	DEHDASHT PETROCHEMICAL INDUSTRY COMPANY DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT	
PPI NARGAN	DOCUMENT TITLE: Mechanical Calculation for Liquid Receiver	POI: IFA
Contract No.: DPIC/98-12	DOCUMENT No:DPIC9812-000-VD-1002-ME-CLN-0094	Rev. No.: D1

Mechanical Calculation for Liquid Receiver

(D-PK6101-2)

PURCHASER'S COMMENT/APPROVAL STATUS		Purchaser: NARGAN
1	AP: Approved (Released for Manufacturing)	Requisition No.: DPIC98-12-001-000-ME-MR-4150-0001-D1
2	AN: Approved With Minor Comments (Fabrication may Proceed)	
3	NF: Approved With Comments (Fabrication not Proceed)	Item No. (Tag No.):(D-PK6101-2)
4	RJ: Rejected	
5	NR: Not be Returned	Vendor Doc. No.:DPIC9812-000-VD-1002-ME-CLN-0094
Date:	Signature:	

REV	DATE ISSUE	PREPARED	CHECKED	APPROVED
D1	18.Feb.2022	A.VOSOUGH	DR.A.NEJATI	DR.A.NEJATI
D0	23.Dec.21	A.VOSOUGH	DR.A.NEJATI	DR.A.NEJATI

KASRAVAND
Engineering & Construction

	DEHDASHT PETROCHEMICAL INDUSTRY COMPANY DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT	
PPI / NARGAN	DOCUMENT TITLE: Mechanical Calculation for Liquid Receiver	POI: IFA
Contract No.: DPIC/98-12	DOCUMENT No: DPIC9812-000-VD-1002-ME-CLN-0094	Rev. No.: D1

Page	Rev-D0	Rev-D1	Rev-D2	Rev-D3	Rev-D4
1	x	x			
2	x	x			
3	x	x			
4	x	x			
5	x	x			
6	x	x			
7	x	x			
8	x	x			
9	x	x			
10	x	x			
11	x	x			
12	x	x			
13	x	x			
14	x	x			
15	x	x			
16	x	x			
17	x	x			
18	x	x			
19	x	x			
20	x	x			
21	x	x			
22	x	x			
23	x	x			
24	x	x			
25	x	x			
26	x	x			
27	x	x			
28	x	x			
29	x	x			
30	x	x			
31	x	x			
32	x	x			
33	x	x			
34	x	x			
35	x	x			

Page	Rev-D0	Rev-D1	Rev-D2	Rev-D3	Rev-D4
36	x	x			
37	x	x			
38	x	x			
39	x	x			
40	x	x			
41	x	x			
42	x	x			
43	x	x			
44	x	x			
45	x	x			
46	x	x			
47	x	x			
48	x	x			
49	x	x			
50	x	x			
51	x	x			
52	x	x			
53	x	x			
54	x	x			
55	x	x			
56	x	x			
57	x	x			
58	x	x			
59	x	x			
60	x	x			
61	x	x			
62	x	x			
63	x	x			
64	x	x			
65	x	x			
66	x	x			
67	x	x			
68	x	x			
69	x	x			
70	x	x			

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY

DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT

NARGAN

	DOCUMENT TITLE: Mechanical Calculation for Liquid Receiver	POI: IFA
Contract No.: DPIC/98-12	DOCUMENT No: DPIC9812-000-VD-1002-ME-CLN-0094	Rev. No.: D1

Page	Rev-D0	Rev-D1	Rev-D2	Rev-D3	Rev-D4
71	x	x			
72	x	x			
73	x	x			
74	x	x			
75	x	x			
76	x	x			
77	x	x			
78	x	x			
79	x	x			
80	x	x			
81	x	x			
82	x	x			
83	x	x			
84	x	x			
85	x	x			
86	x	x			
87	x	x			
88	x	x			
89	x	x			
90	x	x			
91	x	x			
92	x	x			
93	x	x			
94	x	x			
95	x	x			
96	x	x			
97	x	x			
98	x	x			
99	x	x			
100	x	x			
101	x	x			
102	x	x			
103	x	x			
104	x	x			
105	x	x			

Page	Rev-D0	Rev-D1	Rev-D2	Rev-D3	Rev-D4
106	x	x			
107	x	x			
108	x	x			
109	x	x			
110	x	x			
111	x	x			
112	x	x			
113	x	x			
114	x	x			
115	x	x			
116	x	x			
117	x	x			
118	x	x			
119	x	x			
120	x	x			
121	x	x			
122	x	x			
123	x	x			
124	x	x			
125	x	x			
126	x	x			
127	x	x			
128	x	x			
129	x	x			
130	x	x			
131	x	x			
132	x	x			
133	x	x			
134	x	x			
135	x	x			
136	x	x			
137	x	x			
138	x	x			
139	x	x			
140	x	x			

	DEHDASHT PETROCHEMICAL INDUSTRY COMPANY **DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT**	
NARGAN	**DOCUMENT TITLE: Mechanical Calculation for Liquid Receiver**	**POI: IFA**
Contract No.: DPIC/98-12	**DOCUMENT No: DPIC9812-000-VD-1002-ME-CLN-0094**	**Rev. No.: D1**

Page	Rev-D0	Rev-D1	Rev-D2	Rev-D3	Rev-D4
141	x	x			
142	x	x			
143	x	x			
144	x	x			
145	x	x			
146	x	x			
147	x	x			
148	x	x			
149	x	x			
150	x	x			
151	x	x			
152	x	x			
153	x	x			
154	x	x			
155	x	x			
156	x	x			
157					
158					
159					
160					
161					
162					
163					
164					
165					
166					
167					
168					
169					
170					
171					
172					
173					
174					
175					

Page	Rev-D0	Rev-D1	Rev-D2	Rev-D3	Rev-D4
176					
177					
178					
179					
180					
181					
182					
183					
184					
185					
186					
187					
188					
189					
190					
191					
192					
193					
194					
195					
196					
197					
198					
199					
200					
201					
202					
203					
204					
205					
206					
207					
208					
209					
210					

Table of Contents

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2017

Analysis Performed by : SPLM Licensed User

Job File :

Date of Analysis : Feb 18,2022 9:17pm

PV Elite 2018 SP2, June 2018

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

Warnings and Errors: Step: 0 9:17pm Feb 18,2022

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

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)

Design Internal Pressure (for Hydrotest)	23	bar
Design Internal Temperature	135.0	°C
Type of Hydrotest	UG-99(b) Note [36]	
Hydrotest Position	Horizontal	
Projection of Nozzle from Vessel Top	0	mm.
Projection of Nozzle from Vessel Bottom	0	mm.
Minimum Design Metal Temperature	-45.0	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-1	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	
Perform a Corroded Hydrotest	Y	
Is this a Heat Exchanger	No	
User Defined Hydro. Press. (Used if > 0)	0	bar
User defined MAWP	0	bar
User defined MAPnc	0	bar

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

Wind Design Code		ASCE-7 2010	
Wind Load Reduction Scale Factor		0.600	
Basic Wind Speed	[V]	200	Km/hr
Surface Roughness Category		C: Open Terrain	
Importance Factor		1.0	
Type of Surface		Moderately Smooth	
Base Elevation		300	mm.
Percent Wind for Hydrotest		33.0	
Using User defined Wind Press. Vs Elev.		N	
Height of Hill or Escarpment	H or Hh	0	mm.
Distance Upwind of Crest	Lh	0	mm.
Distance from Crest to the Vessel	x	0	mm.
Type of Terrain (Hill, Escarpment)		Flat	
Damping Factor (Beta) for Wind (Ope)		0.0100	

```
Damping Factor (Beta) for Wind (Empty)                   0.0000
Damping Factor (Beta) for Wind (Filled)                  0.0000

Seismic Design Code                                 ASCE 7-2010
Seismic Load Reduction Scale Factor                       0.700
Importance Factor                                         1.500
Table Value Fa                                            1.000
Table Value Fv                                            1.300
Short Period Acceleration value Ss                        0.900
Long Period Acceleration Value Sl                         0.537
Moment Reduction Factor Tau                               1.000
Force Modification Factor R                               2.500
Site Class                                                    C
Component Elevation Ratio           z/h                   1.000
Amplification Factor                 Ap                   2.500
Force Factor                                              0.000
Consider Vertical Acceleration                              Yes
Minimum Acceleration Multiplier                           0.000
User Value of Sds (used if > 0 )                          0.624

Design Pressure + Static Head                                 Y
Consider MAP New and Cold in Noz. Design                      N
Consider External Loads for Nozzle Des.                       Y
Use ASME VIII-1 Appendix 1-9                                  N

Material Database Year        Current w/Addenda or Code Year
```

Configuration Directives:

```
Do not use Nozzle MDMT Interpretation VIII-1 01-37          No
Use Table G instead of exact equation for "A"              Yes
Shell Head Joints are Tapered                              Yes
Compute "K" in corroded condition                          Yes
Use Code Case 2286                                          No
Use the MAWP to compute the MDMT                           Yes
For thickness ratios <= 0.35, MDMT will be -155F (-104C)   Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)       No

Using Metric Material Databases, ASME II D                  No
Calculate B31.3 type stress for Nozzles with Loads         Yes
Reduce the MDMT due to lower membrane stress               Yes
```

Complete Listing of Vessel Elements and Details:

```
Element From Node                                           10
Element To Node                                             20
Element Type                                       Elliptical
Description                                          head 001
Distance "FROM" to "TO"                                     50  mm.
Element Outside Diameter                                   914  mm.
Element Thickness                                           12  mm.
Internal Corrosion Allowance                                 3  mm.
Nominal Thickness                                           15  mm.
External Corrosion Allowance                                 0  mm.
Design Internal Pressure                                    23  bar
Design Temperature Internal Pressure                       135  °C
Design External Pressure                                   1.1  bar
Design Temperature External Pressure                       100  °C
Effective Diameter Multiplier                              1.2
Material Name                                       SA-516 70 [Normalized]
    Allowable Stress, Ambient                            137.9  N./mm^2
    Allowable Stress, Operating                          137.9  N./mm^2
    Allowable Stress, Hydrotest                         235.81  N./mm^2
```

```
        Material Density                               0.00775  kg./cm^3
        P Number Thickness                              30.988  mm.
        Yield Stress, Operating                         233.74  N./mm^2
        UCS-66 Chart Curve Designation                       D
        External Pressure Chart Name                      CS-2
        UNS Number                                      K02700
        Product Form                                     Plate
    Efficiency, Longitudinal Seam                          1.0
    Efficiency, Circumferential Seam                       1.0
    Elliptical Head Factor                                 2.0
    Weld is pre-Heated                                      No

        Element From Node                                   10
        Detail Type                                     Liquid
        Detail ID                                   Liquid: 10
        Dist. from "FROM" Node / Offset dist                 0  mm.
        Height/Length of Liquid                            890  mm.
        Liquid Density                                  460.79  kg/m³

        Element From Node                                   10
        Detail Type                                 Insulation
        Detail ID                                      Ins: 20
        Dist. from "FROM" Node / Offset dist            -228.5  mm.
        Height/Length of Insulation                      278.5  mm.
        Thickness of Insulation                            100  mm.
        Density                                        0.00023  kg./cm^3

        Element From Node                                   10
        Detail Type                                     Nozzle
        Detail ID                                            M
        Dist. from "FROM" Node / Offset dist                 0  mm.
        Nozzle Diameter                                     20  in.
        Nozzle Schedule                                   None
        Nozzle Class                                       300
        Layout Angle                                       0.0
        Blind Flange (Y/N)                                   Y
        Weight of Nozzle ( Used if > 0 )                4.6436  kN
        Grade of Attached Flange                        GR 1.1
        Nozzle Matl                                SA-516 70 [Normalized]

    --------------------------------------------------------------------

    Element From Node                                       20
    Element To Node                                         30
    Element Type                                      Cylinder
    Description                                      shell 001
    Distance "FROM" to "TO"                               3900  mm.
    Element Outside Diameter                               914  mm.
    Element Thickness                                       12  mm.
    Internal Corrosion Allowance                             3  mm.
    Nominal Thickness                                       12  mm.
    External Corrosion Allowance                             0  mm.
    Design Internal Pressure                                23  bar
    Design Temperature Internal Pressure                   135  °C
    Design External Pressure                               1.1  bar
    Design Temperature External Pressure                   100  °C
    Effective Diameter Multiplier                          1.2
    Material Name                                  SA-516 70 [Normalized]
    Efficiency, Longitudinal Seam                          1.0
    Efficiency, Circumferential Seam                       1.0
    Weld is pre-Heated                                      No

        Element From Node                                   20
```

Detail Type	Saddle	
Detail ID	Fixed Saddle	
Dist. from "FROM" Node / Offset dist	630	mm.
Width of Saddle	172	mm.
Height of Saddle at Bottom	840	mm.
Saddle Contact Angle	120.0	
Height of Composite Ring Stiffener	0	mm.
Width of Wear Plate	200	mm.
Thickness of Wear Plate	10	mm.
Contact Angle, Wear Plate (degrees)	140.0	

Element From Node	20	
Detail Type	Saddle	
Detail ID	Sliding Saddle	
Dist. from "FROM" Node / Offset dist	3270	mm.
Width of Saddle	172	mm.
Height of Saddle at Bottom	840	mm.
Saddle Contact Angle	120.0	
Height of Composite Ring Stiffener	0	mm.
Width of Wear Plate	200	mm.
Thickness of Wear Plate	10	mm.
Contact Angle, Wear Plate (degrees)	140.0	

Element From Node	20	
Detail Type	Liquid	
Detail ID	Liquid: 20	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Liquid	890	mm.
Liquid Density	460.79	kg/m^3

Element From Node	20	
Detail Type	Insulation	
Detail ID	Ins: 20	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Insulation	3900	mm.
Thickness of Insulation	100	mm.
Density	0.00023	kg./cm^3

Element From Node	20	
Detail Type	Nozzle	
Detail ID	A1	
Dist. from "FROM" Node / Offset dist	450	mm.
Nozzle Diameter	8	in.
Nozzle Schedule	80	
Nozzle Class	300	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	1.1507	kN
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6	[Impact Tested]

Element From Node	20	
Detail Type	Nozzle	
Detail ID	B	
Dist. from "FROM" Node / Offset dist	1950	mm.
Nozzle Diameter	8	in.
Nozzle Schedule	80	
Nozzle Class	300	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.7092	kN
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6	[Impact Tested]

```
Element From Node                                  20
Detail Type                                    Nozzle
Detail ID                                          A2
Dist. from "FROM" Node / Offset dist             3250  mm.
Nozzle Diameter                                     2  in.
Nozzle Schedule                                   160
Nozzle Class                                      300
Layout Angle                                      0.0
Blind Flange (Y/N)                                  N
Weight of Nozzle ( Used if > 0 )              0.09943  kN
Grade of Attached Flange                       GR 1.1
Nozzle Matl                                  SA-333 6 [Impact Tested]

Element From Node                                  20
Detail Type                                    Nozzle
Detail ID                                          PT
Dist. from "FROM" Node / Offset dist             1700  mm.
Nozzle Diameter                                   1.5  in.
Nozzle Schedule                                   XXS
Nozzle Class                                      300
Layout Angle                                      0.0
Blind Flange (Y/N)                                  N
Weight of Nozzle ( Used if > 0 )              0.07753  kN
Grade of Attached Flange                       GR 1.1
Nozzle Matl                                  SA-333 6 [Impact Tested]

Element From Node                                  20
Detail Type                                    Nozzle
Detail ID                                          A3
Dist. from "FROM" Node / Offset dist             1150  mm.
Nozzle Diameter                                     2  in.
Nozzle Schedule                                   160
Nozzle Class                                      300
Layout Angle                                      0.0
Blind Flange (Y/N)                                  N
Weight of Nozzle ( Used if > 0 )                 0.12  kN
Grade of Attached Flange                       GR 1.1
Nozzle Matl                                  SA-333 6 [Impact Tested]

Element From Node                                  20
Detail Type                                    Nozzle
Detail ID                                         LT1
Dist. from "FROM" Node / Offset dist             3650  mm.
Nozzle Diameter                                     2  in.
Nozzle Schedule                                   160
Nozzle Class                                      300
Layout Angle                                    180.0
Blind Flange (Y/N)                                  N
Weight of Nozzle ( Used if > 0 )               0.1585  kN
Grade of Attached Flange                       GR 1.1
Nozzle Matl                                  SA-333 6 [Impact Tested]

Element From Node                                  20
Detail Type                                    Nozzle
Detail ID                                         LT2
Dist. from "FROM" Node / Offset dist             3600  mm.
Nozzle Diameter                                     2  in.
Nozzle Schedule                                   160
Nozzle Class                                      300
Layout Angle                                      0.0
Blind Flange (Y/N)                                  N
Weight of Nozzle ( Used if > 0 )               0.1585  kN
```

```
    Grade of Attached Flange                         GR 1.1
    Nozzle Matl                                  SA-333 6 [Impact Tested]

    Element From Node                                    20
    Detail Type                                      Nozzle
    Detail ID                                             D
    Dist. from "FROM" Node / Offset dist                250  mm.
    Nozzle Diameter                                       2  in.
    Nozzle Schedule                                     160
    Nozzle Class                                        300
    Layout Angle                                      180.0
    Blind Flange (Y/N)                                    N
    Weight of Nozzle ( Used if > 0 )                 0.1488  kN
    Grade of Attached Flange                         GR 1.1
    Nozzle Matl                                  SA-333 6 [Impact Tested]

    Element From Node                                    20
    Detail Type                                      Nozzle
    Detail ID                                            SV
    Dist. from "FROM" Node / Offset dist               2250  mm.
    Nozzle Diameter                                       4  in.
    Nozzle Schedule                                     120
    Nozzle Class                                        300
    Layout Angle                                        0.0
    Blind Flange (Y/N)                                    N
    Weight of Nozzle ( Used if > 0 )                  0.413  kN
    Grade of Attached Flange                         GR 1.1
    Nozzle Matl                                  SA-333 6 [Impact Tested]

--------------------------------------------------------------------

Element From Node                                        30
Element To Node                                          40
Element Type                                     Elliptical
Description                                        head 002
Distance "FROM" to "TO"                                  50  mm.
Element Outside Diameter                                914  mm.
Element Thickness                                        12  mm.
Internal Corrosion Allowance                              3  mm.
Nominal Thickness                                        15  mm.
External Corrosion Allowance                              0  mm.
Design Internal Pressure                                 23  bar
Design Temperature Internal Pressure                    135  °C
Design External Pressure                                1.1  bar
Design Temperature External Pressure                    100  °C
Effective Diameter Multiplier                           1.2
Material Name                                   SA-516 70 [Normalized]
Efficiency, Longitudinal Seam                           1.0
Efficiency, Circumferential Seam                        1.0
Elliptical Head Factor                                  2.0
Weld is pre-Heated                                       No

    Element From Node                                    30
    Detail Type                                      Liquid
    Detail ID                                    Liquid: 30
    Dist. from "FROM" Node / Offset dist                  0  mm.
    Height/Length of Liquid                             890  mm.
    Liquid Density                                   460.79  kg/m³

    Element From Node                                    30
    Detail Type                                  Insulation
    Detail ID                                       Ins: 20
    Dist. from "FROM" Node / Offset dist                  0  mm.
```

Height/Length of Insulation	278.5	mm.
Thickness of Insulation	100	mm.
Density	0.00023	kg./cm^3
Element From Node	30	
Detail Type	Nozzle	
Detail ID	TI	
Dist. from "FROM" Node / Offset dist	300	mm.
Nozzle Diameter	1.5	in.
Nozzle Schedule	XXS	
Nozzle Class	300	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.0557	kN
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6	[Impact Tested]

XY Coordinate Calculations:

From	To	X (Horiz.) mm.	Y (Vert.) mm.	DX (Horiz.) mm.	DY (Vert.) mm.
head	001	50	...	50	...
shell	001	3950	...	3900	...
head	002	4000	...	50	...

```
DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for  LIQID RECEIVER D-PK6101-2
Internal Pressure Calculations:        Step:    3   9:17pm  Feb 18,2022
```

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd bar	Nominal Thickness mm.	Total Corr Allowance mm.	Element Diameter mm.	Allowable Stress(SE) N./mm^2
head	001	23.04	15	3	914	137.9
shell	001	23.04	12	3	914	137.9
head	002	23.04	15	3	914	137.9

Element Required Thickness and MAWP :

From	To	Design Pressure bar	M.A.W.P. Corroded bar	M.A.P. New & Cold bar	Minimum Thickness mm.	Required Thickness mm.
head	001	23	27.8493	37.0811	12	10.4581
shell	001	23	27.3289	36.5891	12	10.586
head	002	23	27.8493	37.0811	12	10.4581
Minimum			27.329	36.589		

MAWP: 23.089 bar, limited by: Nozzle Reinforcement.

Internal Pressure Calculation Results :

ASME Code, Section VIII Division 1, 2017

Elliptical Head From 10 To 20 SA-516 70 , UCS-66 Crv. D at 135 °C

head 001

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

```
  = (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
  = (23.04*914*0.991)/(2*137.9*1+2*23.04*(0.991-0.1))
  = 7.4581 + 3.0000 = 10.4581 mm.
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.040 bar

```
  = (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
  = (2*137.9*1*9)/(0.991*914-2*9*(0.991-0.1))
  = 27.890 - 0.040 = 27.849  bar
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
  = (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
  = (2*137.9*1*12)/(1*914-2*12*(1-0.1))
  = 37.081 bar
```

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

```
  = (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
  = (23.04*(0.991*914-2*9*(0.991-0.1)))/(2*1*9)
  = 113.923 N./mm^2
```

Straight Flange Required Thickness:

```
  = (P*Ro)/(S*E+0.4*P) + ca   per Appendix 1-1 (a)(1)
  = (23.04*457)/(137.9*1+0.4*23.04)+3
  = 10.586 mm.
```

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 0.040 bar

```
  = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
  = (137.9 * 1 * 12 )/(457 - 0.4 * 12 )
  = 36.589 - 0.040 = 36.549  bar
```

Factor K, corroded condition [Kcor]:

```
  = ( 2 + ( Inside Diameter/( 2 * Inside Head Depth ))²)/6
  = ( 2 + ( 896/( 2 * 225.5 ))²)/6
  = 0.991160
```

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 7.130 %
Note: Please Check Requirements of UCS-79 as Elongation is > 5%.

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 12, tr = 7.486, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.832, Temp. Reduction = 9 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D            -48 °C
```

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 15, tr = 7.615, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.635, Temp. Reduction = 20 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D            -47 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -48 °C
```

Cylindrical Shell From 20 To 30 SA-516 70 , UCS-66 Crv. D at 135 °C

shell 001

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

```
  = (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
  = (23.04*457)/(137.9*1+0.4*23.04)
  = 7.5860 + 3.0000 = 10.5860 mm.
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.040 bar

```
  = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
  = (137.9*1*9)/(457-0.4*9)
  = 27.369 - 0.040 = 27.329  bar
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
  = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
  = (137.9*1*12)/(457-0.4*12)
  = 36.589 bar
```

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

```
  = (P*(Ro-0.4*t))/(E*t)
  = (23.04*((457-0.4*9))/(1*9)
  = 116.089 N./mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 1.330 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 12, tr = 7.615, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.846, Temp. Reduction = 9 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D            -48 °C
```

Elliptical Head From 30 To 40 SA-516 70 , UCS-66 Crv. D at 135 °C

head 002

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:
```
  = (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
  = (23.04*914*0.991)/(2*137.9*1+2*23.04*(0.991-0.1))
  = 7.4581 + 3.0000 = 10.4581 mm.
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.040 bar
```
  = (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
  = (2*137.9*1*9)/(0.991*914-2*9*(0.991-0.1))
  = 27.890 - 0.040 = 27.849  bar
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
  = (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
  = (2*137.9*1*12)/(1*914-2*12*(1-0.1))
  = 37.081 bar
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
  = (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
  = (23.04*(0.991*914-2*9*(0.991-0.1)))/(2*1*9)
  = 113.923 N./mm^2
```

Straight Flange Required Thickness:
```
  = (P*Ro)/(S*E+0.4*P) + ca   per Appendix 1-1 (a)(1)
  = (23.04*457)/(137.9*1+0.4*23.04)+3
  = 10.586 mm.
```

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 0.040 bar
```
  = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
  = (137.9 * 1 * 12 )/(457 - 0.4 * 12 )
  = 36.589 - 0.040 = 36.549  bar
```

Factor K, corroded condition [Kcor]:
```
  = ( 2 + ( Inside Diameter/( 2 * Inside Head Depth ))²)/6
  = ( 2 + ( 896/( 2 * 225.5 ))²)/6
  = 0.991160
```

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 7.130 %
Note: Please Check Requirements of UCS-79 as Elongation is > 5%.

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 12, tr = 7.486, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.832, Temp. Reduction = 9 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D            -48 °C
```

MDMT Calculations in the Head Straight Flange:

Internal Pressure Calculations: Step: 3 9:17pm Feb 18,2022

Govrn. thk, tg = 15, tr = 7.615, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.635, Temp. Reduction = 20 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D           -47 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -48 °C
```

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

Hydrostatic Test Pressure Results:

```
Pressure per UG99b      = 1.30 * M.A.W.P. * Sa/S         30.015  bar
Pressure per UG99b[36]  = 1.30 * Design Pres * Sa/S      29.900  bar
Pressure per UG99c      = 1.30 * M.A.P. - Head(Hyd)      47.476  bar
Pressure per UG100      = 1.10 * M.A.W.P. * Sa/S         25.398  bar
Pressure per PED        = max(1.43*DP, 1.25*DP*ratio)    32.775  bar
Pressure per App 27-4   = 1.30 * M.A.W.P. * Sa/S         30.015  bar
```

UG-99(b) Note 36, Test Pressure Calculation:
```
  = Test Factor * Design Pressure * Stress Ratio
  = 1.3 * 23 * 1
  = 29.900 bar
```

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

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

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

From To	Stress	Allowable	Ratio	Pressure
head 001	148.3	235.8	0.629	29.99
shell 001	151.1	235.8	0.641	29.99
head 002	148.3	235.8	0.629	29.99

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

Description	Pad/Nozzle	Ambient	Operating	Ratio
M	Nozzle	137.90	137.90	1.000
M	Pad	137.90	137.90	1.000
A1	Nozzle	117.90	117.90	1.000
A1	Pad	137.90	137.90	1.000
B	Nozzle	117.90	117.90	1.000
B	Pad	137.90	137.90	1.000
A2	Nozzle	117.90	117.90	1.000
A2	Pad	137.90	137.90	1.000
PT	Nozzle	117.90	117.90	1.000
A3	Nozzle	117.90	117.90	1.000
A3	Pad	137.90	137.90	1.000
LT1	Nozzle	117.90	117.90	1.000
LT1	Pad	137.90	137.90	1.000
LT2	Nozzle	117.90	117.90	1.000
LT2	Pad	137.90	137.90	1.000
D	Nozzle	117.90	117.90	1.000
D	Pad	137.90	137.90	1.000
SV	Nozzle	117.90	117.90	1.000
SV	Pad	137.90	137.90	1.000
TI	Nozzle	117.90	117.90	1.000

Minimum	1.000

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

Description	Ambient	Operating	Ratio
head 001	137.90	137.90	1.000
shell 001	137.90	137.90	1.000
head 002	137.90	137.90	1.000
Minimum			1.000

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

Description	Ambient	Operating	Ratio
M	62.29	235.80	0.264
A1	39.30	217.19	0.181
B	39.30	217.19	0.181
A2	18.28	217.19	0.084
PT	11.09	217.19	0.051
A3	18.28	217.19	0.084
LT1	18.28	217.19	0.084
LT2	18.28	217.19	0.084
D	18.28	217.19	0.084
SV	24.25	217.19	0.112
TI	11.09	217.19	0.051

Elements Suitable for Internal Pressure.

External Pressure Calculation Results :

External Pressure Calculations:

From	To	Section Length mm.	Outside Diameter mm.	Corroded Thickness mm.	Factor A	Factor B N./mm^2
10	20	No Calc	914	9	0.0013676	94.3429
20	30	4148.33	914	9	0.00026007	26.0008
30	40	No Calc	914	9	0.0013676	94.3429

External Pressure Calculations:

From	To	External Actual T. mm.	External Required T. mm.	External Design Pressure bar	External M.A.W.P. bar
10	20	12	5.44078	1.1	10.3205
20	30	12	8.66323	1.1	3.41318
30	40	12	5.44078	1.1	10.3205
Minimum					3.413

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm.	Allowable Length Bet. Stiffeners mm.	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	4148.33	86665.1	No Calc	No Calc
30	40	No Calc	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

ASME Code, Section VIII Division 1, 2017

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

head 001

Elastic Modulus from Chart: CS-2 at 100 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

```
     Tca          OD          D/t     Factor A           B
   9.000      914.00       101.56    0.0013676       94.34
 EMAP = B/(K0*D/t) = 94.34/(0.9 *101.6 ) = 10.32 bar
```

Results for Required Thickness (Tca):

```
     Tca          OD          D/t     Factor A           B
   2.441      914.00       374.47    0.0003709       37.08
 EMAP = B/(K0*D/t) = 37.08/(0.9 *374.5 ) = 1.1 bar
```

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

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:
```
  = (P*D*Kcor)/(2*S*E-0.2*P) Appendix 1-4(c)
  = (1.837*896*0.991)/(2*137.9*1-0.2*1.837)
  = 0.5917 + 3.0000 = 3.5917 mm.
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
  = ((2*S*E*t)/(Kcor*D+0.2*t))/1.67 per Appendix 1-4 (c)
  = ((2*137.9*1*9)/(0.991*896+0.2*9))/1.67
  = 16.700 bar
```

Maximum Allowable External Pressure [MAEP]:
```
  = min( MAEP, MAWP )
  = min( 10.32, 16.7 )
  = 10.320 bar
```

Thickness requirements per UG-33(a)(1) do not govern the required thickness of this head.

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

shell 001

Elastic Modulus from Chart: CS-2 at 100 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
9.000	914.00	4148.33	101.56	4.5387	0.0002601	26.00

```
 EMAP = (4*B)/(3*(D/t)) = (4*26 )/(3*101.6 ) = 3.413 bar
```

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
5.663	914.00	4148.33	161.39	4.5387	0.0001332	13.32

```
 EMAP = (4*B)/(3*(D/t)) = (4*13.32 )/(3*161.4 ) = 1.1 bar
```

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
9.000	914.00	86665.13	101.56	50.0000	0.0001071	10.71

```
 EMAP = (4*B)/(3*(D/t)) = (4*10.71 )/(3*101.6 ) = 1.406 bar
```

Elliptical Head From 30 to 40 Ext. Chart: CS-2 at 100 °C

head 002

Elastic Modulus from Chart: CS-2 at 100 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
9.000	914.00	101.56	0.0013676	94.34

