Pressure                     Dp    4534.307  kPa
 Include Pressure Thrust                                 No
```

External Forces and Moments in WRC 107 Convention:

```
 Radial Load             (SUS)                P      8000.0  N
 Longitudinal Shear      (SUS)               Vl      8000.0  N
 Circumferential Shear   (SUS)               Vc      8000.0  N
```

Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of		Stress Values at (kPa)							
Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend.	P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb.	MC	0	0	0	0	-128	-128	128	128
Circ. Bend.	MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb.	ML	-651	-651	651	651	0	0	0	0
Circ. Bend.	ML	-30154	30154	30154	-30154	0	0	0	0

Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831
Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62988	62988	62988	62988	62988	62988	62988	62988
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125976	130510	125976	130510	125976	130510	125976	130510
Pm+Pl (SUS)	124941	129474	126243	130776	125450	129982	125707	130240
Pm+Pl+Q (Total)	97873	173043	161769	108676	80963	187974	178127	94094

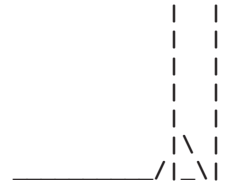
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130510	137892	Passed
Pm+Pl (SUS)	130776	206838	Passed
Pm+Pl+Q (TOTAL)	187974	413676	Passed

INPUT VALUES, Nozzle Description: K7A From : 20

Pressure for Nozzle Reinforcement Calculations	P	4511.010	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	650.0000	mm
Distance from Bottom/Left Tangent		13354.8008	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		290.98	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	183.0320	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Abutting Nozzle No Pad

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K7A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    60.325  mm.
Actual Nozzle Thickness Used in Calculation            8.738  mm
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
  = (4511.01*1752.9999)/(137892*1.00-0.6*4511.01)
  = 58.4960 mm
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
  = (4511.01*30.1625)/(117897*1.00+0.4*4511.01)
  = 1.1367 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2992 mm

UG-40, Limits of Reinforcement : [Int. Press]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   187.9415  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    14.3440  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for K7A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B
```
Nozzle, tg = 7.645 , tr = 1.137 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.245

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B
```
Nozzle is governing, tg = 7.645 , tr = 1.137 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.245

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
Minimum Temp. w/o impact per UG-20(f)            -29  C
```

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)      -35  C
```

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4511.01/5102.00 = 0.884

Weld Size Calculations, Description: K7A

Intermediate Calc. for nozzle/shell Welds	Tmin	5.7376	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo	mm

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

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case	4511.010	kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure	100.000	kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K7A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation	60.325	mm.
Actual Nozzle Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4511.01*1752.9999)/(137892*1.00-0.6*4511.01)
= 58.4960 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4511.01*30.1625)/(117897*1.00+0.4*4511.01)
= 1.1367 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2992 mm

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	184.3250	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	14.3440	mm

Note: Taking a UG-36(c)(3)(a) exemption for K7A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

Wall Thickness per UG45(a), tra = 4.1367 mm
Wall Thickness per UG16(b), tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.4960 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.4960 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm

Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness, tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness = .875 * 8.7376 = 7.6454 mm --> OK

Weld Size Calculations, Description: K7A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo	mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4511.010 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 12.3937 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 265.2343 mm

Input Echo, WRC107 Item 1, Description: K7A :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	60.325	mm
Nozzle Thickness	Tn	8.738	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4511.010	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control No

WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0
Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831

Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125329	129840	125329	129840	125329	129840	125329	129840
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62664	62664	62664	62664	62664	62664	62664	62664
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125329	129840	125329	129840	125329	129840	125329	129840
Pm+Pl (SUS)	124294	128803	125596	130105	124803	129312	125060	129569
Pm+Pl+Q (Total)	97247	172426	161168	108023	80363	187321	177501	93475

Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129840	137892	Passed
Pm+Pl (SUS)	130105	206838	Passed
Pm+Pl+Q (TOTAL)	187321	413676	Passed

INPUT VALUES, Nozzle Description: K7B **From : 20**

Pressure for Nozzle Reinforcement Calculations	P	4531.655	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	1534.4000	mm
Distance from Bottom/Left Tangent		13354.8008	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		212.29	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	191.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		18.5900	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	211.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		F-4	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K7B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    60.325  mm.
Actual Nozzle Thickness Used in Calculation            8.738  mm
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
  = (4531.66*1752.9999)/(137892*1.00-0.6*4531.66)
  = 58.7691 mm
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
  = (4531.66*30.1625)/(137892*1.00+0.4*4531.66)
  = 0.9784 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.3169 mm

UG-40, Limits of Reinforcement : [Int. Press]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   231.5918  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp   155.0000  mm
```

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	2824.342	995.181	NA	mm²
Area in Shell	A1	4418.587	5594.070	NA	mm²
Area in Nozzle Wall	A2	1475.354	1680.425	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	81.000	81.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub + Bevel	A6	1814.957	1814.957	NA	mm²
TOTAL AREA AVAILABLE	Atot	7789.897	9170.452	NA	mm²

The Internal Pressure Case Governs the Analysis.

```
Nozzle Angle Used in Area Calculations                30.55  Degs.
```

The area available without a pad is Sufficient.

Note: The value of tr in the following equation has been multiplied by
the F correction factor of 0.5.

Reinforcement Area Required for Nozzle [Ar]:
```
  = ( Dlr * tr + 2 * tn * tr * (1-fr1) ) UG-37(c)
  = (96.1166*29.3845+2*(8.7376-3.0000)*29.3845*(1-1.0000))
  = 2824.342 mm²
```

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
```
  = (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
  = (231.592-96.117)*(1.00*(65.0000-3.000)-29.385)-2*(8.738-3.000)
    *(1.00*(65.0000-3.0000)-29.3845)*(1-1.0000)
  = 4418.587 mm²
```

Area Available in Nozzle Wall, no Pad [A2np]:
```
  = ( 2 * min(Tlnp,ho) ) * ( tn - can - trn ) * fr2
  = ( 2 * min(155.00 ,211.00 ) ) * ( 8.74 - 3.00 - 0.98 ) * 1.0000 )
  = 1475.354 mm²
```

Area Available in Welds, no Pad [A4np]:
```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
```

= 9.0000² * 1.0000 + (0.0000)² * 1.0000
= 81.000 mm²

Area Available in the Hub Section [A6]:
= ((Hubtk - tn) * h - atrap) * fr
= ((18.5900 - 8.7376) * 191.0000 - 66.8519) * 1.0000
= 1814.957 mm²

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
Shell is governing, tg = 18.590 , tr = 58.769 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 3.770

Minimum Temp. w/o impact per UCS-66 -42 C

Governing MDMT of the all the sub-joints of this Junction : -42 C

Weld Size Calculations, Description: K7B

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4563.304 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K7B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 60.325 mm.
Actual Nozzle Thickness Used in Calculation 8.738 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4531.66*1752.9999)/(137892*1.00-0.6*4531.66)
= 58.7691 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4531.66*30.1625)/(137892*1.00+0.4*4531.66)
= 0.9784 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3169 mm

UG-40, Limits of Reinforcement : [Int. Press]
Parallel to Vessel Wall (Diameter Limit) Dl 184.3250 mm
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 155.0000 mm

Note: Taking a UG-36(c)(3)(a) exemption for K7B .

