Table of Contents

Cover Sheet 2

Title Page 3

Warnings and Errors 4

Input Echo 5

[XY Coordinate Calculations 14](#_TOC_250004)

Internal Pressure Calculations 15

[External Pressure Calculations 19](#_TOC_250003)

[Element and Detail Weights 22](#_TOC_250002)

Nozzle Flange MAWP 25

Wind Load Calculation 26

[Earthquake Load Calculation 29](#_TOC_250001)

Center of Gravity Calculation 31

Lifting Lug Calcs : Left Side 33

Lifting Lug Calcs : Right Side 41

Horizontal Vessel Analysis (Ope.) 49

Horizontal Vessel Analysis (Test) 63

Nozzle Calcs. : F1 76

Nozzle Calcs. : Y 87

Nozzle Calcs. : L4 91

Nozzle Calcs. : P 95

Nozzle Calcs. : V 99

Nozzle Calcs. : A 106

Nozzle Calcs. : M 117

Nozzle Calcs. : R1 126

Nozzle Calcs. : W1 137

Nozzle Calcs. : B 144

Nozzle Calcs. : L2 155

Nozzle Calcs. : L1 160

Nozzle Calcs. : T 165

[Nozzle Schedule 170](#_TOC_250000)

Nozzle Summary 172

MDMT Summary 174

Vessel Design Summary 176

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2013

Analysis Performed by : KUNSHAN BEXCELLE SPECIAL EQUIPMENT CO.

Job File : E:\ BASF TERRIER \D4470.PVDB

Date of Analysis : Apr 4,2014

PV Elite 2014, January 2014

**FileName : D4470**

**Warnings and Errors : Step: 0 1:43p Apr 4,2014**

Class From To : Basic Element Checks.

==========================================================================

Class From To: Check of Additional Element Data

==========================================================================

There were no geometry errors or warnings.

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**FileName : D4470**

**Input Echo : Step: 1 1:43p Apr 4,2014**

**PV Elite Vessel Analysis Program: Input Data**

Design Internal Pressure (for Hydrotest) 363.00 psig Design Internal Temperature 248 F Type of Hydrotest UG-99(b)

Hydrotest Position Horizontal Projection of Nozzle from Vessel Top 31.000 in

Projection of Nozzle from Vessel Bottom 7.6000 in Minimum Design Metal Temperature 0 F Type of Construction Welded

Special Service None

Degree of Radiography RT-3

Miscellaneous Weight Percent 0.0

Use Higher Longitudinal Stresses (Flag) Y

Select t for Internal Pressure (Flag) Y

Select t for External Pressure (Flag) Y

Select t for Axial Stress (Flag) N

Select Location for Stiff. Rings (Flag) Y Consider Vortex Shedding N

Perform a Corroded Hydrotest N

Is this a Heat Exchanger No

User Defined Hydro. Press. (Used if > 0) 0.0000 psig User defined MAWP 0.0000 psig

User defined MAPnc 0.0000 psig

|  |  |  |  |
| --- | --- | --- | --- |
| 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 |

**FileName : D4470**

**Input Echo : Step: 1 1:43p Apr 4,2014**

|  |  |  |
| --- | --- | --- |
| Wind Design Code Basic Wind Speed  Surface Roughness Category Importance Factor  Type of Surface  Base Elevation | [V] | ASCE 7-05  140.00 mile/hr C: Open Terrain  1.15  Moderately Smooth  0.0000 ft |
| Percent Wind for Hydrotest |  | 0.0 |

Using User defined Wind Press. Vs Elev. N Height of Hill or Escarpment H or Hh 0.0000 ft Distance Upwind of Crest Lh 0.0000 ft Distance from Crest to the Vessel x 0.0000 ft 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 7-05 Importance Factor 1.250

Table Value Fa 1.000

Table Value Fv 1.400

Short Period Acceleration value Ss 0.112

Long Period Acceleration Value Sl 0.052

Moment Reduction Factor Tau 1.000

Force Modification Factor R 3.000

Site Class D

Component Elevation Ratio z/h 0.000

Amplification Factor Ap 0.000

Force Factor 0.000

Consider Vertical Acceleration No

Minimum Acceleration Multiplier 0.000

User Value of Sds (used if > 0 ) 0.000

User Value of Sd1 (used if > 0 ) 0.000

Design Nozzle for Des. Press. + St. 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

**FileName : D4470**

**Input Echo : Step: 1 1:43p Apr 4,2014**

Compute "K" in corroded condition Yes

Use Code Case 2286 No

Use the MAWP to compute the MDMT Yes Using Metric Material Databases, ASME II D No

**Complete Listing of Vessel Elements and Details:**

Element From Node 10

Element To Node 20

Element Type Elliptical

Description left head

Distance "FROM" to "TO" 0.08202 ft

Inside Diameter 60.000 in

Element Thickness 0.8268 in

Internal Corrosion Allowance 0.0000 in

Nominal Thickness 0.9449 in

External Corrosion Allowance 0.0000 in

Design Internal Pressure 363.00 psig Design Temperature Internal Pressure 248 F Design External Pressure 14.500 psig Design Temperature External Pressure 248 F

|  |  |  |
| --- | --- | --- |
| Effective Diameter Multiplier | 1.2 |  |
| Material Name | SA-240 304L |
| Allowable Stress, Ambient | 16700. | psi |
| Allowable Stress, Operating | 16700. | psi |
| Allowable Stress, Hydrotest | 22500. | psi |
| Material Density | 0.2900 lb/in^3 | |
| P Number Thickness | 0.0000 in | |
| Yield Stress, Operating | 20248. psi | |
| External Pressure Chart Name | HA-3 | |
| UNS Number | S30403 | |
| Product Form | Plate | |
| Efficiency, Longitudinal Seam | 0.85 | |
| Efficiency, Circumferential Seam | 0.85 | |
| Elliptical Head Factor | 2.0 | |

Element From Node 10

Detail Type Liquid

Detail ID L

Dist. from "FROM" Node / Offset dist 0.0000 ft Height/Length of Liquid 3.0000 ft

Liquid Density 36.485 lb/ft^3

Element From Node 10

Detail Type Insulation

Detail ID Ins: 20

**FileName : D4470**

**Input Echo : Step: 1 1:43p Apr 4,2014**

Dist. from "FROM" Node / Offset dist -1.2500 ft Height/Length of Insulation 1.3320 ft

Thickness of Insulation 2.0000 in Density 7.4906 lb/ft^3

|  |  |
| --- | --- |
| Element From Node | 20 |
| Element To Node | 30 |
| Element Type | Cylinder |
| Description | shell |
| Distance "FROM" to "TO" | 12.336 ft |
| Inside Diameter | 60.000 in |
| Element Thickness | 0.8661 in |
| Internal Corrosion Allowance | 0.0000 in |
| Nominal Thickness | 0.0000 in |
| External Corrosion Allowance | 0.0000 in |
| Design Internal Pressure | 363.00 psig |
| Design Temperature Internal Pressure | 248 F |
| Design External Pressure | 14.500 psig |
| Design Temperature External Pressure | 248 F |
| Effective Diameter Multiplier | 1.2 |
| Material Name | SA-240 304L |
| Efficiency, Longitudinal Seam | 0.85 |
| Efficiency, Circumferential Seam | 0.85 |

Element From Node 20

Detail Type Saddle

Detail ID L Sdl

Dist. from "FROM" Node / Offset dist 1.7500 ft

|  |  |
| --- | --- |
| Width of Saddle | 7.2500 in |
| Height of Saddle at Bottom | 43.000 in |
| Saddle Contact Angle | 120.0 |
| Height of Composite Ring Stiffener | 0.0000 in |
| Width of Wear Plate | 11.811 in |
| Thickness of Wear Plate | 0.4724 in |
| Contact Angle, Wear Plate (degrees) | 132.0 |

Element From Node 20

Detail Type Saddle

Detail ID R Sdl

Dist. from "FROM" Node / Offset dist 10.750 ft Width of Saddle 7.2500 in

Height of Saddle at Bottom 43.000 in

Saddle Contact Angle 120.0

Height of Composite Ring Stiffener 0.0000 in

**FileName : D4470**

**Input Echo : Step: 1 1:43p Apr 4,2014**

Width of Wear Plate 11.811 in

Thickness of Wear Plate 0.4724 in Contact Angle, Wear Plate (degrees) 132.0

Element From Node 20

Detail Type Liquid

Detail ID L

Dist. from "FROM" Node / Offset dist 0.0000 ft Height/Length of Liquid 3.0000 ft

Liquid Density 36.485 lb/ft^3

Element From Node 20

Detail Type Insulation

Detail ID Ins: 20

Dist. from "FROM" Node / Offset dist 0.0000 ft

Height/Length of Insulation 12.336 ft

Thickness of Insulation 2.0000 in Density 7.4906 lb/ft^3

Element From Node 20

Detail Type Nozzle

Detail ID F1

Dist. from "FROM" Node / Offset dist 0.7500 ft

Nozzle Diameter 4.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 0.0

Blind Flange (Y/N) Y

Weight of Nozzle ( Used if > 0 ) 90.749 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 20

Detail Type Nozzle

Detail ID Y

Dist. from "FROM" Node / Offset dist 1.7500 ft

Nozzle Diameter 2.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 0.0

Blind Flange (Y/N) N

Weight of Nozzle ( Used if > 0 ) 21.060 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 20

**FileName : D4470**

**Input Echo : Step: 1 1:43p Apr 4,2014**

Detail Type Nozzle

Detail ID L4

Dist. from "FROM" Node / Offset dist 2.7500 ft

Nozzle Diameter 2.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 0.0

Blind Flange (Y/N) N

Weight of Nozzle ( Used if > 0 ) 21.060 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 20

Detail Type Nozzle

Detail ID P

Dist. from "FROM" Node / Offset dist 3.7500 ft

Nozzle Diameter 2.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 0.0

Blind Flange (Y/N) N

Weight of Nozzle ( Used if > 0 ) 21.060 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 20

Detail Type Nozzle

Detail ID V

Dist. from "FROM" Node / Offset dist 4.7500 ft

Nozzle Diameter 2.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 0.0

Blind Flange (Y/N) N

Weight of Nozzle ( Used if > 0 ) 21.060 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 20

Detail Type Nozzle

Detail ID A

Dist. from "FROM" Node / Offset dist 12.000 ft

Nozzle Diameter 3.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 0.0

**FileName : D4470**

**Input Echo : Step: 1 1:43p Apr 4,2014**

Blind Flange (Y/N) Y

Weight of Nozzle ( Used if > 0 ) 48.626 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 20

Detail Type Nozzle

Detail ID M

Dist. from "FROM" Node / Offset dist 8.5000 ft

Nozzle Diameter 24.0 in.

Nozzle Schedule None

Nozzle Class 300

Layout Angle 0.0

Blind Flange (Y/N) Y

Weight of Nozzle ( Used if > 0 ) 247.58 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-240 304L

Element From Node 20

Detail Type Nozzle

Detail ID R1

Dist. from "FROM" Node / Offset dist 5.7500 ft

Nozzle Diameter 4.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 0.0

Blind Flange (Y/N) Y

Weight of Nozzle ( Used if > 0 ) 90.749 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 20

Detail Type Nozzle

Detail ID W1

Dist. from "FROM" Node / Offset dist 4.0000 ft

Nozzle Diameter 2.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 180.0

Blind Flange (Y/N) N

Weight of Nozzle ( Used if > 0 ) 14.206 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 20

Detail Type Nozzle

**FileName : D4470**

**Input Echo : Step: 1 1:43p Apr 4,2014**

Detail ID B

Dist. from "FROM" Node / Offset dist 12.000 ft

Nozzle Diameter 3.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 180.0

Blind Flange (Y/N) N

Weight of Nozzle ( Used if > 0 ) 27.332 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

|  |  |
| --- | --- |
| Element From Node | 30 |
| Element To Node | 40 |
| Element Type | Elliptical |
| Description | right head |
| Distance "FROM" to "TO" | 0.08202 ft |
| Inside Diameter | 60.000 in |
| Element Thickness | 0.8268 in |
| Internal Corrosion Allowance | 0.0000 in |
| Nominal Thickness | 0.9449 in |
| External Corrosion Allowance | 0.0000 in |
| Design Internal Pressure | 363.00 psig |
| Design Temperature Internal Pressure | 248 F |
| Design External Pressure | 14.500 psig |
| Design Temperature External Pressure | 248 F |
| Effective Diameter Multiplier | 1.2 |
| Material Name | SA-240 304L |
| Efficiency, Longitudinal Seam | 0.85 |
| Efficiency, Circumferential Seam | 0.85 |
| Elliptical Head Factor | 2.0 |

Element From Node 30

Detail Type Liquid

Detail ID L

Dist. from "FROM" Node / Offset dist 0.0000 ft Height/Length of Liquid 3.0000 ft

Liquid Density 36.485 lb/ft^3

Element From Node 30

Detail Type Insulation

Detail ID Ins: 20

Dist. from "FROM" Node / Offset dist 0.0000 ft

Height/Length of Insulation 1.3320 ft

Thickness of Insulation 2.0000 in

**FileName : D4470**

**Input Echo : Step: 1 1:43p Apr 4,2014**

Density 7.4906 lb/ft^3

Element From Node 30

Detail Type Nozzle

Detail ID L2

Dist. from "FROM" Node / Offset dist 24.000 in

Nozzle Diameter 2.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 0.0

Blind Flange (Y/N) N

Weight of Nozzle ( Used if > 0 ) 14.767 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 30

Detail Type Nozzle

Detail ID L1

Dist. from "FROM" Node / Offset dist 24.000 in

Nozzle Diameter 2.0 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 180.0

Blind Flange (Y/N) N

Weight of Nozzle ( Used if > 0 ) 14.767 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

Element From Node 30

Detail Type Nozzle

Detail ID T

Dist. from "FROM" Node / Offset dist 0.10000 in Nozzle Diameter 1.5 in.