```
 EMAP = B/(K0*D/t) = 94.34/(0.9 *101.6 ) = 10.32 bar
```

Results for Required Thickness (Tca):

Tca	OD	D/t	Factor A	B
2.441	914.00	374.47	0.0003709	37.08

```
 EMAP = B/(K0*D/t) = 37.08/(0.9 *374.5 ) = 1.1 bar
```

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

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

```
  = (P*D*Kcor)/(2*S*E-0.2*P) Appendix 1-4(c)
  = (1.837*896*0.991)/(2*137.9*1-0.2*1.837)
  = 0.5917 + 3.0000 = 3.5917 mm.
```

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

```
  = ((2*S*E*t)/(Kcor*D+0.2*t))/1.67 per Appendix 1-4 (c)
  = ((2*137.9*1*9)/(0.991*896+0.2*9))/1.67
  = 16.700 bar
```

Maximum Allowable External Pressure [MAEP]:

```
  = min( MAEP, MAWP )
  = min( 10.32, 16.7 )
  = 10.320 bar
```

Thickness requirements per UG-33(a)(1) do not govern the required thickness of this head.

Element and Detail Weights:

From	To	Element Metal Wgt. kg.	Element ID Volume m^3	Corroded Metal Wgt. kg.	Corroded ID Volume m^3	Extra due Misc % kg.
10	20	130.489	0.12047	104.391	0.12272	13.0489
20	30	1027.86	2.36894	773.455	2.40098	102.786
30	40	130.489	0.12047	104.391	0.12272	13.0489
Total		1288	2.61	982	2.65	128

Weight of Details:

From	Type	Weight of Detail kg.	X Offset, Dtl. Cent. mm.	Y Offset, Dtl. Cent. mm.	Description
10	Liqd	56.8564	-74.1667	...	Liquid: 10
10	Insl	36.3186	-89.25	...	Ins: 20
10	Nozl	520.903	-222.5	...	M
20	Sadl	109.343	630	631.5	Fixed Saddle
20	Sadl	109.343	3270	631.5	Sliding Saddle
20	Liqd	1118.02	1950	...	Liquid: 20
20	Insl	286.081	1950	...	Ins: 20
20	Nozl	129.078	450	554.537	A1
20	Nozl	79.5605	1950	554.537	B
20	Nozl	11.1539	3250	475.163	A2
20	Nozl	8.69744	1700	469.13	PT
20	Nozl	13.4637	1150	475.163	A3
20	Nozl	17.7786	3650	475.163	LT1
20	Nozl	17.7786	3600	475.163	LT2
20	Nozl	16.6915	250	475.163	D
20	Nozl	46.3273	2250	502.15	SV
30	Liqd	56.8564	124.167	...	Liquid: 30
30	Insl	36.3186	139.25	...	Ins: 20
30	Nozl	6.24799	214.336	...	TI

Total Weight of Each Detail Type

Total Weight of Saddles	218.7
Total Weight of Liquid	1231.7
Total Weight of Insulation	358.7
Total Weight of Nozzles	867.7
Sum of the Detail Weights	2676.8 kg.

Weight Summation: kg.

Fabricated	Shop Test	Shipping	Erected	Empty	Operating
1417.7	2504.1	1417.7	2504.1	1417.7	2862.8
218.7	2671.9	218.7	...	218.7	1231.7
867.7	...	867.7	...	...	...
...	...	...	358.7	...	...
...	...	...	...	358.7	...
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	867.7	...
2504.1	5175.9	2504.1	2862.8	2862.8	4094.5

Miscellaneous Weight Percent: 10.0 %

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

Weight Summary

Fabricated Wt.	- Bare Weight W/O Removable Internals	2504.1 kg.
Shop Test Wt.	- Fabricated Weight + Water (Full)	5175.9 kg.
Shipping Wt.	- Fab. Wt + Rem. Intls.+ Shipping App.	2504.1 kg.
Erected Wt.	- Fab. Wt + Rem. Intls.+ Insul. (etc)	2862.8 kg.
Ope. Wt. no Liq	- Fab. Wt + Intls. + Details + Wghts.	2862.8 kg.
Operating Wt.	- Empty Wt + Operating Liq. Uncorroded	4094.5 kg.
Oper. Wt. + CA	- Corr Wt. + Operating Liquid	3757.3 kg.
Field Test Wt.	- Empty Weight + Water (Full)	5234.8 kg.

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

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

Outside Surface Areas of Elements:

From	To	Surface Area cm²
10	20	10620
20	30	111985
30	40	10620
Total		133225.188 cm²

Nozzle Flange MAWP Results:

Nozzle Description	Flange Rating Ope. bar	Flange Rating Ambient bar	Design Temp °C	Class	Grade/ Group	Equiv. Press	Max Pressure PVP	Max Pressure 50%	Max Pressure DNV bar
M	45.5	51.1	135	300	GR 1.1	...	...	...	...
A1	45.5	51.1	135	300	GR 1.1	...	...	...	...
B	45.5	51.1	135	300	GR 1.1	...	...	...	...
A2	45.5	51.1	135	300	GR 1.1	...	...	...	...
PT	45.5	51.1	135	300	GR 1.1	...	...	...	...
A3	45.5	51.1	135	300	GR 1.1	...	...	...	...
LT1	45.5	51.1	135	300	GR 1.1	...	...	...	...
LT2	45.5	51.1	135	300	GR 1.1	...	...	...	...
D	45.5	51.1	135	300	GR 1.1	...	...	...	...
SV	45.5	51.1	135	300	GR 1.1	...	...	...	...
TI	45.5	51.1	135	300	GR 1.1	...	...	...	...
Min Rating	45.546	51.096 bar [for Core Elements]					0.000	0.000	0.000

Selected Method for Derating ANSI Flange MAWP: None Selected

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

The PVP Method is based on the paper PVP 2013-97814. PV Elite uses the maximum loads from each load category to determine ME and FE. In many cases, the computed maximum allowable pressure will be greater than the flange rating. In these cases, the minimum of the rating from the table and the PVP method will be used. SA-193 B8 Cl. 2 bolts or ones with higher allowable stresses at the specified bolt size shall be used. Note that ANSI pipe nominal sizes up to 24 inch (600mm) are addressed.

How the 50% Stress Method Works:
If the computed stress/allowable stress is < 0.5 on the pipe wall, then the allowable pressure is the table rating from the ANSI/ASME standard. If the stress ratio is >= 0.5, then the full equivalent pressure is subtracted from the flange rating.

The DNV Method:
minimum(table rating, 1.5 * Operating rating - equivalent pressure)

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Wind Load Calculation: Step: 7 9:17pm Feb 18,2022

Input Values:

Wind Design Code		ASCE-7 2010	
Wind Load Reduction Scale Factor		0.600	
Basic Wind Speed	[V]	200	Km/hr
Surface Roughness Category		C: Open Terrain	
Importance Factor		1.0	
Type of Surface		Moderately Smooth	
Base Elevation		300	mm.
Percent Wind for Hydrotest		33.0	
Using User defined Wind Press. Vs Elev.		N	
Height of Hill or Escarpment	H or Hh	0	mm.
Distance Upwind of Crest	Lh	0	mm.
Distance from Crest to the Vessel	x	0	mm.
Type of Terrain (Hill, Escarpment)		Flat	
Damping Factor (Beta) for Wind (Ope)		0.0100	
Damping Factor (Beta) for Wind (Empty)		0.0000	
Damping Factor (Beta) for Wind (Filled)		0.0000	

Wind Analysis Results

Static Gust-Effect Factor, Operating Case [G]:
= min(0.85, 0.925((1 + 1.7 * gQ * Izbar * Q)/(1 + 1.7 * gV * Izbar)))
= min(0.85,0.925((1+1.7*3.4*0.228*0.982)/(1+1.7*3.4*0.228)))
= min(0.85, 0.916)
= 0.850

Natural Frequency of Vessel (Operating)	33.000 Hz
Natural Frequency of Vessel (Empty)	33.000 Hz
Natural Frequency of Vessel (Test)	33.000 Hz

Force Coefficient	[Cf]	0.549
Structure Height to Diameter ratio		3.956

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

Sample Calculation for the First Element

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

Value of [Alpha] and [Zg]:
Exposure Category: C from Table 26.9.1
Alpha = 9.5 : Zg = 274320 mm.

Effective Height [z]:
= Centroid Height + Vessel Base Elevation
= 840 + 300 = 1140 mm.
= 3.74 ft. Imperial Units

Velocity Pressure coefficient evaluated at height z [Kz]:
Because z (3.74 ft.) < 15 ft.
= $2.01 * (15 / Zg)^{2 / Alpha}$
= $2.01 * (15/900)^{2/9.5}$
= 0.849

Type of Hill: No Hill

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

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Wind Load Calculation: Step: 7 9:17pm Feb 18,2022

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

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

Velocity Pressure evaluated at height z, Imperial Units [qz]:
= max(16, 0.00256 * Kz * Kzt * Kd * V(mph)²)
= max(16, 0.00256 * 0.849 * 1 * 0.95 * 124.3²)
= 31.89 psf [155.7] Kgs/m^2

Force on the first element [F]:
= qz * G * Cf * WindArea
= 31.89 * 0.85 * 0.549 * 3.87
= 57.61 lbs. [0.256] kN

Element	Hgt (z) mm.	K1	K2	K3	Kz	Kzt	qz Kgs/m^2
head 001	1140.0	0.000	0.000	0.000	0.849	1.000	155.683
shell 001	1140.0	0.000	0.000	0.000	0.849	1.000	155.683
head 002	1140.0	0.000	0.000	0.000	0.849	1.000	155.683

Wind Load Calculation:

From	To	Wind Height mm.	Wind Diameter mm.	Wind Area cm²	Wind Pressure Kgs/m^2	Element Wind Load kN
10	20	1140	1336.8	3595.05	155.683	0.15374
20	30	1140	1336.8	52135.2	155.683	2.22958
30	40	1140	1336.8	3595.05	155.683	0.15374

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

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

```
DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for  LIQID RECEIVER D-PK6101-2
Earthquake Load Calculation:          Step:    8   9:17pm  Feb 18,2022
```

Earthquake Load Calculation:

Input Values:

```
    Seismic Design Code                                        ASCE 7-2010
    Seismic Load Reduction Scale Factor                              0.700
    Importance Factor                                                1.500
    Table Value Fa                                                   1.000
    Table Value Fv                                                   1.300
    Short Period Acceleration value Ss                               0.900
    Long Period Acceleration Value Sl                                0.537
    Moment Reduction Factor Tau                                      1.000
    Force Modification Factor R                                      2.500
    Site Class                                                           C
    Component Elevation Ratio            z/h                         1.000
    Amplification Factor                  Ap                         2.500
    Force Factor                                                     0.000
    Consider Vertical Acceleration                                     Yes
    Minimum Acceleration Multiplier                                  0.000
    User Value of Sds (used if > 0 )                                 0.624
```

Seismic Analysis Results:

```
  Sms = Fa * Ss = 1 * 0.9 = 0.9
  Sm1 = Fv * S1 = 1.3 * 0.537 = 0.698
  Sds = 2/3 * Sms = 2/3 * 0.9 = 0.6

  Sds = Max( 0.8*Sds, SdsUser )
      = Max( 0.48, 0.624 )
      = 0.624

  Sd1 = 2/3 * Sm1 = 2/3 * 0.698 = 0.465

  Sd1 = Max( 0.8*Sd1, Sd1User )
      = Max( 0.372, 0.39 )
      = 0.390
```

Check Approximate Fundamental Period from 12.8-7 [Ta]:
  = Ct * hn^x where Ct = 0.020, x = 0.75 and hn = Structural Height (ft.)
  = 0.020 * ($4.216^{0.75}$)
  = 0.059 seconds

The Coefficient Cu from Table 12.8-1 is : 1.400

Fundamental Period (1/Frequency) [T]:
  = (1/Natural Frequency) = (1/33)
  = 0.030

Check the Value of T which is the smaller of Cu*Ta and T:
  = Minimum Value of (1.4 * 0.0588, 0.0303) per 12.8.2
  = 0.030

Compute the Seismic Force per equation 13.3-1, [Fp]:
  = 0.4 * Ap * Sds * W * (1 + 2*(z/h)) / (R / Ie)
  = 0.4 * 2.5 * 0.624 * 36.84 * (1 + 2*1)/(2.5/1.5)
  = 41.383 kN

Check the Maximum value of Fp per equation 13.3-2:
  = 1.6 * Sds * I * W
  = 1.6 * 0.624 * 1.5 * 36.84 = 55.18 kN

Check the Minimum value of Fp per equation 13.3-3:

```
  = 0.3 * 0.624 * 1.5 * 36.84
  = 10.346 kN
```

Compute the Total Base Shear V = Fp, [V]:

```
  = 41.383 kN
```

Vertical load per 12.4-4, [YEq]:

```
  = 0.2 * Sds * W
  = 0.2 * 0.624 * 36.84 = 4.598 kN
```

```
 Final Base Shear,        V = 28.97 kN
 Final Vertical Load, YEq = 3.22 kN
```

Earthquake Load Calculation:

From	To	Earthquake Height mm.	Earthquake Weight kN	Element Ope Load kN
10	20	445	7.36876	5.79362
20	Sadl	445	7.36876	5.79362
Sadl	30	445	7.36876	5.79362
20	30	445	7.36876	5.79362
30	40	445	7.36876	5.79362

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

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Center of Gravity Calculation: Step: 9 9:17pm Feb 18,2022

Shop/Field Installation Options :

Insulation is installed in the Field.

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

```
Center of Gravity of Saddles                          2000.000 mm.
Center of Gravity of Liquid                           2000.000 mm.
Center of Gravity of Insulation                       2000.000 mm.
Center of Gravity of Nozzles                           511.935 mm.

Center of Gravity of Bare Shell New and Cold          2000.000 mm.
Center of Gravity of Bare Shell Corroded             2000.000 mm.

Vessel CG in the Operating Condition                 1656.356 mm.
Vessel CG in the Fabricated (Shop/Empty) Condition   1484.376 mm.
Vessel CG in the Test Condition                      1750.545 mm.
```

Warning: Lifting Lug is Higher than top of vessel !

Rigging Analysis Results:

```
Total Effective Length of Vessel for this analysis        4000.00 mm.
Total vessel weight (No Liquid)                  Twt        28.07 kN
Impact weight multiplication factor              Imp         1.50
Design lifting weight,  DWT = Imp * Twt                     42.11 kN
Elevation of the Tailing Lug (bottom)                      500.00 mm.
Elevation of the Lifting Lug (top    )                    5400.00 mm.
Design Reaction force at the tailing lug                    33.65 kN
Design Reaction force at the lifting lug                     8.46 kN

CG Distance from Tailing Lug                               984.38 mm.
CG Distance from the Nearer Lifting Lug                    984.38 mm.
```

Critical Values:

	Max Stress N./mm^2	Elevation mm.	Allowables N./mm^2	
Bending	2.13	3170.00	113.45	(UG-23)
Shear	0.46	10.00	96.53	(0.7*S)

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

Distance mm.	Bending Moment N-m	Bending Stress N./mm^2	Shear Force kN	Shear Stress N./mm^2
0.00	0.0	0.0	14.6	0.4
830.00	1821.0	0.2	10.8	0.3
2390.00	14111.9	1.9	0.7	0.0
3950.00	14272.8	1.9	9.4	0.3

Unity Check (Actual Stress / Allowable Stress):

Maximum Unity Check is 0.0188 at elevation 3170 mm. - Must be <=1

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

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

ASME Horizontal Vessel Analysis: Stresses for the Left Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

Horizontal Vessel Stress Calculations : Operating Case

Note:
Wear Pad Width (200.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:
```
= min( b + 1.56*sqrt( Rm * t ), 2a )
= min( 172 + 1.56*sqrt( 452.5 * 9 ), 2 * 680 )
= 271.5532 mm.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	452.50	mm.
Stiffened Vessel Length per 4.15.6	L	4000.00	mm.
Distance from Saddle to Vessel tangent	a	680.00	mm.
Saddle Width	b	172.00	mm.
Saddle Bearing Angle	theta	120.00	degrees
Inside Depth of Head	h2	225.50	mm.
Shell Allowable Stress used in Calculation		137.90	N./mm^2
Head Allowable Stress used in Calculation		137.90	N./mm^2
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Saddle Force Q, Operating Case		70.33	kN

Horizontal Vessel Analysis Results:	Actual N./mm^2	Allowable N./mm^2
Long. Stress at Top of Midspan	54.62	137.90
Long. Stress at Bottom of Midspan	61.13	137.90
Long. Stress at Top of Saddles	73.51	137.90
Long. Stress at Bottom of Saddles	49.22	137.90
Tangential Shear in Shell	12.41	110.32
Circ. Stress at Horn of Saddle	76.03	172.38
Circ. Compressive Stress in Shell	2.19	137.90

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  * ( 2.537/2 + 0 ) * 840/783.8
= 4.1 kN
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:
```
= max( Fl, Friction Load, Sum of X Forces) * B / Ls
= max( 0.721, 0, 0 ) * 840/2640
= 0.2 kN
```

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:
```
= max( Fl, Friction Force, Sum of X Forces ) * B / Ls
= max( 28.97, 0, 0 ) * 840/2640
= 9.2 kN
```

Saddle Reaction Force due to Earthquake Ft [Fst]:
```
  = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3   * ( 28.97/2 + 0 ) * 840/783.8
  = 46.6 kN
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
  = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
  = 23.75 + Max( 0.229, 4.079, 9.217, 46.57 )
  = 70.3 kN
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	71.40	kN
Transverse Shear Load Saddle	14.48	kN
Longitudinal Shear Load Saddle	28.97	kN

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, k = 0.1

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0529	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:
```
  = -Q*a [1 - (1- a/L + (R²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -70.33*680[1-(1-680/4000+(452.5²-225.5²)/
     (2*680*4000))/(1+(4*225.5)/(3*4000))]
  = -9650.1 N-m
```

Moment per Equation 4.15.4 [M2]:
```
  = Q*L/4(1+2(R²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 70.33*4000/4(1+2(452.5²-225.5²)/(4000²))/(1+(4*225.5)/
     (3*4000))-4*680/4000
  = 18853.6 N-m
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:
```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 23.02 * 452.5/(2*9 ) - 18854/(pi*452.5²*9 )
  = 54.62 N./mm^2
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:
```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 23.02 * 452.5/(2 * 9 ) + 18854/(pi * 452.5² * 9 )
  = 61.13 N./mm^2
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:
```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 23.02*452.5/(2*9)--9650/(0.107*pi*452.5²*9)
  = 73.51 N./mm^2
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:
```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 23.02*452.5/(2*9)+-9650/(0.192*pi*452.5²*9)
  = 49.22 N./mm^2
```

Maximum Shear Force in the Saddle (4.15.5) [T]:
```
  = Q(L-2a)/(L+(4*h2/3))
  = 70.33 ( 4000 - 2 * 680 )/(4000 + ( 4 * 225.5/3))
```

```
  = 43.2 kN
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:
```
  = K2 * T / ( Rm * t )
  = 1.171 * 43.17/( 452.5 * 9 )
  = 12.41 N./mm^2
```

Decay Length (4.15.22) [x1,x2]:
```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 452.5 * 9 )
  = 49.777 mm.
```

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:
```
  = -K5 * Q * k / ( t * ( b + X1 + X2 ) )
  = -0.76 * 70.33 * 0.1/( 9 * ( 172 + 49.78 + 49.78 ) )
  = -2.19 N./mm^2
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.24) [sigma7]:
```
  = -Q/(4*t*(b+X1+X2)) - 3*K7*Q/(2*t²)
  = -70.33/(4*9 *(172 +49.78 +49.78 )) -
     3*0.0529 *70.33/(2*9²)
  = -76.03 N./mm^2
```

Effective reinforcing plate width (4.15.1) [B1]:
```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 172 + 1.56 * sqrt( 452.5 * 9 ), 2 * 680 )
  = 271.55 mm.
```

Free Un-Restrained Thermal Expansion between the Saddles [Exp]:
```
  = Alpha * Ls * ( Design Temperature - Ambient Temperature )
  = 0.00000233 * 2640 * ( 135 - 21.11 )
  = 3.707 mm.
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	890.0000	mm.
Baseplate Thickness	Bpthk	16.0000	mm.
Baseplate Width	Bpwid	200.0000	mm.
Number of Ribs (inc. outside ribs)	Nribs	2	
Rib Thickness	Ribtk	12.0000	mm.
Web Thickness	Webtk	12.0000	mm.
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	B	D	Y	A	AY	Io
Shell	299.	9.	4.	27.	12112.	7.27
Wearplate	200.	10.	14.	20.	28000.	40.9
Web	12.	357.	197.	43.	846090.	0.213E+05
BasePlate	200.	16.	384.	32.	1228800.	0.472E+05
Totals	...	...	...	122.	2115001.	0.685E+05

```
Value  C1 = Sumof(Ay)/Sumof(A)          =     174.      mm.
Value   I = Sumof(Io) - C1*Sumof(Ay)    =    0.318E+05  cm**4
Value  As = Sumof(A) - Ashell           =     94.8      cm²

K1 = (1+cos(beta)-0.5*sin(beta)² )/(pi-beta+sin(beta)*cos(beta)) = 0.2035

Fh = K1 * Q = 0.204 * 70.33 = 14.31 kN

Tension Stress, St = ( Fh/As )       =        1.5093  N./mm^2
Allowed Stress, Sa = 0.6 * Yield Str =      124.1100  N./mm^2
```

Saddle Splitting Dimension [d]:
```
  = B - R * sin( theta )/ theta
  = 840 - 448 * sin( 1.047 )/1.047
  = 469.507 mm.

 Bending Moment, M  = Fh * d          =       6722.6606  N-m

 Bending Stress, Sb = ( M * C1 / I  ) =          3.6756  N./mm^2
 Allowed Stress, Sa = 2/3 * Yield Str =        137.9000  N./mm^2
```

Minimum Thickness of Baseplate per Moss:
```
  = ( 3( Q + Saddle_Wt )BasePlateWidth / ( 4 * BasePlateLength * AllStress ))½
  = ( 3(70.33 + 1.072 )200/( 4 * 890 * 137.9 ))½
  = 9.342 mm.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Distance between Ribs [e]:
```
  = Web Length / ( Nribs - 1 )
  = 814.1/( 2 - 1 )
  = 814.064 mm.
```

Baseplate Pressure Area [Ap]:
```
  = e * Bpwid / 2
  = 814.1 * 200/2
  = 814.064 cm²
```

Axial Load [P]:
```
  = Ap * Bp
  = 814.1 * 0.0395
  = 32.163 kN
```

Area of the Rib and Web [Ar]:
```
  = Rib Area + Web Area
  = 19.2 + 48.84
  = 68.044 cm²
```

Compressive Stress [Sc]:
```
  = P/Ar
  = 32.16/68.04
  = 4.727 N./mm^2
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib+Web	12.0	172.0	...	20.6	...	509.

Bending Moment [Rm]:
```
  = Fl /( 2 * Bplen ) * e * rl / 2
  = 28.97/( 2 * 890 ) * 814.1 * 589/2
  = 3903.189 N-m
```

Compressive Allowable, KL/R < Cc (21.54 < 138.1) per AISC E2-1 [Sca]:
```
  = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 21.54 )²/(2 * 138.1² )) * 206.9/
    ( 5/3+3*(21.54 )/(8* 138.1 )-( 21.54³)/(8*138.1³)
  = 118.478 N./mm^2
```

AISC Unity Check of Outside Ribs (must be <= 1)
```
  = Sc/Sca + ( Rm * Distance Side/I )/Sba
```

```
  = 4.727/118.5 + ( 3903 * 86/5088448 )/137.9
  = 0.518
```

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	4	
Total Number of Bolts in Tension/Baseplate	Nbt	2	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	172.38	N./mm^2
Bolt Corrosion Allowance	Bca	0.0	mm.
Distance from Bolts to Edge	Edgedis	105.0	mm.
Nominal Bolt Diameter	Bnd	20.0000	mm.
Thread Series	Series	TEMA Metric	
BasePlate Allowable Stress	S	108.25	N./mm^2
Area Available in a Single Bolt	BltArea	2.1705	cm²
Saddle Load QO (Weight)	QO	24.8	kN
Saddle Load QL (Wind/Seismic contribution)	QL	9.2	kN
Maximum Transverse Force	Ft	14.5	kN
Maximum Longitudinal Force	Fl	29.0	kN
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)
  = 28.97/(172.4 * 4 )
  = 0.4202 cm²
```

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:

```
  = B * Ft + Sum of X Moments
  = 840 * 14.48 + 0
  = 12171.53 N-m
```

Eccentricity (e):

```
  = Rmom / QO
  = 12172/24.83
  = 490.05 mm. > Bplen/6 --> Uplift in Transverse direction

 f = Bplen / 2 - Edgedis
   = 890/2 - 105
   = 340.00 mm.
```

Modular Ratio Of Steel/Concrete (n1):

```
  = ES / EC
  = 203402/21526
  = 9.45

 K1 = 3 (e - 0.5 * Bplen)
    = 3 (490.1 - 0.5*890 )
    = 135.16 mm.

 K2 = 6 * n1 * At / Bpwid * (f + e)
    = 6 * 9.449 * 4.341/200 * (340 + 490.1 )
    = 102142.13 mm.²

 K3 = -K2 * (0.5 * Bplen + f)
    = -102142 * (0.5 * 890 + 340 )
```

```
    = -80181564.59 mm.³
```

Iteratively Solving for the Effective Bearing Length:

```
 Y³ + K1 * Y² + K2 * Y + K3 = 0
 Y³ + 135.2 * Y² + 102142 * Y + -80181560 = 0
 Y  = 321.78 mm.

 Num = (Bplen / 2 - Y / 3 - e)
     = (890/2 - 321.8/3 - 490.1 )
     = -152.31

 Denom = (Bplen / 2 - Y / 3 + f)
       = (890/2 - 321.8/3 + 340 )
       = 677.74
```

Total Bolt Tension Force [Tforce]:

```
  = - QO * Num / Denom
  = - 24.83 * -152.3/677.7
  = 5.58 kN
```

Bolt Area Required due to Transverse Load [Bltareart]:

```
  = Tforce / (Stba * Nbt)
  = 5.58/( 172.4 * 2 )
  = 0.1619 cm²
```

Required Area of a Single Bolt [Bltarear]:

```
  = max[Bltarearl, Bltarears, Bltareart]
  = max[0, 0.42, 0.162 ]
  = 0.4202 cm²
```

Baseplate Thickness Calculation per D. Moss:

Bearing Pressure (fc)

```
  = 2(QO + Tforce) / (Y * Bpwid)
  = 2(24.83 + 5.58 )/(321.8 * 200 )
  = 9.45 bar
```

Distance from Baseplate Edge to the Web [ADIST]:

```
  = (Bplen - Weblngth) / 2
  = (890 - 839.2 )/2
  = 25.4000 mm.
```

Overturning Moment due To Bolt Tension [Mt]:

```
  = Tforce * Adist
  = 5.58 * 25.4
  = 141.78 N-m
```

Equivalent Bearing Pressure (f1):

```
  = fc * (Y - Adist) / Y
  = 9.449 * (321.8 - 25.4 )/321.8
  = 8.70 bar
```

Overturning Moment due to Bearing Pressure [Mc]:

```
  = (Adist² * Bpwid / 6) * (f1 + 2 * fc)
  = (25.4² * 200/6) * (8.703 + 2 * 9.449 )
  = 59.38 N-m
```

Baseplate Required Thickness [Treq]:

```
  = (6 * max(Mt,Mc) / (Bpwid * Sba))½
  = (6 *max(141.8,59.38/(200 * 162.4 ))½
  = 5.1172 mm.
```

ASME Horizontal Vessel Analysis: Stresses for the Right Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

Note:
Wear Pad Width (200.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:

```
= min( b + 1.56*sqrt( Rm * t ), 2a )
= min( 172 + 1.56*sqrt( 452.5 * 9 ), 2 * 680 )
= 271.5532 mm.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	452.50	mm.
Stiffened Vessel Length per 4.15.6	L	4000.00	mm.
Distance from Saddle to Vessel tangent	a	680.00	mm.
Saddle Width	b	172.00	mm.
Saddle Bearing Angle	theta	120.00	degrees
Inside Depth of Head	h2	225.50	mm.
Shell Allowable Stress used in Calculation		137.90	N./mm^2
Head Allowable Stress used in Calculation		137.90	N./mm^2
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Saddle Force Q, Operating Case		60.73	kN

Horizontal Vessel Analysis Results:	Actual N./mm^2	Allowable N./mm^2
Long. Stress at Top of Midspan	55.07	137.90
Long. Stress at Bottom of Midspan	60.69	137.90
Long. Stress at Top of Saddles	71.38	137.90
Long. Stress at Bottom of Saddles	50.40	137.90
Tangential Shear in Shell	10.72	110.32
Circ. Stress at Horn of Saddle	65.66	172.38
Circ. Compressive Stress in Shell	1.89	137.90

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 * ( 2.537/2 + 0 ) * 840/783.8
= 4.1 kN
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

```
= max( Fl, Friction Load, Sum of X Forces) * B / Ls
= max( 0.721, 0, 0 ) * 840/2640
= 0.2 kN
```

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:

```
= max( Fl, Friction Force, Sum of X Forces ) * B / Ls
= max( 28.97, 0, 0 ) * 840/2640
= 9.2 kN
```

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Horizontal Vessel Analysis (Ope.): Step: 10 9:17pm Feb 18,2022

Saddle Reaction Force due to Earthquake Ft [Fst]:
```
  = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3   * ( 28.97/2 + 0 ) * 840/783.8
  = 46.6 kN
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
  = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
  = 14.16 + Max( 0.229, 4.079, 9.217, 46.57 )
  = 60.7 kN
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	61.81	kN
Transverse Shear Load Saddle	14.48	kN
Longitudinal Shear Load Saddle	28.97	kN

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, k = 0.1

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0529	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:
```
  = -Q*a [1 - (1- a/L + (R²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -60.73*680[1-(1-680/4000+(452.5²-225.5²)/
     (2*680*4000))/(1+(4*225.5)/(3*4000))]
  = -8333.9 N-m
```

Moment per Equation 4.15.4 [M2]:
```
  = Q*L/4(1+2(R²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 60.73*4000/4(1+2(452.5²-225.5²)/(4000²))/(1+(4*225.5)/
     (3*4000))-4*680/4000
  = 16282.1 N-m
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:
```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 23.02 * 452.5/(2*9 ) - 16282/(pi*452.5²*9 )
  = 55.07 N./mm^2
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:
```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 23.02 * 452.5/(2 * 9 ) + 16282/(pi * 452.5² * 9 )
  = 60.69 N./mm^2
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:
```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 23.02*452.5/(2*9)--8334/(0.107*pi*452.5²*9)
  = 71.38 N./mm^2
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:
```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 23.02*452.5/(2*9)+-8334/(0.192*pi*452.5²*9)
  = 50.40 N./mm^2
```

Maximum Shear Force in the Saddle (4.15.5) [T]:
```
  = Q(L-2a)/(L+(4*h2/3))
  = 60.73 ( 4000 - 2 * 680 )/(4000 + ( 4 * 225.5/3))
  = 37.3 kN
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:
```
  = K2 * T / ( Rm * t )
  = 1.171 * 37.28/( 452.5 * 9 )
  = 10.72 N./mm^2
```