This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 3.9784 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.7691 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.7691 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness     = .875 * 8.7376 = 7.6454 mm --> OK
```

Weld Size Calculations, Description: K7B

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

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case     4531.655  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 57.5042 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 396.4617 mm

Input Echo, WRC107 Item 1, Description: K7B :

```
Diameter Basis for Vessel                Vbasis      ID
Cylindrical or Spherical Vessel          Cylsph      Cylindrical
Internal Corrosion Allowance                Cas      3.0000  mm
Vessel Diameter                              Dv    3500.000  mm
Vessel Thickness                             Tv      65.000  mm

Design Temperature                                   120.00  C
Vessel Material                                  SA-516 70
Vessel Cold S.I. Allowable                  Smc   137892.00  kPa
Vessel Hot  S.I. Allowable                  Smh   137892.00  kPa

Attachment Type                            Type      Round

Diameter Basis for Nozzle                Nbasis      OD
Corrosion Allowance for Nozzle              Can      3.0000  mm
Nozzle Diameter                              Dn      60.325  mm
Nozzle Thickness                             Tn       8.738  mm
Nozzle Material                                  SA-350 LF2
Nozzle Cold S.I. Allowable                 SNmc   137892.00  kPa
Nozzle Hot  S.I. Allowable                 SNmh   137892.00  kPa

Design Internal Pressure                     Dp    4531.655  kPa
Include Pressure Thrust                                 No
```

External Forces and Moments in WRC 107 Convention:

```
Radial Load            (SUS)                 P      8000.0  N
```

Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0

Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831
Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125902	130434	125902	130434	125902	130434	125902	130434
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62951	62951	62951	62951	62951	62951	62951	62951
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125902	130434	125902	130434	125902	130434	125902	130434
Pm+Pl (SUS)	124868	129397	126170	130699	125376	129906	125634	130163
Pm+Pl+Q (Total)	97801	172973	161700	108602	80895	187900	178055	94024

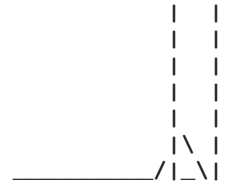
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130434	137892	Passed
Pm+Pl (SUS)	130699	206838	Passed
Pm+Pl+Q (TOTAL)	187900	413676	Passed

INPUT VALUES, Nozzle Description: K1A From : 20

Pressure for Nozzle Reinforcement Calculations	P	4511.010	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	650.0000	mm
Distance from Bottom/Left Tangent		13854.7998	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		290.98	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	183.0320	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Abutting Nozzle No Pad

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K1A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    60.325  mm.
Actual Nozzle Thickness Used in Calculation            8.738  mm
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
  = (4511.01*1752.9999)/(137892*1.00-0.6*4511.01)
  = 58.4960 mm
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
  = (4511.01*30.1625)/(117897*1.00+0.4*4511.01)
  = 1.1367 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2992 mm

UG-40, Limits of Reinforcement : [Int. Press]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   187.9415  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    14.3440  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for K1A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B
```
Nozzle, tg = 7.645 , tr = 1.137 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.245

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B
```
Nozzle is governing, tg = 7.645 , tr = 1.137 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.245

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
Minimum Temp. w/o impact per UG-20(f)            -29  C
```

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)      -35  C
```

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4511.01/5102.00 = 0.884

Weld Size Calculations, Description: K1A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4511.010 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K1A

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 60.325 mm.
Actual Nozzle Thickness Used in Calculation 8.738 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4511.01*1752.9999)/(137892*1.00-0.6*4511.01)
= 58.4960 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4511.01*30.1625)/(117897*1.00+0.4*4511.01)
= 1.1367 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2992 mm

UG-40, Limits of Reinforcement : [Int. Press]
Parallel to Vessel Wall (Diameter Limit) Dl 184.3250 mm
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 14.3440 mm

Note: Taking a UG-36(c)(3)(a) exemption for K1A .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
Wall Thickness per UG45(a), tra = 4.1367 mm
Wall Thickness per UG16(b), tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.4960 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.4960 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm

Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness, tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness = .875 * 8.7376 = 7.6454 mm --> OK

Weld Size Calculations, Description: K1A

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo	mm

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

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4511.010 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

The Drop for this Nozzle is : 12.3937 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 265.2343 mm

Input Echo, WRC107 Item 1, Description: K1A :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	60.325	mm
Nozzle Thickness	Tn	8.738	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4511.010	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control No

WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0
Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831

Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125329	129840	125329	129840	125329	129840	125329	129840
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62664	62664	62664	62664	62664	62664	62664	62664
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125329	129840	125329	129840	125329	129840	125329	129840
Pm+Pl (SUS)	124294	128803	125596	130105	124803	129312	125060	129569
Pm+Pl+Q (Total)	97247	172426	161168	108023	80363	187321	177501	93475

Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129840	137892	Passed
Pm+Pl (SUS)	130105	206838	Passed
Pm+Pl+Q (TOTAL)	187321	413676	Passed

INPUT VALUES, Nozzle Description: K1B From : 20

Pressure for Nozzle Reinforcement Calculations	P	4531.655	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	1534.4000	mm
Distance from Bottom/Left Tangent		13854.7998	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		212.29	deg
Nozzle Diameter	Dia	50.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	160	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	191.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		18.5900	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	211.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		F-4	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

NOZZLE CALCULATION, Description: K1B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    60.325  mm.
Actual Nozzle Thickness Used in Calculation            8.738  mm
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
  = (4531.66*1752.9999)/(137892*1.00-0.6*4531.66)
  = 58.7691 mm
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
  = (4531.66*30.1625)/(137892*1.00+0.4*4531.66)
  = 0.9784 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.3169 mm

UG-40, Limits of Reinforcement : [Int. Press]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   231.5918  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp   155.0000  mm
```

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	2824.342	995.181	NA	mm²
Area in Shell	A1	4418.587	5594.070	NA	mm²
Area in Nozzle Wall	A2	1475.354	1680.425	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	81.000	81.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub + Bevel	A6	1814.957	1814.957	NA	mm²
TOTAL AREA AVAILABLE	Atot	7789.897	9170.452	NA	mm²

The Internal Pressure Case Governs the Analysis.

```
Nozzle Angle Used in Area Calculations                30.55  Degs.
```

The area available without a pad is Sufficient.