Nozzle Schedule 80S

Nozzle Class 300

Layout Angle 0.0

Blind Flange (Y/N) N

Weight of Nozzle ( Used if > 0 ) 11.682 lbf

Grade of Attached Flange GR 2.1 Nozzle Matl SA-312 TP304L

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**FileName : D4470**

**XY Coordinate Calculations : Step: 2 1:43p Apr 4,2014**

# XY Coordinate Calculations

| | | | | |

From| To | X (Horiz.)| Y (Vert.) |DX (Horiz.)| DY (Vert.) |

| | ft | ft | ft | ft |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| left head| | 0.082021 | | ... | | 0.082021 | | ... | |
| shell| | 12.4180 | | ... | | 12.3360 | | ... | |
| right head| | 12.5000 | | ... | | 0.082021 | | ... | |

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**FileName : D4470**

**Internal Pressure Calculations : Step: 3 1:43p Apr 4,2014**

**Element Thickness, Pressure, Diameter and Allowable Stress :**

| | Int. Press | Nominal | Total Corr| Element | Allowable | From| To | + Liq. Hd | Thickness | Allowance | Diameter | Stress(SE)|

| | psig | in | in | in | psi |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| left head| | 363.760 | | | 0.94488 | | ... | | 60.0000 | | 14195.0 | |
| shell| | 363.760 | | | ... | | ... | | 60.0000 | | 14195.0 | |
| right head| | 363.760 | | | 0.94488 | | ... | | 60.0000 | | 14195.0 | |

**Element Required Thickness and MAWP :**

| | Design | M.A.W.P. | M.A.P. | Minimum | Required | From| To | Pressure | Corroded | New & Cold | Thickness | Thickness |

| | psig | psig | psig | in | in |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| left head| | 363.000 | | 389.366 | | 390.126 | | 0.82677 | | 0.77075 | |
| shell| | 363.000 | | 402.091 | | 402.851 | | 0.86614 | | 0.78078 | |
| right head| | 363.000 | | 389.366 | | 390.126 | | 0.82677 | | 0.77075 | |
| Minimum |  | 389.366 390.125 | |  |  |

MAWP: 389.366 psig, limited by: right head.

**Internal Pressure Calculation Results :**

# ASME Code, Section VIII, Division 1, 2013

**Elliptical Head From 10 To 20 SA-240 304L at 248 F**

left head

Material UNS Number: S30403

Required Thickness due to Internal Pressure [tr]:

= (P\*D\*Kcor)/(2\*S\*E-0.2\*P) Appendix 1-4(c)

= (363.760\*60.0000\*1.000)/(2\*16700.00\*0.85-0.2\*363.760)

= 0.7708 + 0.0000 = 0.7708 in

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]: Less Operating Hydrostatic Head Pressure of 0.760 psig

= (2\*S\*E\*t)/(Kcor\*D+0.2\*t) per Appendix 1-4 (c)

= (2\*16700.00\*0.85\*0.8268)/(1.000\*60.0000+0.2\*0.8268)

= 390.126 - 0.760 = 389.366 psig

Maximum Allowable Pressure, New and Cold [MAPNC]:

**FileName : D4470**

**Internal Pressure Calculations : Step: 3 1:43p Apr 4,2014**

= (2\*S\*E\*t)/(K\*D+0.2\*t) per Appendix 1-4 (c)

= (2\*16700.00\*0.85\*0.8268)/(1.000\*60.0000+0.2\*0.8268)

= 390.126 psig

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

= (P\*(Kcor\*D+0.2\*t))/(2\*E\*t)

= (363.760\*(1.000\*60.0000+0.2\*0.8268))/(2\*0.85\*0.8268)

= 15571.377 psi

Straight Flange Required Thickness:

= (P\*R)/(S\*E-0.6\*P) + c per UG-27 (c)(1)

= (363.760\*30.0000)/(16700.00\*0.85-0.6\*363.760)+0.000

= 0.781 in

Straight Flange Maximum Allowable Working Pressure:

Less Operating Hydrostatic Head Pressure of 0.760 psig

= (S\*E\*t)/(R+0.6\*t) per UG-27 (c)(1)

= (16700.00 \* 0.85 \* 0.9449 )/(30.0000 + 0.6 \* 0.9449 )

= 438.794 - 0.760 = 438.034 psig

Percent Elongation per UHA-44 (75\*tnom/Rf)\*(1-Rf/Ro) 6.640 %

Note: Please Check Requirements of Table UHA-44 for Elongation limits.

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

**Cylindrical** Shell **From 20 To 30 SA-240 304L at 248 F**

shell

Material UNS Number: S30403

Required Thickness due to Internal Pressure [tr]:

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.760\*30.0000)/(16700.00\*0.85-0.6\*363.760)

= 0.7808 + 0.0000 = 0.7808 in

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]: Less Operating Hydrostatic Head Pressure of 0.760 psig

= (S\*E\*t)/(R+0.6\*t) per UG-27 (c)(1)

= (16700.00\*0.85\*0.8661)/(30.0000+0.6\*0.8661)

= 402.851 - 0.760 = 402.091 psig

Maximum Allowable Pressure, New and Cold [MAPNC]:

= (S\*E\*t)/(R+0.6\*t) per UG-27 (c)(1)

= (16700.00\*0.85\*0.8661)/(30.0000+0.6\*0.8661)

= 402.851 psig

**FileName : D4470**

**Internal Pressure Calculations : Step: 3 1:43p Apr 4,2014**

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

= (P\*(R+0.6\*t))/(E\*t)

= (363.760\*(30.0000+0.6\*0.8661))/(0.85\*0.8661)

= 15079.509 psi

Percent Elongation per UHA-44 (50\*tnom/Rf)\*(1-Rf/Ro) 1.423 %

Note: Please Check Requirements of Table UHA-44 for Elongation limits.

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

**Elliptical Head From 30 To 40 SA-240 304L at 248 F**

right head

Material UNS Number: S30403

Required Thickness due to Internal Pressure [tr]:

= (P\*D\*Kcor)/(2\*S\*E-0.2\*P) Appendix 1-4(c)

= (363.760\*60.0000\*1.000)/(2\*16700.00\*0.85-0.2\*363.760)

= 0.7708 + 0.0000 = 0.7708 in

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]: Less Operating Hydrostatic Head Pressure of 0.760 psig

= (2\*S\*E\*t)/(Kcor\*D+0.2\*t) per Appendix 1-4 (c)

= (2\*16700.00\*0.85\*0.8268)/(1.000\*60.0000+0.2\*0.8268)

= 390.126 - 0.760 = 389.366 psig

Maximum Allowable Pressure, New and Cold [MAPNC]:

= (2\*S\*E\*t)/(K\*D+0.2\*t) per Appendix 1-4 (c)

= (2\*16700.00\*0.85\*0.8268)/(1.000\*60.0000+0.2\*0.8268)

= 390.126 psig

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

= (P\*(Kcor\*D+0.2\*t))/(2\*E\*t)

= (363.760\*(1.000\*60.0000+0.2\*0.8268))/(2\*0.85\*0.8268)

= 15571.377 psi

Straight Flange Required Thickness:

= (P\*R)/(S\*E-0.6\*P) + c per UG-27 (c)(1)

= (363.760\*30.0000)/(16700.00\*0.85-0.6\*363.760)+0.000

= 0.781 in

Straight Flange Maximum Allowable Working Pressure:

Less Operating Hydrostatic Head Pressure of 0.760 psig

= (S\*E\*t)/(R+0.6\*t) per UG-27 (c)(1)

**FileName : D4470**

**Internal Pressure Calculations : Step: 3 1:43p Apr 4,2014**

= (16700.00 \* 0.85 \* 0.9449 )/(30.0000 + 0.6 \* 0.9449 )

= 438.794 - 0.760 = 438.034 psig

Percent Elongation per UHA-44 (75\*tnom/Rf)\*(1-Rf/Ro) 6.640 %

Note: Please Check Requirements of Table UHA-44 for Elongation limits.

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

**Hydrostatic Test Pressure Results:**

Pressure per UG99b = 1.3 \* M.A.W.P. \* Sa/S 506.175 psig Pressure per UG99b[34] = 1.3 \* Design Pres \* Sa/S 471.900 psig Pressure per UG99c = 1.3 \* M.A.P. - Head(Hyd) 503.602 psig Pressure per UG100 = 1.1 \* M.A.W.P. \* Sa/S 428.302 psig Pressure per PED = 1.43 \* MAWP 556.793 psig

UG-99(b), Test Pressure Calculation:

= Test Factor \* MAWP \* Stress Ratio

= 1.3 \* 389.366 \* 1.000

= 506.175 psig

# Horizontal Test performed per: UG-99b

*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:**

From To Stress Allowable Ratio Pressure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| left head | 21760.4 | 22500.0 | 0.967 | 508.34 |
| shell | 21073.1 | 22500.0 | 0.937 | 508.34 |
| right head | 21760.4 | 22500.0 | 0.967 | 508.34 |

Elements Suitable for Internal Pressure.

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**FileName : D4470**

**External Pressure Calculations : Step: 4 1:43p Apr 4,2014**

**External Pressure Calculation Results :**

# ASME Code, Section VIII, Division 1, 2013

**Elliptical Head From 10 to 20 Ext. Chart: HA-3 at 248 F**

left head

Elastic Modulus from Chart: HA-3 at 248 F : 0.270E+08 psi

Results for Maximum Allowable External Pressure (MAEP):

|  |  |  |  |
| --- | --- | --- | --- |
| Tca | OD | D/t Factor A | B |
| 0.827 | 61.65 | 74.57 0.0018625 | 8147.17 |

EMAP = B/(K0\*D/t) = 8147.1709/(0.9000 \*74.5714 ) = 121.3925 psig

Results for Required Thickness (Tca):

|  |  |  |  |
| --- | --- | --- | --- |
| Tca | OD | D/t Factor A | B |
| 0.163 | 61.65 | 378.78 0.0003667 | 4943.46 |

EMAP = B/(K0\*D/t) = 4943.4629/(0.9000 \*378.7831 ) = 14.5010 psig

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

Material UNS Number: S30403

Required Thickness due to Internal Pressure [tr]:

= (P\*D\*Kcor)/(2\*S\*E-0.2\*P) Appendix 1-4(c)

= (24.215\*60.0000\*1.000)/(2\*16700.00\*1.00-0.2\*24.215)

= 0.0435 + 0.0000 = 0.0435 in

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\*16700.00\*1.00\*0.8268)/(1.000\*60.0000+0.2\*0.8268))/1.67

= 274.833 psig

Maximum Allowable External Pressure [MAEP]:

= min( MAEP, MAWP )

= min( 121.39 , 274.8332 )

= 121.393 psig

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

**Cylindrical** Shell **From 20 to 30 Ext. Chart: HA-3 at 248 F**

**FileName : D4470**

**External Pressure Calculations : Step: 4 1:43p Apr 4,2014**

shell

Elastic Modulus from Chart: HA-3 at 248 F : 0.270E+08 psi

Results for Maximum Allowable External Pressure (MAEP):

Tca OD SLEN D/t L/D Factor A B 0.866 61.73 160.00 71.27 2.5918 0.0008196 6863.67

EMAP = (4\*B)/(3\*(D/t)) = (4\*6863.6660 )/(3\*71.2727 ) = 128.4019 psig

Results for Required Thickness (Tca):

Tca OD SLEN D/t L/D Factor A B

0.299 61.73 160.00 206.16 2.5918 0.0001663 2242.08

EMAP = (4\*B)/(3\*(D/t)) = (4\*2242.0771 )/(3\*206.1585 ) = 14.5007 psig

Results for Maximum Stiffened Length (Slen):

Tca OD SLEN D/t L/D Factor A B 0.866 61.73 4002.22 71.27 50.0000 0.0002236 3014.83