Decay Length (4.15.22) [x1,x2]:
```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 452.5 * 9 )
  = 49.777 mm.
```

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:
```
  = -K5 * Q * k / ( t * ( b + X1 + X2 ) )
  = -0.76 * 60.73 * 0.1/( 9 * ( 172 + 49.78 + 49.78 ) )
  = -1.89 N./mm^2
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.24) [sigma7]:
```
  = -Q/(4*t*(b+X1+X2)) - 3*K7*Q/(2*t²)
  = -60.73/(4*9 *(172 +49.78 +49.78 )) -
     3*0.0529 *60.73/(2*9²)
  = -65.66 N./mm^2
```

Effective reinforcing plate width (4.15.1) [B1]:
```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 172 + 1.56 * sqrt( 452.5 * 9 ), 2 * 680 )
  = 271.55 mm.
```

Results for Vessel Ribs, Web and Base

Baseplate Length	Bplen	890.0000	mm.
Baseplate Thickness	Bpthk	16.0000	mm.
Baseplate Width	Bpwid	200.0000	mm.
Number of Ribs (inc. outside ribs)	Nribs	2	
Rib Thickness	Ribtk	12.0000	mm.
Web Thickness	Webtk	12.0000	mm.
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	B	D	Y	A	AY	Io
Shell	299.	9.	4.	27.	12112.	7.27
Wearplate	200.	10.	14.	20.	28000.	40.9
Web	12.	357.	197.	43.	846090.	0.213E+05
BasePlate	200.	16.	384.	32.	1228800.	0.472E+05
Totals	...	...	...	122.	2115001.	0.685E+05

```
Value  C1 = Sumof(Ay)/Sumof(A)           =     174.      mm.
Value   I = Sumof(Io) - C1*Sumof(Ay)     =    0.318E+05  cm**4
Value  As = Sumof(A) - Ashell            =     94.8      cm²

K1 = (1+cos(beta)-0.5*sin(beta)² )/(pi-beta+sin(beta)*cos(beta)) = 0.2035

Fh = K1 * Q = 0.204 * 60.73 = 12.36 kN

Tension Stress, St = ( Fh/As )       =         1.3034  N./mm^2
Allowed Stress, Sa = 0.6 * Yield Str =       124.1100  N./mm^2
```

Saddle Splitting Dimension [d]:
```
  = B - R * sin( theta )/ theta
  = 840 - 448 * sin( 1.047 )/1.047
  = 469.507 mm.
```

```
Bending Moment, M  = Fh * d          =       5805.7461  N-m

Bending Stress, Sb = ( M * C1 / I  ) =          3.1743  N./mm^2
Allowed Stress, Sa = 2/3 * Yield Str =        137.9000  N./mm^2
```

Minimum Thickness of Baseplate per Moss:

```
= ( 3( Q + Saddle_Wt )BasePlateWidth / ( 4 * BasePlateLength * AllStress ))½
= ( 3(60.73 + 1.072 )200/( 4 * 890 * 137.9 ))½
= 8.692 mm.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Distance between Ribs [e]:

```
= Web Length / ( Nribs - 1 )
= 814.1/( 2 - 1 )
= 814.064 mm.
```

Baseplate Pressure Area [Ap]:

```
= e * Bpwid / 2
= 814.1 * 200/2
= 814.064 cm²
```

Axial Load [P]:

```
= Ap * Bp
= 814.1 * 0.0341
= 27.776 kN
```

Area of the Rib and Web [Ar]:

```
= Rib Area + Web Area
= 19.2 + 48.84
= 68.044 cm²
```

Compressive Stress [Sc]:

```
= P/Ar
= 27.78/68.04
= 4.082 N./mm^2
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib+Web	12.0	172.0	...	20.6	...	509.

Bending Moment [Rm]:

```
= Fl /( 2 * Bplen ) * e * rl / 2
= 28.97/( 2 * 890 ) * 814.1 * 589/2
= 3903.189 N-m
```

Compressive Allowable, KL/R < Cc (21.54 < 138.1) per AISC E2-1 [Sca]:

```
= (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
= ( 1-( 21.54 )²/(2 * 138.1² )) * 206.9/
  ( 5/3+3*(21.54 )/(8* 138.1 )-( 21.54³)/(8*138.1³)
= 118.478 N./mm^2
```

AISC Unity Check of Outside Ribs (must be <= 1)

```
= Sc/Sca + ( Rm * Distance Side/I )/Sba
= 4.082/118.5 + ( 3903 * 86/5088448 )/137.9
= 0.513
```

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	4	
Total Number of Bolts in Tension/Baseplate	Nbt	2	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	172.38	N./mm^2
Bolt Corrosion Allowance	Bca	0.0	mm.
Distance from Bolts to Edge	Edgedis	105.0	mm.
Nominal Bolt Diameter	Bnd	20.0000	mm.
Thread Series	Series	TEMA Metric	
BasePlate Allowable Stress	S	108.25	N./mm^2
Area Available in a Single Bolt	BltArea	2.1705	cm²
Saddle Load QO (Weight)	QO	15.2	kN
Saddle Load QL (Wind/Seismic contribution)	QL	9.2	kN
Maximum Transverse Force	Ft	14.5	kN
Maximum Longitudinal Force	Fl	29.0	kN
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)
 = 28.97/(172.4 * 4)
 = 0.4202 cm²

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:
 = B * Ft + Sum of X Moments
 = 840 * 14.48 + 0
 = 12171.53 N-m

Eccentricity (e):
 = Rmom / QO
 = 12172/15.24
 = 798.58 mm. > Bplen/6 --> Uplift in Transverse direction

f = Bplen / 2 - Edgedis
 = 890/2 - 105
 = 340.00 mm.

Modular Ratio Of Steel/Concrete (n1):
 = ES / EC
 = 203402/21526
 = 9.45

K1 = 3 (e - 0.5 * Bplen)
 = 3 (798.6 - 0.5*890)
 = 1060.73 mm.

K2 = 6 * n1 * At / Bpwid * (f + e)
 = 6 * 9.449 * 4.341/200 * (340 + 798.6)
 = 140107.64 mm.²

K3 = -K2 * (0.5 * Bplen + f)
 = -140108 * (0.5 * 890 + 340)
 = -109984490.42 mm.³

Iteratively Solving for the Effective Bearing Length:
Y³ + K1 * Y² + K2 * Y + K3 = 0
Y³ + 1061 * Y² + 140108 * Y + -109984488 = 0

```
 Y  = 241.74 mm.

 Num = (Bplen / 2 - Y / 3 - e)
     = (890/2 - 241.7/3 - 798.6 )
     = -434.16

 Denom = (Bplen / 2 - Y / 3 + f)
       = (890/2 - 241.7/3 + 340 )
       = 704.42
```

Total Bolt Tension Force [Tforce]:

```
  = - QO * Num / Denom
  = - 15.24 * -434.2/704.4
  = 9.39 kN
```

Bolt Area Required due to Transverse Load [Bltareart]:

```
  = Tforce / (Stba * Nbt)
  = 9.39/( 172.4 * 2 )
  = 0.2724 cm²
```

Required Area of a Single Bolt [Bltarear]:

```
  = max[Bltarearl, Bltarears, Bltareart]
  = max[0, 0.42, 0.272 ]
  = 0.4202 cm²
```

Baseplate Thickness Calculation per D. Moss:

Bearing Pressure (fc)

```
  = 2(QO + Tforce) / (Y * Bpwid)
  = 2(15.24 + 9.39 )/(241.7 * 200 )
  = 10.19 bar
```

Distance from Baseplate Edge to the Web [ADIST]:

```
  = (Bplen - Weblngth) / 2
  = (890 - 839.2 )/2
  = 25.4000 mm.
```

Overturning Moment due To Bolt Tension [Mt]:

```
  = Tforce * Adist
  = 9.39 * 25.4
  = 238.60 N-m
```

Equivalent Bearing Pressure (f1):

```
  = fc * (Y - Adist) / Y
  = 10.19 * (241.7 - 25.4 )/241.7
  = 9.12 bar
```

Overturning Moment due to Bearing Pressure [Mc]:

```
  = (Adist² * Bpwid / 6) * (f1 + 2 * fc)
  = (25.4² * 200/6) * (9.116 + 2 * 10.19 )
  = 63.44 N-m
```

Baseplate Required Thickness [Treq]:

```
  = (6 * max(Mt,Mc) / (Bpwid * Sba))½
  = (6 *max(238.6,63.44/(200 * 162.4 ))½
  = 6.6384 mm.
```

ASME Horizontal Vessel Analysis: Stresses for the Left Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

Horizontal Vessel Stress Calculations : Test Case

Note:
Wear Pad Width (200.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:

```
= min( b + 1.56*sqrt( Rm * t ), 2a )
= min( 172 + 1.56*sqrt( 452.5 * 9 ), 2 * 680 )
= 271.5532 mm.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	452.50	mm.
Stiffened Vessel Length per 4.15.6	L	4000.00	mm.
Distance from Saddle to Vessel tangent	a	680.00	mm.
Saddle Width	b	172.00	mm.
Saddle Bearing Angle	theta	120.00	degrees
Inside Depth of Head	h2	225.50	mm.
Shell Allowable Stress used in Calculation		235.81	N./mm^2
Head Allowable Stress used in Calculation		235.81	N./mm^2
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Saddle Force Q, Test Case, no Ext. Forces		32.21	kN

Horizontal Vessel Analysis Results:	Actual N./mm^2	Allowable N./mm^2
Long. Stress at Top of Midspan	73.80	235.81
Long. Stress at Bottom of Midspan	76.78	235.81
Long. Stress at Top of Saddles	82.45	235.81
Long. Stress at Bottom of Saddles	71.32	235.81
Tangential Shear in Shell	5.68	188.65
Circ. Stress at Horn of Saddle	34.82	353.71
Circ. Compressive Stress in Shell	1.00	235.81

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   * ( 0.837/2 + 0 ) * 840/783.8
= 1.3 kN
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

```
= max( Fl, Friction Load, Sum of X Forces) * B / Ls
= max( 0.238, 0, 0 ) * 840/2640
= 0.1 kN
```

Load Combination Results for Q + Wind or Seismic [Q]:

```
= Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
= 30.86 + Max( 0.0757, 1.346, 0, 0 )
= 32.2 kN
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	33.28	kN
Transverse Shear Load Saddle	0.42	kN
Longitudinal Shear Load Saddle	0.24	kN

Hydrostatic Test Pressure at center of Vessel: 29.944 bar

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, k = 0.1

The Computed K values from Table 4.15.1:

```
K1  = 0.1066     K2  = 1.1707     K3  = 0.8799     K4  = 0.4011
K5  = 0.7603     K6  = 0.0529     K7  = 0.0529     K8  = 0.3405
K9  = 0.2711     K10 = 0.0581     K1* = 0.1923
```

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:

```
= -Q*a [1 - (1- a/L + (R²-h2²)/(2a*L))/(1+(4h2)/3L)]
= -32.21*680[1-(1-680/4000+(452.5²-225.5²)/
  (2*680*4000))/(1+(4*225.5)/(3*4000))]
= -4419.3 N-m
```

Moment per Equation 4.15.4 [M2]:

```
= Q*L/4(1+2(R²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
= 32.21*4000/4(1+2(452.5²-225.5²)/(4000²))/(1+(4*225.5)/
  (3*4000))-4*680/4000
= 8634.1 N-m
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
= P * Rm/(2t) - M2/(pi*Rm²t)
= 29.94 * 452.5/(2*9 ) - 8634/(pi*452.5²*9 )
= 73.80 N./mm^2
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

```
= P * Rm/(2t) + M2/(pi * Rm² * t)
= 29.94 * 452.5/(2 * 9 ) + 8634/(pi * 452.5² * 9 )
= 76.78 N./mm^2
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

```
= P * Rm/(2t) - M1/(K1*pi*Rm²t)
= 29.94*452.5/(2*9)--4419/(0.107*pi*452.5²*9)
= 82.45 N./mm^2
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

```
= P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
= 29.94*452.5/(2*9)+-4419/(0.192*pi*452.5²*9)
= 71.32 N./mm^2
```

Maximum Shear Force in the Saddle (4.15.5) [T]:

```
= Q(L-2a)/(L+(4*h2/3))
= 32.21 ( 4000 - 2 * 680 )/(4000 + ( 4 * 225.5/3))
= 19.8 kN
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

```
= K2 * T / ( Rm * t )
= 1.171 * 19.77/( 452.5 * 9 )
= 5.68 N./mm^2
```

Decay Length (4.15.22) [x1,x2]:

```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 452.5 * 9 )
  = 49.777 mm.
```

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:

```
  = -K5 * Q * k / ( t * ( b + X1 + X2 ) )
  = -0.76 * 32.21 * 0.1/( 9 * ( 172 + 49.78 + 49.78 ) )
  = -1.00 N./mm^2
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.24) [sigma7]:

```
  = -Q/(4*t*(b+X1+X2)) - 3*K7*Q/(2*t²)
  = -32.21/(4*9 *(172 +49.78 +49.78 )) -
     3*0.0529 *32.21/(2*9²)
  = -34.82 N./mm^2
```

Effective reinforcing plate width (4.15.1) [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 172 + 1.56 * sqrt( 452.5 * 9 ), 2 * 680 )
  = 271.55 mm.
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	890.0000	mm.
Baseplate Thickness	Bpthk	16.0000	mm.
Baseplate Width	Bpwid	200.0000	mm.
Number of Ribs (inc. outside ribs)	Nribs	2	
Rib Thickness	Ribtk	12.0000	mm.
Web Thickness	Webtk	12.0000	mm.
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	B	D	Y	A	AY	Io
Shell	299.	9.	4.	27.	12112.	7.27
Wearplate	200.	10.	14.	20.	28000.	40.9
Web	12.	357.	197.	43.	846090.	0.213E+05
BasePlate	200.	16.	384.	32.	1228800.	0.472E+05
Totals	...	...	...	122.	2115001.	0.685E+05

```
 Value  C1 = Sumof(Ay)/Sumof(A)           =     174.      mm.
 Value   I = Sumof(Io) - C1*Sumof(Ay)     =    0.318E+05  cm**4
 Value  As = Sumof(A) - Ashell            =     94.8      cm²

 K1 = (1+cos(beta)-0.5*sin(beta)² )/(pi-beta+sin(beta)*cos(beta)) = 0.2035

 Fh = K1 * Q = 0.204 * 32.21 = 6.555 kN

 Tension Stress, St = ( Fh/As )       =        0.6912  N./mm^2
 Allowed Stress, Sa = 0.6 * Yield Str =      124.1100  N./mm^2
```

Saddle Splitting Dimension [d]:

```
  = B - R * sin( theta )/ theta
  = 840 - 448 * sin( 1.047 )/1.047
  = 469.507 mm.

 Bending Moment, M  = Fh * d          =     3078.6970  N-m

 Bending Stress, Sb = ( M * C1 / I  ) =        1.6833  N./mm^2
 Allowed Stress, Sa = 2/3 * Yield Str =      137.9000  N./mm^2
```

Minimum Thickness of Baseplate per Moss:

```
  = ( 3( Q + Saddle_Wt )BasePlateWidth / ( 4 * BasePlateLength * AllStress ))½
```

```
= ( 3(32.21 + 1.072 )200/( 4 * 890 * 137.9 ))½
= 6.378 mm.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Distance between Ribs [e]:
```
= Web Length / ( Nribs - 1 )
= 814.1/( 2 - 1 )
= 814.064 mm.
```

Baseplate Pressure Area [Ap]:
```
= e * Bpwid / 2
= 814.1 * 200/2
= 814.064 cm²
```

Axial Load [P]:
```
= Ap * Bp
= 814.1 * 0.0181
= 14.729 kN
```

Area of the Rib and Web [Ar]:
```
= Rib Area + Web Area
= 19.2 + 48.84
= 68.044 cm²
```

Compressive Stress [Sc]:
```
= P/Ar
= 14.73/68.04
= 2.165 N./mm^2
```

<u>Check of Outside Ribs:</u>
Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib+Web	12.0	172.0	...	20.6	...	509.

Bending Moment [Rm]:
```
= Fl /( 2 * Bplen ) * e * rl / 2
= 0.238/( 2 * 890 ) * 814.1 * 589/2
= 32.067 N-m
```

Compressive Allowable, KL/R < Cc (21.54 < 138.1) per AISC E2-1 [Sca]:
```
= (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
= ( 1-( 21.54 )²/(2 * 138.1² )) * 206.9/
  ( 5/3+3*(21.54 )/(8* 138.1 )-( 21.54³)/(8*138.1³)
= 118.478 N./mm^2
```

AISC Unity Check of Outside Ribs (must be <= 1)
```
= Sc/Sca + ( Rm * Distance Side/I )/Sba
= 2.165/118.5 + ( 32.07 * 86/5088448 )/137.9
= 0.022
```

<u>Input Data for Base Plate Bolting Calculations:</u>

Total Number of Bolts per BasePlate	Nbolts	4	
Total Number of Bolts in Tension/Baseplate	Nbt	2	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	172.38	N./mm^2
Bolt Corrosion Allowance	Bca	0.0	mm.
Distance from Bolts to Edge	Edgedis	105.0	mm.
Nominal Bolt Diameter	Bnd	20.0000	mm.
Thread Series	Series	TEMA Metric	

```
BasePlate Allowable Stress                         S      108.25  N./mm^2
Area Available in a Single Bolt              BltArea      2.1705  cm²
Saddle Load QO (Weight)                           QO        31.9  kN
Saddle Load QL (Wind/Seismic contribution)        QL         0.1  kN
Maximum Transverse Force                          Ft         0.4  kN
Maximum Longitudinal Force                        Fl         0.2  kN
Saddle Bolted to Steel Foundation                         No
```

<u>Bolt Area Calculation per Dennis R. Moss</u>

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)
= 0.238/(172.4 * 4 )
= 0.0035 cm²
```

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:
```
= B * Ft + Sum of X Moments
= 840 * 0.419 + 0
= 351.78 N-m
```

Eccentricity (e):
```
= Rmom / QO
= 351.8/31.93
= 11.01 mm. < Bplen/6 --> No Uplift in Transverse direction
```

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

Required Area of a Single Bolt [Bltarear]:
```
= max[Bltarearl, Bltarears, Bltareart]
= max[0, 0.00345, 0 ]
= 0.0035 cm²
```

ASME Horizontal Vessel Analysis: Stresses for the Right Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

Note:
Wear Pad Width (200.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:
```
= min( b + 1.56*sqrt( Rm * t ), 2a )
= min( 172 + 1.56*sqrt( 452.5 * 9 ), 2 * 680 )
= 271.5532 mm.
```

Input and Calculated Values:

```
Vessel Mean Radius                          Rm     452.50  mm.
Stiffened Vessel Length per 4.15.6           L    4000.00  mm.
Distance from Saddle to Vessel tangent       a     680.00  mm.

Saddle Width                                 b     172.00  mm.
Saddle Bearing Angle                     theta     120.00  degrees

Inside Depth of Head                        h2     225.50  mm.
```

Shell Allowable Stress used in Calculation	235.81	N./mm^2
Head Allowable Stress used in Calculation	235.81	N./mm^2
Circumferential Efficiency in Plane of Saddle	1.00	
Circumferential Efficiency at Mid-Span	1.00	

Saddle Force Q, Test Case, no Ext. Forces 22.61 kN

Horizontal Vessel Analysis Results:	Actual N./mm^2	Allowable N./mm^2
Long. Stress at Top of Midspan	74.24	235.81
Long. Stress at Bottom of Midspan	76.33	235.81
Long. Stress at Top of Saddles	80.31	235.81
Long. Stress at Bottom of Saddles	72.50	235.81
Tangential Shear in Shell	3.99	188.65
Circ. Stress at Horn of Saddle	24.45	353.71
Circ. Compressive Stress in Shell	0.70	235.81

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   * ( 0.837/2 + 0 ) * 840/783.8
  = 1.3 kN
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:
```
  = max( Fl, Friction Load, Sum of X Forces) * B / Ls
  = max( 0.238, 0, 0 ) * 840/2640
  = 0.1 kN
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
  = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
  = 21.27 + Max( 0.0757, 1.346, 0, 0 )
  = 22.6 kN
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	23.69	kN
Transverse Shear Load Saddle	0.42	kN
Longitudinal Shear Load Saddle	0.24	kN

Hydrostatic Test Pressure at center of Vessel: 29.944 bar

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, k = 0.1

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0529	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:
```
  = -Q*a [1 - (1- a/L + (R²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -22.61*680[1-(1-680/4000+(452.5²-225.5²)/
    (2*680*4000))/(1+(4*225.5)/(3*4000))]
  = -3103.1 N-m
```

Moment per Equation 4.15.4 [M2]:

```
  = Q*L/4(1+2(R²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 22.61*4000/4(1+2(452.5²-225.5²)/(4000²))/(1+(4*225.5)/
    (3*4000))-4*680/4000
  = 6062.7 N-m
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 29.94 * 452.5/(2*9 ) - 6063/(pi*452.5²*9 )
  = 74.24 N./mm^2
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 29.94 * 452.5/(2 * 9 ) + 6063/(pi * 452.5² * 9 )
  = 76.33 N./mm^2
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 29.94*452.5/(2*9)--3103/(0.107*pi*452.5²*9)
  = 80.31 N./mm^2
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 29.94*452.5/(2*9)+-3103/(0.192*pi*452.5²*9)
  = 72.50 N./mm^2
```

Maximum Shear Force in the Saddle (4.15.5) [T]:

```
  = Q(L-2a)/(L+(4*h2/3))
  = 22.61 ( 4000 - 2 * 680 )/(4000 + ( 4 * 225.5/3))
  = 13.9 kN
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

```
  = K2 * T / ( Rm * t )
  = 1.171 * 13.88/( 452.5 * 9 )
  = 3.99 N./mm^2
```

Decay Length (4.15.22) [x1,x2]:

```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 452.5 * 9 )
  = 49.777 mm.
```

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:

```
  = -K5 * Q * k / ( t * ( b + X1 + X2 ) )
  = -0.76 * 22.61 * 0.1/( 9 * ( 172 + 49.78 + 49.78 ) )
  = -0.70 N./mm^2
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.24) [sigma7]:

```
  = -Q/(4*t*(b+X1+X2)) - 3*K7*Q/(2*t²)
  = -22.61/(4*9 *(172 +49.78 +49.78 )) -
     3*0.0529 *22.61/(2*9²)
  = -24.45 N./mm^2
```

Effective reinforcing plate width (4.15.1) [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 172 + 1.56 * sqrt( 452.5 * 9 ), 2 * 680 )
  = 271.55 mm.
```

Results for Vessel Ribs, Web and Base

Baseplate Length	Bplen	890.0000	mm.
Baseplate Thickness	Bpthk	16.0000	mm.
Baseplate Width	Bpwid	200.0000	mm.
Number of Ribs (inc. outside ribs)	Nribs	2	

```
Rib Thickness                    Ribtk          12.0000  mm.
Web Thickness                    Webtk          12.0000  mm.
Web Location                    Webloc           Center
```

Moment of Inertia of Saddle - Lateral Direction

	B	D	Y	A	AY	Io
Shell	299.	9.	4.	27.	12112.	7.27
Wearplate	200.	10.	14.	20.	28000.	40.9
Web	12.	357.	197.	43.	846090.	0.213E+05
BasePlate	200.	16.	384.	32.	1228800.	0.472E+05
Totals	...	...	...	122.	2115001.	0.685E+05

```
Value  C1 = Sumof(Ay)/Sumof(A)          =     174.      mm.
Value   I = Sumof(Io) - C1*Sumof(Ay)    =    0.318E+05  cm**4
Value  As = Sumof(A) - Ashell           =     94.8      cm²

K1 = (1+cos(beta)-0.5*sin(beta)² )/(pi-beta+sin(beta)*cos(beta)) = 0.2035

Fh = K1 * Q = 0.204 * 22.61 = 4.603 kN

Tension Stress, St = ( Fh/As )       =         0.4853  N./mm^2
Allowed Stress, Sa = 0.6 * Yield Str =       124.1100  N./mm^2
```

Saddle Splitting Dimension [d]:

```
  = B - R * sin( theta )/ theta
  = 840 - 448 * sin( 1.047 )/1.047
  = 469.507 mm.

Bending Moment, M  = Fh * d          =      2161.7832  N-m

Bending Stress, Sb = ( M * C1 / I  ) =         1.1819  N./mm^2
Allowed Stress, Sa = 2/3 * Yield Str =       137.9000  N./mm^2
```

Minimum Thickness of Baseplate per Moss:

```
  = ( 3( Q + Saddle_Wt )BasePlateWidth / ( 4 * BasePlateLength * AllStress ))½
  = ( 3(22.61 + 1.072 )200/( 4 * 890 * 137.9 ))½
  = 5.381 mm.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Distance between Ribs [e]:

```
  = Web Length / ( Nribs - 1 )
  = 814.1/( 2 - 1 )
  = 814.064 mm.
```

Baseplate Pressure Area [Ap]:

```
  = e * Bpwid / 2
  = 814.1 * 200/2
  = 814.064 cm²
```

Axial Load [P]:

```
  = Ap * Bp
  = 814.1 * 0.0127
  = 10.342 kN
```

Area of the Rib and Web [Ar]:

```
  = Rib Area + Web Area
  = 19.2 + 48.84
  = 68.044 cm²
```

Compressive Stress [Sc]:
```
  = P/Ar
  = 10.34/68.04
  = 1.520 N./mm^2
```

<u>Check of Outside Ribs:</u>
Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib+Web	12.0	172.0	...	20.6	...	509.

Bending Moment [Rm]:
```
  = Fl /( 2 * Bplen ) * e * rl / 2
  = 0.238/( 2 * 890 ) * 814.1 * 589/2
  = 32.067 N-m
```

Compressive Allowable, KL/R < Cc (21.54 < 138.1) per AISC E2-1 [Sca]:
```
  = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 21.54 )²/(2 * 138.1² )) * 206.9/
    ( 5/3+3*(21.54 )/(8* 138.1 )-( 21.54³)/(8*138.1³)
  = 118.478 N./mm^2
```

AISC Unity Check of Outside Ribs (must be <= 1)
```
  = Sc/Sca + ( Rm * Distance Side/I )/Sba
  = 1.52/118.5 + ( 32.07 * 86/5088448 )/137.9
  = 0.017
```

<u>Input Data for Base Plate Bolting Calculations:</u>

Total Number of Bolts per BasePlate	Nbolts	4	
Total Number of Bolts in Tension/Baseplate	Nbt	2	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	172.38	N./mm^2
Bolt Corrosion Allowance	Bca	0.0	mm.
Distance from Bolts to Edge	Edgedis	105.0	mm.
Nominal Bolt Diameter	Bnd	20.0000	mm.
Thread Series	Series	TEMA Metric	
BasePlate Allowable Stress	S	108.25	N./mm^2
Area Available in a Single Bolt	BltArea	2.1705	cm²
Saddle Load QO (Weight)	QO	22.3	kN
Saddle Load QL (Wind/Seismic contribution)	QL	0.1	kN
Maximum Transverse Force	Ft	0.4	kN
Maximum Longitudinal Force	Fl	0.2	kN
Saddle Bolted to Steel Foundation		No	

<u>Bolt Area Calculation per Dennis R. Moss</u>

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)
  = 0.238/(172.4 * 4 )
  = 0.0035 cm²
```

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:
```
  = B * Ft + Sum of X Moments
  = 840 * 0.419 + 0
  = 351.78 N-m
```

Eccentricity (e):
```
  = Rmom / QO
  = 351.8/22.34
  = 15.74 mm. < Bplen/6 --> No Uplift in Transverse direction
```

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

Required Area of a Single Bolt [Bltarear]:
```
  = max[Bltarearl, Bltarears, Bltareart]
  = max[0, 0.00345, 0 ]
  = 0.0035 cm²
```

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Nozzle Summary: Step: 24 9:17pm Feb 18,2022

Nozzle Calculation Summary:

Description	MAWP bar	Ext	MAPNC bar	UG-45	[tr] mm.	Weld Path	Areas or Stresses
M	23.87	OK	...	...		OK	Passed
A1	27.33	OK	...	OK	10.16	OK	Passed
B	27.33	OK	...	OK	10.16	OK	Passed
A2	27.33	OK	...	OK	6.42	OK	Passed
PT	23.09	OK	...	OK	6.22	OK	Passed
A3	27.33	OK	...	OK	6.42	OK	Passed
LT1	27.33	OK	...	OK	6.42	OK	Passed
LT2	27.33	OK	...	OK	6.42	OK	Passed
D	27.33	OK	...	OK	6.42	OK	Passed
SV	27.33	OK	...	OK	8.26	OK	Passed
TI	24.68	OK	...	OK	6.22	OK	Passed
TI	25.10	OK	...	OK	6.22	OK	Passed

MAWP Summary:

```
Minimum MAWP Nozzles         :      23.089 Nozzle  : PT
Minimum MAWP Shells/Flanges  :      27.329 Element : shell 001
Minimum MAPnc Shells/Flanges :      36.589 Element : shell 001
------------------------------------------------------------------
Computed Vessel M.A.W.P.     :      23.089 bar
```

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

Warning: A Nozzle Reinforcement is governing the MAWP of this Vessel.

Check the Spatial Relationship between the Nozzles

From Node	Nozzle Description	X Coordinate mm.	Layout Angle deg	Dia. Limit mm.
10	M	0.000	0.000	968.000
20	A1	500.000	0.000	405.700
20	B	2000.000	180.000	405.700
20	A2	3300.000	0.000	102.068
20	PT	1750.000	0.000	72.960
20	A3	1200.000	0.000	102.068
20	LT1	3700.000	180.000	102.068
20	LT2	3650.000	0.000	102.068
20	D	300.000	180.000	102.068
20	SV	2300.000	0.000	201.662
30	TI	0.000	180.000	72.960

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 !