Note: The value of tr in the following equation has been multiplied by
the F correction factor of 0.5.

Reinforcement Area Required for Nozzle [Ar]:
```
  = ( Dlr * tr + 2 * tn * tr * (1-fr1) ) UG-37(c)
  = (96.1166*29.3845+2*(8.7376-3.0000)*29.3845*(1-1.0000))
  = 2824.342 mm²
```

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
```
  = (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
  = (231.592-96.117)*(1.00*(65.0000-3.000)-29.385)-2*(8.738-3.000)
    *(1.00*(65.0000-3.0000)-29.3845)*(1-1.0000)
  = 4418.587 mm²
```

Area Available in Nozzle Wall, no Pad [A2np]:
```
  = ( 2 * min(Tlnp,ho) ) * ( tn - can - trn ) * fr2
  = ( 2 * min(155.00 ,211.00 ) ) * ( 8.74 - 3.00 - 0.98 ) * 1.0000 )
  = 1475.354 mm²
```

Area Available in Welds, no Pad [A4np]:
```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
```

= 9.0000² * 1.0000 + (0.0000)² * 1.0000
= 81.000 mm²

Area Available in the Hub Section [A6]:
= ((Hubtk - tn) * h - atrap) * fr
= ((18.5900 - 8.7376) * 191.0000 - 66.8519) * 1.0000
= 1814.957 mm²

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D
Shell is governing, tg = 18.590 , tr = 58.769 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 3.770

Minimum Temp. w/o impact per UCS-66 -42 C

Governing MDMT of the all the sub-joints of this Junction : -42 C

Weld Size Calculations, Description: K1B

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 4563.304 kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure 100.000 kPa

Note : Checking Nozzle in plane parallel to the vessel axis.

NOZZLE CALCULATION, Description: K1B

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 60.325 mm.
Actual Nozzle Thickness Used in Calculation 8.738 mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4531.66*1752.9999)/(137892*1.00-0.6*4531.66)
= 58.7691 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (4531.66*30.1625)/(137892*1.00+0.4*4531.66)
= 0.9784 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.3169 mm

UG-40, Limits of Reinforcement : [Int. Press]
Parallel to Vessel Wall (Diameter Limit) Dl 184.3250 mm
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 155.0000 mm

Note: Taking a UG-36(c)(3)(a) exemption for K1B .

This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 3.9784 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.7691 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.7691 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 6.4227 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 6.4227 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 6.4227 mm
Available Nozzle Neck Thickness     = .875 * 8.7376 = 7.6454 mm --> OK
```

Weld Size Calculations, Description: K1B

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

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * TMIN	6.3630 = 0.7 * Wo mm

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case     4531.655  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 57.5042 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 396.4617 mm

Input Echo, WRC107 Item 1, Description: K1B :

```
Diameter Basis for Vessel                Vbasis      ID
Cylindrical or Spherical Vessel          Cylsph      Cylindrical
Internal Corrosion Allowance                Cas      3.0000  mm
Vessel Diameter                              Dv    3500.000  mm
Vessel Thickness                             Tv      65.000  mm

Design Temperature                                   120.00  C
Vessel Material                                  SA-516 70
Vessel Cold S.I. Allowable                  Smc   137892.00  kPa
Vessel Hot  S.I. Allowable                  Smh   137892.00  kPa

Attachment Type                            Type      Round

Diameter Basis for Nozzle                Nbasis      OD
Corrosion Allowance for Nozzle              Can      3.0000  mm
Nozzle Diameter                              Dn      60.325  mm
Nozzle Thickness                             Tn       8.738  mm
Nozzle Material                                  SA-350 LF2
Nozzle Cold S.I. Allowable                 SNmc   137892.00  kPa
Nozzle Hot  S.I. Allowable                 SNmh   137892.00  kPa

Design Internal Pressure                     Dp    4531.655  kPa
Include Pressure Thrust                                 No
```

External Forces and Moments in WRC 107 Convention:

```
Radial Load            (SUS)                 P      8000.0  N
```

Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N
Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979
Include Pressure Stress Indices per Div. 2		No
Compute Pressure Stress per WRC-368		No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.015	4C		5.709	(A,B)
N(PHI) / (P/Rm)	0.015	3C		5.898	(C,D)
M(PHI) / (P)	0.015	2C1		0.261	(A,B)
M(PHI) / (P)	0.015	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.015	3A		0.047	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.015	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.015	3B		0.238	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.015	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.015	3C		5.898	(A,B)
N(x) / (P/Rm)	0.015	4C		5.709	(C,D)
M(x) / (P)	0.015	1C1	!	0.292	(A,B)
M(x) / (P)	0.015	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.015	4A		0.063	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.015	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.015	4B		0.048	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.015	2B	!	0.107	(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

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-412	-412	-412	-412	-426	-426	-426	-426
Circ. Bend. P	-3254	3254	-3254	3254	-3577	3577	-3577	3577
Circ. Memb. MC	0	0	0	0	-128	-128	128	128
Circ. Bend. MC	0	0	0	0	-49580	49580	49580	-49580
Circ. Memb. ML	-651	-651	651	651	0	0	0	0

Circ. Bend. ML	-30154	30154	30154	-30154	0	0	0	0
Tot. Circ. Str.	-34473	32344	27138	-26662	-53713	52602	45705	-46301
Long. Memb. P	-426	-426	-426	-426	-412	-412	-412	-412
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-173	-173	173	173
Long. Bend. MC	0	0	0	0	-29831	29831	29831	-29831
Long. Memb. ML	-130	-130	130	130	0	0	0	0
Long. Bend. ML	-50777	50777	50777	-50777	0	0	0	0
Tot. Long. Str.	-54981	53866	46834	-47426	-33689	32516	26320	-26800
Shear VC	1361	1361	-1361	-1361	0	0	0	0
Shear VL	0	0	0	0	-1361	-1361	1361	1361
Shear MT	22564	22564	22564	22564	22564	22564	22564	22564
Tot. Shear	23925	23925	21202	21202	21202	21202	23925	23925
Str. Int.	70757	69340	60364	60652	67148	66020	61827	62387

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125902	130434	125902	130434	125902	130434	125902	130434
Circ. Pl (SUS)	-1064	-1064	238	238	-555	-555	-297	-297
Circ. Q (SUS)	-33409	33409	26900	-26900	-53158	53158	46003	-46003
Long. Pm (SUS)	62951	62951	62951	62951	62951	62951	62951	62951
Long. Pl (SUS)	-557	-557	-296	-296	-586	-586	-239	-239
Long. Q (SUS)	-54424	54424	47130	-47130	-33102	33102	26560	-26560
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	1361	1361	-1361	-1361	-1361	-1361	1361	1361
Shear Q (SUS)	22564	22564	22564	22564	22564	22564	22564	22564
Pm (SUS)	125902	130434	125902	130434	125902	130434	125902	130434
Pm+Pl (SUS)	124868	129397	126170	130699	125376	129906	125634	130163
Pm+Pl+Q (Total)	97801	172973	161700	108602	80895	187900	178055	94024

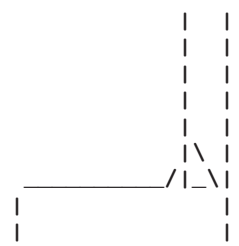
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	130434	137892	Passed
Pm+Pl (SUS)	130699	206838	Passed
Pm+Pl+Q (TOTAL)	187900	413676	Passed

INPUT VALUES, Nozzle Description: K9 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		7500.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	117897.66	kPa
Nozzle Allowable Stress At Ambient	Sna	117897.66	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	25.0000	mm.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	XXS	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	215.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	8.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		600	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



|_____|

Abutting Nozzle No Pad

NOZZLE CALCULATION, Description: K9

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