EMAP = (4\*B)/(3\*(D/t)) = (4\*3014.8267 )/(3\*71.2727 ) = 56.3998 psig

**Elliptical Head From 30 to 40 Ext. Chart: HA-3 at 248 F**

right head

Elastic Modulus from Chart: HA-3 at 248 F : 0.270E+08 psi

Results for Maximum Allowable External Pressure (MAEP):

|  |  |  |  |
| --- | --- | --- | --- |
| Tca | OD | D/t Factor A | B |
| 0.827 | 61.65 | 74.57 0.0018625 | 8147.17 |

EMAP = B/(K0\*D/t) = 8147.1709/(0.9000 \*74.5714 ) = 121.3925 psig

Results for Required Thickness (Tca):

|  |  |  |  |
| --- | --- | --- | --- |
| Tca | OD | D/t Factor A | B |
| 0.163 | 61.65 | 378.78 0.0003667 | 4943.46 |

EMAP = B/(K0\*D/t) = 4943.4629/(0.9000 \*378.7831 ) = 14.5010 psig

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

Material UNS Number: S30403

Required Thickness due to Internal Pressure [tr]:

= (P\*D\*Kcor)/(2\*S\*E-0.2\*P) Appendix 1-4(c)

= (24.215\*60.0000\*1.000)/(2\*16700.00\*1.00-0.2\*24.215)

= 0.0435 + 0.0000 = 0.0435 in

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

**FileName : D4470**

**External Pressure Calculations : Step: 4 1:43p Apr 4,2014**

= ((2\*S\*E\*t)/(Kcor\*D+0.2\*t))/1.67 per Appendix 1-4 (c)

= ((2\*16700.00\*1.00\*0.8268)/(1.000\*60.0000+0.2\*0.8268))/1.67

= 274.833 psig

Maximum Allowable External Pressure [MAEP]:

= min( MAEP, MAWP )

= min( 121.39 , 274.8332 )

= 121.393 psig

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

# External Pressure Calculations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| | | | | Section | | Outside | Corroded | | Factor | | | Factor | |
| From| | To | | Length | | Diameter | Thickness | | A | | | B | |

| | ft | in | in | | psi |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 10| 20| | No Calc | | 61.6535 | | 0.82677 | | 0.0018625 | | 8147.17 | |
| 20| 30| | 13.3333 | | 61.7323 | | 0.86614 | 0.00081961 | | | 6863.67 | |
| 30| 40| | No Calc | | 61.6535 | | 0.82677 | | 0.0018625 | | 8147.17 | |
| **External Pressure Calculations** | | |  |  |  |

| | External | External | External | External | From| To | Actual T. | Required T.|Des. Press. | M.A.W.P. |

| | in | in | psig | psig |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 10| | 20| | 0.82677 | | | 0.16277 | | | 14.5000 | | | 121.393 | | |
| 20| | 30| | 0.86614 | | | 0.29944 | | | 14.5000 | | | 128.402 | | |
| 30| | 40| | 0.82677 | | | 0.16277 | | | 14.5000 | | | 121.393 | | |

Minimum 121.393

**External Pressure Calculations**

| | Actual Len.| Allow. Len.| Ring Inertia | Ring Inertia | From| To | Bet. Stiff.| Bet. Stiff.| Required | Available |

| | ft | ft | in\*\*4 | in\*\*4 |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 10| | 20| | No Calc | | | No Calc | | | No | Calc | | | No | Calc | | |
| 20| | 30| | 13.3333 | | | 333.518 | | | No | Calc | | | No | Calc | | |
| 30| | 40| | No Calc | | | No Calc | | | No | Calc | | | No | Calc | | |

Elements Suitable for External Pressure.

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**FileName : D4470**

**Element and Detail Weights : Step: 5 1:43p Apr 4,2014**

# Element and Detail Weights

| | Element | Element | Corroded | Corroded | Extra due | From| To | Metal Wgt. | ID Volume |Metal Wgt. | ID Volume | Misc % |

| | lbf | in3 | lbf | in3 | lbf |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 10| 20| | 1269.76 | | 31057.2 | | 1269.76 | | 31057.2 | | 380.928 | |
| 20| 30| | 7109.96 | | 418549. | | 7109.96 | | 418549. | | 2132.99 | |
| 30| 40| | 1269.76 | | 31057.2 | | 1269.76 | | 31057.2 | | 380.928 | |

Total 9649 480663 9649 480663 2894

**Weight of Details**

| | Weight of | X Offset, | Y Offset, |

From|Type| Detail | Dtl. Cent. |Dtl. Cent. | Description

| | lbf | ft | ft |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 10|Liqd| | 424.924 | | | -0.41667 | | | 1.00000 | | | L |
| 10|Insl| | 48.0475 | | | -0.58399 | | | ... | | | Ins: 20 |
| 20|Sadl| | 551.307 | | | 1.75000 | | | 2.98589 | | | L Sdl |
| 20|Sadl| | 551.307 | | | 10.7500 | | | 2.98589 | | | R Sdl |
| 20|Liqd| | 5536.31 | | | 6.16798 | | | 1.00000 | | | L |
| 20|Insl| | 256.963 | | | 6.16800 | | | ... | | | Ins: 20 |
| 20|Nozl| | 117.974 | | | 0.75000 | | | 2.68750 | | | F1 |
| 20|Nozl| | 27.3786 | | | 1.75000 | | | 2.59896 | | | Y |
| 20|Nozl| | 27.3786 | | | 2.75000 | | | 2.59896 | | | L4 |
| 20|Nozl| | 27.3786 | | | 3.75000 | | | 2.59896 | | | P |
| 20|Nozl| | 27.3786 | | | 4.75000 | | | 2.59896 | | | V |
| 20|Nozl| | 63.2139 | | | 12.0000 | | | 2.64583 | | | A |
| 20|Nozl| | 321.857 | | | 8.50000 | | | 3.50000 | | | M |
| 20|Nozl| | 117.974 | | | 5.75000 | | | 2.68750 | | | R1 |
| 20|Nozl| | 18.4678 | | | 4.00000 | | | 2.59896 | | | W1 |
| 20|Nozl| | 35.5311 | | | 12.0000 | | | 2.64583 | | | B |
| 30|Liqd| | 424.924 | | | 0.49869 | | | 1.00000 | | | L |
| 30|Insl| | 48.0475 | | | 0.66601 | | | ... | | | Ins: 20 |
| 30|Nozl| | 19.1968 | | | 0.83202 | | | ... | | | L2 |
| 30|Nozl| | 19.1968 | | | 0.83202 | | | ... | | | L1 |
| 30|Nozl| | 15.1865 | | | 1.33201 | | | ... | | | T |

# Total Weight of Each Detail Type

Total Weight of Saddles 1102.6

Total Weight of Liquid 6386.2

Total Weight of Insulation 353.1

**FileName : D4470**

**Element and Detail Weights : Step: 5 1:43p Apr 4,2014**

Total Weight of Nozzles 838.1

Sum of the Detail Weights 8679.9 lbf

# Weight Summation

Fabricated Shop Test Shipping Erected Empty Operating

12544.3 14485.0 12544.3 14485.0 12544.3 14838.1

1102.6 17357.3 1102.6 ... 1102.6 6386.2

|  |  |  |  |
| --- | --- | --- | --- |
| 838.1 ... 838.1 | ... | ... | ... |
| ... ... ... | 353.1 | ... | ... |
| ... ... ... | ... | 353.1 | ... |
| ... ... ... | ... | ... | ... |
| ... ... ... | ... | ... | ... |
| ... ... ... | ... | 838.1 | ... |

14485.0 31842.3 14838.1 14838.1 14838.1 21224.3 lbf

# Miscellaneous Weight Percent: 30.0 %

*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.*

*Note: The shipping total has been modified because some items have been specified as being installed in the shop.*

**Weight Summary**

Fabricated Wt. - Bare Weight W/O Removable Internals 14485.0 lbf Shop Test Wt. - Fabricated Weight + Water ( Full ) 31842.3 lbf Shipping Wt. - Fab. Wt + Rem. Intls.+ Shipping App. 14838.1 lbf Erected Wt. - Fab. Wt + Rem. Intls.+ Insul. (etc) 14838.1 lbf Ope. Wt. no Liq - Fab. Wt + Intls. + Details + Wghts. 14838.1 lbf Operating Wt. - Empty Wt + Operating Liq. Uncorroded 21224.3 lbf Oper. Wt. + CA - Corr Wt. + Operating Liquid 21224.3 lbf Field Test Wt. - Empty Weight + Water (Full) 32195.4 lbf

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

**Outside Surface Areas of Elements**

**FileName : D4470**

**Element and Detail Weights : Step: 5 1:43p Apr 4,2014**

|  |  |  |  |
| --- | --- | --- | --- |
| | | | | Surface | | |
| From| To | | | Area | | |
| | | | | in^2 | | |

10| 20| 4343.41 |

20| 30| 28708.9 |

30| 40| 4343.41 |

Total 37395.699 in^2 [259.7 Square Feet ]

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**FileName : D4470**

**Nozzle Flange MAWP : Step: 6 1:43p Apr 4,2014**

# Nozzle Flange MAWP Results :

Nozzle ----- Flange Rating

Description Operating Ambient Temperature Class Grade|Group psig psig F

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| F1 | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| Y | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| L4 | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| P | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| V | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| A | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| M | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| R1 | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| W1 | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| B | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| L2 | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| L1 | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |
| T | 571.2 | 720.0 | 248 | 300 | GR | 2.1 |

Minimum Rating 571.200 720.000 psig (for Core Elements)

Note: ANSI Ratings are per ANSI/ASME B16.5 2009 Edition

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**FileName : D4470**

**Wind Load Calculation : Step: 7 1:43p Apr 4,2014**

**Input Values:**

|  |  |  |
| --- | --- | --- |
| Wind Design Code Basic Wind Speed  Surface Roughness Category Importance Factor  Type of Surface  Base Elevation | [V] | ASCE 7-05  140.00 mile/hr C: Open Terrain  1.15  Moderately Smooth  0.0000 ft |
| Percent Wind for Hydrotest |  | 0.0 |

Using User defined Wind Press. Vs Elev. N Height of Hill or Escarpment H or Hh 0.0000 ft Distance Upwind of Crest Lh 0.0000 ft Distance from Crest to the Vessel x 0.0000 ft 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\*3.400\*0.228\*0.958)/(1+1.7\*3.400\*0.228)))

= min(0.85, 0.903 )

= 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

Note: Per Section 1609 of IBC 2003/06/09 these results are also applicable for the determination of Wind Loads on structures (1609.1.1).

|  |  |  |
| --- | --- | --- |
| User Entered Importance Factor is |  | 1.150 |
| Force Coefficient | [Cf] | 0.527 |
| Structure Height to Diameter ratio |  | 2.613 |

*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]:

**FileName : D4470**

**Wind Load Calculation : Step: 7 1:43p Apr 4,2014**

Exposure Category: C from Table C6-2 Alpha = 9.500 : Zg = 900.000 ft

Effective Height [z]:

= Centroid Height + Vessel Base Elevation

= 3.583 + 0.000 = 3.583 ft

Velocity Pressure coefficient evaluated at height z [Kz]:

Because z (3.583 ft.) < 15 ft.

= 2.01 \* ( 15 / Zg ) 2 / Alpha

= 2.01 \* ( 15/900.000 )2/9.500

= 0.849

Type of Hill: No Hill

Wind Directionality Factor [Kd]:

= 0.95 per [6-6 ASCE-7 98][6-4 ASCE-7 02/05]

As there is No Hill Present: [Kzt]:

K1 = 0, K2 = 0, K3 = 0

Topographical Factor [Kzt]:

= ( 1 + K1 \* K2 \* K3 )2

= ( 1 + 0.000 \* 0.000 \* 0.000 )2

= 1.0000

Velocity Pressure evaluated at height z, Imperial Units [qz]:

= 0.00256 \* Kz \* Kzt \* Kd \* I \* Vr(mph)2

= 0.00256 \* 0.849 \* 1.000 \* 0.950 \* 1.150 \* 140.0002

= 46.5 psf

Force on the first element [F]:

= qz \* G \* Cf \* WindArea

= 46.534 \* 0.850 \* 0.527 \* 6.922

= 144.3 lbf

Element Hgt (z) K1 K2 K3 Kz Kzt qz ft psf

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| left head | 3.6 | 0.000 | 0.000 | 0.000 | 0.849 | 1.000 | 46.534 |
| shell | 3.6 | 0.000 | 0.000 | 0.000 | 0.849 | 1.000 | 46.534 |
| right head | 3.6 | 0.000 | 0.000 | 0.000 | 0.849 | 1.000 | 46.534 |
| **Wind Load Calculation** | |  |  |  |  |  |  |

| | Wind | Wind | Wind | Wind | Element |

**FileName : D4470**

**Wind Load Calculation : Step: 7 1:43p Apr 4,2014**

From| To | Height | Diameter | Area | Pressure | Wind Load |

| | ft | ft | in^2 | psf | lbf |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 10| 20| | 3.58333 | | 6.56535 | | 996.766 | | 46.5335 | | 144.255 | |
| 20| 30| | 3.58333 | | 6.57323 | | 11676.5 | | 46.5335 | | 1689.86 | |
| 30| 40| | 3.58333 | | 6.56535 | | 996.766 | | 46.5335 | | 144.255 | |

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**FileName : D4470**

**Earthquake Load Calculation : Step: 8 1:43p Apr 4,2014**

# Input Values:

**Earthquake Analysis per ASCE 7-05**

|  |  |
| --- | --- |
| Short-period site coefficient 9.4.1.2.4a | Fa: 1.000 |
| Long -period site coefficient 9.4.1.2.4b | Fv: 1.400 |
| Maximum Mapped Acceleration Value for Short Periods | Ss: 0.112 |
| Maximum Mapped Acceleration Value for 1 Sec. Period | S1: 0.052 |

Response Modification Factor R: 3.000 Importance Factor Ie: 1.250

Site Class D

# Seismic Analysis Results:

Sms = Fa \* Ss = 1.000 \* 0.112 = 0.112 Sm1 = Fv \* S1 = 1.400 \* 0.052 = 0.073 Sds = 2/3 \* Sms = 2/3 \* 0.112 = 0.075 Sd1 = 2/3 \* Sm1 = 2/3 \* 0.073 = 0.049

Check Approximate Fundamental Period from 9.5.5.3.2-1 [Ta]:

= Ct \* hnx where Ct = 0.020, x = 0.75 and hn = Structural Height (ft.)