INPUT VALUES, Nozzle Description: M From : 10

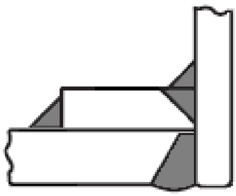
Pressure for Reinforcement Calculations	P	23.020	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Elliptical Head	D	890.00	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	12.0000	mm.
Head Internal Corrosion Allowance	c	3.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.
Distance from Head Centerline	L1	0.0000	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Normalized]		SA-516 70	
Material UNS Number		K02700	
Material Specification/Type		Plate	
Allowable Stress at Temperature	Sn	137.90	N./mm^2
Allowable Stress At Ambient	Sna	137.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		20.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	15.0000	mm.
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N./mm^2
Diameter of Pad along vessel surface	Dp	738.0000	mm.
Thickness of Pad	te	15.0000	mm.
Weld leg size between Pad and Shell	Wp	9.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	15.0000	mm.
Reinforcing Pad Width		115.0000	mm.
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 (may not represent actual weld type/configuration)



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

Reinforcement CALCULATION, Description: M

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation           20.000  in.
 Actual Thickness Used in Calculation                   0.591  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Elliptical Head, Tr [Int. Press]
```
   = (P*D*K)/(2*Sv*E-0.2*P) Appendix 1-4(c)
   = (23.02*896*0.991)/( 2*137.9*1-0.2*23.02)
   = 7.4260 mm.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
   = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
   = (23.02*254)/(137.9*1+0.4*23.02)
   = 4.2126 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 1.1318 mm.

Note: The diameter limit is greater than the head diameter.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)            Dl    968.0000   mm.
 Parallel to Vessel Wall, opening length              d    484.0000   mm.
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp     22.5000   mm.
```

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

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

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

Weld Strength Reduction Factor [fr3]:

```
= min( fr2, fr4 )
= min( 1, 1 )
= 1.000
```

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

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	35.942	5.907	NA
Area in Shell	A1	7.618	31.747	NA
Area in Nozzle Wall	A2	3.504	4.891	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	1.747	1.747	NA
Area in Element	A5	25.875	25.875	NA
TOTAL AREA AVAILABLE	Atot	38.745	64.260	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	713.0812	15.0000	mm.
Based on given Pad Diameter:	738.0000	13.3749	mm.
Based on Shell or Nozzle Thickness:	764.3515	12.0000	mm.

Area Required [A]:

```
= ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
= (484*7.426*1+2*12*7.426*1*(1-1))
= 35.942 cm²
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

```
= d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
= 484 ( 1 * 9 - 1 * 7.426 ) - 2 * 12
  ( 1 * 9 - 1 * 7.426 ) * ( 1 - 1 )
= 7.618 cm²
```

Area Available in Nozzle Wall Projecting Outward [A2]:

```
= ( 2 * Tlwp ) * ( tn - trn ) * fr2
= ( 2 * 22.5 ) * ( 12 - 4.213 ) * 1
= 3.504 cm²
```

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

```
= (Wo² - Ar Lost)*Fr3+((Wi-can/0.707)² - Ar Lost)*fr2 + Wp²*fr4
= (0.938 ) * 1 + (0 ) * 1 + 228.6² * 1
= 1.747 cm²
```

Area Available in Element, also see UG-37(h) [A5]:

```
= (min(Dp,DL)-(Nozzle OD))(min(tp,Tlwp,te)) * fr4 * 0.75
= ( 738 - 508 )15 * 1 * 0.75
= 25.875 cm²
```

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: D

Govrn. thk, tg = 15, tr = 4.213, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.351, Temp. Reduction = 77 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D            -47 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -48 °C
```

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

Govrn. thk, tg = 15, tr = 4.213, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.351, Temp. Reduction = 77 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D            -47 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -48 °C
```

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

Govrn. thk, tg = 15, tr = 4.213, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.351, Temp. Reduction = 77 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D            -47 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -48 °C
```

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

Govrn. thk, tg = 12, tr = 7.426, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.825, Temp. Reduction = 10 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D            -48 °C
```

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

Govrn. thk, tg = 12, tr = 7.426, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.825, Temp. Reduction = 10 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D            -48 °C

 Governing MDMT of the Nozzle                          :   -48 °C
 Governing MDMT of the Reinforcement Pad               :   -48 °C
 Governing MDMT of all the sub-joints of this Junction :   -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
 MDMT of ANSI B16.5/47 flange per Matl. Specification      -46 °C
 Flange MDMT with Temp reduction per UCS-66(i)(2)          -48 °C
 Flange MDMT with Temp reduction per UCS-66(i)(3)          -48 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
 Design Pressure/Ambient Rating = 23.02/51.10 = 0.451

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: M

```
 Intermediate Calc. for nozzle/shell Welds   Tmin      12.0000  mm.
 Intermediate Calc. for pad/shell Welds   TminPad      12.0000  mm.
```

Results Per UW-16.1:

```
                         Required Thickness    Actual Thickness
 Nozzle Weld            6.0000 = Min per Code 7.0700 = 0.7 * Wo mm.
 Pad Weld               6.0000 = 0.5*TminPad  6.3630 = 0.7 * Wp mm.
```

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

Weld Load [W]:
```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (35.94 - 7.618 + 2 * 12 * 1 *
     (1 * 9 - 7.426 ) )137.9 )
  = 395.76 kN
```

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

Weld Load [W1]:
```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 3.504 + 25.88 + 1.747 - 0 * 1 ) * 137.9
  = 429.20 kN
```

Weld Load [W2]:
```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 3.504 + 0 + 1 + ( 2.16 ) ) * 137.9
  = 91.89 kN
```

Weld Load [W3]:
```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 3.504 + 0 + 1.747 + 25.88 + ( 2.16 ) ) * 137.9
  = 458.99 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 508 * 10 * 0.49 * 137.9
  = 539. kN
```

Shear, Pad Element Weld [Spew]:
```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 738 * 9 * 0.49 * 137.9
  = 705. kN
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 248 ) * ( 15 - 3 ) * 0.7 * 137.9
  = 902. kN
```

Tension, Pad Groove Weld [Tpgw]:
```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 508 * 15 * 0.74 * 137.9
  = 1221. kN
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 508 * ( 12 - 3 ) * 0.74 * 137.9
  = 733. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 704.9 + 902.4 ) = 1607 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 539.1 + 1221 + 732.8 + 0 ) = 2493 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 704.9 + 732.8 + 0 ) = 1438 kN
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 1607 kN , must exceed W = 395 kN  or W1 = 429 kN
 Path 2-2 = 2493 kN , must exceed W = 395 kN  or W2 = 91 kN
 Path 3-3 = 1437 kN , must exceed W = 395 kN  or W3 = 458 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case       23.893  bar

 Nozzle is O.K. for the External Pressure                1.100  bar
```

The Drop for this Nozzle is : 40.8232 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 252.8232 mm.

Percent Elongation Calculations:

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


INPUT VALUES, Nozzle Description: A1 From : 20

Pressure for Reinforcement Calculations	P	23.000	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Cylindrical Shell	D	890.00	mm.
Design Length of Section	L	4148.3335	mm.
Shell Finished (Minimum) Thickness	t	12.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		500.00	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

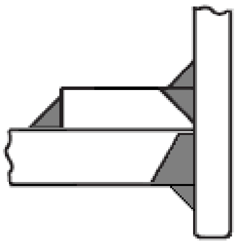
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm^2
Allowable Stress At Ambient	Sna	117.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		8.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	80	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	800.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N./mm^2
Diameter of Pad along vessel surface	Dp	379.0750	mm.
Thickness of Pad	te	12.0000	mm.
Weld leg size between Pad and Shell	Wp	10.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm.
Reinforcing Pad Width		80.0000	mm.
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

```
DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for  LIQID RECEIVER D-PK6101-2
Nozzle Calcs.: A1                      Nozl:    13    9:17pm   Feb 18,2022
```

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



Insert/Set-in Nozzle With Pad, with Inside projection

Reinforcement CALCULATION, Description: A1

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation              8.625  in.
 Actual Thickness Used in Calculation                     0.438  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (23*448)/(137.9*1-0.6*23)
  = 7.5487 mm.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (23*109.5)/(117.9*1+0.4*23)
  = 2.1205 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.6930 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)            Dl   405.7000  mm.
 Parallel to Vessel Wall, opening length              d   202.8500  mm.
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp    22.5000  mm.
 Normal to Vessel Wall, Inward                             12.7812  mm.
```

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

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

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

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

= 0.855

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	15.490	5.811	NA
Area in Shell	A1	2.910	6.690	NA
Area in Nozzle Wall	A2	2.305	2.855	NA
Area in Inward Nozzle	A3	1.117	1.117	NA
Area in Welds	A41+A42+A43	1.855	1.855	NA
Area in Element	A5	14.400	14.400	NA
TOTAL AREA AVAILABLE	Atot	22.588	26.917	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	300.2150	12.0000	mm.
Based on given Pad Diameter:	379.0750	6.0855	mm.
Based on Shell or Nozzle Thickness:	306.6952	11.1125	mm.

Area Required [A]:
```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (202.8*7.549*1+2*8.113*7.549*1*(1-0.855))
  = 15.490 cm²
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 202.8 ( 1 * 9 - 1 * 7.549 ) - 2 * 8.113
    ( 1 * 9 - 1 * 7.549 ) * ( 1 - 0.855 )
  = 2.910 cm²
```

Area Available in Nozzle Wall Projecting Outward [A2]:
```
  = ( 2 * Tlwp ) * ( tn - trn ) * fr2
  = ( 2 * 22.5 ) * ( 8.113 - 2.121 ) * 0.855
  = 2.305 cm²
```

Area Available in Inward Nozzle [A3]:
```
  = 2 * ti * min( h, Tl, 2.5 * ti) * fr2
  = 2 * 5.112 * ( 12.78 ) * 0.855
  = 1.117 cm²
```

Area Available in Welds [A41 + A42 + A43]:
```
  = Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
  = 10² * 0.855 + (0 )² * 0.855 + 10² * 1
  = 1.855 cm²
```

Area Available in Element, also see UG-37(h) [A5]:
```
  = (min(Dp,DL)-(Nozzle OD))(min(tp,Tlwp,te)) * fr4 * 0.75
  = ( 379.1 - 219.1 )12 * 1 * 0.75
  = 14.400 cm²
```

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

Wall Thickness for Internal/External pressures ta = 5.1205 mm.
Wall Thickness per UG16(b), tr16b = 4.5000 mm.

```
Wall Thickness, shell/head, internal pressure      trb1 = 10.5487 mm.
Wall Thickness                    tb1 = max(trb1, tr16b) = 10.5487 mm.
Wall Thickness, shell/head, external pressure      trb2 = 3.3576 mm.
Wall Thickness                    tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45                      tb3 = 10.1600 mm.
```

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 10.16, max( 10.55, 4.5 ) ]
  = 10.1600 mm.
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 5.121, 10.16 )
  = 10.1600 mm.
```

Available Nozzle Neck Thickness = 11.1125 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

Sustained :	50.5,	Allowable :	117.9 N./mm^2	Passed
Expansion :	0.0,	Allowable :	244.3 N./mm^2	Passed
Occasional :	13.8,	Allowable :	156.8 N./mm^2	Passed
Shear :	20.4,	Allowable :	82.5 N./mm^2	Passed

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

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

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

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

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

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

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

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

Govrn. thk, tg = 11.11, tr = 2.121, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.261, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C
```

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

Govrn. thk, tg = 12, tr = 7.549, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.839, Temp. Reduction = 9 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
```

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

Govrn. thk, tg = 11.11, tr = 2.121, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.261, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D           -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)        -104 °C

Governing MDMT of the Nozzle                         :  -104 °C
Governing MDMT of the Reinforcement Pad              :   -48 °C
Governing MDMT of all the sub-joints of this Junction :  -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification     -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)         -48 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)        -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 23.00/51.10 = 0.450

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: A1

```
Intermediate Calc. for nozzle/shell Welds   Tmin      8.1125  mm.
Intermediate Calc. for pad/shell Welds   TminPad      9.0000  mm.
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	5.6788 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm.
Pad Weld	4.5000 = 0.5*TminPad	7.0700 = 0.7 * Wp mm.

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

Weld Load [W]:
```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (15.49 - 2.91 + 2 * 8.113 * 0.855 *
     (1 * 9 - 7.549 ) )137.9 )
  = 176.24 kN
```

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

Weld Load [W1]:
```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 2.305 + 14.4 + 1.855 - 0 * 0.855 ) * 137.9
  = 255.93 kN
```

Weld Load [W2]:
```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 2.305 + 1.117 + 0.855 + ( 1.249 ) ) * 137.9
  = 76.20 kN
```

Weld Load [W3]:
```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 2.305 + 1.117 + 1.855 + 14.4 + ( 1.249 ) ) * 137.9
  = 288.55 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 219.1 * 10 * 0.49 * 117.9
  = 199. kN
```

Shear, Pad Element Weld [Spew]:
```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 379.1 * 10 * 0.49 * 137.9
  = 402. kN
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 105.5 ) * ( 11.11 - 3 ) * 0.7 * 117.9
  = 222. kN
```

Tension, Pad Groove Weld [Tpgw]:
```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 219.1 * 12 * 0.74 * 137.9
  = 421. kN
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 219.1 * ( 12 - 3 ) * 0.74 * 137.9
  = 316. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 402.3 + 221.9 ) = 624.2 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 198.8 + 421.4 + 316 + 0 ) = 936.2 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 402.3 + 316 + 0 ) = 718.3 kN
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 624 kN , must exceed W = 176 kN  or W1 = 255 kN
 Path 2-2 = 936 kN , must exceed W = 176 kN  or W2 = 76 kN
 Path 3-3 = 718 kN , must exceed W = 176 kN  or W3 = 288 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case       27.329  bar
```

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

```
 Nozzle is O.K. for the External Pressure                1.100  bar
```

The Drop for this Nozzle is : 13.6920 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 1012.0001 mm.

Input Echo, WRC107/537 Item 1, Description: A1 :

```
 Diameter Basis for Vessel                    Vbasis       ID
 Cylindrical or Spherical Vessel              Cylsph       Cylindrical
 Internal Corrosion Allowance                    Cas       3.0000  mm.
 Vessel Diameter                                  Dv     890.000  mm.
 Vessel Thickness                                 Tv      12.000  mm.

 Design Temperature                                       135.00  °C
 Vessel Material                                       SA-516 70
 Vessel Cold S.I. Allowable                      Smc      137.90  N./mm^2
 Vessel Hot  S.I. Allowable                      Smh      137.90  N./mm^2

 Attachment Type                                Type       Round
```

```
Diameter Basis for Nozzle                      Nbasis       OD
Corrosion Allowance for Nozzle                    Can      3.0000  mm.
Nozzle Diameter                                    Dn     219.075  mm.
Nozzle Thickness                                   Tn      11.113  mm.
Nozzle Material                                          SA-333 6
Nozzle Cold S.I. Allowable                       SNmc      117.90  N./mm^2
Nozzle Hot  S.I. Allowable                       SNmh      117.90  N./mm^2

Thickness of Reinforcing Pad                     Tpad      12.000  mm.
Diameter  of Reinforcing Pad                     Dpad     379.075  mm.

Design Internal Pressure                           Dp      23.000  bar
Include Pressure Thrust                                        No
```

External Forces and Moments in WRC 107/537 Convention:

```
Radial Load              (SUS)                      P         8.0  kN
Longitudinal Shear       (SUS)                     Vl         8.0  kN
Circumferential Shear    (SUS)                     Vc         8.0  kN
Circumferential Moment   (SUS)                     Mc      6800.0  N-m
Longitudinal Moment      (SUS)                     Ml      6800.0  N-m
Torsional Moment         (SUS)                     Mt      8400.0  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
Local Loads applied at end of Nozzle/Attachment                No
```

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

Stress Attenuation Diameter (for Insert Plates) per WRC 297:

```
  = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
  = 219.075 + 2 * 1.65 * sqrt( 452.5  ( 12.0 - 3.0 ) )
  = 429.668 mm.
```

WRC 107 Stress Calculation for SUStained loads:

```
Radial Load                                        P          8.0  kN
Circumferential Shear                             VC          8.0  kN
Longitudinal Shear                                VL          8.0  kN
Circumferential Moment                            MC       6800.0  N-m
Longitudinal Moment                               ML       6800.0  N-m
Torsional Moment                                  MT       8400.0  N-m

Dimensionless Parameters used :    Gamma =    21.83
```

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.209	4C	3.315	(A,B)
N(PHI) / (P/Rm)	0.209	3C	2.402	(C,D)
M(PHI) / (P)	0.209	2C1	0.050	(A,B)
M(PHI) / (P)	0.209	1C	0.080	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.209	3A	0.874	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.209	1A	0.087	(A,B,C,D)

N(PHI) / (ML/(Rm**2 * Beta))	0.209	3B	2.431	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.209	1B	0.033	(A,B,C,D)
N(x) / (P/Rm)	0.209	3C	2.402	(A,B)
N(x) / (P/Rm)	0.209	4C	3.315	(C,D)
M(x) / (P)	0.209	1C1	0.084	(A,B)
M(x) / (P)	0.209	2C	0.050	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.209	4A	1.433	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.209	2A	0.044	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.209	4B	0.826	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.209	2B	0.054	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-2.8	-2.8	-2.8	-2.8	-2.0	-2.0	-2.0	-2.0
Circ. Bend. P	-5.4	5.4	-5.4	5.4	-8.7	8.7	-8.7	8.7
Circ. Memb. MC	0.0	0.0	0.0	0.0	-6.4	-6.4	6.4	6.4
Circ. Memb. MC	0.0	0.0	0.0	0.0	-83.6	83.6	83.6	-83.6
Circ. Memb. ML	-17.9	-17.9	17.9	17.9	0.0	0.0	0.0	0.0
Circ. Bend. ML	-32.1	32.1	32.1	-32.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-58.2	16.9	41.8	-11.5	-100.8	83.9	79.3	-70.5
Long. Memb. P	-2.0	-2.0	-2.0	-2.0	-2.8	-2.8	-2.8	-2.8
Long. Bend. P	-9.1	9.1	-9.1	9.1	-5.5	5.5	-5.5	5.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-10.6	-10.6	10.6	10.6
Long. Bend. MC	0.0	0.0	0.0	0.0	-42.7	42.7	42.7	-42.7
Long. Memb. ML	-6.1	-6.1	6.1	6.1	0.0	0.0	0.0	0.0
Long. Bend. ML	-52.0	52.0	52.0	-52.0	0.0	0.0	0.0	0.0
Tot. Long. Str.	-69.2	53.0	47.0	-38.8	-61.5	34.9	45.0	-29.4
Shear VC	1.1	1.1	-1.1	-1.1	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.1	-1.1	1.1	1.1
Shear MT	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Tot. Shear	6.4	6.4	4.2	4.2	4.2	4.2	6.4	6.4
Str. Int.	72.1	54.1	49.3	39.4	101.2	84.2	80.5	71.4

Dimensionless Parameters used : Gamma = 50.28

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.367	4C	4.320	(A,B)
N(PHI) / (P/Rm)	0.367	3C	1.750	(C,D)
M(PHI) / (P)	0.367	2C1	0.009	(A,B)
M(PHI) / (P)	0.367	1C !	0.065	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.367	3A	1.360	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.367	1A	0.059	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.367	3B	2.531	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.367	1B	0.007	(A,B,C,D)
N(x) / (P/Rm)	0.367	3C	1.750	(A,B)
N(x) / (P/Rm)	0.367	4C	4.320	(C,D)

```
M(x)    / ( P )                      0.367   1C1        0.022   (A,B)
M(x)    / ( P )                      0.367   2C  !      0.033   (C,D)
N(x)    / ( MC/(Rm**2 * Beta) )      0.367   4A         4.848   (A,B,C,D)
M(x)    / ( MC/(Rm    * Beta) )      0.367   2A         0.023   (A,B,C,D)
N(x)    / ( ML/(Rm**2 * Beta) )      0.367   4B         1.484   (A,B,C,D)
M(x)    / ( ML/(Rm    * Beta) )      0.367   2B         0.010   (A,B,C,D)
```

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-8.5	-8.5	-8.5	-8.5	-3.4	-3.4	-3.4	-3.4
Circ. Bend.	P	-5.2	5.2	-5.2	5.2	-38.6	38.6	-38.6	38.6
Circ. Memb.	MC	0.0	0.0	0.0	0.0	-13.7	-13.7	13.7	13.7
Circ. Memb.	MC	0.0	0.0	0.0	0.0	-177.9	177.9	177.9	-177.9
Circ. Memb.	ML	-25.5	-25.5	25.5	25.5	0.0	0.0	0.0	0.0
Circ. Bend.	ML	-20.1	20.1	20.1	-20.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.		-59.3	-8.7	32.0	2.0	-233.7	199.4	149.5	-129.0
Long. Memb.	P	-3.4	-3.4	-3.4	-3.4	-8.5	-8.5	-8.5	-8.5
Long. Bend.	P	-13.2	13.2	-13.2	13.2	-19.8	19.8	-19.8	19.8
Long. Memb.	MC	0.0	0.0	0.0	0.0	-48.8	-48.8	48.8	48.8
Long. Bend.	MC	0.0	0.0	0.0	0.0	-70.3	70.3	70.3	-70.3
Long. Memb.	ML	-14.9	-14.9	14.9	14.9	0.0	0.0	0.0	0.0
Long. Bend.	ML	-31.0	31.0	31.0	-31.0	0.0	0.0	0.0	0.0
Tot. Long. Str.		-62.5	25.8	29.3	-6.3	-147.3	32.8	90.7	-10.1
Shear	VC	1.5	1.5	-1.5	-1.5	0.0	0.0	0.0	0.0
Shear	VL	0.0	0.0	0.0	0.0	-1.5	-1.5	1.5	1.5
Shear	MT	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Tot. Shear		5.6	5.6	2.6	2.6	2.6	2.6	5.6	5.6
Str. Int.		66.8	36.2	33.6	9.8	233.7	199.4	150.0	129.3

WRC 107/537 Stress Summations:

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

Type of Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm	(SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3
Circ. Pl	(SUS)	-20.7	-20.7	15.1	15.1	-8.4	-8.4	4.4	4.4
Circ. Q	(SUS)	-37.5	37.5	26.6	-26.6	-92.3	92.3	74.9	-74.9
Long. Pm	(SUS)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Long. Pl	(SUS)	-8.1	-8.1	4.1	4.1	-13.3	-13.3	7.8	7.8
Long. Q	(SUS)	-61.1	61.1	42.9	-42.9	-48.2	48.2	37.2	-37.2

Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.1	1.1	-1.1	-1.1	-1.1	-1.1	1.1	1.1
Shear Q (SUS)	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3
Pm+Pl (SUS)	27.4	29.7	63.1	65.4	39.6	41.9	52.4	54.7
Pm+Pl+Q (Total)	46.3	80.2	90.6	54.3	53.9	134.4	128.0	22.6

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	50.25	137.90	Passed
Pm+Pl (SUS)	65.43	206.85	Passed
Pm+Pl+Q (TOTAL)	134.37	413.70	Passed

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Circ. Pl (SUS)	-34.0	-34.0	17.0	17.0	-17.1	-17.1	10.3	10.3
Circ. Q (SUS)	-25.3	25.3	15.0	-15.0	-216.5	216.5	139.3	-139.3
Long. Pm (SUS)	56.7	56.7	56.7	56.7	56.7	56.7	56.7	56.7
Long. Pl (SUS)	-18.4	-18.4	11.5	11.5	-57.3	-57.3	40.3	40.3
Long. Q (SUS)	-44.2	44.2	17.8	-17.8	-90.1	90.1	50.4	-50.4
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.5	1.5	-1.5	-1.5	-1.5	-1.5	1.5	1.5
Shear Q (SUS)	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Pm+Pl (SUS)	79.5	81.8	130.4	132.7	96.9	99.2	123.7	126.0
Pm+Pl+Q (Total)	61.0	108.2	145.4	117.8	120.5	315.1	263.1	60.9

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	115.67	137.90	Passed
Pm+Pl (SUS)	132.69	206.85	Passed
Pm+Pl+Q (TOTAL)	315.10	413.70	Passed

INPUT VALUES, Nozzle Description: B From : 20

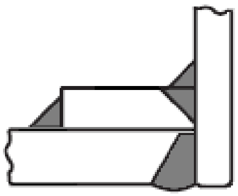
Pressure for Reinforcement Calculations	P	23.040	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Cylindrical Shell	D	890.00	mm.
Design Length of Section	L	4148.3335	mm.
Shell Finished (Minimum) Thickness	t	12.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		2000.00	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm^2
Allowable Stress At Ambient	Sna	117.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		180.00	deg
Diameter		8.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	80	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N./mm^2
Diameter of Pad along vessel surface	Dp	379.0750	mm.
Thickness of Pad	te	12.0000	mm.
Weld leg size between Pad and Shell	Wp	10.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm.
Reinforcing Pad Width		80.0000	mm.
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: B

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation               8.625  in.
 Actual Thickness Used in Calculation                      0.438  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
   = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
   = (23.04*448)/(137.9*1-0.6*23.04)
   = 7.5621 mm.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
   = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
   = (23.04*109.5)/(117.9*1+0.4*23.04)
   = 2.1242 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.6930 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)            Dl   405.7000  mm.
 Parallel to Vessel Wall, opening length              d   202.8500  mm.
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp    22.5000  mm.
```

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

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

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

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

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

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	15.518	5.811	NA
Area in Shell	A1	2.883	6.690	NA
Area in Nozzle Wall	A2	2.304	2.855	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	1.855	1.855	NA
Area in Element	A5	19.200	19.200	NA
TOTAL AREA AVAILABLE	Atot	26.242	30.600	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	289.7040	12.0000	mm.
Based on given Pad Diameter:	379.0750	5.2972	mm.
Based on Shell or Nozzle Thickness:	295.3448	11.1125	mm.

Area Required [A]:
```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (202.8*7.562*1+2*8.113*7.562*1*(1-0.855))
  = 15.518 cm²
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 202.8 ( 1 * 9 - 1 * 7.562 ) - 2 * 8.113
    ( 1 * 9 - 1 * 7.562 ) * ( 1 - 0.855 )
  = 2.883 cm²
```

Area Available in Nozzle Wall Projecting Outward [A2]:
```
  = ( 2 * Tlwp ) * ( tn - trn ) * fr2
  = ( 2 * 22.5 ) * ( 8.113 - 2.124 ) * 0.855
  = 2.304 cm²
```

Area Available in Welds [A41 + A42 + A43]:
```
  = Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
  = 10² * 0.855 + (0 )² * 0.855 + 10² * 1
  = 1.855 cm²
```

Area Available in Element [A5]:
```
  = (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
  = ( 379.1 - 219.1 ) * 12 * 1
  = 19.200 cm²
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures           ta = 5.1242 mm.
Wall Thickness per UG16(b),                           tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure          trb1 = 10.5621 mm.
Wall Thickness                  tb1 = max(trb1, tr16b) = 10.5621 mm.
Wall Thickness, shell/head, external pressure          trb2 = 3.3576 mm.
Wall Thickness                  tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45                          tb3 = 10.1600 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 10.16, max( 10.56, 4.5 ) ]
  = 10.1600 mm.
```

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

```
  = max( ta, tb )
  = max( 5.124, 10.16 )
  = 10.1600 mm.
```

Available Nozzle Neck Thickness = 11.1125 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
 Sustained  :     50.5,  Allowable :    117.9 N./mm^2  Passed
 Expansion  :      0.0,  Allowable :    244.3 N./mm^2  Passed
 Occasional :     13.9,  Allowable :    156.8 N./mm^2  Passed
 Shear      :     20.4,  Allowable :     82.5 N./mm^2  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

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

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

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

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

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

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

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

Govrn. thk, tg = 11.11, tr = 2.124, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.262, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C
```

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

Govrn. thk, tg = 12, tr = 7.562, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.84, Temp. Reduction = 9 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
```

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

Govrn. thk, tg = 11.11, tr = 2.124, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.262, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C

Governing MDMT of the Nozzle                           :   -104 °C
Governing MDMT of the Reinforcement Pad                :    -48 °C
Governing MDMT of all the sub-joints of this Junction  :    -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification        -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)            -48 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)           -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
 Design Pressure/Ambient Rating = 23.04/51.10 = 0.451

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: B

```
Intermediate Calc. for nozzle/shell Welds    Tmin      8.1125  mm.
Intermediate Calc. for pad/shell Welds    TminPad      9.0000  mm.
```

Results Per UW-16.1:

```
                      Required Thickness     Actual Thickness
Nozzle Weld          5.6788 = 0.7 * tmin.   7.0700 = 0.7 * Wo mm.
Pad Weld             4.5000 = 0.5*TminPad   7.0700 = 0.7 * Wp mm.
```

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

Weld Load [W]:
```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (15.52 - 2.883 + 2 * 8.113 * 0.855 *
     (1 * 9 - 7.562 ) )137.9 )
  = 176.97 kN
```

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

Weld Load [W1]:
```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 2.304 + 19.2 + 1.855 - 0 * 0.855 ) * 137.9
  = 322.09 kN
```

Weld Load [W2]:
```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 2.304 + 0 + 0.855 + ( 1.249 ) ) * 137.9
  = 60.77 kN
```

Weld Load [W3]:
```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 2.304 + 0 + 1.855 + 19.2 + ( 1.249 ) ) * 137.9
  = 339.31 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 219.1 * 10 * 0.49 * 117.9
  = 199. kN
```

Shear, Pad Element Weld [Spew]:

```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 379.1 * 10 * 0.49 * 137.9
  = 402. kN
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 105.5 ) * ( 11.11 - 3 ) * 0.7 * 117.9
  = 222. kN
```

Tension, Pad Groove Weld [Tpgw]:

```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 219.1 * 12 * 0.74 * 137.9
  = 421. kN
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 219.1 * ( 12 - 3 ) * 0.74 * 137.9
  = 316. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 402.3 + 221.9 ) = 624.2 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 198.8 + 421.4 + 316 + 0 ) = 936.2 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 402.3 + 316 + 0 ) = 718.3 kN
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 624 kN , must exceed W = 176 kN  or W1 = 322 kN
 Path 2-2 = 936 kN , must exceed W = 176 kN  or W2 = 60 kN
 Path 3-3 = 718 kN , must exceed W = 176 kN  or W3 = 339 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case       27.369  bar
```

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

```
 Nozzle is O.K. for the External Pressure                1.100  bar
```

The Drop for this Nozzle is : 13.6920 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 225.6920 mm.

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

```
 Diameter Basis for Vessel                    Vbasis       ID
 Cylindrical or Spherical Vessel              Cylsph       Cylindrical
 Internal Corrosion Allowance                    Cas       3.0000  mm.
 Vessel Diameter                                  Dv     890.000  mm.
 Vessel Thickness                                 Tv      12.000  mm.

 Design Temperature                                       135.00  °C
 Vessel Material                                       SA-516 70
 Vessel Cold S.I. Allowable                      Smc      137.90  N./mm^2
 Vessel Hot  S.I. Allowable                      Smh      137.90  N./mm^2

 Attachment Type                                Type       Round

 Diameter Basis for Nozzle                    Nbasis       OD
 Corrosion Allowance for Nozzle                  Can       3.0000  mm.
 Nozzle Diameter                                  Dn     219.075  mm.
 Nozzle Thickness                                 Tn      11.113  mm.
 Nozzle Material                                         SA-333 6
```

```
 Nozzle Cold S.I. Allowable                   SNmc      117.90  N./mm^2
 Nozzle Hot  S.I. Allowable                   SNmh      117.90  N./mm^2

 Thickness of Reinforcing Pad                 Tpad      12.000  mm.
 Diameter  of Reinforcing Pad                 Dpad     379.075  mm.