```
Actual Nozzle Outside Diameter Used in Calculation    33.401  mm.
Actual Nozzle Thickness Used in Calculation            9.093  mm
```

Nozzle input data check completed without errors.

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

```
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm
```

Reqd thk per App. 1 of Nozzle Wall, Trn [Int. Press]

```
= Ro * ( Z^½ - 1 ) / Z^½  per Appendix 1-2 (a)(1)
= 16.701*(1.0794^½-1)/1.0794^½
= 0.6257 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2243 mm

UG-40, Limits of Reinforcement : [Int. Press]

```
Parallel to Vessel Wall (Diameter Limit)            Dl   157.4010  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    15.2330  mm
```

Note: Taking a UG-36(c)(3)(a) exemption for K9 .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

```
Wall Thickness per UG45(a),     tra = 3.6257 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 5.9559 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 5.9559 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 5.9559 mm
Available Nozzle Neck Thickness     = .875 * 9.0932 = 7.9565 mm --> OK
```

Nozzle Junction MDMT Calculations:

Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B

```
Nozzle, tg = 7.957 , tr = 0.626 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.126

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

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

```
Nozzle is governing, tg = 7.957 , tr = 0.626 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 0.126

Minimum Temp. w/o impact per UCS-66              -46  C
Minimum Temp. at required thickness             -104  C
```

Minimum Temp. w/o impact per UG-20(f)	-29	C

Governing MDMT of the all the sub-joints of this Junction : -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 Temperature reduction per UCS-66(b)(1)(b)	-48	C

Where the Temperature Reduction per UCS-66(b)(1)(b) is:
Stress ratio: P/Ambient Rating = 4500.00/10204.01 = 0.441

Weld Size Calculations, Description: K9

Intermediate Calc. for nozzle/shell Welds	Tmin	6.0932	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	4.2652 = 0.7 * TMIN	5.6560 = 0.7 * Wo	mm

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

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case		4500.000	kPa

Note: The MAWP of this junction was limited by the shell.

Nozzle is O.K. for the External Pressure		100.000	kPa

The Drop for this Nozzle is : 0.0796 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 280.0796 mm

Input Echo, WRC107 Item 1, Description: K9 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	33.401	mm
Nozzle Thickness	Tn	9.093	mm
Nozzle Material		SA-106 B	
Nozzle Cold S.I. Allowable	SNmc	117897.66	kPa
Nozzle Hot S.I. Allowable	SNmh	117897.66	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	8000.0	N
Longitudinal Shear	(SUS)	Vl	8000.0	N
Circumferential Shear	(SUS)	Vc	8000.0	N

Circumferential Moment	(SUS)	Mc	8000.0	N-m
Longitudinal Moment	(SUS)	Ml	8000.0	N-m
Torsional Moment	(SUS)	Mt	8000.0	N-m

Use Interactive Control		No
WRC107 Version	Version	March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No

Error/Warning Messages for WRC107 Analysis 1
Warning - The ratio Ro/Rm, 0.0094 , must be > 0.0571 and < 0.571.

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	8000.0	N
Circumferential Shear	VC	8000.0	N
Longitudinal Shear	VL	8000.0	N
Circumferential Moment	MC	8000.0	N-m
Longitudinal Moment	ML	8000.0	N-m
Torsional Moment	MT	8000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.008	4C		5.752	(A,B)
N(PHI) / (P/Rm)	0.008	3C		5.977	(C,D)
M(PHI) / (P)	0.008	2C1	!	0.269	(A,B)
M(PHI) / (P)	0.008	1C	!	0.286	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.008	3A	!	0.018	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.008	1A	!	0.105	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.008	3B	!	0.105	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.008	1B	!	0.064	(A,B,C,D)
N(x) / (P/Rm)	0.008	3C		5.977	(A,B)
N(x) / (P/Rm)	0.008	4C		5.752	(C,D)
M(x) / (P)	0.008	1C1	!	0.292	(A,B)
M(x) / (P)	0.008	2C	!	0.262	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.008	4A	!	0.023	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.008	2A	!	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.008	4B		0.019	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.008	2B	!	0.107	(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

Type of	Load	Stress Values at (kPa) Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-416	-416	-416	-416	-432	-432	-432	-432
Circ. Bend.	P	-3364	3364	-3364	3364	-3577	3577	-3577	3577
Circ. Memb.	MC	0	0	0	0	-89	-89	89	89

Circ. Bend. MC	0	0	0	0	-89547	89547	89547	-89547
Circ. Memb. ML	-518	-518	518	518	0	0	0	0
Circ. Bend. ML	-54461	54461	54461	-54461	0	0	0	0
Tot. Circ. Str.	-58761	56892	51199	-50994	-93646	92602	85626	-86312
Long. Memb. P	-432	-432	-432	-432	-416	-416	-416	-416
Long. Bend. P	-3646	3646	-3646	3646	-3271	3271	-3271	3271
Long. Memb. MC	0	0	0	0	-113	-113	113	113
Long. Bend. MC	0	0	0	0	-53878	53878	53878	-53878
Long. Memb. ML	-94	-94	94	94	0	0	0	0
Long. Bend. ML	-91708	91708	91708	-91708	0	0	0	0
Tot. Long. Str.	-95881	94828	87723	-88400	-57679	56619	50304	-50909
Shear VC	2459	2459	-2459	-2459	0	0	0	0
Shear VL	0	0	0	0	-2459	-2459	2459	2459
Shear MT	73602	73602	73602	73602	73602	73602	73602	73602
Tot. Shear	76062	76062	71143	71143	71143	71143	76062	76062
Str. Int.	156588	156783	146899	147121	149044	147994	156171	156189

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-934	-934	102	102	-521	-521	-342	-342
Circ. Q (SUS)	-57826	57826	51097	-51097	-93124	93124	85969	-85969
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-526	-526	-338	-338	-529	-529	-302	-302
Long. Q (SUS)	-95354	95354	88061	-88061	-57149	57149	50607	-50607
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	2459	2459	-2459	-2459	-2459	-2459	2459	2459