= 0.020 \* ( 5.00000.75)

= 0.067 seconds

The Coefficient Cu from Table 9.5.5.3.1 is : 1.700

Fundamental Period (1/Frequency) [T]:

= ( 1/Natural Frequency ) = ( 1/33.000 )

= 0.030

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

= Minimum Value of (1.700 \* 0.067 , 0.030 ) per 9.5.5.3

= 0.030

As the time period is < 0.06 second, use section 9.14.5.2.

Compute the Base Shear per equation 9.14.5.2, [V]:

= 0.3 \* Sds \* W \* I

= 0.3 \* 0.075 \* 21224 \* 1.25

= 594.279 lbf

Note: Loads multiplied by the Scalar multiplier value of 0.7000

Final Base Shear, V = 416.00 lbf

# Earthquake Load Calculation

**FileName : D4470**

**Earthquake Load Calculation : Step: 8 1:43p Apr 4,2014**

| | Earthquake | Earthquake | Element | From| To | Height | Weight | Ope Load |

| | ft | lbf | lbf |

|  |  |  |  |
| --- | --- | --- | --- |
| 10| 20| | 2.50000 | | 4244.85 | | 83.1991 | |
| 20|Sadl| | 2.50000 | | 4244.85 | | 83.1991 | |
| Sadl| 30| | 2.50000 | | 4244.85 | | 83.1991 | |
| 20| 30| | 2.50000 | | 4244.85 | | 83.1991 | |
| 30| 40| | 2.50000 | | 4244.85 | | 83.1991 | |

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|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **FileName :** | **D4470** |  | | | |
| **Center of Gravity Calculation :** | **Step:** | **9** | **1:43p** | **Apr** | **4,2014** |

**Shop/Field Installation Options :**

Insulation is installed in the Shop.

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

Center of Gravity of Saddles 6.332 ft

Center of Gravity of Liquid 6.250 ft

Center of Gravity of Insulation 6.250 ft

Center of Gravity of Nozzles 7.039 ft

Center of Gravity of Bare Shell New and Cold 6.250 ft

Center of Gravity of Bare Shell Corroded 6.250 ft

Vessel CG in the Operating Condition 6.285 ft Vessel CG in the Fabricated (Shop/Empty) Condition 6.301 ft Vessel CG in the Test Condition 6.273 ft

**Rigging Analysis Results:**

|  |  |  |
| --- | --- | --- |
| Total Effective Length of Vessel for this analysis | | 12.50 ft |
| Total vessel weight (No Liquid) | Twt | 14838.10 lbf |
| Impact weight multiplication factor | Imp | 2.00 |
| Design lifting weight, DWT = Imp \* Twt | | 29676.21 lbf |
| Elevation of the Tailing Lug (bottom) | | 1.56 ft |
| Elevation of the Lifting Lug (top | ) | 10.78 ft |
| Design Reaction force at the tailing lug | | 14411.12 lbf |
| Design Reaction force at the lifting lug | | 15265.09 lbf |
| CG Distance from Tailing Lug |  | 4.74 ft |
| CG Distance from the Nearer Lifting Lug | | 4.48 ft |
| **Critical Values:** | |  |

|  |  |  |
| --- | --- | --- |
| Max Stress | Elevation | Allowables |
| psi | ft | psi |

-----------|-----------|---------------|------------------------

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bending | | | 52.93 | | 2.55 | | | 11365.84 | (UG-23) |
| Shear | | | -71.38 | | 0.02 | | | 11690.00 | (0.7\*S) |

-----------|-----------|---------------|------------------------

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

Distance Bending Moment Bending Stress Shear Force Shear Stress ft ft-lbf psi lbf psi

**FileName : D4470**

**Center of Gravity Calculation : Step: 9 1:43p Apr 4,2014**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0.00 | 0.0 | 0.0 | -10683.4 | -67.6 |
| 2.55 | 10962.2 | 52.9 | 3775.6 | 22.8 |
| 7.48 | -1810.6 | -8.7 | -3346.7 | -20.2 |
| 12.42 | 2413.9 | 12.2 | 593.5 | 3.8 |

**Unity Check (Actual Stress / Allowable Stress):**

Maximum Unity Check is 0.0047 at elevation 2.5492 ft - Must be <=1

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

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

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**FileName : D4470**

**Lifting Lug Calcs : Left Side Step: 10 1:43p Apr 4,2014**

# Lifting Lug Calculations: Lug(s) on Left End of Vessel

**Input Values:**

**Lifting Lug Material** SA-283 C

Lifting Lug Yield Stress Yield 30007.25 psi

Total Height of Lifting Lug w 11.0236 in

Thickness of Lifting Lug t 0.7874 in

Diameter of Hole in Lifting Lug dh 1.4961 in Radius of Semi-Circular Arc of Lifting Lug r 3.1496 in Height of Lug from bottom to Center of Hole h 5.5118 in Offset from Vessel OD to Center of Hole off 5.5118 in Lug Fillet Weld Size tw 0.6299 in Length of weld along side of Lifting Lug wl 11.0236 in Length of Weld along Bottom of Lifting Lug wb 0.7874 in Thickness of Collar (if any) tc 0.0000 in

Diameter of Collar (if any) dc 0.0000 in Impact Factor Impfac 2.00

Sling Angle from Horizontal 90.0000 deg Number of Lugs in Group 2

Lifting Lug Orientation to Vessel: Perpendicular Lift Orientation : Horizontal Lift

*PV Elite does not compute weak axis bending forces on the lugs. It is assumed that a spreader bar is used.*

# Computed Results:

|  |  |  |  |
| --- | --- | --- | --- |
| Force | Along Vessel Axis | Fax | 0.00 lbf |
| Force | Normal to Vessel | Fn | 7205.56 lbf |
| Force | Tangential to Vessel | Ft | 0.00 lbf |

*Converting the weld leg dimension (tw) to the weld throat dimension.*

# Weld Group Inertia Calculations:

Weld Group Inertia about the Circumferential Axis Ilc 122.507 in\*\*4 Weld Group Centroid distance in the Long. Direction Yll 5.957 in

|  |  |  |  |
| --- | --- | --- | --- |
| Dist. of Weld Group Centroid | from Lug bottom | Yll\_b | 5.512 in |
| Weld Group Inertia about the | Longitudinal Axis | Ill | 0.486 in\*\*4 |

Weld Group Centroid Distance in the Circ. Direction Ylc 0.394 in

*Note: The Impact Factor is applied to the Forces acting on the Lug.*

**FileName : D4470**

**Lifting Lug Calcs : Left Side Step: 10 1:43p Apr 4,2014**

Primary Shear Stress in the Welds due to Shear Loads [Ssll]:

= sqrt( Fax2 + Ft2 + Fn2 )/(( 2 \* (wl + wb) ) \* tw )

= sqrt(02+02+72052)/((2\*(11.0+0.8))\*0.4454)

= 684.93 psi

Shear Stress in the Welds due to Bending Loads [Sblf]:

= (Fn\*(h-Yll\_b)) \*Yll/Ilc + (Fax\*off \*Yll/Ilc) + (Ft\*off \*Ylc/Ill)

= (7205 \*(5.512 -5.512 )) \* 5.957/122.507 + (0 \*5.512 \* 5.957/122.507 ) +

(0 \*5.512 \* 0.394/0.486 )

= 0.00 psi

Total Shear Stress for Combined Loads [St]:

= Ssll + Sblf

= 684.927 + 0.000

= 684.93 psi

Allowable Shear Stress for Combined Loads [Sta]:

= 0.4 \* Yield \* Occfac (AISC Shear Allowable)

= 0.4 \* 30007 \* 1.00

= 12002.90 psi

Shear Stress in Lug above Hole [Shs]:

= sqrt( Pl2 + Fax2 ) / Sha

= sqrt( 72052 + 02 )/3.782

= 1905.22 psi

Allowable Shear Stress in Lug above Hole [Sas]:

= 0.4 \* Yield \* Occfac

= 0.4 \* 30007 \* 1.00

= 12002.90 psi

Pin Hole Bearing Stress [Pbs]:

= sqrt( Fax2 + Fn2 ) / ( t \* dh )

= sqrt( 02 + 72052 )/( 0.787 \* 1.496 )

= 6116.76 psi

Allowable Bearing Stress [Pba]:

= min( 0.75 \* Yield \* Occfac, 0.9 \* Yield ) AISC Bearing All.

= min( 0.75 \* 30007 \* 1.00 , 27006.5 )

= 22505.44 psi

Bending Stress at the Base of the Lug [Fbs]:

= Ft \* off/(w \* t2/6) + Fax \* off/(w2 \* t/6)

= 0 \* 5.512/(11.024 \* 0.7872/6) +

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **FileName :** | **D4470** |  | | | |
| **Lifting Lug Calcs : Left Side** | **Step:** | **10** | **1:43p** | **Apr** | **4,2014** |

0 \* 5.512/(11.0242 \* 0.787/6)

= 0.00 psi

Tensile Stress at the Base of the Lug [Fa]:

= Fn / (w \* t)

= 0/(11.024 \* 0.787 )

= 830.13 psi

Total Combined Stress at the Base of the Lug:

= Fbs + Fa

= 0.0 + 830.1

= 830.13 psi

Lug Allowable Stress for Bending and Tension:

= min( 0.66 \* Yield \* Occfac, 0.75 \* Yield )

= min( 0.66 \* 30007 \* 1.00 , 22505.4 )

= 19804.79 psi

Required Shackle Pin Diameter [Spd]:

= sqrt[(2 \* sqrt(Fn2 + Fax2)/( Pi \* Sta))]

= sqrt[2 \* sqrt(72052 + 02)/( Pi \* 12002 )]

= 0.6182 in

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

*Note: Since Beta1/Beta2 >= 0.25, C22 (C22p) is adjusted per table 6 in paragraph 4.3 of WRC Bulletin 107.*

# Input Echo, WRC107/537 Item 1, Description: Lift Lug

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Diameter Basis for Vessel | | Vbasis | ID | |
| Cylindrical or Spherical Vessel | | Cylsph | Cylindrical | |
| Internal Corrosion Allowance | | Cas | 0.0000 in | |
| Vessel | Diameter | Dv | 60.000 | in |
| Vessel | Thickness | Tv | 0.866 | in |
| Design | Temperature |  | 100.00 | 癋 |
| Attachment Type | | Type | Rectangular | |
| Parameter C11 | | C11 | 0.79 in | |
| Parameter C22 | | C22 | 3.15 in | |

Thickness of Reinforcing Pad Tpad 0.630 in

|  |  |  |
| --- | --- | --- |
| Pad Parameter C11P | C11p | 7.874 in |
| Pad Parameter C22P | C22p | 13.780 in |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **FileName :** | **D4470** |  | | | |
| **Lifting Lug Calcs :** | **Left Side** | **Step:** | **10** | **1:43p** | **Apr** | **4,2014** |

Design Internal Pressure Dp 0.000 psig Include Pressure Thrust No

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS) P -7205.6 lbf

Longitudinal Shear (SUS) Vl 0.0 lbf

Circumferential Shear (SUS) Vc 0.0 lbf

Circumferential Moment (SUS) Mc 0.0 ft-lbf

Longitudinal Moment (SUS) Ml 0.0 ft-lbf

Torsional Moment (SUS) Mt 0.0 ft-lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Use Interactive Control |  | No |  |
| WRC107 Version | Version | March | 1979 |