 Design Internal Pressure                       Dp      23.040  bar
 Include Pressure Thrust                                    No
```

External Forces and Moments in WRC 107/537 Convention:

```
 Radial Load              (SUS)                 P          8.0  kN
 Longitudinal Shear       (SUS)                Vl          8.0  kN
 Circumferential Shear    (SUS)                Vc          8.0  kN
 Circumferential Moment   (SUS)                Mc       6800.0  N-m
 Longitudinal Moment      (SUS)                Ml       6800.0  N-m
 Torsional Moment         (SUS)                Mt       8400.0  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
 Local Loads applied at end of Nozzle/Attachment            No
```

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

Stress Attenuation Diameter (for Insert Plates) per WRC 297:

```
   = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
   = 219.075 + 2 * 1.65 * sqrt( 452.5  ( 12.0 - 3.0 ) )
   = 429.668 mm.
```

WRC 107 Stress Calculation for SUStained loads:

```
 Radial Load                                    P          8.0  kN
 Circumferential Shear                         VC          8.0  kN
 Longitudinal Shear                            VL          8.0  kN
 Circumferential Moment                        MC       6800.0  N-m
 Longitudinal Moment                           ML       6800.0  N-m
 Torsional Moment                              MT       8400.0  N-m

 Dimensionless Parameters used :    Gamma =    21.83
```

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

```
 -------------------------------------------------------------------
 Curves read for 1979                 Beta  Figure     Value    Location
 -------------------------------------------------------------------
 N(PHI) / ( P/Rm )                   0.209   4C        3.315    (A,B)
 N(PHI) / ( P/Rm )                   0.209   3C        2.402    (C,D)
 M(PHI) / ( P )                      0.209   2C1       0.050    (A,B)
 M(PHI) / ( P )                      0.209   1C        0.080    (C,D)
 N(PHI) / ( MC/(Rm**2 * Beta) )      0.209   3A        0.874    (A,B,C,D)
 M(PHI) / ( MC/(Rm    * Beta) )      0.209   1A        0.087    (A,B,C,D)
 N(PHI) / ( ML/(Rm**2 * Beta) )      0.209   3B        2.431    (A,B,C,D)
 M(PHI) / ( ML/(Rm    * Beta) )      0.209   1B        0.033    (A,B,C,D)

 N(x)   / ( P/Rm )                   0.209   3C        2.402    (A,B)
 N(x)   / ( P/Rm )                   0.209   4C        3.315    (C,D)
 M(x)   / ( P )                      0.209   1C1       0.084    (A,B)
```

```
M(x)   / ( P )                    0.209   2C        0.050   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )    0.209   4A        1.433   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )    0.209   2A        0.044   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )    0.209   4B        0.826   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )    0.209   2B        0.054   (A,B,C,D)
```

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
	Stress Intensity Values at							
Circ. Memb. P	-2.8	-2.8	-2.8	-2.8	-2.0	-2.0	-2.0	-2.0
Circ. Bend. P	-5.4	5.4	-5.4	5.4	-8.7	8.7	-8.7	8.7
Circ. Memb. MC	0.0	0.0	0.0	0.0	-6.4	-6.4	6.4	6.4
Circ. Memb. MC	0.0	0.0	0.0	0.0	-83.6	83.6	83.6	-83.6
Circ. Memb. ML	-17.9	-17.9	17.9	17.9	0.0	0.0	0.0	0.0
Circ. Bend. ML	-32.1	32.1	32.1	-32.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-58.2	16.9	41.8	-11.5	-100.8	83.9	79.3	-70.5
Long. Memb. P	-2.0	-2.0	-2.0	-2.0	-2.8	-2.8	-2.8	-2.8
Long. Bend. P	-9.1	9.1	-9.1	9.1	-5.5	5.5	-5.5	5.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-10.6	-10.6	10.6	10.6
Long. Bend. MC	0.0	0.0	0.0	0.0	-42.7	42.7	42.7	-42.7
Long. Memb. ML	-6.1	-6.1	6.1	6.1	0.0	0.0	0.0	0.0
Long. Bend. ML	-52.0	52.0	52.0	-52.0	0.0	0.0	0.0	0.0
Tot. Long. Str.	-69.2	53.0	47.0	-38.8	-61.5	34.9	45.0	-29.4
Shear VC	1.1	1.1	-1.1	-1.1	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.1	-1.1	1.1	1.1
Shear MT	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Tot. Shear	6.4	6.4	4.2	4.2	4.2	4.2	6.4	6.4
Str. Int.	72.1	54.1	49.3	39.4	101.2	84.2	80.5	71.4

Dimensionless Parameters used : Gamma = 50.28

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.367	4C	4.320	(A,B)
N(PHI) / (P/Rm)	0.367	3C	1.750	(C,D)
M(PHI) / (P)	0.367	2C1	0.009	(A,B)
M(PHI) / (P)	0.367	1C !	0.065	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.367	3A	1.360	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.367	1A	0.059	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.367	3B	2.531	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.367	1B	0.007	(A,B,C,D)
N(x) / (P/Rm)	0.367	3C	1.750	(A,B)
N(x) / (P/Rm)	0.367	4C	4.320	(C,D)
M(x) / (P)	0.367	1C1	0.022	(A,B)
M(x) / (P)	0.367	2C !	0.033	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.367	4A	4.848	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.367	2A	0.023	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.367	4B	1.484	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.367	2B	0.010	(A,B,C,D)

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-8.5	-8.5	-8.5	-8.5	-3.4	-3.4	-3.4	-3.4
Circ. Bend. P	-5.2	5.2	-5.2	5.2	-38.6	38.6	-38.6	38.6
Circ. Memb. MC	0.0	0.0	0.0	0.0	-13.7	-13.7	13.7	13.7
Circ. Memb. MC	0.0	0.0	0.0	0.0	-177.9	177.9	177.9	-177.9
Circ. Memb. ML	-25.5	-25.5	25.5	25.5	0.0	0.0	0.0	0.0
Circ. Bend. ML	-20.1	20.1	20.1	-20.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-59.3	-8.7	32.0	2.0	-233.7	199.4	149.5	-129.0
Long. Memb. P	-3.4	-3.4	-3.4	-3.4	-8.5	-8.5	-8.5	-8.5
Long. Bend. P	-13.2	13.2	-13.2	13.2	-19.8	19.8	-19.8	19.8
Long. Memb. MC	0.0	0.0	0.0	0.0	-48.8	-48.8	48.8	48.8
Long. Bend. MC	0.0	0.0	0.0	0.0	-70.3	70.3	70.3	-70.3
Long. Memb. ML	-14.9	-14.9	14.9	14.9	0.0	0.0	0.0	0.0
Long. Bend. ML	-31.0	31.0	31.0	-31.0	0.0	0.0	0.0	0.0
Tot. Long. Str.	-62.5	25.8	29.3	-6.3	-147.3	32.8	90.7	-10.1
Shear VC	1.5	1.5	-1.5	-1.5	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.5	-1.5	1.5	1.5
Shear MT	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Tot. Shear	5.6	5.6	2.6	2.6	2.6	2.6	5.6	5.6
Str. Int.	66.8	36.2	33.6	9.8	233.7	199.4	150.0	129.3

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3
Circ. Pl (SUS)	-20.7	-20.7	15.1	15.1	-8.4	-8.4	4.4	4.4
Circ. Q (SUS)	-37.5	37.5	26.6	-26.6	-92.3	92.3	74.9	-74.9
Long. Pm (SUS)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Long. Pl (SUS)	-8.1	-8.1	4.1	4.1	-13.3	-13.3	7.8	7.8
Long. Q (SUS)	-61.1	61.1	42.9	-42.9	-48.2	48.2	37.2	-37.2
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.1	1.1	-1.1	-1.1	-1.1	-1.1	1.1	1.1
Shear Q (SUS)	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3
Pm+Pl (SUS)	27.5	29.8	63.2	65.5	39.6	41.9	52.5	54.8

Pm+Pl+Q (Total)	46.3	80.2	90.7	54.3	53.8	134.5	128.1	22.5

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	50.34	137.90	Passed
Pm+Pl (SUS)	65.52	206.85	Passed
Pm+Pl+Q (TOTAL)	134.46	413.70	Passed

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	113.6	115.9	113.6	115.9	113.6	115.9	113.6	115.9
Circ. Pl (SUS)	-34.0	-34.0	17.0	17.0	-17.1	-17.1	10.3	10.3
Circ. Q (SUS)	-25.3	25.3	15.0	-15.0	-216.5	216.5	139.3	-139.3
Long. Pm (SUS)	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
Long. Pl (SUS)	-18.4	-18.4	11.5	11.5	-57.3	-57.3	40.3	40.3
Long. Q (SUS)	-44.2	44.2	17.8	-17.8	-90.1	90.1	50.4	-50.4
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.5	1.5	-1.5	-1.5	-1.5	-1.5	1.5	1.5
Shear Q (SUS)	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Pm (SUS)	113.6	115.9	113.6	115.9	113.6	115.9	113.6	115.9
Pm+Pl (SUS)	79.7	82.0	130.6	132.9	97.0	99.3	123.9	126.2
Pm+Pl+Q (Total)	61.1	108.4	145.6	118.0	120.3	315.3	263.3	60.8

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	115.87	137.90	Passed
Pm+Pl (SUS)	132.89	206.85	Passed
Pm+Pl+Q (TOTAL)	315.30	413.70	Passed

INPUT VALUES, Nozzle Description: A2 From : 20

Pressure for Reinforcement Calculations	P	23.000	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Cylindrical Shell	D	890.00	mm.
Design Length of Section	L	4148.3335	mm.
Shell Finished (Minimum) Thickness	t	12.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		3300.00	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

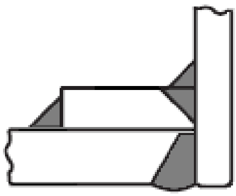
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm^2
Allowable Stress At Ambient	Sna	117.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N./mm^2
Diameter of Pad along vessel surface	Dp	160.3250	mm.
Thickness of Pad	te	12.0000	mm.
Weld leg size between Pad and Shell	Wp	10.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm.
Reinforcing Pad Width		50.0000	mm.
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

```
DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for  LIQID RECEIVER D-PK6101-2
Nozzle Calcs.: A2                        Nozl:    15    9:17pm  Feb 18,2022
```

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



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

Reinforcement CALCULATION, Description: A2

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation             2.375  in.
 Actual Thickness Used in Calculation                    0.301  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (23*448)/(137.9*1-0.6*23)
  = 7.5487 mm.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (23*30.16)/(117.9*1+0.4*23)
  = 0.5839 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.3261 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)            Dl   102.0684  mm.
 Parallel to Vessel Wall, opening length              d    51.0342  mm.
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp    22.5000  mm.
```

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

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

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

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

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

= min(0.855, 1)
= 0.855

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	3.954	1.483	NA
Area in Shell	A1	0.721	1.658	NA
Area in Nozzle Wall	A2	1.563	1.662	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.855	0.855	NA
Area in Element	A5	5.009	5.009	NA
TOTAL AREA AVAILABLE	Atot	8.148	9.184	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	67.1197	12.0000	mm.
Based on given Pad Diameter:	160.3250	1.9533	mm.
Based on Shell or Nozzle Thickness:	70.9898	7.6454	mm.

Area Required [A]:
= (d * tr*F + 2 * tn * tr*F * (1-fr1)) UG-37(c)
= (51.03*7.549*1+2*4.645*7.549*1*(1-0.855))
= 3.954 cm²

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
= d(E1*t - F*tr) - 2 * tn(E1*t - F*tr) * (1 - fr1)
= 51.03 (1 * 9 - 1 * 7.549) - 2 * 4.645
(1 * 9 - 1 * 7.549) * (1 - 0.855)
= 0.721 cm²

Area Available in Nozzle Wall Projecting Outward [A2]:
= (2 * Tlwp) * (tn - trn) * fr2
= (2 * 22.5) * (4.645 - 0.584) * 0.855
= 1.563 cm²

Area Available in Welds [A41 + A42 + A43]:
= Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
= 10² * 0.855 + (0)² * 0.855 + 0² * 1
= 0.855 cm²

Area Available in Element [A5]:
= (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
= (102.1 - 60.33) * 12 * 1
= 5.009 cm²

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

Wall Thickness for Internal/External pressures	ta =	3.5839 mm.
Wall Thickness per UG16(b),	tr16b =	4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 =	10.5487 mm.
Wall Thickness	tb1 = max(trb1, tr16b) =	10.5487 mm.
Wall Thickness, shell/head, external pressure	trb2 =	3.3576 mm.
Wall Thickness	tb2 = max(trb2, tr16b) =	4.5000 mm.

```
 Wall Thickness per table UG-45                     tb3 = 6.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 6.42, max( 10.55, 4.5 ) ]
  = 6.4200 mm.
```

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

```
  = max( ta, tb )
  = max( 3.584, 6.42 )
  = 6.4200 mm.
```

Available Nozzle Neck Thickness = 7.6454 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
 Sustained  :     62.0,  Allowable :    117.9 N./mm^2  Passed
 Expansion  :      0.0,  Allowable :    232.7 N./mm^2  Passed
 Occasional :      5.8,  Allowable :    156.8 N./mm^2  Passed
 Shear      :     33.9,  Allowable :     82.5 N./mm^2  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

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

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

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

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

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

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

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

Govrn. thk, tg = 7.645, tr = 0.584, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C
```

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

Govrn. thk, tg = 12, tr = 7.549, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.839, Temp. Reduction = 9 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
```

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

Govrn. thk, tg = 7.645, tr = 0.584, c = 3 mm., E* = 1

```
DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for  LIQID RECEIVER D-PK6101-2
Nozzle Calcs.: A2                        Nozl:    15    9:17pm  Feb 18,2022
```

Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C

Governing MDMT of the Nozzle                             :  -104 °C
Governing MDMT of the Reinforcement Pad                  :   -48 °C
Governing MDMT of all the sub-joints of this Junction    :   -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification        -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)            -48 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)           -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 23.00/51.10 = 0.450
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: A2

```
Intermediate Calc. for nozzle/shell Welds   Tmin       4.6454  mm.
Intermediate Calc. for pad/shell Welds   TminPad       9.0000  mm.
```

Results Per UW-16.1:

```
                       Required Thickness    Actual Thickness
Nozzle Weld           3.2518 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
Pad Weld              4.5000 = 0.5*TminPad  7.0700 = 0.7 * Wp mm.
```

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

Weld Load [W]:

```
 = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
 = max( 0, (3.954 - 0.721 + 2 * 4.645 * 0.855 *
    (1 * 9 - 7.549 ) )137.9 )
 = 46.17 kN
```

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

Weld Load [W1]:

```
 = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
 = ( 1.563 + 5.009 + 0.855 - 0 * 0.855 ) * 137.9
 = 102.41 kN
```

Weld Load [W2]:

```
 = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
 = ( 1.563 + 0 + 0.855 + ( 0.715 ) ) * 137.9
 = 43.19 kN
```

Weld Load [W3]:

```
 = (A2+A3+A4+A5+(2*tn*t*fr1))*S
 = ( 1.563 + 0 + 0.855 + 5.009 + ( 0.715 ) ) * 137.9
 = 112.27 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
 = (pi/2) * Dlo * Wo * 0.49 * Snw
 = ( 3.142/2.0 ) * 60.33 * 10 * 0.49 * 117.9
 = 55. kN
```

Shear, Pad Element Weld [Spew]:
```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 160.3 * 10 * 0.49 * 137.9
  = 170. kN
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 27.84 ) * ( 7.645 - 3 ) * 0.7 * 117.9
  = 34. kN
```

Tension, Pad Groove Weld [Tpgw]:
```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 60.33 * 12 * 0.74 * 137.9
  = 116. kN
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 60.33 * ( 12 - 3 ) * 0.74 * 137.9
  = 87. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 170.2 + 33.53 ) = 203.7 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 54.74 + 116 + 87.02 + 0 ) = 257.8 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 170.2 + 87.02 + 0 ) = 257.2 kN
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 203 kN , must exceed W = 46 kN  or W1 = 102 kN
 Path 2-2 = 257 kN , must exceed W = 46 kN  or W2 = 43 kN
 Path 3-3 = 257 kN , must exceed W = 46 kN  or W3 = 112 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case       27.329   bar
```

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

```
 Nozzle is O.K. for the External Pressure                1.100   bar
```

The Drop for this Nozzle is : 1.0234 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 213.0234 mm.

Input Echo, WRC107/537 Item 1, Description: A2 :

```
 Diameter Basis for Vessel                    Vbasis       ID
 Cylindrical or Spherical Vessel              Cylsph       Cylindrical
 Internal Corrosion Allowance                    Cas       3.0000  mm.
 Vessel Diameter                                  Dv     890.000  mm.
 Vessel Thickness                                 Tv       12.000  mm.

 Design Temperature                                        135.00   °C
 Vessel Material                                        SA-516 70
 Vessel Cold S.I. Allowable                      Smc       137.90  N./mm^2
 Vessel Hot  S.I. Allowable                      Smh       137.90  N./mm^2

 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        7.645  mm.
 Nozzle Material                                         SA-333 6
 Nozzle Cold S.I. Allowable                      SNmc      117.90  N./mm^2
 Nozzle Hot  S.I. Allowable                      SNmh      117.90  N./mm^2

 Thickness of Reinforcing Pad                    Tpad      12.000  mm.
 Diameter  of Reinforcing Pad                    Dpad     160.325  mm.

 Design Internal Pressure                          Dp      23.000  bar
 Include Pressure Thrust                                       No
```

External Forces and Moments in WRC 107/537 Convention:

```
 Radial Load             (SUS)                      P         2.0  kN
 Longitudinal Shear      (SUS)                     Vl         2.0  kN
 Circumferential Shear   (SUS)                     Vc         2.0  kN
 Circumferential Moment  (SUS)                     Mc       400.0  N-m
 Longitudinal Moment     (SUS)                     Ml       400.0  N-m
 Torsional Moment        (SUS)                     Mt       500.0  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
 Local Loads applied at end of Nozzle/Attachment               No
```

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

Stress Attenuation Diameter (for Insert Plates) per WRC 297:

```
  = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
  = 60.325 + 2 * 1.65 * sqrt( 452.5 ( 12.0 - 3.0 ) )
  = 270.918 mm.
```

WRC 107 Stress Calculation for SUStained loads:

```
 Radial Load                                        P         2.0  kN
 Circumferential Shear                             VC         2.0  kN
 Longitudinal Shear                                VL         2.0  kN
 Circumferential Moment                            MC       400.0  N-m
 Longitudinal Moment                               ML       400.0  N-m
 Torsional Moment                                  MT       500.0  N-m

 Dimensionless Parameters used :   Gamma =   21.83
```

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

```
 -------------------------------------------------------------------
 Curves read for 1979                Beta  Figure     Value   Location
 -------------------------------------------------------------------
 N(PHI) / ( P/Rm )                  0.058   4C         4.229   (A,B)
 N(PHI) / ( P/Rm )                  0.058   3C         4.165   (C,D)
 M(PHI) / ( P )                     0.058   2C1        0.168   (A,B)
 M(PHI) / ( P )                     0.058   1C         0.202   (C,D)
 N(PHI) / ( MC/(Rm**2 * Beta) )     0.058   3A         0.246   (A,B,C,D)
 M(PHI) / ( MC/(Rm    * Beta) )     0.058   1A         0.104   (A,B,C,D)
 N(PHI) / ( ML/(Rm**2 * Beta) )     0.058   3B         0.967   (A,B,C,D)
 M(PHI) / ( ML/(Rm    * Beta) )     0.058   1B         0.060   (A,B,C,D)

 N(x)   / ( P/Rm )                  0.058   3C         4.165   (A,B)
```

N(x) / (P/Rm)	0.058	4C	4.229	(C,D)
M(x) / (P)	0.058	1C1	0.207	(A,B)
M(x) / (P)	0.058	2C	0.166	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.058	4A	0.309	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.058	2A	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.058	4B	0.238	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.058	2B	0.099	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Circ. Bend. P	-4.6	4.6	-4.6	4.6	-5.5	5.5	-5.5	5.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-0.4	-0.4	0.4	0.4
Circ. Memb. MC	0.0	0.0	0.0	0.0	-21.4	21.4	21.4	-21.4
Circ. Memb. ML	-1.5	-1.5	1.5	1.5	0.0	0.0	0.0	0.0
Circ. Bend. ML	-12.3	12.3	12.3	-12.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-19.3	14.5	8.4	-7.1	-28.2	25.7	15.4	-16.4
Long. Memb. P	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Long. Bend. P	-5.6	5.6	-5.6	5.6	-4.5	4.5	-4.5	4.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-0.5	-0.5	0.5	0.5
Long. Bend. MC	0.0	0.0	0.0	0.0	-12.9	12.9	12.9	-12.9
Long. Memb. ML	-0.4	-0.4	0.4	0.4	0.0	0.0	0.0	0.0
Long. Bend. ML	-20.5	20.5	20.5	-20.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	-27.4	24.9	14.3	-15.3	-18.8	16.1	8.0	-8.8
Shear VC	1.0	1.0	-1.0	-1.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.0	-1.0	1.0	1.0
Shear MT	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Tot. Shear	5.2	5.2	3.2	3.2	3.2	3.2	5.2	5.2
Str. Int.	29.9	27.0	15.7	16.4	29.1	26.6	18.1	19.0

Dimensionless Parameters used : Gamma = 50.28

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.155	4C	7.575	(A,B)
N(PHI) / (P/Rm)	0.155	3C	5.538	(C,D)
M(PHI) / (P)	0.155	2C1	0.044	(A,B)
M(PHI) / (P)	0.155	1C !	0.077	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.155	3A	2.036	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.155	1A	0.079	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.155	3B	5.450	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.155	1B	0.030	(A,B,C,D)
N(x) / (P/Rm)	0.155	3C	5.538	(A,B)
N(x) / (P/Rm)	0.155	4C	7.575	(C,D)
M(x) / (P)	0.155	1C1	0.080	(A,B)
M(x) / (P)	0.155	2C !	0.044	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.155	4A	3.512	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.155	2A	0.040	(A,B,C,D)

N(x)	/ (ML/(Rm**2 * Beta))	0.155	4B	1.955	(A,B,C,D)
M(x)	/ (ML/(Rm * Beta))	0.155	2B	0.042	(A,B,C,D)

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-3.7	-3.7	-3.7	-3.7	-2.7	-2.7	-2.7	-2.7
Circ. Bend. P	-6.5	6.5	-6.5	6.5	-11.5	11.5	-11.5	11.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-2.8	-2.8	2.8	2.8
Circ. Memb. MC	0.0	0.0	0.0	0.0	-33.4	33.4	33.4	-33.4
Circ. Memb. ML	-7.6	-7.6	7.6	7.6	0.0	0.0	0.0	0.0
Circ. Bend. ML	-12.6	12.6	12.6	-12.6	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-30.5	7.8	10.0	-2.2	-50.5	39.3	22.1	-21.8
Long. Memb. P	-2.7	-2.7	-2.7	-2.7	-3.7	-3.7	-3.7	-3.7
Long. Bend. P	-11.9	11.9	-11.9	11.9	-6.5	6.5	-6.5	6.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-4.9	-4.9	4.9	4.9
Long. Bend. MC	0.0	0.0	0.0	0.0	-16.7	16.7	16.7	-16.7
Long. Memb. ML	-2.7	-2.7	2.7	2.7	0.0	0.0	0.0	0.0
Long. Bend. ML	-17.7	17.7	17.7	-17.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	-35.1	24.2	5.8	-5.8	-31.8	14.6	11.5	-9.1
Shear VC	0.9	0.9	-0.9	-0.9	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.9	-0.9	0.9	0.9
Shear MT	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Tot. Shear	2.3	2.3	0.5	0.5	0.5	0.5	2.3	2.3
Str. Int.	36.0	24.5	10.1	5.9	50.5	39.3	22.6	22.2

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3
Circ. Pl (SUS)	-2.4	-2.4	0.6	0.6	-1.3	-1.3	-0.5	-0.5
Circ. Q (SUS)	-16.9	16.9	7.7	-7.7	-26.9	26.9	15.9	-15.9
Long. Pm (SUS)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Long. Pl (SUS)	-1.2	-1.2	-0.5	-0.5	-1.4	-1.4	-0.4	-0.4
Long. Q (SUS)	-26.1	26.1	14.8	-14.8	-17.4	17.4	8.4	-8.4
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.0	1.0	-1.0	-1.0	-1.0	-1.0	1.0	1.0
Shear Q (SUS)	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3

Pm+Pl (SUS)	45.6	47.9	48.6	50.9	46.7	49.0	47.5	49.8
Pm+Pl+Q (Total)	33.7	66.2	56.9	43.4	20.4	76.2	64.2	35.2

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	50.25	137.90	Passed
Pm+Pl (SUS)	50.93	206.85	Passed
Pm+Pl+Q (TOTAL)	76.20	413.70	Passed

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Circ. Pl (SUS)	-11.3	-11.3	3.9	3.9	-5.6	-5.6	0.1	0.1
Circ. Q (SUS)	-19.1	19.1	6.1	-6.1	-44.9	44.9	22.0	-22.0
Long. Pm (SUS)	56.7	56.7	56.7	56.7	56.7	56.7	56.7	56.7
Long. Pl (SUS)	-5.5	-5.5	0.0	0.0	-8.6	-8.6	1.2	1.2
Long. Q (SUS)	-29.7	29.7	5.8	-5.8	-23.2	23.2	10.3	-10.3
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.9	0.9	-0.9	-0.9	-0.9	-0.9	0.9	0.9
Shear Q (SUS)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Pm+Pl (SUS)	102.0	104.3	117.3	119.6	107.8	110.1	113.5	115.8
Pm+Pl+Q (Total)	83.0	123.6	123.4	113.4	62.9	155.0	135.5	93.9

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	115.67	137.90	Passed
Pm+Pl (SUS)	119.59	206.85	Passed
Pm+Pl+Q (TOTAL)	155.00	413.70	Passed

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Nozzle Calcs.: PT Nozl: 16 9:17pm Feb 18,2022

INPUT VALUES, Nozzle Description: PT From : 20

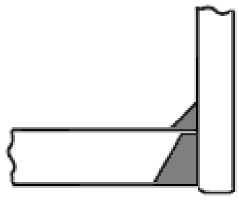
Pressure for Reinforcement Calculations	P	23.000	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Cylindrical Shell	D	890.00	mm.
Design Length of Section	L	4148.3335	mm.
Shell Finished (Minimum) Thickness	t	12.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1750.00	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm^2
Allowable Stress At Ambient	Sna	117.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		1.5000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	XXS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	11.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: PT

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation             1.900  in.
 Actual Thickness Used in Calculation                    0.350  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
   = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
   = (23*448)/(137.9*1-0.6*23)
   = 7.5487 mm.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
   = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
   = (23*24.13)/(117.9*1+0.4*23)
   = 0.4671 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2542 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)           Dl    72.9600  mm.
 Parallel to Vessel Wall, opening length             d    36.4800  mm.
 Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    14.7250  mm.
```

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

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

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

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	2.883	1.081	NA
Area in Shell	A1	0.505	1.160	NA
Area in Nozzle Wall	A2	1.365	1.419	NA

Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	1.035	1.035	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	2.905	3.614	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:
```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (36.48*7.549*1+2*5.89*7.549*1*(1-0.855))
  = 2.883 cm²
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 36.48 ( 1 * 9 - 1 * 7.549 ) - 2 * 5.89
    ( 1 * 9 - 1 * 7.549 ) * ( 1 - 0.855 )
  = 0.505 cm²
```

Area Available in Nozzle Projecting Outward [A2]:
```
  = ( 2 * tlnp )( tn - trn )fr2
  = ( 2 * 14.72 )( 5.89 - 0.467 )0.855
  = 1.365 cm²
```

Area Available in Inward Weld + Outward Weld [A41 + A43]:
```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
  = 11² * 0.855 + ( 0 )² * 0.855
  = 1.035 cm²
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
 Wall Thickness for Internal/External pressures      ta = 3.4671 mm.
 Wall Thickness per UG16(b),                      tr16b = 4.5000 mm.
 Wall Thickness, shell/head, internal pressure     trb1 = 10.5487 mm.
 Wall Thickness                 tb1 = max(trb1, tr16b) = 10.5487 mm.
 Wall Thickness, shell/head, external pressure     trb2 = 3.3576 mm.
 Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5000 mm.
 Wall Thickness per table UG-45                     tb3 = 6.2200 mm.
```

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 6.22, max( 10.55, 4.5 ) ]
  = 6.2200 mm.
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 3.467, 6.22 )
  = 6.2200 mm.
```

Available Nozzle Neck Thickness = 8.8900 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

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

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

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

Govrn. thk, tg = 8.89, tr = 0.467, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0793, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C

 Governing MDMT of all the sub-joints of this Junction  :   -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
 MDMT of ANSI B16.5/47 flange per Matl. Specification        -46 °C
 Flange MDMT with Temp reduction per UCS-66(i)(2)            -48 °C
 Flange MDMT with Temp reduction per UCS-66(i)(3)           -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
 Design Pressure/Ambient Rating = 23.00/51.10 = 0.450

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: PT

```
 Intermediate Calc. for nozzle/shell Welds    Tmin       5.8900  mm.
```

Results Per UW-16.1:

```
                          Required Thickness     Actual Thickness
 Nozzle Weld            4.1230 = 0.7 * tmin.   7.7770 = 0.7 * Wo mm.
```

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

Weld Load [W]:
```
   = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
   = max( 0, (2.883 - 0.505 + 2 * 5.89 * 0.855 *
     (1 * 9 - 7.549 ) )137.9 )
   = 34.81 kN
```

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

Weld Load [W1]:
```
   = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
   = ( 1.365 + 0 + 1.035 - 0 * 0.855 ) * 137.9
   = 33.09 kN
```

Weld Load [W2]:
```
   = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
   = ( 1.365 + 0 + 1.035 + ( 0.906 ) ) * 137.9
   = 45.59 kN
```

Weld Load [W3]:
```
   = (A2+A3+A4+A5+(2*tn*t*fr1))*S
   = ( 1.365 + 0 + 1.035 + 0 + ( 0.906 ) ) * 137.9
   = 45.59 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 48.26 * 11 * 0.49 * 117.9
  = 48. kN
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 21.18 ) * ( 8.89 - 3 ) * 0.7 * 117.9
  = 32. kN
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 48.26 * ( 12 - 3 ) * 0.74 * 137.9
  = 70. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 48.17 + 32.35 ) = 80.52 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 48.17 + 0 + 69.62 + 0 ) = 117.8 kN
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 48.17 + 69.62 + 0 ) = 117.8 kN
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 80 kN , must exceed W = 34 kN  or W1 = 33 kN
 Path 2-2 = 117 kN , must exceed W = 34 kN  or W2 = 45 kN
 Path 3-3 = 117 kN , must exceed W = 34 kN  or W3 = 45 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case       23.089   bar

 Nozzle is O.K. for the External Pressure                1.100   bar
```

The Drop for this Nozzle is : 0.6547 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 162.6547 mm.