Shear Q (SUS)	73602	73602	73602	73602	73602	73602	73602	73602
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Pm+Pl (SUS)	124185	128679	125221	129715	124598	129091	124777	129270
Pm+Pl+Q (Total)	181847	249316	235549	176489	144741	258454	252167	155373

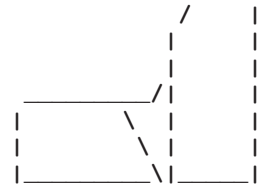
Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	129715	206838	Passed
Pm+Pl+Q (TOTAL)	258454	413676	Passed

INPUT VALUES, Nozzle Description: N5 From : 20

Pressure for Nozzle Reinforcement Calculations	P	4500.000	kPa
Temperature for Internal Pressure	Temp	120	C
Design External Pressure	Pext	100.00	kPa
Temperature for External Pressure	Tempex	120	C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	137892.00	kPa
Shell Allowable Stress At Ambient	Sa	137892.00	kPa
Inside Diameter of Cylindrical Shell	D	3500.00	mm
Design Length of Section	L	15583.3350	mm
Shell Finished (Minimum) Thickness	t	65.0000	mm
Shell Internal Corrosion Allowance	cas	3.0000	mm
Shell External Corrosion Allowance	caext	0.0000	mm
Distance from Bottom/Left Tangent		5500.0000	mm
User Entered Minimum Design Metal Temperature		5.00	C
Nozzle Material		SA-350 LF2	
Nozzle Material UNS Number		K03011	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	137892.00	kPa
Nozzle Allowable Stress At Ambient	Sna	137892.00	kPa
Nozzle Diameter Basis (for tr calc only)	Inbase	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	146.3600	mm.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	10.9700	mm
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Hub Height of Integral Nozzle	h	87.0000	mm
Height of Beveled Transition	L`	24.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		52.0000	mm
Nozzle Corrosion Allowance	Can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	137.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	20.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	65.0000	mm
Nozzle Inside Projection	h	0.0000	mm
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



Hub Nozzle

NOZZLE CALCULATION, Description: N5

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation	146.360	mm.
Actual Nozzle Thickness Used in Calculation	10.970	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*1752.9999)/(137892*1.00-0.6*4500.00)
= 58.3503 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (4500.00*76.18)/(137892*1.00-0.6*4500.00)
= 2.5357 mm

Required Nozzle thickness under External Pressure per UG-28 : 0.4893 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):

Height value from sketch (e-1) [te]:
= (Hub Thickness - Neck Thickness) / cos(30)
= 41.030 / 0.5773
= 71.0661 mm

Note: Hub Height was < 2.5 times Hub Thickness, use sketch UG-40 (e-1).

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	304.7200	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	90.9911	mm

Note: Hub Height was < 2.5 times Hub Thickness, using sketch UG-40 (e-1).

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	8890.258	1577.519	NA	mm²
Area in Shell	A1	556.062	6291.282	NA	mm²
Area in Nozzle Wall	A2	988.941	1361.352	NA	mm²
Area in Inward Nozzle	A3	0.000	0.000	NA	mm²
Area in Welds	A4	400.000	400.000	NA	mm²
Area in Pad	A5	0.000	0.000	NA	mm²
Area in Hub + Bevel	A6	7439.497	7439.497	NA	mm²
TOTAL AREA AVAILABLE	Atot	9384.499	15492.131	NA	mm²

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
= (Dlr * tr + 2 * tn * tr * (1-fr1)) UG-37(c)
= (152.3600*58.3503+2*(52.0000-3.0000)*58.3503*(1-1.0000))
= 8890.258 mm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(Es*(t-cas)-tr)-2*(tn-can)*(Es*(t-cas)-tr)*(1-fr1)
= (304.720-152.360)*(1.00*(65.0000-3.000)-58.350)-2*(52.000-3.000)
(1.00(65.0000-3.0000)-58.3503)*(1-1.0000)
= 556.062 mm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (tn - can - trn) * fr2
= (2 * min(90.99 ,137.00)) * (10.97 - 3.00 - 2.54) * 1.0000)
= 988.941 mm²

Area Available in Welds, no Pad [A4np]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 20.0000² * 1.0000 + (0.0000)² * 1.0000
= 400.000 mm²

Area Available in the Hub Section [A6]:
= (2 * min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2
= (2 * min(91.0 ,137.0 ,87.0)) * (52.0 - 11.0) * 1.000)
= 7439.497 mm² Includes Bevel Area of 300.277 mm²

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

```
Wall Thickness per UG45(a),     tra = 5.5357 mm
Wall Thickness per UG16(b),   tr16b = 4.5875 mm
Wall Thickness per UG45(b)(1), trb1 = 61.3503 mm
Wall Thickness per UG45(b)(2), trb2 = 4.2718 mm
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 61.3503 mm
Std. Wall Pipe per UG45(b)(4), trb4 = 10.1564 mm
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 10.1564 mm

Final Required Thickness,      tr45 = Max(tra, trb) = 10.1564 mm
Available Nozzle Neck Thickness     = 10.9700 mm --> OK
```

Nozzle Junction MDMT Calculations:

Nozzle to Flange Weld skipped as Nozzle is Impact Tested Material.

Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: D

```
Shell is governing, tg = 52.000 , tr = 58.350 , c = 3.000 mm , E* = 1.00
Stress Ratio = tr * (E*) / (tg - c) = 1.191

Minimum Temp. w/o impact per UCS-66              -19  C
```

Governing MDMT of the all the sub-joints of this Junction : -19 C

Weld Size Calculations, Description: N5

```
Intermediate Calc. for nozzle/shell Welds   Tmin     19.0000  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	14.1400 = 0.7 * Wo mm

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

Weld Load [W]:
```
= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S
= (8890.2578 - 556.0616 + 2 * ( 52.0000 - 3.0000 ) * 1.0000 *
  (1.00 * ( 65.0000 - 3.0000 ) - 58.3503 ) ) * 137892
= 1198506.00 N
```

Weld Load [W1]:
```
= ((A2+A6)+A4-(Wi-Can/.707)²*Fr2)*S
= ( 8428.4375 + 400.0000 - 0.0000 * 1.00 ) * 137892
= 1217338.12 N
```

Weld Load [W2]:
```
= ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
= ( 8428.4375 + 0.0000 + 400.0000 + 6076.0000 ) * 137892
= 2055147.25 N
```