Include Pressure Stress Indices per Div. 2 No

Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

|  |  |  |  |
| --- | --- | --- | --- |
| Radial Load | P | -7205.6 | lbf |
| Circumferential Shear | VC | 0.0 | lbf |
| Longitudinal Shear | VL | 0.0 | lbf |
| Circumferential Moment | MC | 0.0 | ft-lbf |
| Longitudinal Moment | ML | 0.0 | ft-lbf |
| Torsional Moment | MT | 0.0 | ft-lbf |

Dimensionless Parameters used : Gamma = 20.55

# Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.038 | 4C | 4.078 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.038 | 3C | 4.109 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.023 | 2C1 | 0.255 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.023 | 1C | 0.289 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.020 3A 0.038 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.026 1A ! 0.105 (A,B,C,D) N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.032 3B 0.391 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.029 1B ! 0.065 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.031 | 3C | 4.159 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.031 | 4C | 4.104 | (C,D) |
| M(x) | / | ( P ) |  | 0.032 | 1C1 | 0.270 | (A,B) |
| M(x) | / | ( P ) |  | 0.032 | 2C | 0.221 | (C,D) |

**FileName : D4470**

**Lifting Lug Calcs : Left Side Step: 10 1:43p Apr 4,2014**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( MC/(Rm\*\*2 \* Beta) ) | 0.020 | 4A | 0.055 | (A,B,C,D) |
| M(x) | / | ( MC/(Rm \* Beta) ) | 0.037 | 2A | 0.064 | (A,B,C,D) |
| N(x) | / | ( ML/(Rm\*\*2 \* Beta) ) | 0.032 | 4B | 0.086 | (A,B,C,D) |
| M(x) | / | ( ML/(Rm \* Beta) ) | 0.040 | 2B | 0.105 | (A,B,C,D) |

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

Stress Concentration Factors Kn = 1.00, Kb = 1.00

# Stresses in the Vessel at the Attachment Junction

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. Memb. P | | | 638 | 638 | 638 | 638 | 643 | 643 | 643 | 643 |
| Circ. Bend. P | | | 4916 | -4916 | 4916 | -4916 | 5577 | -5577 | 5577 | -5577 |
| Circ. Memb. MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Bend. MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Memb. ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Bend. ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | |  |  |  |  |  |  |  |  |  |
| Tot. Circ. Str.| | | 5555 | -4278 | 5555 | -4278 | 6220 | -4933 | 6220 | -4933 |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Memb. | P | | | 651 | 651 | 651 | 651 | 642 | 642 | 642 | 642 |
| Long. | Bend. | P | | | 5218 | -5218 | 5218 | -5218 | 4267 | -4267 | 4267 | -4267 |
| Long. | Memb. | MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Bend. | MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Memb. | ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Bend. | ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  |  |  |  |  |

Tot. Long. Str.| 5870 -4567 5870 -4567 4909 -3624 4909 -3624

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear | VC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Shear | VL | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Shear | MT | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
|  | | |  |  |  |  |  |  |  |  |  | |
| Tot. Shear| | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
| Str. Int. | | | | 5870 | 4567 | 5870 | 4567 | 6220 | 4933 | 6220 |  | 4933 |

Dimensionless Parameters used : Gamma = 35.14

**FileName : D4470**

**Lifting Lug Calcs : Left Side Step: 10 1:43p Apr 4,2014**

# Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.218 | 4C | 4.791 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.218 | 3C | 2.984 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.159 | 2C1 | 0.054 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.159 | 1C | 0.085 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.156 3A 1.345 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.170 1A 0.085 (A,B,C,D) N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.188 3B 3.690 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.179 1B 0.031 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.191 | 3C | 3.450 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.191 | 4C | 5.089 | (C,D) |
| M(x) | / | ( P ) |  | 0.196 | 1C1 | 0.072 | (A,B) |
| M(x) | / | ( P ) |  | 0.196 | 2C ! | 0.039 | (C,D) |

N(x) / ( MC/(Rm\*\*2 \* Beta) ) 0.156 4A 2.205 (A,B,C,D)

M(x) / ( MC/(Rm \* Beta) ) 0.205 2A 0.038 (A,B,C,D)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( ML/(Rm\*\*2 \* Beta) ) | 0.188 | 4B | 1.421 | (A,B,C,D) |
| M(x) | / | ( ML/(Rm \* Beta) ) | 0.206 | 2B | 0.040 | (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

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. Memb. P | | | 1309 | 1309 | 1309 | 1309 | 815 | 815 | 815 | 815 |
| Circ. Bend. P | | | 3112 | -3112 | 3112 | -3112 | 4913 | -4913 | 4913 | -4913 |
| Circ. Memb. MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Bend. MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Memb. ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Bend. ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | |  |  |  |  |  |  |  |  |  |
| Tot. Circ. Str.| | | 4422 | -1802 | 4422 | -1802 | 5728 | -4097 | 5728 | -4097 |

Long. Memb. P | 943 943 943 943 1391 1391 1391 1391

Long. Bend. P | 4169 -4169 4169 -4169 2242 -2242 2242 -2242

**FileName : D4470**

**Lifting Lug Calcs : Left Side Step: 10 1:43p Apr 4,2014**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Memb. | MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Bend. | MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Memb. | ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Bend. | ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  |  |  |  |  |

Tot. Long. Str.| 5112 -3226 5112 -3226 3634 -851 3634 -851

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear | VC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Shear | VL | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Shear | MT | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
|  | | |  |  |  |  |  |  |  |  |  | |
| Tot. Shear| | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
| Str. Int. | | | | 5112 | 3226 | 5112 | 3226 | 5728 | 4097 | 5728 |  | 4097 |

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Attachment Junction**

Type of | Stress Values at Stress Int. | (psi )

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. | Pl (SUS) | | 638 | 638 | 638 | 638 | 643 | 643 | 643 | 643 |
| Circ. | Q (SUS) | | 4916 | -4916 | 4916 | -4916 | 5577 | -5577 | 5577 | -5577 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Pl (SUS) | | 651 | 651 | 651 | 651 | 642 | 642 | 642 | 642 |
| Long. | Q (SUS) | | 5218 | -5218 | 5218 | -5218 | 4267 | -4267 | 4267 | -4267 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear | Pl (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear | Q (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Pm (SUS) | 0 0 0 0 0 0 0 0

Pm+Pl (SUS) | 651 651 651 651 643 643 643 643

Pm+Pl+Q (Total)| 5870 4567 5870 4567 6220 4933 6220 4933

Type of | Max. S.I. S.I. Allowable | Result

**FileName : D4470**

**Lifting Lug Calcs : Left Side Step: 10 1:43p Apr 4,2014**

Stress Int. | psi |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 0 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 651 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 6220 50100 | Passed

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Reinforcing Pad Edge**

Type of | Stress Values at Stress Int. | (psi )

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. | Pl (SUS) | | 1309 | 1309 | 1309 | 1309 | 815 | 815 | 815 | 815 |
| Circ. | Q (SUS) | | 3112 | -3112 | 3112 | -3112 | 4913 | -4913 | 4913 | -4913 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Pl (SUS) | | 943 | 943 | 943 | 943 | 1391 | 1391 | 1391 | 1391 |
| Long. | Q (SUS) | | 4169 | -4169 | 4169 | -4169 | 2242 | -2242 | 2242 | -2242 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Pl (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Q (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pm+Pl (SUS) | | | 1309 | 1309 | 1309 | 1309 | 1391 | 1391 |  | 1391 1391 |

Pm+Pl+Q (Total)| 5112 3226 5112 3226 5728 4097 5728 4097

Type of | Max. S.I. S.I. Allowable | Result Stress Int. | psi |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 0 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 1391 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 5728 50100 | Passed

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**FileName : D4470**

**Lifting Lug Calcs : Right Side Step: 11 1:43p Apr 4,2014**

# Lifting Lug Calculations: Lug(s) on Right End of Vessel

**Input Values:**

**Lifting Lug Material** SA-283 C

Lifting Lug Yield Stress Yield 30007.25 psi

Total Height of Lifting Lug w 11.0236 in

Thickness of Lifting Lug t 0.7874 in

Diameter of Hole in Lifting Lug dh 1.4961 in Radius of Semi-Circular Arc of Lifting Lug r 3.1496 in Height of Lug from bottom to Center of Hole h 5.5118 in Offset from Vessel OD to Center of Hole off 5.5118 in Lug Fillet Weld Size tw 0.6299 in Length of weld along side of Lifting Lug wl 11.0236 in Length of Weld along Bottom of Lifting Lug wb 0.7874 in Thickness of Collar (if any) tc 0.0000 in

Diameter of Collar (if any) dc 0.0000 in Impact Factor Impfac 2.00

Sling Angle from Horizontal 90.0000 deg Number of Lugs in Group 2

Lifting Lug Orientation to Vessel: Perpendicular Lift Orientation : Horizontal Lift

*PV Elite does not compute weak axis bending forces on the lugs. It is assumed that a spreader bar is used.*

# Computed Results:

|  |  |  |  |
| --- | --- | --- | --- |
| Force | Along Vessel Axis | Fax | 0.00 lbf |
| Force | Normal to Vessel | Fn | 7632.55 lbf |
| Force | Tangential to Vessel | Ft | 0.00 lbf |

*Converting the weld leg dimension (tw) to the weld throat dimension.*

# Weld Group Inertia Calculations:

Weld Group Inertia about the Circumferential Axis Ilc 122.507 in\*\*4 Weld Group Centroid distance in the Long. Direction Yll 5.957 in

|  |  |  |  |
| --- | --- | --- | --- |
| Dist. of Weld Group Centroid | from Lug bottom | Yll\_b | 5.512 in |
| Weld Group Inertia about the | Longitudinal Axis | Ill | 0.486 in\*\*4 |

Weld Group Centroid Distance in the Circ. Direction Ylc 0.394 in

*Note: The Impact Factor is applied to the Forces acting on the Lug.*

**FileName : D4470**

**Lifting Lug Calcs : Right Side Step: 11 1:43p Apr 4,2014**

Primary Shear Stress in the Welds due to Shear Loads [Ssll]:

= sqrt( Fax2 + Ft2 + Fn2 )/(( 2 \* (wl + wb) ) \* tw )

= sqrt(02+02+76322)/((2\*(11.0+0.8))\*0.4454)

= 725.51 psi

Shear Stress in the Welds due to Bending Loads [Sblf]:

= (Fn\*(h-Yll\_b)) \*Yll/Ilc + (Fax\*off \*Yll/Ilc) + (Ft\*off \*Ylc/Ill)

= (7632 \*(5.512 -5.512 )) \* 5.957/122.507 + (0 \*5.512 \* 5.957/122.507 ) +

(0 \*5.512 \* 0.394/0.486 )

= 0.00 psi

Total Shear Stress for Combined Loads [St]:

= Ssll + Sblf

= 725.515 + 0.000

= 725.51 psi

Allowable Shear Stress for Combined Loads [Sta]:

= 0.4 \* Yield \* Occfac (AISC Shear Allowable)

= 0.4 \* 30007 \* 1.00

= 12002.90 psi

Shear Stress in Lug above Hole [Shs]:

= sqrt( Pl2 + Fax2 ) / Sha

= sqrt( 76322 + 02 )/3.782

= 2018.12 psi

Allowable Shear Stress in Lug above Hole [Sas]:

= 0.4 \* Yield \* Occfac

= 0.4 \* 30007 \* 1.00

= 12002.90 psi

Pin Hole Bearing Stress [Pbs]:

= sqrt( Fax2 + Fn2 ) / ( t \* dh )

= sqrt( 02 + 76322 )/( 0.787 \* 1.496 )

= 6479.23 psi

Allowable Bearing Stress [Pba]:

= min( 0.75 \* Yield \* Occfac, 0.9 \* Yield ) AISC Bearing All.