INPUT VALUES, Nozzle Description: A3 From : 20

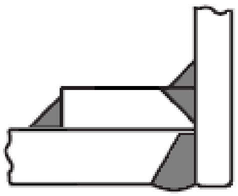
Pressure for Reinforcement Calculations	P	23.000	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Cylindrical Shell	D	890.00	mm.
Design Length of Section	L	4148.3335	mm.
Shell Finished (Minimum) Thickness	t	12.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1200.00	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm^2
Allowable Stress At Ambient	Sna	117.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	8.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N./mm^2
Diameter of Pad along vessel surface	Dp	160.3250	mm.
Thickness of Pad	te	12.0000	mm.
Weld leg size between Pad and Shell	Wp	10.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm.
Reinforcing Pad Width		50.0000	mm.
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: A3

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation           2.375  in.
Actual Thickness Used in Calculation                  0.301  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (23*448)/(137.9*1-0.6*23)
  = 7.5487 mm.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (23*30.16)/(117.9*1+0.4*23)
  = 0.5839 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2901 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   102.0684  mm.
Parallel to Vessel Wall, opening length              d    51.0342  mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp    22.5000  mm.
```

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

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

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

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

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


= min(0.855, 1)
= 0.855

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	3.954	1.483	NA
Area in Shell	A1	0.721	1.658	NA
Area in Nozzle Wall	A2	1.563	1.676	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.547	0.547	NA
Area in Element	A5	5.009	5.009	NA
TOTAL AREA AVAILABLE	Atot	7.840	8.890	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	69.6847	12.0000	mm.
Based on given Pad Diameter:	160.3250	2.6906	mm.
Based on Shell or Nozzle Thickness:	75.0158	7.6454	mm.

Area Required [A]:
```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (51.03*7.549*1+2*4.645*7.549*1*(1-0.855))
  = 3.954 cm²
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 51.03 ( 1 * 9 - 1 * 7.549 ) - 2 * 4.645
    ( 1 * 9 - 1 * 7.549 ) * ( 1 - 0.855 )
  = 0.721 cm²
```

Area Available in Nozzle Wall Projecting Outward [A2]:
```
  = ( 2 * Tlwp ) * ( tn - trn ) * fr2
  = ( 2 * 22.5 ) * ( 4.645 - 0.584 ) * 0.855
  = 1.563 cm²
```

Area Available in Welds [A41 + A42 + A43]:
```
  = Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
  = 8² * 0.855 + (0 )² * 0.855 + 0² * 1
  = 0.547 cm²
```

Area Available in Element [A5]:
```
  = (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
  = ( 102.1 - 60.33 ) * 12 * 1
  = 5.009 cm²
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
 Wall Thickness for Internal/External pressures      ta = 3.5839 mm.
 Wall Thickness per UG16(b),                      tr16b = 4.5000 mm.
 Wall Thickness, shell/head, internal pressure     trb1 = 10.5487 mm.
 Wall Thickness                 tb1 = max(trb1, tr16b) = 10.5487 mm.
 Wall Thickness, shell/head, external pressure     trb2 = 3.3576 mm.
 Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5000 mm.
```

```
Wall Thickness per table UG-45                    tb3 = 6.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 6.42, max( 10.55, 4.5 ) ]
  = 6.4200 mm.
```

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

```
  = max( ta, tb )
  = max( 3.584, 6.42 )
  = 6.4200 mm.
```

Available Nozzle Neck Thickness = 7.6454 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
Sustained  :    62.0,  Allowable :   117.9 N./mm^2  Passed
Expansion  :     0.0,  Allowable :   232.7 N./mm^2  Passed
Occasional :     5.8,  Allowable :   156.8 N./mm^2  Passed
Shear      :    33.9,  Allowable :    82.5 N./mm^2  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

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

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

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

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

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

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

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

Govrn. thk, tg = 7.645, tr = 0.584, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C
```

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

Govrn. thk, tg = 12, tr = 7.549, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.839, Temp. Reduction = 9 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
```

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

Govrn. thk, tg = 7.645, tr = 0.584, c = 3 mm., E* = 1

Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C

Governing MDMT of the Nozzle                             : -104 °C
Governing MDMT of the Reinforcement Pad                  :  -48 °C
Governing MDMT of all the sub-joints of this Junction    :  -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification        -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)            -48 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)           -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 23.00/51.10 = 0.450

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: A3

```
Intermediate Calc. for nozzle/shell Welds   Tmin      4.6454  mm.
Intermediate Calc. for pad/shell Welds   TminPad      9.0000  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          3.2518 = 0.7 * tmin.  5.6560 = 0.7 * Wo mm.
Pad Weld             4.5000 = 0.5*TminPad  7.0700 = 0.7 * Wp mm.
```

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

Weld Load [W]:
```
= max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
= max( 0, (3.954 - 0.721 + 2 * 4.645 * 0.855 *
  (1 * 9 - 7.549 ) )137.9 )
= 46.17 kN
```

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

Weld Load [W1]:
```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 1.563 + 5.009 + 0.547 - 0 * 0.855 ) * 137.9
= 98.16 kN
```

Weld Load [W2]:
```
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= ( 1.563 + 0 + 0.547 + ( 0.715 ) ) * 137.9
= 38.95 kN
```

Weld Load [W3]:
```
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= ( 1.563 + 0 + 0.547 + 5.009 + ( 0.715 ) ) * 137.9
= 108.02 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.142/2.0 ) * 60.33 * 8 * 0.49 * 117.9
= 44. kN
```

Shear, Pad Element Weld [Spew]:
```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 160.3 * 10 * 0.49 * 137.9
  = 170. kN
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 27.84 ) * ( 7.645 - 3 ) * 0.7 * 117.9
  = 34. kN
```

Tension, Pad Groove Weld [Tpgw]:
```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 60.33 * 12 * 0.74 * 137.9
  = 116. kN
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 60.33 * ( 12 - 3 ) * 0.74 * 137.9
  = 87. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 170.2 + 33.53 ) = 203.7 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 43.79 + 116 + 87.02 + 0 ) = 246.8 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 170.2 + 87.02 + 0 ) = 257.2 kN
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 203 kN , must exceed W = 46 kN  or W1 = 98 kN
 Path 2-2 = 246 kN , must exceed W = 46 kN  or W2 = 38 kN
 Path 3-3 = 257 kN , must exceed W = 46 kN  or W3 = 108 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case       27.329  bar
```

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

```
 Nozzle is O.K. for the External Pressure                1.100  bar
```

The Drop for this Nozzle is : 1.0234 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 163.0234 mm.

Input Echo, WRC107/537 Item 1, Description: A3 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	890.000	mm.
Vessel Thickness	Tv	12.000	mm.
Design Temperature		135.00	°C
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	137.90	N./mm^2
Vessel Hot S.I. Allowable	Smh	137.90	N./mm^2
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm.
Nozzle Diameter	Dn	60.325	mm.

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Nozzle Calcs.: A3 Nozl: 17 9:17pm Feb 18,2022

Nozzle Thickness	Tn	7.645	mm.
Nozzle Material		SA-333 6	
Nozzle Cold S.I. Allowable	SNmc	117.90	N./mm^2
Nozzle Hot S.I. Allowable	SNmh	117.90	N./mm^2
Thickness of Reinforcing Pad	Tpad	12.000	mm.
Diameter of Reinforcing Pad	Dpad	160.325	mm.
Design Internal Pressure	Dp	23.000	bar
Include Pressure Thrust		No	

External Forces and Moments in WRC 107/537 Convention:

Radial Load	(SUS)	P	2.0	kN
Longitudinal Shear	(SUS)	Vl	2.0	kN
Circumferential Shear	(SUS)	Vc	2.0	kN
Circumferential Moment	(SUS)	Mc	400.0	N-m
Longitudinal Moment	(SUS)	Ml	400.0	N-m
Torsional Moment	(SUS)	Mt	500.0	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
Local Loads applied at end of Nozzle/Attachment		No

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

Stress Attenuation Diameter (for Insert Plates) per WRC 297:

```
= NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
= 60.325 + 2 * 1.65 * sqrt( 452.5 ( 12.0 - 3.0 ) )
= 270.918 mm.
```

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	2.0	kN
Circumferential Shear	VC	2.0	kN
Longitudinal Shear	VL	2.0	kN
Circumferential Moment	MC	400.0	N-m
Longitudinal Moment	ML	400.0	N-m
Torsional Moment	MT	500.0	N-m

Dimensionless Parameters used : Gamma = 21.83

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.058	4C	4.229	(A,B)
N(PHI) / (P/Rm)	0.058	3C	4.165	(C,D)
M(PHI) / (P)	0.058	2C1	0.168	(A,B)
M(PHI) / (P)	0.058	1C	0.202	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.058	3A	0.246	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.058	1A	0.104	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.058	3B	0.967	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.058	1B	0.060	(A,B,C,D)
N(x) / (P/Rm)	0.058	3C	4.165	(A,B)

N(x) / (P/Rm)	0.058	4C	4.229	(C,D)
M(x) / (P)	0.058	1C1	0.207	(A,B)
M(x) / (P)	0.058	2C	0.166	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.058	4A	0.309	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.058	2A	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.058	4B	0.238	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.058	2B	0.099	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Circ. Bend. P	-4.6	4.6	-4.6	4.6	-5.5	5.5	-5.5	5.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-0.4	-0.4	0.4	0.4
Circ. Memb. MC	0.0	0.0	0.0	0.0	-21.4	21.4	21.4	-21.4
Circ. Memb. ML	-1.5	-1.5	1.5	1.5	0.0	0.0	0.0	0.0
Circ. Bend. ML	-12.3	12.3	12.3	-12.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-19.3	14.5	8.4	-7.1	-28.2	25.7	15.4	-16.4
Long. Memb. P	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Long. Bend. P	-5.6	5.6	-5.6	5.6	-4.5	4.5	-4.5	4.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-0.5	-0.5	0.5	0.5
Long. Bend. MC	0.0	0.0	0.0	0.0	-12.9	12.9	12.9	-12.9
Long. Memb. ML	-0.4	-0.4	0.4	0.4	0.0	0.0	0.0	0.0
Long. Bend. ML	-20.5	20.5	20.5	-20.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	-27.4	24.9	14.3	-15.3	-18.8	16.1	8.0	-8.8
Shear VC	1.0	1.0	-1.0	-1.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.0	-1.0	1.0	1.0
Shear MT	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Tot. Shear	5.2	5.2	3.2	3.2	3.2	3.2	5.2	5.2
Str. Int.	29.9	27.0	15.7	16.4	29.1	26.6	18.1	19.0

Dimensionless Parameters used : Gamma = 50.28

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.155	4C	7.575	(A,B)
N(PHI) / (P/Rm)	0.155	3C	5.538	(C,D)
M(PHI) / (P)	0.155	2C1	0.044	(A,B)
M(PHI) / (P)	0.155	1C !	0.077	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.155	3A	2.036	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.155	1A	0.079	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.155	3B	5.450	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.155	1B	0.030	(A,B,C,D)
N(x) / (P/Rm)	0.155	3C	5.538	(A,B)
N(x) / (P/Rm)	0.155	4C	7.575	(C,D)
M(x) / (P)	0.155	1C1	0.080	(A,B)
M(x) / (P)	0.155	2C !	0.044	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.155	4A	3.512	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.155	2A	0.040	(A,B,C,D)

```
N(x)    / ( ML/(Rm**2 * Beta) )    0.155    4B        1.955    (A,B,C,D)
M(x)    / ( ML/(Rm    * Beta) )    0.155    2B        0.042    (A,B,C,D)
```

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-3.7	-3.7	-3.7	-3.7	-2.7	-2.7	-2.7	-2.7
Circ. Bend. P	-6.5	6.5	-6.5	6.5	-11.5	11.5	-11.5	11.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-2.8	-2.8	2.8	2.8
Circ. Memb. MC	0.0	0.0	0.0	0.0	-33.4	33.4	33.4	-33.4
Circ. Memb. ML	-7.6	-7.6	7.6	7.6	0.0	0.0	0.0	0.0
Circ. Bend. ML	-12.6	12.6	12.6	-12.6	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-30.5	7.8	10.0	-2.2	-50.5	39.3	22.1	-21.8
Long. Memb. P	-2.7	-2.7	-2.7	-2.7	-3.7	-3.7	-3.7	-3.7
Long. Bend. P	-11.9	11.9	-11.9	11.9	-6.5	6.5	-6.5	6.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-4.9	-4.9	4.9	4.9
Long. Bend. MC	0.0	0.0	0.0	0.0	-16.7	16.7	16.7	-16.7
Long. Memb. ML	-2.7	-2.7	2.7	2.7	0.0	0.0	0.0	0.0
Long. Bend. ML	-17.7	17.7	17.7	-17.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	-35.1	24.2	5.8	-5.8	-31.8	14.6	11.5	-9.1
Shear VC	0.9	0.9	-0.9	-0.9	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.9	-0.9	0.9	0.9
Shear MT	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Tot. Shear	2.3	2.3	0.5	0.5	0.5	0.5	2.3	2.3
Str. Int.	36.0	24.5	10.1	5.9	50.5	39.3	22.6	22.2

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3
Circ. Pl (SUS)	-2.4	-2.4	0.6	0.6	-1.3	-1.3	-0.5	-0.5
Circ. Q (SUS)	-16.9	16.9	7.7	-7.7	-26.9	26.9	15.9	-15.9
Long. Pm (SUS)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Long. Pl (SUS)	-1.2	-1.2	-0.5	-0.5	-1.4	-1.4	-0.4	-0.4
Long. Q (SUS)	-26.1	26.1	14.8	-14.8	-17.4	17.4	8.4	-8.4
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.0	1.0	-1.0	-1.0	-1.0	-1.0	1.0	1.0
Shear Q (SUS)	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3

Pm+Pl (SUS)	45.6	47.9	48.6	50.9	46.7	49.0	47.5	49.8
Pm+Pl+Q (Total)	33.7	66.2	56.9	43.4	20.4	76.2	64.2	35.2

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	50.25	137.90	Passed
Pm+Pl (SUS)	50.93	206.85	Passed
Pm+Pl+Q (TOTAL)	76.20	413.70	Passed

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Circ. Pl (SUS)	-11.3	-11.3	3.9	3.9	-5.6	-5.6	0.1	0.1
Circ. Q (SUS)	-19.1	19.1	6.1	-6.1	-44.9	44.9	22.0	-22.0
Long. Pm (SUS)	56.7	56.7	56.7	56.7	56.7	56.7	56.7	56.7
Long. Pl (SUS)	-5.5	-5.5	0.0	0.0	-8.6	-8.6	1.2	1.2
Long. Q (SUS)	-29.7	29.7	5.8	-5.8	-23.2	23.2	10.3	-10.3
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.9	0.9	-0.9	-0.9	-0.9	-0.9	0.9	0.9
Shear Q (SUS)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Pm+Pl (SUS)	102.0	104.3	117.3	119.6	107.8	110.1	113.5	115.8
Pm+Pl+Q (Total)	83.0	123.6	123.4	113.4	62.9	155.0	135.5	93.9

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	115.67	137.90	Passed
Pm+Pl (SUS)	119.59	206.85	Passed
Pm+Pl+Q (TOTAL)	155.00	413.70	Passed

INPUT VALUES, Nozzle Description: LT1 From : 20

Pressure for Reinforcement Calculations	P	23.040	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Cylindrical Shell	D	890.00	mm.
Design Length of Section	L	4148.3335	mm.
Shell Finished (Minimum) Thickness	t	12.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		3700.00	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

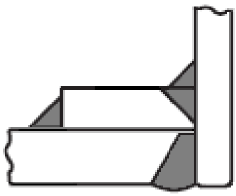
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm^2
Allowable Stress At Ambient	Sna	117.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		180.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N./mm^2
Diameter of Pad along vessel surface	Dp	160.3250	mm.
Thickness of Pad	te	12.0000	mm.
Weld leg size between Pad and Shell	Wp	10.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm.
Reinforcing Pad Width		50.0000	mm.
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

```
DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for  LIQID RECEIVER D-PK6101-2
Nozzle Calcs.: LT1                       Nozl:    18    9:17pm  Feb 18,2022
```

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



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

Reinforcement CALCULATION, Description: LT1

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation             2.375  in.
 Actual Thickness Used in Calculation                    0.301  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (23.04*448)/(137.9*1-0.6*23.04)
  = 7.5621 mm.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (23.04*30.16)/(117.9*1+0.4*23.04)
  = 0.5849 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2901 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)             Dl   102.0684  mm.
 Parallel to Vessel Wall, opening length               d    51.0342  mm.
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp    22.5000  mm.
```

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

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

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

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

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

```
  = min( 0.855, 1 )
  = 0.855
```

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	3.961	1.483	NA
Area in Shell	A1	0.714	1.658	NA
Area in Nozzle Wall	A2	1.562	1.676	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.855	0.855	NA
Area in Element	A5	5.009	5.009	NA
TOTAL AREA AVAILABLE	Atot	8.141	9.198	NA

The Internal Pressure Case Governs the Analysis.

```
 Nozzle Angle Used in Area Calculations                  90.00  Degs.
```

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	67.2364	12.0000	mm.
Based on given Pad Diameter:	160.3250	1.9868	mm.
Based on Shell or Nozzle Thickness:	71.1729	7.6454	mm.

Area Required [A]:

```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (51.03*7.562*1+2*4.645*7.562*1*(1-0.855))
  = 3.961 cm²
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 51.03 ( 1 * 9 - 1 * 7.562 ) - 2 * 4.645
    ( 1 * 9 - 1 * 7.562 ) * ( 1 - 0.855 )
  = 0.714 cm²
```

Area Available in Nozzle Wall Projecting Outward [A2]:

```
  = ( 2 * Tlwp ) * ( tn - trn ) * fr2
  = ( 2 * 22.5 ) * ( 4.645 - 0.585 ) * 0.855
  = 1.562 cm²
```

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

```
  = Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
  = 10² * 0.855 + (0 )² * 0.855 + 0² * 1
  = 0.855 cm²
```

Area Available in Element [A5]:

```
  = (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
  = ( 102.1 - 60.33 ) * 12 * 1
  = 5.009 cm²
```

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

```
 Wall Thickness for Internal/External pressures        ta = 3.5849 mm.
 Wall Thickness per UG16(b),                       tr16b = 4.5000 mm.
 Wall Thickness, shell/head, internal pressure      trb1 = 10.5621 mm.
 Wall Thickness              tb1 = max(trb1, tr16b) = 10.5621 mm.
 Wall Thickness, shell/head, external pressure      trb2 = 3.3576 mm.
 Wall Thickness              tb2 = max(trb2, tr16b) = 4.5000 mm.
```

```
 Wall Thickness per table UG-45                   tb3 = 6.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 6.42, max( 10.56, 4.5 ) ]
  = 6.4200 mm.
```

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

```
  = max( ta, tb )
  = max( 3.585, 6.42 )
  = 6.4200 mm.
```

Available Nozzle Neck Thickness = 7.6454 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

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

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

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

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

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

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

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

Govrn. thk, tg = 7.645, tr = 0.585, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C
```

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

Govrn. thk, tg = 12, tr = 7.562, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.84, Temp. Reduction = 9 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
```

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

Govrn. thk, tg = 7.645, tr = 0.585, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C

 Governing MDMT of the Nozzle                          :    -104 °C
 Governing MDMT of the Reinforcement Pad               :     -48 °C
 Governing MDMT of all the sub-joints of this Junction :     -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)           -48 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 23.04/51.10 = 0.451
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: LT1

```
Intermediate Calc. for nozzle/shell Welds   Tmin        4.6454  mm.
Intermediate Calc. for pad/shell Welds   TminPad        9.0000  mm.
```

Results Per UW-16.1:

```
                         Required Thickness    Actual Thickness
Nozzle Weld             3.2518 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
Pad Weld                4.5000 = 0.5*TminPad  7.0700 = 0.7 * Wp mm.
```

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

Weld Load [W]:

```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (3.961 - 0.714 + 2 * 4.645 * 0.855 *
     (1 * 9 - 7.562 ) )137.9 )
  = 46.34 kN
```

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

Weld Load [W1]:

```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 1.562 + 5.009 + 0.855 - 0 * 0.855 ) * 137.9
  = 102.40 kN
```

Weld Load [W2]:

```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 1.562 + 0 + 0.855 + ( 0.715 ) ) * 137.9
  = 43.19 kN
```

Weld Load [W3]:

```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 1.562 + 0 + 0.855 + 5.009 + ( 0.715 ) ) * 137.9
  = 112.26 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 60.33 * 10 * 0.49 * 117.9
  = 55. kN
```

Shear, Pad Element Weld [Spew]:

```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 160.3 * 10 * 0.49 * 137.9
  = 170. kN
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 27.84 ) * ( 7.645 - 3 ) * 0.7 * 117.9
  = 34. kN
```

Tension, Pad Groove Weld [Tpgw]:

```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 60.33 * 12 * 0.74 * 137.9
  = 116. kN
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 60.33 * ( 12 - 3 ) * 0.74 * 137.9
  = 87. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 170.2 + 33.53 ) = 203.7 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 54.74 + 116 + 87.02 + 0 ) = 257.8 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 170.2 + 87.02 + 0 ) = 257.2 kN
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 203 kN , must exceed W = 46 kN  or W1 = 102 kN
 Path 2-2 = 257 kN , must exceed W = 46 kN  or W2 = 43 kN
 Path 3-3 = 257 kN , must exceed W = 46 kN  or W3 = 112 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case       27.369   bar
```

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

```
 Nozzle is O.K. for the External Pressure                1.100   bar
```

The Drop for this Nozzle is : 1.0234 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 163.0234 mm.

INPUT VALUES, Nozzle Description: LT2 From : 20

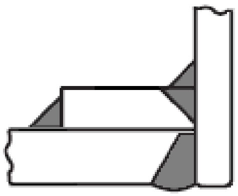
Pressure for Reinforcement Calculations	P	23.000	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Cylindrical Shell	D	890.00	mm.
Design Length of Section	L	4148.3335	mm.
Shell Finished (Minimum) Thickness	t	12.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		3650.00	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm^2
Allowable Stress At Ambient	Sna	117.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N./mm^2
Diameter of Pad along vessel surface	Dp	160.3250	mm.
Thickness of Pad	te	12.0000	mm.
Weld leg size between Pad and Shell	Wp	10.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm.
Reinforcing Pad Width		50.0000	mm.
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: LT2

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation            2.375  in.
Actual Thickness Used in Calculation                   0.301  in.
```

Nozzle input data check completed without errors.

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

```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (23*448)/(137.9*1-0.6*23)
  = 7.5487 mm.
```

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

```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (23*30.16)/(117.9*1+0.4*23)
  = 0.5839 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2901 mm.

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

```
Parallel to Vessel Wall (Diameter Limit)             Dl    102.0684  mm.
Parallel to Vessel Wall, opening length               d     51.0342  mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp     22.5000  mm.
```

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

Weld Strength Reduction Factor [fr1]:

```
  = min( 1, Sn/Sv )
  = min( 1, 117.9/137.9 )
  = 0.855
```

Weld Strength Reduction Factor [fr2]:

```
  = min( 1, Sn/Sv )
  = min( 1, 117.9/137.9 )
  = 0.855
```

Weld Strength Reduction Factor [fr4]:

```
  = min( 1, Sp/Sv )
  = min( 1, 137.9/137.9 )
  = 1.000
```

Weld Strength Reduction Factor [fr3]:

```
  = min( fr2, fr4 )
```

= min(0.855, 1)
= 0.855

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	3.954	1.483	NA
Area in Shell	A1	0.721	1.658	NA
Area in Nozzle Wall	A2	1.563	1.676	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.855	0.855	NA
Area in Element	A5	5.009	5.009	NA
TOTAL AREA AVAILABLE	Atot	8.148	9.198	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	67.1197	12.0000	mm.
Based on given Pad Diameter:	160.3250	1.9533	mm.
Based on Shell or Nozzle Thickness:	70.9898	7.6454	mm.

Area Required [A]:
= (d * tr*F + 2 * tn * tr*F * (1-fr1)) UG-37(c)
= (51.03*7.549*1+2*4.645*7.549*1*(1-0.855))
= 3.954 cm²

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
= d(E1*t - F*tr) - 2 * tn(E1*t - F*tr) * (1 - fr1)
= 51.03 (1 * 9 - 1 * 7.549) - 2 * 4.645
(1 * 9 - 1 * 7.549) * (1 - 0.855)
= 0.721 cm²

Area Available in Nozzle Wall Projecting Outward [A2]:
= (2 * Tlwp) * (tn - trn) * fr2
= (2 * 22.5) * (4.645 - 0.584) * 0.855
= 1.563 cm²

Area Available in Welds [A41 + A42 + A43]:
= Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
= 10² * 0.855 + (0)² * 0.855 + 0² * 1
= 0.855 cm²

Area Available in Element [A5]:
= (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
= (102.1 - 60.33) * 12 * 1
= 5.009 cm²

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

Wall Thickness for Internal/External pressures ta = 3.5839 mm.
Wall Thickness per UG16(b), tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure trb1 = 10.5487 mm.
Wall Thickness tb1 = max(trb1, tr16b) = 10.5487 mm.
Wall Thickness, shell/head, external pressure trb2 = 3.3576 mm.
Wall Thickness tb2 = max(trb2, tr16b) = 4.5000 mm.


```
 Wall Thickness per table UG-45                      tb3 = 6.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 6.42, max( 10.55, 4.5 ) ]
  = 6.4200 mm.
```

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

```
  = max( ta, tb )
  = max( 3.584, 6.42 )
  = 6.4200 mm.
```

Available Nozzle Neck Thickness = 7.6454 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
 Sustained  :     62.0,  Allowable :    117.9 N./mm^2  Passed
 Expansion  :      0.0,  Allowable :    232.7 N./mm^2  Passed
 Occasional :      5.8,  Allowable :    156.8 N./mm^2  Passed
 Shear      :     33.9,  Allowable :     82.5 N./mm^2  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

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

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

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

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

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

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

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

Govrn. thk, tg = 7.645, tr = 0.584, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D               -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)            -104 °C
```

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

Govrn. thk, tg = 12, tr = 7.549, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.839, Temp. Reduction = 9 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D               -48 °C
```

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

Govrn. thk, tg = 7.645, tr = 0.584, c = 3 mm., E* = 1

Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C

Governing MDMT of the Nozzle                          :    -104 °C
Governing MDMT of the Reinforcement Pad               :     -48 °C
Governing MDMT of all the sub-joints of this Junction :     -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification        -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)            -48 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)           -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 23.00/51.10 = 0.450
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: LT2

```
Intermediate Calc. for nozzle/shell Welds    Tmin       4.6454  mm.
Intermediate Calc. for pad/shell Welds    TminPad       9.0000  mm.
```

Results Per UW-16.1:

```
                       Required Thickness    Actual Thickness
Nozzle Weld          3.2518 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
Pad Weld             4.5000 = 0.5*TminPad  7.0700 = 0.7 * Wp mm.
```

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

Weld Load [W]:

```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (3.954 - 0.721 + 2 * 4.645 * 0.855 *
     (1 * 9 - 7.549 ) )137.9 )
  = 46.17 kN
```

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

Weld Load [W1]:

```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 1.563 + 5.009 + 0.855 - 0 * 0.855 ) * 137.9
  = 102.41 kN
```

Weld Load [W2]:

```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 1.563 + 0 + 0.855 + ( 0.715 ) ) * 137.9
  = 43.19 kN
```

Weld Load [W3]:

```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 1.563 + 0 + 0.855 + 5.009 + ( 0.715 ) ) * 137.9
  = 112.27 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 60.33 * 10 * 0.49 * 117.9
  = 55. kN
```

Shear, Pad Element Weld [Spew]:
```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 160.3 * 10 * 0.49 * 137.9
  = 170. kN
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 27.84 ) * ( 7.645 - 3 ) * 0.7 * 117.9
  = 34. kN
```

Tension, Pad Groove Weld [Tpgw]:
```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 60.33 * 12 * 0.74 * 137.9
  = 116. kN
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 60.33 * ( 12 - 3 ) * 0.74 * 137.9
  = 87. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 170.2 + 33.53 ) = 203.7 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 54.74 + 116 + 87.02 + 0 ) = 257.8 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 170.2 + 87.02 + 0 ) = 257.2 kN
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 203 kN , must exceed W = 46 kN  or W1 = 102 kN
 Path 2-2 = 257 kN , must exceed W = 46 kN  or W2 = 43 kN
 Path 3-3 = 257 kN , must exceed W = 46 kN  or W3 = 112 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case       27.329   bar
```

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

```
 Nozzle is O.K. for the External Pressure                1.100   bar
```

The Drop for this Nozzle is : 1.0234 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 163.0234 mm.