Weld Load [W3]:
```
= ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
= ( 8428.4375 + 0.0000 + 400.0000 + 0.0000 + 6076.0000 ) * 137892
= 2055147.25 N
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.1416 / 2.0 ) * 250.3600 * 20.0000 * 0.49 * 137892
= 531420. N
```

Shear, Nozzle Wall [Snw]:
```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.1416 * 100.6800 ) * ( 52.0000 - 3.0000 ) * 0.7 * 137892
= 1495941. N
```

Tension, Nozzle Groove Weld [Tngw]:
```
= (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
= ( 3.1416 / 2.0 ) * 250.3600 * ( 65.0000 - 3.0000 ) * 0.74 * 137892
= 2487916. N
```

Strength of Failure Paths:

```
PATH11 = ( SONW + SNW ) = ( 531420 + 1495941 ) = 2027361 N
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 531420 + 0 + 2487915 + 0 ) = 3019335 N
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 531420 + 2487915 + 0 ) = 3019335 N
```

Summary of Failure Path Calculations:
```
Path 1-1 = 2027361 N  , must exceed W = 1198506 N   or W1 = 1217338 N
Path 2-2 = 3019335 N  , must exceed W = 1198506 N   or W2 = 2055147 N
Path 3-3 = 3019335 N  , must exceed W = 1198506 N   or W3 = 2055147 N
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
Converged Max. Allow. Pressure in Operating case     4499.993  kPa
```

Note: The MAWP of this junction was limited by the shell.

```
Nozzle is O.K. for the External Pressure              100.000  kPa
```

The Drop for this Nozzle is : 4.4829 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 206.4828 mm

Input Echo, WRC107 Item 1, Description: N5 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	3500.000	mm
Vessel Thickness	Tv	65.000	mm
Design Temperature		120.00	C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137892.00	kPa
Vessel Hot S.I. Allowable	Smh	137892.00	kPa
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm
Nozzle Diameter	Dn	146.360	mm
Nozzle Thickness	Tn	52.000	mm
Nozzle Material		SA-350 LF2	
Nozzle Cold S.I. Allowable	SNmc	137892.00	kPa
Nozzle Hot S.I. Allowable	SNmh	137892.00	kPa
Design Internal Pressure	Dp	4500.000	kPa
Include Pressure Thrust		No	

External Forces and Moments in WRC 107 Convention:

Radial Load	(SUS)	P	12000.0	N
Longitudinal Shear	(SUS)	Vl	12000.0	N
Circumferential Shear	(SUS)	Vc	12000.0	N
Circumferential Moment	(SUS)	Mc	12000.0	N-m
Longitudinal Moment	(SUS)	Ml	12000.0	N-m
Torsional Moment	(SUS)	Mt	12000.0	N-m

Use Interactive Control		No	
WRC107 Version	Version	March 1979	
Include Pressure Stress Indices per Div. 2		No	
Compute Pressure Stress per WRC-368		No	

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	12000.0	N
Circumferential Shear	VC	12000.0	N
Longitudinal Shear	VL	12000.0	N
Circumferential Moment	MC	12000.0	N-m
Longitudinal Moment	ML	12000.0	N-m
Torsional Moment	MT	12000.0	N-m

Dimensionless Parameters used : Gamma = 28.77

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.061	4C	5.415	(A,B)
N(PHI) / (P/Rm)	0.061	3C	5.275	(C,D)
M(PHI) / (P)	0.061	2C1	0.147	(A,B)
M(PHI) / (P)	0.061	1C	0.185	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.061	3A	0.427	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.061	1A	0.103	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.061	3B	1.582	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.061	1B	0.057	(A,B,C,D)
N(x) / (P/Rm)	0.061	3C	5.275	(A,B)

N(x) / (P/Rm)	0.061	4C	5.415	(C,D)
M(x) / (P)	0.061	1C1	0.189	(A,B)
M(x) / (P)	0.061	2C	0.147	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.061	4A	0.538	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.061	2A	0.061	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.061	4B	0.422	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.061	2B	0.096	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of	Stress Values at (kPa)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-587	-587	-587	-587	-572	-572	-572	-572
Circ. Bend. P	-2758	2758	-2758	2758	-3456	3456	-3456	3456
Circ. Memb. MC	0	0	0	0	-422	-422	422	422
Circ. Bend. MC	0	0	0	0	-17660	17660	17660	-17660
Circ. Memb. ML	-1566	-1566	1566	1566	0	0	0	0
Circ. Bend. ML	-9727	9727	9727	-9727	0	0	0	0
Tot. Circ. Str.	-14639	10332	7948	-5991	-22112	20122	14054	-14353
Long. Memb. P	-572	-572	-572	-572	-587	-587	-587	-587
Long. Bend. P	-3533	3533	-3533	3533	-2749	2749	-2749	2749
Long. Memb. MC	0	0	0	0	-532	-532	532	532
Long. Bend. MC	0	0	0	0	-10506	10506	10506	-10506
Long. Memb. ML	-417	-417	417	417	0	0	0	0
Long. Bend. ML	-16344	16344	16344	-16344	0	0	0	0
Tot. Long. Str.	-20867	18888	12655	-12965	-14375	12135	7702	-7812
Shear VC	492	492	-492	-492	0	0	0	0
Shear VL	0	0	0	0	-492	-492	492	492
Shear MT	1965	1965	1965	1965	1965	1965	1965	1965
Tot. Shear	2457	2457	1472	1472	1472	1472	2457	2457
Str. Int.	21720	19543	13078	13263	22383	20385	14893	15173

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (kPa)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Circ. Pl (SUS)	-2153	-2153	978	978	-994	-994	-149	-149
Circ. Q (SUS)	-12485	12485	6969	-6969	-21117	21117	14203	-14203
Long. Pm (SUS)	62511	62511	62511	62511	62511	62511	62511	62511
Long. Pl (SUS)	-989	-989	-154	-154	-1119	-1119	-55	-55
Long. Q (SUS)	-19878	19878	12810	-12810	-13255	13255	7757	-7757
Shear Pm (SUS)	0	0	0	0	0	0	0	0

Shear Pl (SUS)	492	492	-492	-492	-492	-492	492	492
Shear Q (SUS)	1965	1965	1965	1965	1965	1965	1965	1965
Pm (SUS)	125023	129523	125023	129523	125023	129523	125023	129523
Pm+Pl (SUS)	122873	127373	126005	130505	124032	128531	124877	129377
Pm+Pl+Q (Total)	110471	139958	133009	123561	102950	149674	139164	115269

Type of Stress Int.	Max. S.I. kPa	S.I. Allowable kPa	Result
Pm (SUS)	129523	137892	Passed
Pm+Pl (SUS)	130505	206838	Passed
Pm+Pl+Q (TOTAL)	149674	413676	Passed

Nozzle Schedule:

Description	Nominal Size mm	Flange Sch/Type Cls		Noz. O/Dia mm	Wall Thk mm	Re-Pad ODia mm	Re-Pad Thick mm	Cut Length mm
K4	25	XXS	WNF	33.401	9.093	-	-	280
K5	25	XXS	WNF	33.401	9.093	-	-	280
K9	25	XXS	WNF	33.401	9.093	-	-	280
K8B	50	160	WNF	60.325	8.738	-	-	119
N12	50	160	N/A	60.325	8.738	-	-	119
K3A	50	160	WNF	60.325	8.738	-	-	222
K3B	50	160	WNF	60.325	8.738	-	-	437
K6A	50	160	WNF	60.325	8.738	-	-	222
K6B	50	160	WNF	60.325	8.738	-	-	437
K8A	50	160	WNF	60.325	8.738	-	-	255
K2A	50	160	WNF	60.325	8.738	-	-	255
K2B	50	160	WNF	60.325	8.738	-	-	119
K7A	50	160	WNF	60.325	8.738	-	-	265
K7B	50	160	WNF	60.325	8.738	-	-	396
K1A	50	160	WNF	60.325	8.738	-	-	265
K1B	50	160	WNF	60.325	8.738	-	-	396
N10	69	300	WNF	88.900	11.130	-	-	202
N13	69	300	WNF	88.900	11.130	-	-	222
N11	69	600	WNF	88.900	11.130	-	-	212
N7	69	300	WNF	88.900	11.130	-	-	222
N8	69	300	WNF	88.900	11.130	-	-	222
N9	69	300	WNF	88.900	11.130	-	-	222
N6	94	300	WNF	114.300	11.130	-	-	198
N4	150	300	WNF	168.300	10.970	-	-	206
N3	150	300	WNF	168.300	10.970	-	-	206
N5	150	300	WNF	168.300	10.970	-	-	206
N2	436	300	WNF	457.000	14.270	-	-	270
N1	483	600	WNF	508.000	15.090	-	-	296
M2	485	300	WNF	508.000	15.090	-	-	320
M1	590	300	WNF	610.000	14.270	-	-	330

Note on the Cut Length Calculation:
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.

Please Note: 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

Nozzle Material and Weld Fillet Leg Size Details:

Nozzle	Material	Shl Grve Weld mm	Noz Shl/Pad Weld mm	Pad OD Weld mm	Pad Grve Weld mm	Inside Weld mm
K4	SA-106 B	6.350	8.000	-	-	-
K5	SA-106 B	6.350	8.000	-	-	-
K9	SA-106 B	6.350	8.000	-	-	-
K8B	SA-106 B	6.350	9.000	-	-	-
N12	SA-106 B	6.350	9.000	-	-	-
K3A	SA-106 B	6.350	9.000	-	-	-
K3B	SA-350 LF2	65.000	9.000	-	-	-
K6A	SA-106 B	6.350	9.000	-	-	-
K6B	SA-350 LF2	65.000	9.000	-	-	-
K8A	SA-106 B	6.350	9.000	-	-	-
K2A	SA-106 B	6.350	9.000	-	-	-

K2B	SA-106 B	6.350	9.000	-	-	-
K7A	SA-106 B	6.350	9.000	-	-	-
K7B	SA-350 LF2	65.000	9.000	-	-	-
K1A	SA-106 B	6.350	9.000	-	-	-
K1B	SA-350 LF2	65.000	9.000	-	-	-
N10	SA-350 LF2	61.500	16.000	-	-	-
N13	SA-350 LF2	65.000	16.000	-	-	-
N11	SA-350 LF2	65.000	16.000	-	-	-
N7	SA-350 LF2	65.000	16.000	-	-	-
N8	SA-350 LF2	65.000	16.000	-	-	-
N9	SA-350 LF2	65.000	16.000	-	-	-
N6	SA-350 LF2	65.000	20.000	-	-	-
N4	SA-350 LF2	65.000	20.000	-	-	-
N3	SA-350 LF2	65.000	20.000	-	-	-
N5	SA-350 LF2	65.000	20.000	-	-	-
N2	SA-350 LF2	65.000	30.000	-	-	-
N1	SA-350 LF2	65.000	30.000	-	-	30.000
M2	SA-350 LF2	65.000	30.000	-	-	-
M1	SA-350 LF2	65.000	30.000	-	-	-

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

Nozzle Miscellaneous Data:

Nozzle	Elevation/Distance From Datum mm	Layout Angle deg.	Projection Outside mm	Projection Inside mm	Installed In Component
K4	6500.000	0.00	215.00	0.00	Node: 20
K5	7000.000	0.00	215.00	0.00	Node: 20
K9	7500.000	0.00	215.00	0.00	Node: 20
K8B	10500.001	180.00	54.65	0.00	Node: 20
N12	4500.000	0.00	54.65	0.00	Node: 20
K3A	9500.001	252.76	144.22	0.00	Node: 20
K3B	9500.001	211.11	243.00	0.00	Node: 20
K6A	10000.001	252.76	144.22	0.00	Node: 20
K6B	10000.001	211.11	243.00	0.00	Node: 20
K8A	10500.001	305.58	151.48	0.00	Node: 20
K2A	11000.000	305.58	151.48	0.00	Node: 20
K2B	11000.000	180.00	54.65	0.00	Node: 20
K7A	13354.801	290.98	183.03	0.00	Node: 20
K7B	13354.801	212.29	211.00	0.00	Node: 20
K1A	13854.800	290.98	183.03	0.00	Node: 20
K1B	13854.800	212.29	211.00	0.00	Node: 20
N10		180.00	119.00	0.00	Node: 10
N13	3500.000	0.00	156.00	0.00	Node: 20
N11	4000.000	0.00	146.00	0.00	Node: 20
N7	1500.000	180.00	156.00	0.00	Node: 20
N8	8000.000	180.00	156.00	0.00	Node: 20
N9	13135.000	180.00	156.00	0.00	Node: 20
N6	5000.000	0.00	131.30	0.00	Node: 20
N4	11500.000	180.00	137.00	0.00	Node: 20
N3	13500.001	180.00	137.00	0.00	Node: 20
N5	5500.000	0.00	137.00	0.00	Node: 20
N2	14000.001	0.00	176.00	0.00	Node: 20
N1	2000.000	0.00	137.00	95.00	Node: 20
M2	4000.000	270.00	223.00	0.00	Node: 20
M1	11450.001	0.00	216.70	0.00	Node: 20