= min( 0.75 \* 30007 \* 1.00 , 27006.5 )

= 22505.44 psi

Bending Stress at the Base of the Lug [Fbs]:

= Ft \* off/(w \* t2/6) + Fax \* off/(w2 \* t/6)

= 0 \* 5.512/(11.024 \* 0.7872/6) +

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **FileName :** | **D4470** |  | | | |
| **Lifting Lug Calcs : Right Side** | **Step:** | **11** | **1:43p** | **Apr** | **4,2014** |

0 \* 5.512/(11.0242 \* 0.787/6)

= 0.00 psi

Tensile Stress at the Base of the Lug [Fa]:

= Fn / (w \* t)

= 0/(11.024 \* 0.787 )

= 879.32 psi

Total Combined Stress at the Base of the Lug:

= Fbs + Fa

= 0.0 + 879.3

= 879.32 psi

Lug Allowable Stress for Bending and Tension:

= min( 0.66 \* Yield \* Occfac, 0.75 \* Yield )

= min( 0.66 \* 30007 \* 1.00 , 22505.4 )

= 19804.79 psi

Required Shackle Pin Diameter [Spd]:

= sqrt[(2 \* sqrt(Fn2 + Fax2)/( Pi \* Sta))]

= sqrt[2 \* sqrt(76322 + 02)/( Pi \* 12002 )]

= 0.6363 in

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

*Note: Since Beta1/Beta2 >= 0.25, C22 (C22p) is adjusted per table 6 in paragraph 4.3 of WRC Bulletin 107.*

# Input Echo, WRC107/537 Item 1, Description: Lift Lug

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Diameter Basis for Vessel | | Vbasis | ID | |
| Cylindrical or Spherical Vessel | | Cylsph | Cylindrical | |
| Internal Corrosion Allowance | | Cas | 0.0000 in | |
| Vessel | Diameter | Dv | 60.000 | in |
| Vessel | Thickness | Tv | 0.866 | in |
| Design | Temperature |  | 100.00 | 癋 |
| Attachment Type | | Type | Rectangular | |
| Parameter C11 | | C11 | 0.79 in | |
| Parameter C22 | | C22 | 3.15 in | |

Thickness of Reinforcing Pad Tpad 0.630 in

|  |  |  |
| --- | --- | --- |
| Pad Parameter C11P | C11p | 7.874 in |
| Pad Parameter C22P | C22p | 13.780 in |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **FileName :** | **D4470** |  | | | |
| **Lifting Lug Calcs :** | **Right Side** | **Step:** | **11** | **1:43p** | **Apr** | **4,2014** |

Design Internal Pressure Dp 0.000 psig Include Pressure Thrust No

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS) P -7632.5 lbf

Longitudinal Shear (SUS) Vl 0.0 lbf

Circumferential Shear (SUS) Vc 0.0 lbf

Circumferential Moment (SUS) Mc 0.0 ft-lbf

Longitudinal Moment (SUS) Ml 0.0 ft-lbf

Torsional Moment (SUS) Mt 0.0 ft-lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Use Interactive Control |  | No |  |
| WRC107 Version | Version | March | 1979 |

Include Pressure Stress Indices per Div. 2 No

Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

|  |  |  |  |
| --- | --- | --- | --- |
| Radial Load | P | -7632.5 | lbf |
| Circumferential Shear | VC | 0.0 | lbf |
| Longitudinal Shear | VL | 0.0 | lbf |
| Circumferential Moment | MC | 0.0 | ft-lbf |
| Longitudinal Moment | ML | 0.0 | ft-lbf |
| Torsional Moment | MT | 0.0 | ft-lbf |

Dimensionless Parameters used : Gamma = 20.55

# Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.038 | 4C | 4.078 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.038 | 3C | 4.109 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.023 | 2C1 | 0.255 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.023 | 1C | 0.289 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.020 3A 0.038 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.026 1A ! 0.105 (A,B,C,D) N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.032 3B 0.391 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.029 1B ! 0.065 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.031 | 3C | 4.159 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.031 | 4C | 4.104 | (C,D) |
| M(x) | / | ( P ) |  | 0.032 | 1C1 | 0.270 | (A,B) |
| M(x) | / | ( P ) |  | 0.032 | 2C | 0.221 | (C,D) |

**FileName : D4470**

**Lifting Lug Calcs : Right Side Step: 11 1:43p Apr 4,2014**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( MC/(Rm\*\*2 \* Beta) ) | 0.020 | 4A | 0.055 | (A,B,C,D) |
| M(x) | / | ( MC/(Rm \* Beta) ) | 0.037 | 2A | 0.064 | (A,B,C,D) |
| N(x) | / | ( ML/(Rm\*\*2 \* Beta) ) | 0.032 | 4B | 0.086 | (A,B,C,D) |
| M(x) | / | ( ML/(Rm \* Beta) ) | 0.040 | 2B | 0.105 | (A,B,C,D) |

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

Stress Concentration Factors Kn = 1.00, Kb = 1.00

# Stresses in the Vessel at the Attachment Junction

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. Memb. P | | | 676 | 676 | 676 | 676 | 681 | 681 | 681 | 681 |
| Circ. Bend. P | | | 5208 | -5208 | 5208 | -5208 | 5907 | -5907 | 5907 | -5907 |
| Circ. Memb. MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Bend. MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Memb. ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Bend. ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | |  |  |  |  |  |  |  |  |  |
| Tot. Circ. Str.| | | 5884 | -4531 | 5884 | -4531 | 6589 | -5225 | 6589 | -5225 |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Memb. | P | | | 690 | 690 | 690 | 690 | 680 | 680 | 680 | 680 |
| Long. | Bend. | P | | | 5528 | -5528 | 5528 | -5528 | 4519 | -4519 | 4519 | -4519 |
| Long. | Memb. | MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Bend. | MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Memb. | ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Bend. | ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  |  |  |  |  |

Tot. Long. Str.| 6218 -4838 6218 -4838 5200 -3838 5200 -3838

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear | VC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Shear | VL | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Shear | MT | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
|  | | |  |  |  |  |  |  |  |  |  | |
| Tot. Shear| | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
| Str. Int. | | | | 6218 | 4838 | 6218 | 4838 | 6589 | 5225 | 6589 |  | 5225 |

Dimensionless Parameters used : Gamma = 35.14

**FileName : D4470**

**Lifting Lug Calcs : Right Side Step: 11 1:43p Apr 4,2014**

# Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.218 | 4C | 4.791 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.218 | 3C | 2.984 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.159 | 2C1 | 0.054 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.159 | 1C | 0.085 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.156 3A 1.345 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.170 1A 0.085 (A,B,C,D) N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.188 3B 3.690 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.179 1B 0.031 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.191 | 3C | 3.450 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.191 | 4C | 5.089 | (C,D) |
| M(x) | / | ( P ) |  | 0.196 | 1C1 | 0.072 | (A,B) |
| M(x) | / | ( P ) |  | 0.196 | 2C ! | 0.039 | (C,D) |

N(x) / ( MC/(Rm\*\*2 \* Beta) ) 0.156 4A 2.205 (A,B,C,D)

M(x) / ( MC/(Rm \* Beta) ) 0.205 2A 0.038 (A,B,C,D)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( ML/(Rm\*\*2 \* Beta) ) | 0.188 | 4B | 1.421 | (A,B,C,D) |
| M(x) | / | ( ML/(Rm \* Beta) ) | 0.206 | 2B | 0.040 | (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

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. Memb. P | | | 1387 | 1387 | 1387 | 1387 | 864 | 864 | 864 | 864 |
| Circ. Bend. P | | | 3297 | -3297 | 3297 | -3297 | 5204 | -5204 | 5204 | -5204 |
| Circ. Memb. MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Bend. MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Memb. ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. Bend. ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | |  |  |  |  |  |  |  |  |  |
| Tot. Circ. Str.| | | 4684 | -1909 | 4684 | -1909 | 6068 | -4340 | 6068 | -4340 |

Long. Memb. P | 998 998 998 998 1473 1473 1473 1473

Long. Bend. P | 4416 -4416 4416 -4416 2375 -2375 2375 -2375

**FileName : D4470**

**Lifting Lug Calcs : Right Side Step: 11 1:43p Apr 4,2014**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Memb. | MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Bend. | MC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Memb. | ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Bend. | ML | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  |  |  |  |  |

Tot. Long. Str.| 5415 -3417 5415 -3417 3849 -902 3849 -902

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear | VC | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Shear | VL | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Shear | MT | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
|  | | |  |  |  |  |  |  |  |  |  | |
| Tot. Shear| | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
| Str. Int. | | | | 5415 | 3417 | 5415 | 3417 | 6068 | 4340 | 6068 |  | 4340 |

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Attachment Junction**

Type of | Stress Values at Stress Int. | (psi )

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. | Pl (SUS) | | 676 | 676 | 676 | 676 | 681 | 681 | 681 | 681 |
| Circ. | Q (SUS) | | 5208 | -5208 | 5208 | -5208 | 5907 | -5907 | 5907 | -5907 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Pl (SUS) | | 690 | 690 | 690 | 690 | 680 | 680 | 680 | 680 |
| Long. | Q (SUS) | | 5528 | -5528 | 5528 | -5528 | 4519 | -4519 | 4519 | -4519 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear | Pl (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear | Q (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Pm (SUS) | 0 0 0 0 0 0 0 0

Pm+Pl (SUS) | 690 690 690 690 681 681 681 681

Pm+Pl+Q (Total)| 6218 4838 6218 4838 6589 5225 6589 5225

Type of | Max. S.I. S.I. Allowable | Result

**FileName : D4470**

**Lifting Lug Calcs : Right Side Step: 11 1:43p Apr 4,2014**

Stress Int. | psi |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 0 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 690 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 6589 50100 | Passed

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Reinforcing Pad Edge**

Type of | Stress Values at Stress Int. | (psi )

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circ. | Pl (SUS) | | 1387 | 1387 | 1387 | 1387 | 864 | 864 | 864 | 864 |
| Circ. | Q (SUS) | | 3297 | -3297 | 3297 | -3297 | 5204 | -5204 | 5204 | -5204 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long. | Pl (SUS) | | 998 | 998 | 998 | 998 | 1473 | 1473 | 1473 | 1473 |
| Long. | Q (SUS) | | 4416 | -4416 | 4416 | -4416 | 2375 | -2375 | 2375 | -2375 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Pl (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Q (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pm+Pl (SUS) | | | 1387 | 1387 | 1387 | 1387 | 1473 | 1473 |  | 1473 1473 |

Pm+Pl+Q (Total)| 5415 3417 5415 3417 6068 4340 6068 4340

Type of | Max. S.I. S.I. Allowable | Result Stress Int. | psi |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 0 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 1473 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 6068 50100 | Passed

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**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

# 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 (11.81) 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( 7.250 + 1.56\*sqrt( 30.4331 \* 0.8661 ), 2 \* 21.000 )

= 15.2593 in

# Input and Calculated Values:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Vessel Mean Radius | Rm | 30.43 | in | |
| Stiffened Vessel Length per 4.15.6 | L | 12.50 | | ft |
| Distance from Saddle to Vessel tangent | a | 21.00 | | in |

|  |  |  |  |
| --- | --- | --- | --- |
| Saddle | Width | b | 7.25 in |
| Saddle | Bearing Angle | theta | 120.00 degrees |

Inside Depth of Head h2 1.25 ft

Shell Allowable Stress used in Calculation 16700.00 psi Head Allowable Stress used in Calculation 16700.00 psi Circumferential Efficiency in Plane of Saddle 1.00

Circumferential Efficiency at Mid-Span 1.00

Saddle Force Q, Operating Case 12591.57 lbf

# Horizontal Vessel Analysis Results: Actual Allowable

Long. Stress at Top of Midspan 6308.78 16700.00 psi Long. Stress at Bottom of Midspan 6450.18 16700.00 psi Long. Stress at Top of Saddles 6520.18 16700.00 psi Long. Stress at Bottom of Saddles 6301.49 16700.00 psi

|  |  |  |
| --- | --- | --- |
| Tangential Shear in Shell | 355.27 | 10020.00 psi |
| Circ. Stress at Horn of Saddle | 1393.75 | 20875.00 psi |
| Circ. Compressive Stress in Shell | 72.43 | 16700.00 psi |

# Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

= Ftr \* ( Ft/Num of Saddles + Z Force Load ) \* B / E

= 3.00 \* ( 1978.4/2 + 0 ) \* 43.0000/52.7116

= 2420.8 lbf

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

= max( Fl, Friction Load, Sum of X Forces) \* B / Ls

= max( 1160.64 , 0.00 , 0 ) \* 43.0000/108.0000

= 462.1 lbf

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

= max( Fl, Friction Force, Sum of X Forces ) \* B / Ls

= max( 416.00 , 0.00 , 0 ) \* 43.0000/108.0000

= 165.6 lbf

Saddle Reaction Force due to Earthquake Ft [Fst]:

= Ftr \* ( Ft/Num of Saddles + Z Force Load ) \* B / E

= 3.00 \* ( 415/2 + 0 ) \* 43.0000/52.7116

= 509.0 lbf

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

= Saddle Load + Max( Fwl, Fwt, Fsl, Fst )

= 10170 + Max( 462 , 2420 , 165 , 509 )

= 12591.6 lbf

**Summary of Loads at the base of this Saddle:**

Vertical Load (including saddle weight) 13142.88 lbf Transverse Shear Load Saddle 989.19 lbf

Longitudinal Shear Load Saddle 1160.64 lbf

**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 = 0.0283 | 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)]

= -12591\*1.75[1-(1-1.75/12.50+(2.5362-1.2502)/ (2\*1.75\*12.50))/(1+(4\*1.25)/(3\*12.50))]

= -3150.4 ft-lbf

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

Moment per Equation 4.15.4 [M2]:

= Q\*L/4(1+2(R2-h22)/(L2))/(1+(4h2)/( 3L))-4a/L

= 12591\*12.5/4(1+2(2.5362-1.2502)/(12.502))/(1+(4\*1.250)/ (3\*12.500))-4\*1.75/12.50

= 14848.1 ft-lbf

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

= P \* Rm/(2t) - M2/(pi\*Rm2t)

= 363.127 \* 30.433/(2\*0.866 ) - 178177.0/(pi\*30.42\*0.866 )