Input Echo, WRC107/537 Item 1, Description: LT2 :

```
 Diameter Basis for Vessel                     Vbasis       ID
 Cylindrical or Spherical Vessel               Cylsph       Cylindrical
 Internal Corrosion Allowance                     Cas       3.0000   mm.
 Vessel Diameter                                   Dv     890.000   mm.
 Vessel Thickness                                  Tv      12.000   mm.

 Design Temperature                                        135.00   °C
 Vessel Material                                        SA-516 70
 Vessel Cold S.I. Allowable                       Smc      137.90   N./mm^2
 Vessel Hot  S.I. Allowable                       Smh      137.90   N./mm^2

 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	7.645	mm.
Nozzle Material		SA-333 6	
Nozzle Cold S.I. Allowable	SNmc	117.90	N./mm^2
Nozzle Hot S.I. Allowable	SNmh	117.90	N./mm^2
Thickness of Reinforcing Pad	Tpad	12.000	mm.
Diameter of Reinforcing Pad	Dpad	160.325	mm.
Design Internal Pressure	Dp	23.000	bar
Include Pressure Thrust		No	

External Forces and Moments in WRC 107/537 Convention:

Radial Load	(SUS)	P	2.0	kN
Longitudinal Shear	(SUS)	Vl	2.0	kN
Circumferential Shear	(SUS)	Vc	2.0	kN
Circumferential Moment	(SUS)	Mc	400.0	N-m
Longitudinal Moment	(SUS)	Ml	400.0	N-m
Torsional Moment	(SUS)	Mt	500.0	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
Local Loads applied at end of Nozzle/Attachment		No

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

Stress Attenuation Diameter (for Insert Plates) per WRC 297:

```
= NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
= 60.325 + 2 * 1.65 * sqrt( 452.5 ( 12.0 - 3.0 ) )
= 270.918 mm.
```

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	2.0	kN
Circumferential Shear	VC	2.0	kN
Longitudinal Shear	VL	2.0	kN
Circumferential Moment	MC	400.0	N-m
Longitudinal Moment	ML	400.0	N-m
Torsional Moment	MT	500.0	N-m

Dimensionless Parameters used : Gamma = 21.83

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.058	4C	4.229	(A,B)
N(PHI) / (P/Rm)	0.058	3C	4.165	(C,D)
M(PHI) / (P)	0.058	2C1	0.168	(A,B)
M(PHI) / (P)	0.058	1C	0.202	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.058	3A	0.246	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.058	1A	0.104	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.058	3B	0.967	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.058	1B	0.060	(A,B,C,D)
N(x) / (P/Rm)	0.058	3C	4.165	(A,B)

```
N(x)   / ( P/Rm )                  0.058   4C       4.229   (C,D)
M(x)   / ( P )                     0.058   1C1      0.207   (A,B)
M(x)   / ( P )                     0.058   2C       0.166   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )     0.058   4A       0.309   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )     0.058   2A       0.063   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )     0.058   4B       0.238   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )     0.058   2B       0.099   (A,B,C,D)
```

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
	Stress Intensity Values at							
Circ. Memb. P	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Circ. Bend. P	-4.6	4.6	-4.6	4.6	-5.5	5.5	-5.5	5.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-0.4	-0.4	0.4	0.4
Circ. Memb. MC	0.0	0.0	0.0	0.0	-21.4	21.4	21.4	-21.4
Circ. Memb. ML	-1.5	-1.5	1.5	1.5	0.0	0.0	0.0	0.0
Circ. Bend. ML	-12.3	12.3	12.3	-12.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-19.3	14.5	8.4	-7.1	-28.2	25.7	15.4	-16.4
Long. Memb. P	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Long. Bend. P	-5.6	5.6	-5.6	5.6	-4.5	4.5	-4.5	4.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-0.5	-0.5	0.5	0.5
Long. Bend. MC	0.0	0.0	0.0	0.0	-12.9	12.9	12.9	-12.9
Long. Memb. ML	-0.4	-0.4	0.4	0.4	0.0	0.0	0.0	0.0
Long. Bend. ML	-20.5	20.5	20.5	-20.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	-27.4	24.9	14.3	-15.3	-18.8	16.1	8.0	-8.8
Shear VC	1.0	1.0	-1.0	-1.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.0	-1.0	1.0	1.0
Shear MT	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Tot. Shear	5.2	5.2	3.2	3.2	3.2	3.2	5.2	5.2
Str. Int.	29.9	27.0	15.7	16.4	29.1	26.6	18.1	19.0

Dimensionless Parameters used : Gamma = 50.28

Dimensionless Loads for Cylindrical Shells at Pad edge:

```
-------------------------------------------------------------------
Curves read for 1979               Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                  0.155   4C       7.575   (A,B)
N(PHI) / ( P/Rm )                  0.155   3C       5.538   (C,D)
M(PHI) / ( P )                     0.155   2C1      0.044   (A,B)
M(PHI) / ( P )                     0.155   1C  !    0.077   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )     0.155   3A       2.036   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )     0.155   1A       0.079   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )     0.155   3B       5.450   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )     0.155   1B       0.030   (A,B,C,D)

N(x)   / ( P/Rm )                  0.155   3C       5.538   (A,B)
N(x)   / ( P/Rm )                  0.155   4C       7.575   (C,D)
M(x)   / ( P )                     0.155   1C1      0.080   (A,B)
M(x)   / ( P )                     0.155   2C  !    0.044   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )     0.155   4A       3.512   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )     0.155   2A       0.040   (A,B,C,D)
```

N(x)	/ (ML/(Rm**2 * Beta))	0.155	4B	1.955	(A,B,C,D)
M(x)	/ (ML/(Rm * Beta))	0.155	2B	0.042	(A,B,C,D)

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-3.7	-3.7	-3.7	-3.7	-2.7	-2.7	-2.7	-2.7
Circ. Bend. P	-6.5	6.5	-6.5	6.5	-11.5	11.5	-11.5	11.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-2.8	-2.8	2.8	2.8
Circ. Memb. MC	0.0	0.0	0.0	0.0	-33.4	33.4	33.4	-33.4
Circ. Memb. ML	-7.6	-7.6	7.6	7.6	0.0	0.0	0.0	0.0
Circ. Bend. ML	-12.6	12.6	12.6	-12.6	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-30.5	7.8	10.0	-2.2	-50.5	39.3	22.1	-21.8
Long. Memb. P	-2.7	-2.7	-2.7	-2.7	-3.7	-3.7	-3.7	-3.7
Long. Bend. P	-11.9	11.9	-11.9	11.9	-6.5	6.5	-6.5	6.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-4.9	-4.9	4.9	4.9
Long. Bend. MC	0.0	0.0	0.0	0.0	-16.7	16.7	16.7	-16.7
Long. Memb. ML	-2.7	-2.7	2.7	2.7	0.0	0.0	0.0	0.0
Long. Bend. ML	-17.7	17.7	17.7	-17.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	-35.1	24.2	5.8	-5.8	-31.8	14.6	11.5	-9.1
Shear VC	0.9	0.9	-0.9	-0.9	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.9	-0.9	0.9	0.9
Shear MT	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Tot. Shear	2.3	2.3	0.5	0.5	0.5	0.5	2.3	2.3
Str. Int.	36.0	24.5	10.1	5.9	50.5	39.3	22.6	22.2

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3
Circ. Pl (SUS)	-2.4	-2.4	0.6	0.6	-1.3	-1.3	-0.5	-0.5
Circ. Q (SUS)	-16.9	16.9	7.7	-7.7	-26.9	26.9	15.9	-15.9
Long. Pm (SUS)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Long. Pl (SUS)	-1.2	-1.2	-0.5	-0.5	-1.4	-1.4	-0.4	-0.4
Long. Q (SUS)	-26.1	26.1	14.8	-14.8	-17.4	17.4	8.4	-8.4
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.0	1.0	-1.0	-1.0	-1.0	-1.0	1.0	1.0
Shear Q (SUS)	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3

Pm+Pl (SUS)	45.6	47.9	48.6	50.9	46.7	49.0	47.5	49.8
Pm+Pl+Q (Total)	33.7	66.2	56.9	43.4	20.4	76.2	64.2	35.2

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	50.25	137.90	Passed
Pm+Pl (SUS)	50.93	206.85	Passed
Pm+Pl+Q (TOTAL)	76.20	413.70	Passed

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Circ. Pl (SUS)	-11.3	-11.3	3.9	3.9	-5.6	-5.6	0.1	0.1
Circ. Q (SUS)	-19.1	19.1	6.1	-6.1	-44.9	44.9	22.0	-22.0
Long. Pm (SUS)	56.7	56.7	56.7	56.7	56.7	56.7	56.7	56.7
Long. Pl (SUS)	-5.5	-5.5	0.0	0.0	-8.6	-8.6	1.2	1.2
Long. Q (SUS)	-29.7	29.7	5.8	-5.8	-23.2	23.2	10.3	-10.3
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.9	0.9	-0.9	-0.9	-0.9	-0.9	0.9	0.9
Shear Q (SUS)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Pm+Pl (SUS)	102.0	104.3	117.3	119.6	107.8	110.1	113.5	115.8
Pm+Pl+Q (Total)	83.0	123.6	123.4	113.4	62.9	155.0	135.5	93.9

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	115.67	137.90	Passed
Pm+Pl (SUS)	119.59	206.85	Passed
Pm+Pl+Q (TOTAL)	155.00	413.70	Passed

INPUT VALUES, Nozzle Description: D From : 20

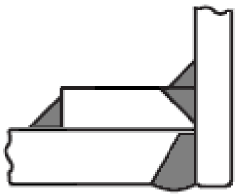
Pressure for Reinforcement Calculations	P	23.040	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Cylindrical Shell	D	890.00	mm.
Design Length of Section	L	4148.3335	mm.
Shell Finished (Minimum) Thickness	t	12.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		300.00	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm^2
Allowable Stress At Ambient	Sna	117.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		180.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N./mm^2
Diameter of Pad along vessel surface	Dp	160.0000	mm.
Thickness of Pad	te	12.0000	mm.
Weld leg size between Pad and Shell	Wp	10.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm.
Reinforcing Pad Width		49.8375	mm.
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: D

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation             2.375  in.
 Actual Thickness Used in Calculation                    0.301  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (23.04*448)/(137.9*1-0.6*23.04)
  = 7.5621 mm.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (23.04*30.16)/(117.9*1+0.4*23.04)
  = 0.5849 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2901 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)            Dl   102.0684  mm.
 Parallel to Vessel Wall, opening length              d    51.0342  mm.
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp    22.5000  mm.
```

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

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

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

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

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

```
  = min( 0.855, 1 )
  = 0.855
```

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	3.961	1.483	NA
Area in Shell	A1	0.714	1.658	NA
Area in Nozzle Wall	A2	1.562	1.676	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.855	0.855	NA
Area in Element	A5	5.009	5.009	NA
TOTAL AREA AVAILABLE	Atot	8.141	9.198	NA

The Internal Pressure Case Governs the Analysis.

```
 Nozzle Angle Used in Area Calculations                90.00  Degs.
```

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	67.2364	12.0000	mm.
Based on given Pad Diameter:	160.0000	1.9868	mm.
Based on Shell or Nozzle Thickness:	71.1729	7.6454	mm.

Area Required [A]:

```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (51.03*7.562*1+2*4.645*7.562*1*(1-0.855))
  = 3.961 cm²
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 51.03 ( 1 * 9 - 1 * 7.562 ) - 2 * 4.645
    ( 1 * 9 - 1 * 7.562 ) * ( 1 - 0.855 )
  = 0.714 cm²
```

Area Available in Nozzle Wall Projecting Outward [A2]:

```
  = ( 2 * Tlwp ) * ( tn - trn ) * fr2
  = ( 2 * 22.5 ) * ( 4.645 - 0.585 ) * 0.855
  = 1.562 cm²
```

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

```
  = Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
  = 10² * 0.855 + (0 )² * 0.855 + 0² * 1
  = 0.855 cm²
```

Area Available in Element [A5]:

```
  = (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
  = ( 102.1 - 60.33 ) * 12 * 1
  = 5.009 cm²
```

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

```
 Wall Thickness for Internal/External pressures      ta = 3.5849 mm.
 Wall Thickness per UG16(b),                      tr16b = 4.5000 mm.
 Wall Thickness, shell/head, internal pressure     trb1 = 10.5621 mm.
 Wall Thickness                 tb1 = max(trb1, tr16b) = 10.5621 mm.
 Wall Thickness, shell/head, external pressure     trb2 = 3.3576 mm.
 Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5000 mm.
```

```
 Wall Thickness per table UG-45                       tb3 = 6.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 6.42, max( 10.56, 4.5 ) ]
  = 6.4200 mm.
```

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

```
  = max( ta, tb )
  = max( 3.585, 6.42 )
  = 6.4200 mm.
```

Available Nozzle Neck Thickness = 7.6454 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
 Sustained  :     62.1,  Allowable :    117.9 N./mm^2  Passed
 Expansion  :      0.0,  Allowable :    232.7 N./mm^2  Passed
 Occasional :      5.8,  Allowable :    156.8 N./mm^2  Passed
 Shear      :     33.9,  Allowable :     82.5 N./mm^2  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

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

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

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

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

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

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

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

Govrn. thk, tg = 7.645, tr = 0.585, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C
```

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

Govrn. thk, tg = 12, tr = 7.562, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.84, Temp. Reduction = 9 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
```

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

Govrn. thk, tg = 7.645, tr = 0.585, c = 3 mm., E* = 1

Thickness Ratio = tr * (E*)/(tg - c) = 0.126, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D           -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)        -104 °C

Governing MDMT of the Nozzle                        :  -104 °C
Governing MDMT of the Reinforcement Pad             :   -48 °C
Governing MDMT of all the sub-joints of this Junction :   -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification     -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)         -48 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)        -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
```
Design Pressure/Ambient Rating = 23.04/51.10 = 0.451
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: D

```
Intermediate Calc. for nozzle/shell Welds   Tmin      4.6454  mm.
Intermediate Calc. for pad/shell Welds   TminPad      9.0000  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          3.2518 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
Pad Weld             4.5000 = 0.5*TminPad  7.0700 = 0.7 * Wp mm.
```

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

Weld Load [W]:
```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (3.961 - 0.714 + 2 * 4.645 * 0.855 *
     (1 * 9 - 7.562 ) )137.9 )
  = 46.34 kN
```

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

Weld Load [W1]:
```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 1.562 + 5.009 + 0.855 - 0 * 0.855 ) * 137.9
  = 102.40 kN
```

Weld Load [W2]:
```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 1.562 + 0 + 0.855 + ( 0.715 ) ) * 137.9
  = 43.19 kN
```

Weld Load [W3]:
```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 1.562 + 0 + 0.855 + 5.009 + ( 0.715 ) ) * 137.9
  = 112.26 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 60.33 * 10 * 0.49 * 117.9
  = 55. kN
```

Shear, Pad Element Weld [Spew]:
```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 160 * 10 * 0.49 * 137.9
  = 170. kN
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 27.84 ) * ( 7.645 - 3 ) * 0.7 * 117.9
  = 34. kN
```

Tension, Pad Groove Weld [Tpgw]:
```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 60.33 * 12 * 0.74 * 137.9
  = 116. kN
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 60.33 * ( 12 - 3 ) * 0.74 * 137.9
  = 87. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 169.8 + 33.53 ) = 203.3 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 54.74 + 116 + 87.02 + 0 ) = 257.8 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 169.8 + 87.02 + 0 ) = 256.8 kN
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 203 kN , must exceed W = 46 kN  or W1 = 102 kN
 Path 2-2 = 257 kN , must exceed W = 46 kN  or W2 = 43 kN
 Path 3-3 = 256 kN , must exceed W = 46 kN  or W3 = 112 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case       27.369   bar
```

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

```
 Nozzle is O.K. for the External Pressure                1.100   bar
```

The Drop for this Nozzle is : 1.0234 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 163.0234 mm.

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

```
 Diameter Basis for Vessel                    Vbasis       ID
 Cylindrical or Spherical Vessel              Cylsph       Cylindrical
 Internal Corrosion Allowance                    Cas       3.0000  mm.
 Vessel Diameter                                  Dv     890.000  mm.
 Vessel Thickness                                 Tv      12.000  mm.

 Design Temperature                                        135.00   °C
 Vessel Material                                        SA-516 70
 Vessel Cold S.I. Allowable                      Smc       137.90  N./mm^2
 Vessel Hot  S.I. Allowable                      Smh       137.90  N./mm^2

 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        7.645  mm.
Nozzle Material                                     SA-333 6
Nozzle Cold S.I. Allowable                  SNmc      117.90  N./mm^2
Nozzle Hot  S.I. Allowable                  SNmh      117.90  N./mm^2

Thickness of Reinforcing Pad                Tpad      12.000  mm.
Diameter  of Reinforcing Pad                Dpad     160.000  mm.

Design Internal Pressure                      Dp      23.040  bar
Include Pressure Thrust                                   No
```

External Forces and Moments in WRC 107/537 Convention:

```
Radial Load              (SUS)                P         2.0  kN
Longitudinal Shear       (SUS)                Vl        2.0  kN
Circumferential Shear    (SUS)                Vc        2.0  kN
Circumferential Moment   (SUS)                Mc      400.0  N-m
Longitudinal Moment      (SUS)                Ml      400.0  N-m
Torsional Moment         (SUS)                Mt      500.0  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
Local Loads applied at end of Nozzle/Attachment          No
```

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

Stress Attenuation Diameter (for Insert Plates) per WRC 297:

```
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 60.325 + 2 * 1.65 * sqrt( 452.5  ( 12.0 - 3.0 ) )
 = 270.918 mm.
```

WRC 107 Stress Calculation for SUStained loads:

```
Radial Load                                   P         2.0  kN
Circumferential Shear                        VC         2.0  kN
Longitudinal Shear                           VL         2.0  kN
Circumferential Moment                       MC       400.0  N-m
Longitudinal Moment                          ML       400.0  N-m
Torsional Moment                             MT       500.0  N-m

Dimensionless Parameters used :    Gamma =    21.83
```

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.058	4C	4.229	(A,B)
N(PHI) / (P/Rm)	0.058	3C	4.165	(C,D)
M(PHI) / (P)	0.058	2C1	0.168	(A,B)
M(PHI) / (P)	0.058	1C	0.202	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.058	3A	0.246	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.058	1A	0.104	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.058	3B	0.967	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.058	1B	0.060	(A,B,C,D)
N(x) / (P/Rm)	0.058	3C	4.165	(A,B)

	Beta	Figure	Value	Location
N(x) / (P/Rm)	0.058	4C	4.229	(C,D)
M(x) / (P)	0.058	1C1	0.207	(A,B)
M(x) / (P)	0.058	2C	0.166	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.058	4A	0.309	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.058	2A	0.063	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.058	4B	0.238	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.058	2B	0.099	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
	Stress Intensity Values at							
Circ. Memb. P	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Circ. Bend. P	-4.6	4.6	-4.6	4.6	-5.5	5.5	-5.5	5.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-0.4	-0.4	0.4	0.4
Circ. Memb. MC	0.0	0.0	0.0	0.0	-21.4	21.4	21.4	-21.4
Circ. Memb. ML	-1.5	-1.5	1.5	1.5	0.0	0.0	0.0	0.0
Circ. Bend. ML	-12.3	12.3	12.3	-12.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-19.3	14.5	8.4	-7.1	-28.2	25.7	15.4	-16.4
Long. Memb. P	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Long. Bend. P	-5.6	5.6	-5.6	5.6	-4.5	4.5	-4.5	4.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-0.5	-0.5	0.5	0.5
Long. Bend. MC	0.0	0.0	0.0	0.0	-12.9	12.9	12.9	-12.9
Long. Memb. ML	-0.4	-0.4	0.4	0.4	0.0	0.0	0.0	0.0
Long. Bend. ML	-20.5	20.5	20.5	-20.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	-27.4	24.9	14.3	-15.3	-18.8	16.1	8.0	-8.8
Shear VC	1.0	1.0	-1.0	-1.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.0	-1.0	1.0	1.0
Shear MT	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Tot. Shear	5.2	5.2	3.2	3.2	3.2	3.2	5.2	5.2
Str. Int.	29.9	27.0	15.7	16.4	29.1	26.6	18.1	19.0

Dimensionless Parameters used : Gamma = 50.28

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.155	4C	7.581	(A,B)
N(PHI) / (P/Rm)	0.155	3C	5.549	(C,D)
M(PHI) / (P)	0.155	2C1	0.044	(A,B)
M(PHI) / (P)	0.155	1C !	0.078	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.155	3A	2.036	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.155	1A	0.079	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.155	3B	5.454	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.155	1B	0.030	(A,B,C,D)
N(x) / (P/Rm)	0.155	3C	5.549	(A,B)
N(x) / (P/Rm)	0.155	4C	7.581	(C,D)
M(x) / (P)	0.155	1C1	0.081	(A,B)
M(x) / (P)	0.155	2C !	0.044	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.155	4A	3.507	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.155	2A	0.040	(A,B,C,D)

```
N(x)    / ( ML/(Rm**2 * Beta) )    0.155    4B        1.954    (A,B,C,D)
M(x)    / ( ML/(Rm    * Beta) )    0.155    2B        0.042    (A,B,C,D)
```

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-3.7	-3.7	-3.7	-3.7	-2.7	-2.7	-2.7	-2.7
Circ. Bend. P	-6.5	6.5	-6.5	6.5	-11.5	11.5	-11.5	11.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-2.9	-2.9	2.9	2.9
Circ. Memb. MC	0.0	0.0	0.0	0.0	-33.5	33.5	33.5	-33.5
Circ. Memb. ML	-7.6	-7.6	7.6	7.6	0.0	0.0	0.0	0.0
Circ. Bend. ML	-12.7	12.7	12.7	-12.7	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-30.6	7.8	10.1	-2.2	-50.6	39.4	22.2	-21.9
Long. Memb. P	-2.7	-2.7	-2.7	-2.7	-3.7	-3.7	-3.7	-3.7
Long. Bend. P	-11.9	11.9	-11.9	11.9	-6.5	6.5	-6.5	6.5
Long. Memb. MC	0.0	0.0	0.0	0.0	-4.9	-4.9	4.9	4.9
Long. Bend. MC	0.0	0.0	0.0	0.0	-16.8	16.8	16.8	-16.8
Long. Memb. ML	-2.7	-2.7	2.7	2.7	0.0	0.0	0.0	0.0
Long. Bend. ML	-17.8	17.8	17.8	-17.8	0.0	0.0	0.0	0.0
Tot. Long. Str.	-35.2	24.3	5.9	-5.9	-31.9	14.6	11.5	-9.1
Shear VC	0.9	0.9	-0.9	-0.9	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.9	-0.9	0.9	0.9
Shear MT	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Tot. Shear	2.3	2.3	0.5	0.5	0.5	0.5	2.3	2.3
Str. Int.	36.1	24.6	10.1	5.9	50.6	39.4	22.6	22.3

Stress Intensity Values at

WRC 107/537 Stress Summations:

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

Type of Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3
Circ. Pl (SUS)	-2.4	-2.4	0.6	0.6	-1.3	-1.3	-0.5	-0.5
Circ. Q (SUS)	-16.9	16.9	7.7	-7.7	-26.9	26.9	15.9	-15.9
Long. Pm (SUS)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Long. Pl (SUS)	-1.2	-1.2	-0.5	-0.5	-1.4	-1.4	-0.4	-0.4
Long. Q (SUS)	-26.1	26.1	14.8	-14.8	-17.4	17.4	8.4	-8.4
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.0	1.0	-1.0	-1.0	-1.0	-1.0	1.0	1.0
Shear Q (SUS)	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3

Stress Intensity Values at

Pm+Pl (SUS)	45.7	48.0	48.7	51.0	46.8	49.1	47.6	49.9
Pm+Pl+Q (Total)	33.7	66.3	57.0	43.5	20.5	76.3	64.3	35.3

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	50.34	137.90	Passed
Pm+Pl (SUS)	51.02	206.85	Passed
Pm+Pl+Q (TOTAL)	76.29	413.70	Passed

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	113.6	115.9	113.6	115.9	113.6	115.9	113.6	115.9
Circ. Pl (SUS)	-11.4	-11.4	3.9	3.9	-5.6	-5.6	0.1	0.1
Circ. Q (SUS)	-19.2	19.2	6.2	-6.2	-45.0	45.0	22.0	-22.0
Long. Pm (SUS)	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
Long. Pl (SUS)	-5.5	-5.5	0.0	0.0	-8.6	-8.6	1.2	1.2
Long. Q (SUS)	-29.8	29.8	5.9	-5.9	-23.3	23.3	10.3	-10.3
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.9	0.9	-0.9	-0.9	-0.9	-0.9	0.9	0.9
Shear Q (SUS)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Pm (SUS)	113.6	115.9	113.6	115.9	113.6	115.9	113.6	115.9
Pm+Pl (SUS)	102.2	104.5	117.5	119.8	108.0	110.3	113.7	116.0
Pm+Pl+Q (Total)	83.1	123.8	123.7	113.6	63.0	155.3	135.8	94.1

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	115.87	137.90	Passed
Pm+Pl (SUS)	119.81	206.85	Passed
Pm+Pl+Q (TOTAL)	155.31	413.70	Passed

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Nozzle Calcs.: SV Nozl: 21 9:17pm Feb 18,2022

INPUT VALUES, Nozzle Description: SV From : 20

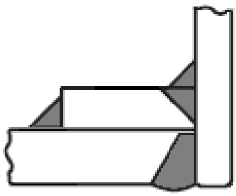
Pressure for Reinforcement Calculations	P	23.000	bar
Temperature for Internal Pressure	Temp	135	°C
Design External Pressure	Pext	1.10	bar
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm^2
Shell Allowable Stress At Ambient	Sva	137.90	N./mm^2
Inside Diameter of Cylindrical Shell	D	890.00	mm.
Design Length of Section	L	4148.3335	mm.
Shell Finished (Minimum) Thickness	t	12.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		2300.00	mm.
User Entered Minimum Design Metal Temperature		-45.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm^2
Allowable Stress At Ambient	Sna	117.90	N./mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		4.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	120	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N./mm^2
Diameter of Pad along vessel surface	Dp	250.0000	mm.
Thickness of Pad	te	12.0000	mm.
Weld leg size between Pad and Shell	Wp	10.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm.
Reinforcing Pad Width		67.8500	mm.
Class of attached Flange		300	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: SV

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation           4.500  in.
 Actual Thickness Used in Calculation                  0.383  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (23*448)/(137.9*1-0.6*23)
  = 7.5487 mm.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (23*57.15)/(117.9*1+0.4*23)
  = 1.1064 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.4205 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)            Dl   201.6618  mm.
 Parallel to Vessel Wall, opening length              d   100.8309  mm.
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp    22.5000  mm.
```

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

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

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

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

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

```
  = min( 0.855, 1 )
  = 0.855
```

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

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	7.759	2.910	NA
Area in Shell	A1	1.435	3.299	NA
Area in Nozzle Wall	A2	2.165	2.429	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.855	0.855	NA
Area in Element	A5	10.483	10.483	NA
TOTAL AREA AVAILABLE	Atot	14.939	17.067	NA

The Internal Pressure Case Governs the Analysis.

```
 Nozzle Angle Used in Area Calculations                   90.00  Degs.
```

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	141.8286	12.0000	mm.
Based on given Pad Diameter:	250.0000	3.7813	mm.
Based on Shell or Nozzle Thickness:	148.2351	9.7345	mm.

Area Required [A]:

```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (100.8*7.549*1+2*6.735*7.549*1*(1-0.855))
  = 7.759 cm²
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 100.8 ( 1 * 9 - 1 * 7.549 ) - 2 * 6.735
    ( 1 * 9 - 1 * 7.549 ) * ( 1 - 0.855 )
  = 1.435 cm²
```

Area Available in Nozzle Wall Projecting Outward [A2]:

```
  = ( 2 * Tlwp ) * ( tn - trn ) * fr2
  = ( 2 * 22.5 ) * ( 6.735 - 1.106 ) * 0.855
  = 2.165 cm²
```

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

```
  = Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
  = 10² * 0.855 + (0 )² * 0.855 + 0² * 1
  = 0.855 cm²
```

Area Available in Element [A5]:

```
  = (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
  = ( 201.7 - 114.3 ) * 12 * 1
  = 10.483 cm²
```

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

```
 Wall Thickness for Internal/External pressures      ta = 4.1064 mm.
 Wall Thickness per UG16(b),                      tr16b = 4.5000 mm.
 Wall Thickness, shell/head, internal pressure     trb1 = 10.5487 mm.
 Wall Thickness               tb1 = max(trb1, tr16b) = 10.5487 mm.
 Wall Thickness, shell/head, external pressure     trb2 = 3.3576 mm.
 Wall Thickness               tb2 = max(trb2, tr16b) = 4.5000 mm.
```

```
 Wall Thickness per table UG-45                    tb3 = 8.2578 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 8.258, max( 10.55, 4.5 ) ]
  = 8.2578 mm.
```

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

```
  = max( ta, tb )
  = max( 4.106, 8.258 )
  = 8.2578 mm.
```

Available Nozzle Neck Thickness = 9.7345 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
 Sustained  :      51.4,  Allowable :    117.9 N./mm^2  Passed
 Expansion  :       0.0,  Allowable :    243.4 N./mm^2  Passed
 Occasional :       8.1,  Allowable :    156.8 N./mm^2  Passed
 Shear      :      24.8,  Allowable :     82.5 N./mm^2  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

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

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

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

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

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

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

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

Govrn. thk, tg = 9.735, tr = 1.106, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.164, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C
```

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

Govrn. thk, tg = 12, tr = 7.549, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.839, Temp. Reduction = 9 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve D              -48 °C
```

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

Govrn. thk, tg = 9.735, tr = 1.106, c = 3 mm., E* = 1

Thickness Ratio = tr * (E*)/(tg - c) = 0.164, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve D          -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -104 °C

Governing MDMT of the Nozzle                         :  -104 °C
Governing MDMT of the Reinforcement Pad              :   -48 °C
Governing MDMT of all the sub-joints of this Junction :  -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification    -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)        -48 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)       -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 23.00/51.10 = 0.450

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: SV

```
Intermediate Calc. for nozzle/shell Welds   Tmin       6.7345  mm.
Intermediate Calc. for pad/shell Welds      TminPad    9.0000  mm.
```

Results Per UW-16.1:

```
                      Required Thickness     Actual Thickness
Nozzle Weld          4.7142 = 0.7 * tmin.   7.0700 = 0.7 * Wo mm.
Pad Weld             4.5000 = 0.5*TminPad   7.0700 = 0.7 * Wp mm.
```

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

Weld Load [W]:
```
= max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
= max( 0, (7.759 - 1.435 + 2 * 6.735 * 0.855 *
   (1 * 9 - 7.549 ) )137.9 )
= 89.50 kN
```

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

Weld Load [W1]:
```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 2.165 + 10.48 + 0.855 - 0 * 0.855 ) * 137.9
= 186.20 kN
```

Weld Load [W2]:
```
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= ( 2.165 + 0 + 0.855 + ( 1.036 ) ) * 137.9
= 55.94 kN
```

Weld Load [W3]:
```
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= ( 2.165 + 0 + 0.855 + 10.48 + ( 1.036 ) ) * 137.9
= 200.49 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.142/2.0 ) * 114.3 * 10 * 0.49 * 117.9
= 104. kN
```

Shear, Pad Element Weld [Spew]:
```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 250 * 10 * 0.49 * 137.9
  = 265. kN
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 53.78 ) * ( 9.735 - 3 ) * 0.7 * 117.9
  = 94. kN
```

Tension, Pad Groove Weld [Tpgw]:
```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 114.3 * 12 * 0.74 * 137.9
  = 220. kN
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 114.3 * ( 12 - 3 ) * 0.74 * 137.9
  = 165. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 265.3 + 93.91 ) = 359.2 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 103.7 + 219.8 + 164.9 + 0 ) = 488.4 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 265.3 + 164.9 + 0 ) = 430.2 kN
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 359 kN , must exceed W = 89 kN  or W1 = 186 kN
 Path 2-2 = 488 kN , must exceed W = 89 kN  or W2 = 55 kN
 Path 3-3 = 430 kN , must exceed W = 89 kN  or W3 = 200 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Max. Allow. Pressure in Operating case       27.329  bar
```

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

```
 Nozzle is O.K. for the External Pressure                1.100  bar
```

The Drop for this Nozzle is : 3.6850 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 165.6850 mm.