Nozzle Calculation Summary

Description	MAWP kPa	Ext	MAPNC kPa	UG45 [tr]	Weld Path	Areas
N10	4500.00	OK	...	OK 7.80	OK	Passed
N10	4500.00	OK	...	OK 7.80	OK	Passed
N1	4499.99	OK	...	OK 11.33	OK	Passed
N13	4499.99	OK	...	OK 7.80	OK	Passed
N4	4534.30	OK	...	OK 10.16	OK	Passed
M2	4517.15	OK	...	...	OK	Passed
M1	4499.99	OK	...	...	OK	Passed
K4	4500.00	...	...	OK 5.96	OK	NoCalc[*]
K8B	4500.00	...	...	OK 6.42	OK	NoCalc[*]
N2	4499.99	OK	...	OK 11.33	OK	Passed
N6	4499.99	OK	...	OK 8.27	OK	Passed
N11	4499.99	OK	...	OK 7.80	OK	Passed
N12	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K5	4500.00	...	...	OK 5.96	OK	NoCalc[*]
N7	4534.30	OK	...	OK 7.80	OK	Passed
N8	4534.30	OK	...	OK 7.80	OK	Passed
N9	4534.30	OK	...	OK 7.80	OK	Passed
N3	4534.30	OK	...	OK 10.16	OK	Passed
K3A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K3A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K3B	4531.83	OK	...	OK 6.42	OK	Passed
K3B	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K6A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K6A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K6B	4531.83	OK	...	OK 6.42	OK	Passed
K6B	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K8A	4507.17	OK	...	OK 6.42	OK	Passed
K8A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K2A	4507.17	OK	...	OK 6.42	OK	Passed
K2A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K2B	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K7A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K7A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K7B	4531.65	OK	...	OK 6.42	OK	Passed
K7B	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K1A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K1A	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K1B	4531.65	OK	...	OK 6.42	OK	Passed
K1B	4500.00	...	...	OK 6.42	OK	NoCalc[*]
K9	4500.00	...	...	OK 5.96	OK	NoCalc[*]
N5	4499.99	OK	...	OK 10.16	OK	Passed
Min. - Nozzles	4499.99 N5					

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

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

Check the Spatial Relationship between the Nozzles

From Node	Nozzle Description	X Coordinate,	Layout Angle,	Dia. Limit
10	N10	0.000	180.000	243.640
20	N1	2000.000	0.000	967.640
20	N13	3500.000	0.000	250.640
20	N4	11500.000	180.000	304.720

20	M2	4000.000	270.000	967.640
20	M1	11450.001	0.000	1174.920
20	K4	6500.000	0.000	157.401
20	K8B	10500.001	180.000	184.325
20	N2	14000.001	0.000	868.920
20	N6	5000.000	0.000	286.040
20	N11	4000.000	0.000	250.640
20	N12	4500.000	0.000	184.325
20	K5	7000.000	0.000	157.401
20	N7	1500.000	180.000	250.640
20	N8	8000.000	180.000	250.640
20	N9	13135.000	180.000	250.640
20	N3	13500.001	180.000	304.720
20	K3A	9500.000	252.757	184.325
20	K3B	9500.000	211.108	184.325
20	K6A	10000.001	252.757	184.325
20	K6B	10000.001	211.108	184.325
20	K8A	10500.001	305.579	184.325
20	K2A	11000.001	305.579	184.325
20	K2B	11000.001	180.000	184.325
20	K7A	13354.800	290.985	184.325
20	K7B	13354.800	212.285	184.325
20	K1A	13854.801	290.985	184.325
20	K1B	13854.801	212.285	184.325
20	K9	7500.000	0.000	157.401
20	N5	5500.000	0.000	304.720

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 !

Design Code: ASME Code Section VIII Division 1, 2007 A-08

Diameter Spec : 3500.000 mm ID		
Vessel Design Length, Tangent to Tangent	15000.00	mm
Specified Datum Line Distance	0.00	mm
Shell/Head Matl	SA-516 70 [Normalized]	
Nozzle Material	SA-350 LF2	
Nozzle Material	SA-106 B	
Internal Design Temperature	120	C
Internal Design Pressure	4500.00	kPa
External Design Temperature	120	C
External Design Pressure	100.00	kPa
Maximum Allowable Working Pressure	4500.00	kPa
External Max. Allowable Working Pressure	1560.30	kPa
Hydrostatic Test Pressure	5850.00	kPa
Required Minimum Design Metal Temperature	5	C
Warmest Computed Minimum Design Metal Temperature	-16	C
Wind Design Code	ASCE-98\02\05\IBC-03\06\STS-1	
Earthquake Design Code	No Seismic	

Element Pressures and MAWP: kPa

Element Desc	Internal	External	M.A.W.P	Corr. All.
Ellipse	4534.336	100.000	4562.430	3.0000
Cylinder	4534.336	100.000	4741.277	3.0000
Ellipse	4534.336	100.000	4562.430	3.0000

Liquid Level: 3500.00 mm Dens.: 999.542 kg/m³ Sp. Gr.: 1.000

Element Type	"To" Elev mm	Length mm	Element Thk mm	R e q d Thk Int.	Thk Ext.	Joint Eff Long	Circ
Ellipse	50.0	50.0	75.0	60.7	12.2	1.00	1.00
Cylinder	14950.0	14900.0	65.0	61.8	23.7	1.00	1.00
Ellipse	15000.0	50.0	75.0	60.7	12.2	1.00	1.00

Element thicknesses are shown as Nominal if specified, otherwise are Minimum

Saddle Parameters:

Saddle Width	300.000	mm
Saddle Bearing Angle	120.000	deg.
Centerline Dimension	2050.000	mm
Wear Pad Width	400.000	mm
Wear Pad Thickness	25.000	mm
Wear Pad Bearing Angle	132.000	deg.
Distance from Saddle to Tangent	600.000	mm
Baseplate Length	2300.000	mm
Baseplate Thickness	40.000	mm
Baseplate Width	300.000	mm
Number of Ribs (including outside ribs)	6	
Rib Thickness	25.000	mm
Web Thickness	30.000	mm
Height of Center Web	260.000	mm

Summary of Maximum Saddle Loads, Operating Case :

Maximum Vertical Saddle Load	2030976.88	N

Maximum Transverse Saddle Shear Load	248098.80	N
Maximum Longitudinal Saddle Shear Load	613560.69	N

Summary of Maximum Saddle Loads, Hydrotest Case :

Maximum Vertical Saddle Load	1585695.25	N
Maximum Transverse Saddle Shear Load	7397.82	N
Maximum Longitudinal Saddle Shear Load	5260.10	N

Weights:

Fabricated - Bare W/O Removable Internals	129579.3	kgm
Shop Test - Fabricated + Water (Full)	285053.8	kgm
Shipping - Fab. + Rem. Intls.+ Shipping App.	129579.3	kgm
Erected - Fab. + Rem. Intls.+ Insul. (etc)	129579.3	kgm
Empty - Fab. + Intls. + Details + Wghts.	129579.3	kgm
Operating - Empty + Operating Liquid (No CA)	285053.8	kgm
Field Test - Empty Weight + Water (Full)	285053.8	kgm