= 6308.78 psi

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

= P \* Rm/(2t) + M2/(pi \* Rm2 \* t)

= 363.127 \* 30.433/(2 \* 0.866 ) + 178177.0/(pi \* 30.42 \* 0.866 )

= 6450.18 psi

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

= P \* Rm/(2t) - M1/(K1\*pi\*Rm2t)

= 363.127\*30.433/(2\*0.866)--37805.4/(0.1066\*pi\*30.42\*0.866)

= 6520.18 psi

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

= P \* Rm/(2t) + M1/(K1\* \* pi \* Rm2 \* t)

= 363.127\*30.433/(2\*0.866)+-37805.4/(0.1923\*pi\*30.42\*0.866)

= 6301.49 psi

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

= Q(L-2a)/(L+(4\*h2/3))

= 12591 ( 12.50 - 2 \* 1.75 )/(12.50 + ( 4 \* 1.25/3))

= 7999.3 lbf

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

= K2 \* T / ( Rm \* t )

= 1.1707 \* 7999.35/( 30.4331 \* 0.8661 )

= 355.27 psi

Decay Length (4.15.22) [x1,x2]:

= 0.78 \* sqrt( Rm \* t )

= 0.78 \* sqrt( 30.433 \* 0.866 )

= 4.005 in

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

= -K5 \* Q \* k / ( t \* ( b + X1 + X2 ) )

= -0.7603 \* 12591 \* 0.1/( 0.866 \* ( 7.25 + 4.00 + 4.00 ) )

= -72.43 psi

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.25) [sigma7\*]:

= -Q/(4\*t\*(b+X1+X2)) - 12\*K7\*Q\*Rm/(L\*t2)

= -12591/(4\*0.866 \*(7.250 +4.005 +4.005 )) -

12 \* 0.028 \* 12591 \* 30.433/(12.500 \* 0.8662)

= -1393.75 psi

Effective reinforcing plate width (4.15.1) [B1]:

= min( b + 1.56 \* sqrt( Rm \* t ), 2a )

= min( 7.25 + 1.56 \* sqrt( 30.433 \* 0.866 ), 2 \* 21.000 )

= 15.26 in

Free Un-Restrained Thermal Expansion between the Saddles [Exp]:

= Alpha \* Ls \* ( Design Temperature - Ambient Temperature )

= 0.909E-05 \* 108.000 \* ( 248.0 - 70.0 )

= 0.175 in

**Results for Vessel Ribs, Web and Base:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Baseplate Length |  |  | Bplen | 54.0000 | in |
| Baseplate Thickness |  |  | Bpthk | 0.6299 | in |
| Baseplate Width |  |  | Bpwid | 8.0000 | in |
| Number of Ribs ( inc. | outside | ribs | ) Nribs |  | 4 |
| Rib Thickness |  |  | Ribtk | 0.5512 | in |
| Web Thickness |  |  | Webtk | 0.5512 | in |
| Web Location |  |  | Webloc | Center |  |

Moment of Inertia of Saddle - Lateral Direction

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | Y | A | AY | Io |
| Shell | | 0. | 17. | 7. | 4. |
| Wearplate | | 1. | 6. | 6. | 7. |
| Web | | 5. | 4. | 24. | 149. |
| BasePlate | | 10. | 5. | 49. | 470. |
| Totals | | 17. | 32. | 86. | 630. |
| Value | C1 = Sumof(Ay)/Sumof(A) | | | = | 3. in |
| Value | I = Sumof(Io) - C1\*Sumof(Ay) | | | = | 401. in\*\*4 |
| Value | As = Sumof(A) - Ashell | | | = | 15. in^2 |

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

Fh = K1 \* Q = 0.2035 \* 12591.568 = 2562.6575 lbf

Tension Stress, St = ( Fh/As ) = 170.5147 psi Allowed Stress, Sa = 0.6 \* Yield Str = 20880.0000 psi

d = B - R\*Sin(theta) / theta = 15.1589 in

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

Bending Moment, M = Fh \* d = 3237.2664 ft-lbf

Bending Stress, Sb = ( M \* C1 / I ) = 258.1586 psi Allowed Stress, Sa = 2/3 \* Yield Str = 23200.0000 psi

# Minimum Thickness of Baseplate per Moss :

= ( 3 \* ( Q + Saddle\_Wt ) \* BasePlateWidth / ( 4 \* BasePlateLength \* AllStress )).5

= ( 3 \* (12591 + 551 ) \* 8.00/( 4 \* 54.000 \* 23200.000 )).5

= 0.251 in

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

= ( Bplen - Clearance ) / ( Nribs - 1)

= ( 54.0000 - 1.0 )/( 4 - 1 ) = 17.6667 in

Baseplate Pressure Area [Ap]:

= e \* Bpwid / 2

= 17.6667 \* 8.0000/2 = 70.6667 in^2

Axial Load [P]:

= Ap \* Bp

= 70.7 \* 29.15 = 2059.7 lbf

Area of the Rib and Web [Ar]:

= ( Bpwid - Clearance - Webtk ) \* Ribtk + e/2 \* Webtk

= ( 8.000 - 1.0 - 0.551 ) \* 0.551 + 17.6667/2 \* 0.551

= 8.423 in^2

Compressive Stress [Sc]:

= P/Ar

= 2059.7/8.4232 = 244.5298 psi

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y | A | AY | Ay2 | Io |  |
| Rib | 3.6 | 3.6 | 13.1 | 0.0 |  | 16.6 |
| Web | 3.6 | 4.9 | 17.6 | 0.0 |  | 0.2 |
| Values | 3.6 | 8.5 | 30.8 | 0.0 |  | 16.9 |

Bending Moment [Rm]:

= Fl /( 2 \* Bplen ) \* e \* rl / 2

= 1160.6/( 2 \* 54.00 ) \* 17.667 \* 24.54/2

= 194.096 ft-lbf

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

KL/R < Cc ( 17.3422 < 128.2548 ) per AISC E2-1

Sca = (1-(Klr)2/(2\*Cc2))\*Fy/(5/3+3\*(Klr)/(8\*Cc)-(Klr3)/(8\*Cc3)

Sca = ( 1-( 17.34 )2/(2 \* 128.252 )) \* 34800/

( 5/3+3\*(17.34 )/(8\* 128.25 )-( 17.343)/(8\*128.253)

Sca = 20081.88 psi

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

Check = Sc/Sca + (Rm/Z)/Sba

Check = 244.53/20081.88 + (2329.15/4.651 )/23200.00

Check = 0.03

Check of Inside Ribs

Inertia of Saddle, Inner Ribs - Axial Direction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y | A | AY | Ay2 | Io |  |
| Rib | 3.5 | 3.6 | 12.4 | 0.0 |  | 15.8 |
| Web | 3.5 | 9.7 | 34.1 | 0.0 |  | 0.2 |
| Values | 3.5 | 13.3 | 46.5 | 0.0 |  | 16.0 |

KL/R < Cc ( 9.0239 < 128.2548 ) per AISC E2-1

Sca = (1-(Klr)2/(2\*Cc2))\*Fy/(5/3+3\*(Klr)/(8\*Cc)-(Klr3)/(8\*Cc3)

Sca = ( 1-( 9.02 )2/(2 \* 128.252 )) \* 34800/

( 5/3+3\*(9.02 )/(8\* 128.25 )-( 9.023)/(8\*128.253)

Sca = 20504.26 psi

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

Check = Sc/Sca + (Rm/Z)/Sba

Check = 309.92/20504.26 + ( 1879.76/4.572 )/23200.00

Check = 0.03

**Input Data for Base Plate Bolting Calculations:**

Total Number of Bolts per BasePlate Nbolts 8

Total Number of Bolts in Tension/Baseplate Nbt 4

Bolt Material Specification SA-307 B Bolt Allowable Stress Stba 7000.00 psi

Bolt Corrosion Allowance Bca 0.1180 in Distance from Bolts to Edge Edgedis 4.1650 in Nominal Bolt Diameter Bnd 0.8750 in Thread Series Series UNC BasePlate Allowable Stress S 13800.00 psi Area Available in a Single Bolt BltArea 0.1920 in^2 Saddle Load QO (Weight) QO 10722.1 lbf Saddle Load QL (Wind/Seismic contribution) QL 462.1 lbf Maximum Transverse Force Ft 989.2 lbf

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

Maximum Longitudinal Force Fl 1160.6 lbf 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)

= 1160.64/(7000.00 \* 8.00 )

= 0.0207 in^2

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:

= B \* Ft + Sum of X Moments

= 3.58 \* 989.19 + 0.00

= 3544.59 ft-lbf

Eccentricity (e):

= Rmom / QO

= 42535.03/10722.06

= 3.97 in < Bplen/6 --> No Uplift in Transverse direction

Bolt Area due to Transverse Load [Bltareart]:

= 0 (No Uplift)

Required of a Single Bolt [Bltarear]

= max[Bltarearl, Bltarears, Bltareart]

= max[0.0000 , 0.0207 , 0.0000 ]

= 0.0207 in^2

# ASME Horizontal Vessel Analysis: Stresses for the Right Saddle

(per ASME Sec. VIII Div. 2 based on the Zick method.)

Note: Wear Pad Width (11.81) 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( 7.250 + 1.56\*sqrt( 30.4331 \* 0.8661 ), 2 \* 21.000 )

= 15.2593 in

# Input and Calculated Values:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **FileName** | **: D4470** |  | | | |
| **Horizontal** | **Vessel** | **Analysis (Ope.)** | **: Step:** | **12** | **1:43p** | **Apr** | **4,2014** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Vessel Mean Radius | Rm | 30.43 | in | |
| Stiffened Vessel Length per 4.15.6 | L | 12.50 | | ft |
| Distance from Saddle to Vessel tangent | a | 21.00 | | in |

|  |  |  |  |
| --- | --- | --- | --- |
| Saddle | Width | b | 7.25 in |
| Saddle | Bearing Angle | theta | 120.00 degrees |

Inside Depth of Head h2 1.25 ft

Shell Allowable Stress used in Calculation 16700.00 psi Head Allowable Stress used in Calculation 16700.00 psi Circumferential Efficiency in Plane of Saddle 1.00

Circumferential Efficiency at Mid-Span 1.00

Saddle Force Q, Operating Case 12371.71 lbf

# Horizontal Vessel Analysis Results: Actual Allowable

Long. Stress at Top of Midspan 6310.01 16700.00 psi Long. Stress at Bottom of Midspan 6448.94 16700.00 psi Long. Stress at Top of Saddles 6517.73 16700.00 psi Long. Stress at Bottom of Saddles 6302.85 16700.00 psi

Tangential Shear in Shell 349.07 10020.00 psi

|  |  |  |  |
| --- | --- | --- | --- |
| Circ. Stress at Horn of Saddle | 1369.41 | 20875.00 | psi |
| Circ. Compressive Stress in Shell | 71.17 | 16700.00 | psi |

# Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:

= Ftr \* ( Ft/Num of Saddles + Z Force Load ) \* B / E

= 3.00 \* ( 1978.4/2 + 0 ) \* 43.0000/52.7116

= 2420.8 lbf

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

= max( Fl, Friction Load, Sum of X Forces) \* B / Ls

= max( 1160.64 , 0.00 , 0 ) \* 43.0000/108.0000

= 462.1 lbf

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

= max( Fl, Friction Force, Sum of X Forces ) \* B / Ls

= max( 416.00 , 0.00 , 0 ) \* 43.0000/108.0000

= 165.6 lbf

Saddle Reaction Force due to Earthquake Ft [Fst]:

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

= Ftr \* ( Ft/Num of Saddles + Z Force Load ) \* B / E

= 3.00 \* ( 415/2 + 0 ) \* 43.0000/52.7116

= 509.0 lbf

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

= Saddle Load + Max( Fwl, Fwt, Fsl, Fst )

= 9950 + Max( 462 , 2420 , 165 , 509 )

= 12371.7 lbf

**Summary of Loads at the base of this Saddle:**

Vertical Load (including saddle weight) 12923.02 lbf Transverse Shear Load Saddle 989.19 lbf

Longitudinal Shear Load Saddle 1160.64 lbf

**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 = 0.0283 | 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)]

= -12371\*1.75[1-(1-1.75/12.50+(2.5362-1.2502)/ (2\*1.75\*12.50))/(1+(4\*1.25)/(3\*12.50))]

= -3095.4 ft-lbf

Moment per Equation 4.15.4 [M2]:

= Q\*L/4(1+2(R2-h22)/(L2))/(1+(4h2)/( 3L))-4a/L

= 12371\*12.5/4(1+2(2.5362-1.2502)/(12.502))/(1+(4\*1.250)/ (3\*12.500))-4\*1.75/12.50

= 14588.8 ft-lbf

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

= P \* Rm/(2t) - M2/(pi\*Rm2t)

= 363.127 \* 30.433/(2\*0.866 ) - 175065.9/(pi\*30.42\*0.866 )

= 6310.01 psi

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

= P \* Rm/(2t) + M2/(pi \* Rm2 \* t)