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

```
 Diameter Basis for Vessel                     Vbasis       ID
 Cylindrical or Spherical Vessel               Cylsph       Cylindrical
 Internal Corrosion Allowance                     Cas       3.0000  mm.
 Vessel Diameter                                   Dv     890.000  mm.
 Vessel Thickness                                  Tv      12.000  mm.

 Design Temperature                                         135.00  °C
 Vessel Material                                         SA-516 70
 Vessel Cold S.I. Allowable                       Smc       137.90  N./mm^2
 Vessel Hot  S.I. Allowable                       Smh       137.90  N./mm^2

 Attachment Type                                 Type       Round

 Diameter Basis for Nozzle                     Nbasis       OD
 Corrosion Allowance for Nozzle                   Can       3.0000  mm.
 Nozzle Diameter                                   Dn     114.300  mm.
```

```
 Nozzle Thickness                                 Tn        9.735  mm.
 Nozzle Material                                        SA-333 6
 Nozzle Cold S.I. Allowable                     SNmc      117.90  N./mm^2
 Nozzle Hot  S.I. Allowable                     SNmh      117.90  N./mm^2

 Thickness of Reinforcing Pad                   Tpad      12.000  mm.
 Diameter  of Reinforcing Pad                   Dpad     250.000  mm.

 Design Internal Pressure                         Dp      23.000  bar
 Include Pressure Thrust                                      No
```

External Forces and Moments in WRC 107/537 Convention:

```
 Radial Load             (SUS)                     P         4.0  kN
 Longitudinal Shear      (SUS)                    Vl         4.0  kN
 Circumferential Shear   (SUS)                    Vc         4.0  kN
 Circumferential Moment  (SUS)                    Mc      1700.0  N-m
 Longitudinal Moment     (SUS)                    Ml      1700.0  N-m
 Torsional Moment        (SUS)                    Mt      2100.0  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
 Local Loads applied at end of Nozzle/Attachment              No
```

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

Stress Attenuation Diameter (for Insert Plates) per WRC 297:

```
  = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
  = 114.3 + 2 * 1.65 * sqrt( 452.5  ( 12.0 - 3.0 ) )
  = 324.893 mm.
```

WRC 107 Stress Calculation for SUStained loads:

```
 Radial Load                                       P         4.0  kN
 Circumferential Shear                            VC         4.0  kN
 Longitudinal Shear                               VL         4.0  kN
 Circumferential Moment                           MC      1700.0  N-m
 Longitudinal Moment                              ML      1700.0  N-m
 Torsional Moment                                 MT      2100.0  N-m

 Dimensionless Parameters used :    Gamma =    21.83
```

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.109	4C	3.985	(A,B)
N(PHI) / (P/Rm)	0.109	3C	3.570	(C,D)
M(PHI) / (P)	0.109	2C1	0.108	(A,B)
M(PHI) / (P)	0.109	1C	0.144	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.109	3A	0.560	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.109	1A	0.100	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.109	3B	1.958	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.109	1B	0.050	(A,B,C,D)
N(x) / (P/Rm)	0.109	3C	3.570	(A,B)

```
N(x)   / ( P/Rm )                0.109   4C        3.985   (C,D)
M(x)   / ( P )                   0.109   1C1       0.146   (A,B)
M(x)   / ( P )                   0.109   2C        0.107   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.109   4A        0.781   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.109   2A        0.056   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.109   4B        0.533   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.109   2B        0.083   (A,B,C,D)
```

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
	Stress Intensity Values at							
Circ. Memb. P	-1.7	-1.7	-1.7	-1.7	-1.5	-1.5	-1.5	-1.5
Circ. Bend. P	-5.9	5.9	-5.9	5.9	-7.8	7.8	-7.8	7.8
Circ. Memb. MC	0.0	0.0	0.0	0.0	-2.0	-2.0	2.0	2.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-46.2	46.2	46.2	-46.2
Circ. Memb. ML	-6.9	-6.9	6.9	6.9	0.0	0.0	0.0	0.0
Circ. Bend. ML	-23.2	23.2	23.2	-23.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-37.6	20.5	22.6	-12.1	-57.5	50.5	38.9	-37.9
Long. Memb. P	-1.5	-1.5	-1.5	-1.5	-1.7	-1.7	-1.7	-1.7
Long. Bend. P	-8.0	8.0	-8.0	8.0	-5.8	5.8	-5.8	5.8
Long. Memb. MC	0.0	0.0	0.0	0.0	-2.8	-2.8	2.8	2.8
Long. Bend. MC	0.0	0.0	0.0	0.0	-26.0	26.0	26.0	-26.0
Long. Memb. ML	-1.9	-1.9	1.9	1.9	0.0	0.0	0.0	0.0
Long. Bend. ML	-38.2	38.2	38.2	-38.2	0.0	0.0	0.0	0.0
Tot. Long. Str.	-49.6	42.9	30.7	-29.9	-36.3	27.5	21.3	-19.1
Shear VC	1.1	1.1	-1.1	-1.1	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.1	-1.1	1.1	1.1
Shear MT	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Tot. Shear	5.9	5.9	3.8	3.8	3.8	3.8	5.9	5.9
Str. Int.	52.0	44.3	32.2	30.7	58.1	51.2	40.7	39.6

Dimensionless Parameters used : Gamma = 50.28

Dimensionless Loads for Cylindrical Shells at Pad edge:

```
-----------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-----------------------------------------------------------------
N(PHI) / ( P/Rm )                0.242   4C        6.159   (A,B)
N(PHI) / ( P/Rm )                0.242   3C        3.233   (C,D)
M(PHI) / ( P )                   0.242   2C1       0.020   (A,B)
M(PHI) / ( P )                   0.242   1C  !     0.065   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.242   3A        1.879   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.242   1A        0.064   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.242   3B        4.235   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.242   1B        0.015   (A,B,C,D)

N(x)   / ( P/Rm )                0.242   3C        3.233   (A,B)
N(x)   / ( P/Rm )                0.242   4C        6.159   (C,D)
M(x)   / ( P )                   0.242   1C1       0.046   (A,B)
M(x)   / ( P )                   0.242   2C  !     0.033   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.242   4A        4.449   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.242   2A        0.028   (A,B,C,D)
```

```
 N(x)    / ( ML/(Rm**2 * Beta) )    0.242    4B         1.966    (A,B,C,D)
 M(x)    / ( ML/(Rm    * Beta) )    0.242    2B         0.022    (A,B,C,D)
```

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-6.0	-6.0	-6.0	-6.0	-3.2	-3.2	-3.2	-3.2
Circ. Bend. P	-6.0	6.0	-6.0	6.0	-19.3	19.3	-19.3	19.3
Circ. Memb. MC	0.0	0.0	0.0	0.0	-7.2	-7.2	7.2	7.2
Circ. Memb. MC	0.0	0.0	0.0	0.0	-73.5	73.5	73.5	-73.5
Circ. Memb. ML	-16.2	-16.2	16.2	16.2	0.0	0.0	0.0	0.0
Circ. Bend. ML	-17.2	17.2	17.2	-17.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-45.4	1.0	21.3	-1.1	-103.1	82.4	58.1	-50.1
Long. Memb. P	-3.2	-3.2	-3.2	-3.2	-6.0	-6.0	-6.0	-6.0
Long. Bend. P	-13.7	13.7	-13.7	13.7	-9.9	9.9	-9.9	9.9
Long. Memb. MC	0.0	0.0	0.0	0.0	-17.0	-17.0	17.0	17.0
Long. Bend. MC	0.0	0.0	0.0	0.0	-31.7	31.7	31.7	-31.7
Long. Memb. ML	-7.5	-7.5	7.5	7.5	0.0	0.0	0.0	0.0
Long. Bend. ML	-25.3	25.3	25.3	-25.3	0.0	0.0	0.0	0.0
Tot. Long. Str.	-49.8	28.4	15.9	-7.3	-64.6	18.6	32.7	-10.9
Shear VC	1.1	1.1	-1.1	-1.1	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.1	-1.1	1.1	1.1
Shear MT	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Tot. Shear	3.5	3.5	1.2	1.2	1.2	1.2	3.5	3.5
Str. Int.	51.7	28.9	21.5	7.5	103.2	82.5	58.6	50.5

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3
Circ. Pl (SUS)	-8.6	-8.6	5.3	5.3	-3.5	-3.5	0.5	0.5
Circ. Q (SUS)	-29.0	29.0	17.3	-17.3	-54.0	54.0	38.4	-38.4
Long. Pm (SUS)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Long. Pl (SUS)	-3.4	-3.4	0.4	0.4	-4.4	-4.4	1.1	1.1
Long. Q (SUS)	-46.2	46.2	30.3	-30.3	-31.9	31.9	20.2	-20.2
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.1	1.1	-1.1	-1.1	-1.1	-1.1	1.1	1.1
Shear Q (SUS)	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Pm (SUS)	48.0	50.3	48.0	50.3	48.0	50.3	48.0	50.3

Pm+Pl (SUS)	39.4	41.7	53.2	55.5	44.5	46.8	48.5	50.8
Pm+Pl+Q (Total)	37.9	75.0	71.4	44.7	15.0	101.1	87.6	15.7

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	50.25	137.90	Passed
Pm+Pl (SUS)	55.54	206.85	Passed
Pm+Pl+Q (TOTAL)	101.08	413.70	Passed

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Circ. Pl (SUS)	-22.2	-22.2	10.1	10.1	-10.3	-10.3	4.0	4.0
Circ. Q (SUS)	-23.2	23.2	11.2	-11.2	-92.8	92.8	54.1	-54.1
Long. Pm (SUS)	56.7	56.7	56.7	56.7	56.7	56.7	56.7	56.7
Long. Pl (SUS)	-10.7	-10.7	4.3	4.3	-23.0	-23.0	10.9	10.9
Long. Q (SUS)	-39.1	39.1	11.6	-11.6	-41.6	41.6	21.8	-21.8
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.1	1.1	-1.1	-1.1	-1.1	-1.1	1.1	1.1
Shear Q (SUS)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Pm (SUS)	113.4	115.7	113.4	115.7	113.4	115.7	113.4	115.7
Pm+Pl (SUS)	91.2	93.5	123.5	125.8	103.0	105.3	117.4	119.7
Pm+Pl+Q (Total)	68.1	117.1	134.7	114.6	18.4	198.1	171.6	66.1

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

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	115.67	137.90	Passed
Pm+Pl (SUS)	125.80	206.85	Passed
Pm+Pl+Q (TOTAL)	198.11	413.70	Passed

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Nozzle Calcs.: TI Nozl: 22 9:17pm Feb 18,2022

INPUT VALUES, Nozzle Description: TI From : 30

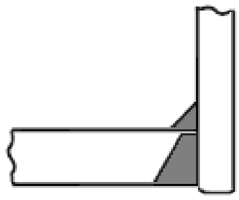
```
Pressure for Reinforcement Calculations        P       23.034  bar
Temperature for Internal Pressure           Temp          135  °C
Design External Pressure                    Pext         1.10  bar
Temperature for External Pressure         Tempex          100  °C

Shell Material   [Normalized]                      SA-516 70
Shell Allowable Stress at Temperature         Sv       137.90  N./mm^2
Shell Allowable Stress At Ambient            Sva       137.90  N./mm^2

Inside Diameter of Elliptical Head             D       890.00  mm.
Aspect Ratio of Elliptical Head               Ar         2.00
Head Finished (Minimum) Thickness              t      12.0000  mm.
Head Internal Corrosion Allowance              c       3.0000  mm.
Head External Corrosion Allowance             co       0.0000  mm.

Distance from Head Centerline                 L1     300.0000  mm.

User Entered Minimum Design Metal Temperature          -45.00  °C
```

Type of Element Connected to the Shell : Nozzle

```
Material         [Impact Tested]                    SA-333 6
Material UNS Number                                   K03006
Material Specification/Type               Smls. & wld. pipe
Allowable Stress at Temperature               Sn       117.90  N./mm^2
Allowable Stress At Ambient                  Sna       117.90  N./mm^2

Diameter Basis (for tr calc only)                        OD
Layout Angle                                           180.00  deg
Diameter                                               1.5000  in.

Size and Thickness Basis                                Minimum
Nominal Thickness                             tn        XXS

Flange Material                                    SA-350 LF2
Flange Type                                  Weld Neck Flange

Corrosion Allowance                          can       3.0000  mm.
Joint Efficiency of Shell Seam at Nozzle      E1         1.00
Joint Efficiency of Nozzle Neck               En         1.00

Outside Projection                            ho     150.0000  mm.
Weld leg size between Nozzle and Pad/Shell    Wo      10.0000  mm.
Groove weld depth between Nozzle and Vessel Wgnv      12.0000  mm.
Inside Projection                              h       0.0000  mm.
Weld leg size, Inside Element to Shell        Wi       0.0000  mm.

Class of attached Flange                             300
Grade of attached Flange                             GR 1.1
```

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle in the Meridional direction.

Reinforcement CALCULATION, Description: TI

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation             1.900  in.
Actual Thickness Used in Calculation                    0.350  in.
```

Nozzle input data check completed without errors.

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

```
  = (P*K1*D))/(2*Sv*E-0.2*P) per UG-37(a)(3)
  = (23.03*0.894*896)/(2 *137.9*1-0.2*23.03)
  = 6.7041 mm.
```

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

```
  = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = (23.03*24.13)/(117.9*1+0.4*23.03)
  = 0.4678 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2542 mm.

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

```
Parallel to Vessel Wall (Diameter Limit)            Dl    80.0925  mm.
Parallel to Vessel Wall, opening length              d    40.0462  mm.
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    14.7250  mm.
```

Weld Strength Reduction Factor [fr1]:

```
  = min( 1, Sn/Sv )
  = min( 1, 117.9/137.9 )
  = 0.855
```

Weld Strength Reduction Factor [fr2]:

```
  = min( 1, Sn/Sv )
  = min( 1, 117.9/137.9 )
  = 0.855
```

Weld Strength Reduction Factor [fr3]:

```
  = min( fr2, fr4 )
  = min( 0.855, 1 )
  = 0.855
```

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	2.799	0.510	NA

Area in Shell	A1	0.880	2.515	NA
Area in Nozzle Wall	A2	1.466	1.524	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.855	0.855	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	3.201	4.894	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 65.64 Degs.

The area available without a pad is Sufficient.

Area Required [A]:
= (d * tr*F + 2 * tn * tr*F * (1-fr1)) UG-37(c)
= (40.05*6.704*1+2*5.89*6.704*1*(1-0.855))
= 2.799 cm²

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
= d(E1*t - F*tr) - 2 * tn(E1*t - F*tr) * (1 - fr1)
= 40.05 (1 * 9 - 1 * 6.704) - 2 * 5.89
(1 * 9 - 1 * 6.704) * (1 - 0.855)
= 0.880 cm²

Area Available in Nozzle Projecting Outward [A2]:
= (2 * tlnp)(tn - trn)fr2/sin(alpha3)
= (2 * 14.72)(5.89 - 0.468)0.855/sin(68.62)
= 1.466 cm²

Note: See ASME VIII-1 2011(a) Appendix L, L-7.7.7(b) for more information.

Area Available in Inward Weld + Outward Weld [A41 + A43]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 10² * 0.855 + (0)² * 0.855
= 0.855 cm²

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

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

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

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

Govrn. thk, tg = 8.89, tr = 0.468, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0794, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Governing MDMT of all the sub-joints of this Junction : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ANSI B16.5/47 flange per Matl. Specification -46 °C

```
 Flange MDMT with Temp reduction per UCS-66(i)(2)           -48 °C
 Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
 Design Pressure/Ambient Rating = 23.03/51.10 = 0.451
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: TI

```
 Intermediate Calc. for nozzle/shell Welds   Tmin      5.8900  mm.
```

Results Per UW-16.1:

```
                          Required Thickness    Actual Thickness
 Nozzle Weld            4.1230 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
```

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

Weld Load [W]:

```
   = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
   = max( 0, (2.799 - 0.88 + 2 * 5.89 * 0.855 *
     (1 * 9 - 6.704 ) )137.9 )
   = 29.65 kN
```

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

Weld Load [W1]:

```
   = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
   = ( 1.466 + 0 + 0.855 - 0 * 0.855 ) * 137.9
   = 32.01 kN
```

Weld Load [W2]:

```
   = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
   = ( 1.466 + 0 + 0.855 + ( 0.906 ) ) * 137.9
   = 44.51 kN
```

Weld Load [W3]:

```
   = (A2+A3+A4+A5+(2*tn*t*fr1))*S
   = ( 1.466 + 0 + 0.855 + 0 + ( 0.906 ) ) * 137.9
   = 44.51 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
   = (pi/2) * Dlo * Wo * 0.49 * Snw
   = ( 3.142/2.0 ) * 52.98 * 10 * 0.49 * 117.9
   = 48. kN
```

Shear, Nozzle Wall [Snw]:

```
   = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
   = (3.142 * 23.26 ) * ( 8.89 - 3 ) * 0.7 * 117.9
   = 36. kN
```

Tension, Shell Groove Weld [Tngw]:

```
   = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
   = ( 3.142/2.0 ) * 52.98 * ( 12 - 3 ) * 0.74 * 137.9
   = 76. kN
```

Strength of Failure Paths:

```
   PATH11 = ( SONW + SNW ) = ( 48.07 + 35.51 ) = 83.59 kN
```

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Nozzle Calcs.: TI Nozl: 22 9:17pm Feb 18,2022

```
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 48.07 + 0 + 76.42 + 0 ) = 124.5 kN
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 48.07 + 76.42 + 0 ) = 124.5 kN
```

Summary of Failure Path Calculations:

```
Path 1-1 = 83 kN , must exceed W = 29 kN  or W1 = 32 kN
Path 2-2 = 124 kN , must exceed W = 29 kN  or W2 = 44 kN
Path 3-3 = 124 kN , must exceed W = 29 kN  or W3 = 44 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case       24.716  bar

Nozzle is O.K. for the External Pressure                1.100  bar
```

Note : Checking Nozzle in the Latitudinal direction.

Reinforcement CALCULATION, Description: TI

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation            1.900  in.
Actual Thickness Used in Calculation                   0.350  in.
```

Nozzle input data check completed without errors.

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

```
= (P*K1*D))/(2*Sv*E-0.2*P) per UG-37(a)(3)
= (23.03*0.894*896)/(2 *137.9*1-0.2*23.03)
= 6.7041 mm.
```

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

```
= (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= (23.03*24.13)/(117.9*1+0.4*23.03)
= 0.4678 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2542 mm.

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

```
Parallel to Vessel Wall (Diameter Limit)           Dl    72.9600   mm.
Parallel to Vessel Wall, opening length             d    36.4800   mm.
Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    14.7250   mm.
```

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

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	2.560	0.466	NA
Area in Shell	A1	0.798	2.281	NA
Area in Nozzle Wall	A2	1.365	1.419	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.855	0.855	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	3.019	4.555	NA

The Internal Pressure Case Governs the Analysis.

```
Nozzle Angle Used in Area Calculations                 90.00   Degs.
```

The area available without a pad is Sufficient.

Area Required [A]:


```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (36.48*6.704*1+2*5.89*6.704*1*(1-0.855))
  = 2.560 cm²
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 36.48 ( 1 * 9 - 1 * 6.704 ) - 2 * 5.89
    ( 1 * 9 - 1 * 6.704 ) * ( 1 - 0.855 )
  = 0.798 cm²
```

Area Available in Nozzle Projecting Outward [A2]:
```
  = ( 2 * tlnp )( tn - trn )fr2
  = ( 2 * 14.72 )( 5.89 - 0.468 )0.855
  = 1.365 cm²
```

Area Available in Inward Weld + Outward Weld [A41 + A43]:
```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
  = 10² * 0.855 + ( 0 )² * 0.855
  = 0.855 cm²
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
 Wall Thickness for Internal/External pressures      ta = 3.4678 mm.
 Wall Thickness per UG16(b),                      tr16b = 4.5000 mm.
 Wall Thickness, shell/head, internal pressure     trb1 = 10.4304 mm.
 Wall Thickness                  tb1 = max(trb1, tr16b) = 10.4304 mm.
 Wall Thickness, shell/head, external pressure     trb2 = 3.3543 mm.
 Wall Thickness                  tb2 = max(trb2, tr16b) = 4.5000 mm.
 Wall Thickness per table UG-45                     tb3 = 6.2200 mm.
```

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 6.22, max( 10.43, 4.5 ) ]
  = 6.2200 mm.
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 3.468, 6.22 )
  = 6.2200 mm.
```

Available Nozzle Neck Thickness = 8.8900 mm. --> OK

Weld Size Calculations, Description: TI

```
 Intermediate Calc. for nozzle/shell Welds   Tmin      5.8900  mm.
```

Results Per UW-16.1:
```
                         Required Thickness    Actual Thickness
 Nozzle Weld           4.1230 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
```

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

Weld Load [W]:
```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (2.56 - 0.798 + 2 * 5.89 * 0.855 *
    (1 * 9 - 6.704 ) )137.9 )
  = 27.48 kN
```

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

Weld Load [W1]:

```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 1.365 + 0 + 0.855 - 0 * 0.855 ) * 137.9
  = 30.62 kN
```

Weld Load [W2]:

```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 1.365 + 0 + 0.855 + ( 0.906 ) ) * 137.9
  = 43.11 kN
```

Weld Load [W3]:

```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 1.365 + 0 + 0.855 + 0 + ( 0.906 ) ) * 137.9
  = 43.11 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 48.26 * 10 * 0.49 * 117.9
  = 44. kN
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 21.18 ) * ( 8.89 - 3 ) * 0.7 * 117.9
  = 32. kN
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 48.26 * ( 12 - 3 ) * 0.74 * 137.9
  = 70. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 43.79 + 32.35 ) = 76.14 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 43.79 + 0 + 69.62 + 0 ) = 113.4 kN
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 43.79 + 69.62 + 0 ) = 113.4 kN
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 76 kN , must exceed W = 27 kN  or W1 = 30 kN
 Path 2-2 = 113 kN , must exceed W = 27 kN  or W2 = 43 kN
 Path 3-3 = 113 kN , must exceed W = 27 kN  or W3 = 43 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case      25.138  bar

 Nozzle is O.K. for the External Pressure               1.100  bar
```

The Drop for this Nozzle is : 10.0669 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 172.9691 mm.

Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia in	Wall Thk mm.	Reinforcing Pad Diameter mm.	Reinforcing Pad Thk mm.	Cut Length mm.	Flg Class
PT	1.500 in	XXS	WNF	1.900	10.160	...	...	162.65	300
TI	1.500 in	XXS	WNF	1.900	10.160	...	...	172.97	300
A2	2.000 in	160	WNF	2.375	8.738	160.32	12.00	213.02	300
A3	2.000 in	160	WNF	2.375	8.738	160.32	12.00	163.02	300
LT1	2.000 in	160	WNF	2.375	8.738	160.32	12.00	163.02	300
LT2	2.000 in	160	WNF	2.375	8.738	160.32	12.00	163.02	300
D	2.000 in	160	WNF	2.375	8.738	160.00	12.00	163.02	300
SV	4.000 in	120	WNF	4.500	11.125	250.00	12.00	165.69	300
A1	8.000 in	80	WNF	8.625	12.700	379.08	12.00	1012.00	300
B	8.000 in	80	WNF	8.625	12.700	379.08	12.00	225.69	300
M	20.000 in	Actual	WNF	20.000	15.000	738.00	15.00	252.82	300

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows: Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

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

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

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
PT	SA-333 6	12.000	11.000	...	...	...
TI	SA-333 6	12.000	10.000	...	...	...
A2	SA-333 6	12.000	10.000	10.000	12.000	...
A3	SA-333 6	12.000	8.000	10.000	12.000	...
LT1	SA-333 6	12.000	10.000	10.000	12.000	...
LT2	SA-333 6	12.000	10.000	10.000	12.000	...
D	SA-333 6	12.000	10.000	10.000	12.000	...
SV	SA-333 6	12.000	10.000	10.000	12.000	...
A1	SA-333 6	12.000	10.000	10.000	12.000	...
B	SA-333 6	12.000	10.000	10.000	12.000	...

M		SA-516 70	12.000	10.000	9.000	15.000	...

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

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm.	Layout Angle deg	Proj Outside mm.	Proj Inside mm.	Installed in Component
PT	1750.000	0.0	150.00	0.00	shell 001
TI	...	180.0	150.00	0.00	head 002
A2	3300.000	0.0	200.00	0.00	shell 001
A3	1200.000	0.0	150.00	0.00	shell 001
LT1	3700.000	180.0	150.00	0.00	shell 001
LT2	3650.000	0.0	150.00	0.00	shell 001
D	300.000	180.0	150.00	0.00	shell 001
SV	2300.000	0.0	150.00	0.00	shell 001
A1	500.000	0.0	200.00	800.00	shell 001
B	2000.000	180.0	200.00	0.00	shell 001
M	...	0.0	200.00	0.00	head 001

Minimum Design Metal Temperature Results Summary :

Description	Notes	Curve	Basic MDMT °C	Reduced MDMT °C	UG-20(f) MDMT °C	Thickness ratio	Gov Thk mm.	E*	PWHT reqd
head 001	[10]	D	-48	-48	-29	0.832	12.000	1.00	No
head 001	[7]	D	-47	-48	-29	0.635	15.000	1.00	No
shell 001	[8]	D	-48	-48	-29	0.846	12.000	1.00	No
head 002	[10]	D	-48	-48	-29	0.832	12.000	1.00	No
head 002	[7]	D	-47	-48	-29	0.635	15.000	1.00	No
M	[1]	D	-47	-48		0.351	15.000	1.00	No
Nozzle Flg	[4]	!	-46	-48					
A1	[1]	D	-48	-48	-29	0.839	12.000	1.00	No
Nozzle Flg	[4]	!	-46	-104					
B	[1]	D	-48	-48	-29	0.840	12.000	1.00	No
Nozzle Flg	[4]	!	-46	-104					
A2	[1]	D	-48	-48	-29	0.839	12.000	1.00	No
Nozzle Flg	[4]	!	-46	-104					
PT	[1]	!	-46	-104		0.079	8.890	1.00	No
Nozzle Flg	[4]	!	-46	-104					
A3	[1]	D	-48	-48	-29	0.839	12.000	1.00	No
Nozzle Flg	[4]	!	-46	-104					
LT1	[1]	D	-48	-48	-29	0.840	12.000	1.00	No
Nozzle Flg	[4]	!	-46	-104					
LT2	[1]	D	-48	-48	-29	0.839	12.000	1.00	No
Nozzle Flg	[4]	!	-46	-104					
D	[1]	D	-48	-48	-29	0.840	12.000	1.00	No
Nozzle Flg	[4]	!	-46	-104					
SV	[1]	D	-48	-48	-29	0.839	12.000	1.00	No
Nozzle Flg	[4]	!	-46	-104					
TI	[1]	!	-46	-104		0.079	8.890	1.00	No
Nozzle Flg	[4]	!	-46	-104					
Warmest MDMT:			-46	-48					

Required Minimum Design Metal Temperature -45 °C
Warmest Computed Minimum Design Metal Temperature -48 °C

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

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

MDMT Summary: Step: 25 9:17pm Feb 18,2022

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

DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT
Tag no:Liquid Receiver (D-PK6101-2)
PV Elite 2018 SP2 Licensee: SPLM Licensed User
FileName : Calculation Book for LIQID RECEIVER D-PK6101-2
Vessel Design Summary: Step: 26 9:17pm Feb 18,2022

ASME Code, Section VIII Division 1, 2017

Diameter Spec : 914.000 mm. OD		
Vessel Design Length, Tangent to Tangent	4000.00	mm.
Specified Datum Line Distance	0.00	mm.
Shell Material	SA-516 70	[Normalized]
Nozzle Material	SA-333 6	[Impact Tested]
Re-Pad Material	SA-516 70	[Normalized]
Internal Design Temperature	135	°C
Internal Design Pressure	23.000	bar
External Design Temperature	100	°C
External Design Pressure	1.100	bar
Maximum Allowable Working Pressure	23.089	bar
External Max. Allowable Working Pressure	3.413	bar
Hydrostatic Test Pressure	29.900	bar
Required Minimum Design Metal Temperature	-45	°C
Warmest Computed Minimum Design Metal Temperature	-48	°C
Wind Design Code	ASCE-2010	
Earthquake Design Code	ASCE 7-2010	

Element Pressures and MAWP (bar):

Element Description	Design Pres. + Stat. head	External Pressure	M.A.W.P	Corrosion Allowance	Str. Flange Governing
head 001	23.040	1.100	27.849	3.0000	No
shell 001	23.040	1.100	27.329	3.0000	N/A
head 002	23.040	1.100	27.849	3.0000	No

Liquid Level: 890.00 mm. Dens.: 460.789 kg/m³ Sp. Gr.: 0.461

Element Types and Properties:

Element Type	"To" Elev mm.	Length mm.	Element Thk mm.	Reqd Thk Int.	Reqd Thk Ext.	Joint Eff Long	Joint Eff Circ
Ellipse	50.0	50.0	15.0	10.5	5.4	1.00	1.00
Cylinder	3950.0	3900.0	12.0	10.6	8.7	1.00	1.00
Ellipse	4000.0	50.0	15.0	10.5	5.4	1.00	1.00

Element thicknesses are shown as Nominal if specified, otherwise are Minimum

Saddle Parameters:

Saddle Width	172.000	mm.
Saddle Bearing Angle	120.000	deg.
Centerline Dimension	840.000	mm.
Wear Pad Width	200.000	mm.
Wear Pad Thickness	10.000	mm.
Wear Pad Bearing Angle	140.000	deg.
Distance from Saddle to Tangent	680.000	mm.
Baseplate Length	890.000	mm.
Baseplate Thickness	16.000	mm.
Baseplate Width	200.000	mm.

```
Number of Ribs (including outside ribs)                           2
Rib Thickness                                                12.000  mm.
Web Thickness                                                12.000  mm.
Height of Center Web                                        357.000  mm.
Number of Bolts in Baseplate                                      4
```

Baseplate Sketch

```
    |------------------- 890.000 mm. --------------------|
    ------------------------------------------------------ ---
    |                                                    |
    |                                                    | 200.000 mm.
    |                                                    |
    ------------------------------------------------------ ---
```

Baseplate Plan View

```
    ------------------------------------------------------ ---
    |                                                    | 16.000 mm.
    ------------------------------------------------------ ---
```

Baseplate Side View

```
Maximum Tensile Bolt Load                                        5.  kN
```

Summary of Maximum Saddle Loads, Operating Case :

```
Maximum Vertical Saddle Load                                 71.40  kN
Maximum Transverse Saddle Shear Load                         14.48  kN
Maximum Longitudinal Saddle Shear Load                       28.97  kN
```

Summary of Maximum Saddle Loads, Hydrotest Case :

```
Maximum Vertical Saddle Load                                 33.28  kN
Maximum Transverse Saddle Shear Load                          0.42  kN
Maximum Longitudinal Saddle Shear Load                        0.24  kN
```

Weights:

```
Fabricated - Bare  W/O Removable Internals                  2504.1  kg.
Shop Test  - Fabricated + Water ( Full )                    5175.9  kg.
Shipping   - Fab. + Rem. Intls.+ Shipping App.              2504.1  kg.
Erected    - Fab. + Rem. Intls.+ Insul. (etc)               2862.8  kg.
Empty      - Fab. + Intls. + Details + Wghts.               2862.8  kg.
Operating  - Empty + Operating Liquid (No CA)               4094.5  kg.
Field Test - Empty Weight + Water (Full)                    5234.8  kg.
```