= 363.127 \* 30.433/(2 \* 0.866 ) + 175065.9/(pi \* 30.42 \* 0.866 )

= 6448.94 psi

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

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

= P \* Rm/(2t) - M1/(K1\*pi\*Rm2t)

= 363.127\*30.433/(2\*0.866)--37145.3/(0.1066\*pi\*30.42\*0.866)

= 6517.73 psi

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

= P \* Rm/(2t) + M1/(K1\* \* pi \* Rm2 \* t)

= 363.127\*30.433/(2\*0.866)+-37145.3/(0.1923\*pi\*30.42\*0.866)

= 6302.85 psi

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

= Q(L-2a)/(L+(4\*h2/3))

= 12371 ( 12.50 - 2 \* 1.75 )/(12.50 + ( 4 \* 1.25/3))

= 7859.7 lbf

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

= K2 \* T / ( Rm \* t )

= 1.1707 \* 7859.67/( 30.4331 \* 0.8661 )

= 349.07 psi

Decay Length (4.15.22) [x1,x2]:

= 0.78 \* sqrt( Rm \* t )

= 0.78 \* sqrt( 30.433 \* 0.866 )

= 4.005 in

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

= -K5 \* Q \* k / ( t \* ( b + X1 + X2 ) )

= -0.7603 \* 12371 \* 0.1/( 0.866 \* ( 7.25 + 4.00 + 4.00 ) )

= -71.17 psi

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.25) [sigma7\*]:

= -Q/(4\*t\*(b+X1+X2)) - 12\*K7\*Q\*Rm/(L\*t2)

= -12371/(4\*0.866 \*(7.250 +4.005 +4.005 )) -

12 \* 0.028 \* 12371 \* 30.433/(12.500 \* 0.8662)

= -1369.41 psi

Effective reinforcing plate width (4.15.1) [B1]:

= min( b + 1.56 \* sqrt( Rm \* t ), 2a )

= min( 7.25 + 1.56 \* sqrt( 30.433 \* 0.866 ), 2 \* 21.000 )

= 15.26 in

**Results for Vessel Ribs, Web and Base**

|  |  |  |
| --- | --- | --- |
| Baseplate Length | Bplen | 54.0000 in |
| Baseplate Thickness | Bpthk | 0.6299 in |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **FileName :** | **D4470** |  | | | |
| **Horizontal Vessel** | **Analysis (Ope.) :** | **Step:** | **12** | **1:43p** | **Apr** | **4,2014** |

Baseplate Width Bpwid 8.0000 in Number of Ribs ( inc. outside ribs ) Nribs 4

Rib Thickness Ribtk 0.5512 in

Web Thickness Webtk 0.5512 in

Web Location Webloc Center

Moment of Inertia of Saddle - Lateral Direction

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Y | | A | AY | Io |
| Shell | 0. | 17. | 7. | 4. |
| Wearplate | 1. | 6. | 6. | 7. |
| Web | 5. | 4. | 24. | 149. |
| BasePlate | 10. | 5. | 49. | 470. |
| Totals | 17. | 32. | 86. | 630. |

|  |  |  |  |
| --- | --- | --- | --- |
| Value | C1 = Sumof(Ay)/Sumof(A) | = | 3. in |
| Value | I = Sumof(Io) - C1\*Sumof(Ay) | = | 401. in\*\*4 |
| Value | As = Sumof(A) - Ashell | = | 15. in^2 |

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

Fh = K1 \* Q = 0.2035 \* 12371.709 = 2517.9114 lbf

Tension Stress, St = ( Fh/As ) = 167.5374 psi Allowed Stress, Sa = 0.6 \* Yield Str = 20880.0000 psi

|  |  |  |
| --- | --- | --- |
| d = B - R\*Sin(theta) / theta | = | 15.1589 in |
| Bending Moment, M = Fh \* d | = | 3180.7410 ft-lbf |

Bending Stress, Sb = ( M \* C1 / I ) = 253.6509 psi Allowed Stress, Sa = 2/3 \* Yield Str = 23200.0000 psi

# Minimum Thickness of Baseplate per Moss :

= ( 3 \* ( Q + Saddle\_Wt ) \* BasePlateWidth / ( 4 \* BasePlateLength \* AllStress )).5

= ( 3 \* (12371 + 551 ) \* 8.00/( 4 \* 54.000 \* 23200.000 )).5

= 0.249 in

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

= ( Bplen - Clearance ) / ( Nribs - 1)

= ( 54.0000 - 1.0 )/( 4 - 1 ) = 17.6667 in

Baseplate Pressure Area [Ap]:

= e \* Bpwid / 2

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

= 17.6667 \* 8.0000/2 = 70.6667 in^2

Axial Load [P]:

= Ap \* Bp

= 70.7 \* 28.64 = 2023.8 lbf

Area of the Rib and Web [Ar]:

= ( Bpwid - Clearance - Webtk ) \* Ribtk + e/2 \* Webtk

= ( 8.000 - 1.0 - 0.551 ) \* 0.551 + 17.6667/2 \* 0.551

= 8.423 in^2

Compressive Stress [Sc]:

= P/Ar

= 2023.8/8.4232 = 240.2602 psi

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y | A | AY | Ay2 | Io |  |
| Rib | 3.6 | 3.6 | 13.1 | 0.0 |  | 16.6 |
| Web | 3.6 | 4.9 | 17.6 | 0.0 |  | 0.2 |
| Values | 3.6 | 8.5 | 30.8 | 0.0 |  | 16.9 |

Bending Moment [Rm]:

= Fl /( 2 \* Bplen ) \* e \* rl / 2

= 1160.6/( 2 \* 54.00 ) \* 17.667 \* 24.54/2

= 194.096 ft-lbf

KL/R < Cc ( 17.3422 < 128.2548 ) per AISC E2-1

Sca = (1-(Klr)2/(2\*Cc2))\*Fy/(5/3+3\*(Klr)/(8\*Cc)-(Klr3)/(8\*Cc3)

Sca = ( 1-( 17.34 )2/(2 \* 128.252 )) \* 34800/

( 5/3+3\*(17.34 )/(8\* 128.25 )-( 17.343)/(8\*128.253)

Sca = 20081.88 psi

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

Check = Sc/Sca + (Rm/Z)/Sba

Check = 240.26/20081.88 + (2329.15/4.651 )/23200.00

Check = 0.03

Check of Inside Ribs

Inertia of Saddle, Inner Ribs - Axial Direction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y | A | AY | Ay2 | Io |  |
| Rib | 3.5 | 3.6 | 12.4 | 0.0 |  | 15.8 |
| Web | 3.5 | 9.7 | 34.1 | 0.0 |  | 0.2 |
| Values | 3.5 | 13.3 | 46.5 | 0.0 |  | 16.0 |

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

KL/R < Cc ( 9.0239 < 128.2548 ) per AISC E2-1

Sca = (1-(Klr)2/(2\*Cc2))\*Fy/(5/3+3\*(Klr)/(8\*Cc)-(Klr3)/(8\*Cc3)

Sca = ( 1-( 9.02 )2/(2 \* 128.252 )) \* 34800/

( 5/3+3\*(9.02 )/(8\* 128.25 )-( 9.023)/(8\*128.253)

Sca = 20504.26 psi

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

Check = Sc/Sca + (Rm/Z)/Sba

Check = 304.51/20504.26 + ( 1879.76/4.572 )/23200.00

Check = 0.03

**Input Data for Base Plate Bolting Calculations:**

Total Number of Bolts per BasePlate Nbolts 8

Total Number of Bolts in Tension/Baseplate Nbt 4

Bolt Material Specification SA-307 B Bolt Allowable Stress Stba 7000.00 psi

Bolt Corrosion Allowance Bca 0.1180 in Distance from Bolts to Edge Edgedis 4.1650 in Nominal Bolt Diameter Bnd 0.8750 in Thread Series Series UNC BasePlate Allowable Stress S 13800.00 psi Area Available in a Single Bolt BltArea 0.1920 in^2 Saddle Load QO (Weight) QO 10502.2 lbf Saddle Load QL (Wind/Seismic contribution) QL 462.1 lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Maximum Transverse Force | Ft | 989.2 | lbf |
| Maximum Longitudinal Force | Fl | 1160.6 | lbf |
| Saddle Bolted to Steel Foundation  **Bolt Area Calculation per Dennis R. Moss** |  | No |  |

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)

= 1160.64/(7000.00 \* 8.00 )

= 0.0207 in^2

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:

= B \* Ft + Sum of X Moments

= 3.58 \* 989.19 + 0.00

= 3544.59 ft-lbf

**FileName : D4470**

**Horizontal Vessel Analysis (Ope.) : Step: 12 1:43p Apr 4,2014**

Eccentricity (e):

= Rmom / QO

= 42535.03/10502.20

= 4.05 in < Bplen/6 --> No Uplift in Transverse direction

Bolt Area due to Transverse Load [Bltareart]:

= 0 (No Uplift)

Required of a Single Bolt [Bltarear]

= max[Bltarearl, Bltarears, Bltareart]

= max[0.0000 , 0.0207 , 0.0000 ]

= 0.0207 in^2

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**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

# 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 (11.81) 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( 7.250 + 1.56\*sqrt( 30.4331 \* 0.8661 ), 2 \* 21.000 )

= 15.2593 in

# Input and Calculated Values:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Vessel Mean Radius | Rm | 30.43 | in | |
| Stiffened Vessel Length per 4.15.6 | L | 12.50 | | ft |
| Distance from Saddle to Vessel tangent | a | 21.00 | | in |

|  |  |  |  |
| --- | --- | --- | --- |
| Saddle | Width | b | 7.25 in |
| Saddle | Bearing Angle | theta | 120.00 degrees |

Inside Depth of Head h2 1.25 ft

|  |  |  |
| --- | --- | --- |
| Shell Allowable Stress used in Calculation | 22500.00 | psi |
| Head Allowable Stress used in Calculation | 22500.00 | psi |
| Circumferential Efficiency in Plane of Saddle | 1.00 |  |
| Circumferential Efficiency at Mid-Span | 1.00 |  |

Saddle Force Q, Test Case, no Ext. Forces 15756.31 lbf

# Horizontal Vessel Analysis Results: Actual Allowable

Long. Stress at Top of Midspan 8823.42 22500.00 psi Long. Stress at Bottom of Midspan 9000.35 22500.00 psi Long. Stress at Top of Saddles 9087.96 22500.00 psi Long. Stress at Bottom of Saddles 8814.29 22500.00 psi

|  |  |  |
| --- | --- | --- |
| Tangential Shear in Shell | 444.57 | 13500.00 psi |
| Circ. Stress at Horn of Saddle | 1744.05 | 33750.00 psi |
| Circ. Compressive Stress in Shell | 90.63 | 22500.00 psi |

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

= Saddle Load + Max( Fwl, Fwt, Fsl, Fst )

= 15756 + Max( 0 , 0 , 0 , 0 )

**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

= 15756.3 lbf

**Summary of Loads at the base of this Saddle:**

Vertical Load (including saddle weight) 16307.61 lbf Transverse Shear Load Saddle 0.00 lbf

Longitudinal Shear Load Saddle 0.00 lbf

Hydrostatic Test Pressure at center of Vessel: 507.274 psig **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 = 0.0283 | 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)]

= -15756\*1.75[1-(1-1.75/12.50+(2.5362-1.2502)/ (2\*1.75\*12.50))/(1+(4\*1.25)/(3\*12.50))]

= -3942.3 ft-lbf

Moment per Equation 4.15.4 [M2]:

= Q\*L/4(1+2(R2-h22)/(L2))/(1+(4h2)/( 3L))-4a/L

= 15756\*12.5/4(1+2(2.5362-1.2502)/(12.502))/(1+(4\*1.250)/ (3\*12.500))-4\*1.75/12.50

= 18580.0 ft-lbf

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

= P \* Rm/(2t) - M2/(pi\*Rm2t)

= 507.274 \* 30.433/(2\*0.866 ) - 222959.7/(pi\*30.42\*0.866 )

= 8823.42 psi

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

= P \* Rm/(2t) + M2/(pi \* Rm2 \* t)

= 507.274 \* 30.433/(2 \* 0.866 ) + 222959.7/(pi \* 30.42 \* 0.866 )

= 9000.35 psi

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

= P \* Rm/(2t) - M1/(K1\*pi\*Rm2t)

= 507.274\*30.433/(2\*0.866)--47307.3/(0.1066\*pi\*30.42\*0.866)

= 9087.96 psi

**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

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

= P \* Rm/(2t) + M1/(K1\* \* pi \* Rm2 \* t)

= 507.274\*30.433/(2\*0.866)+-47307.3/(0.1923\*pi\*30.42\*0.866)

= 8814.29 psi

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

= Q(L-2a)/(L+(4\*h2/3))

= 15756 ( 12.50 - 2 \* 1.75 )/(12.50 + ( 4 \* 1.25/3))

= 10009.9 lbf

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

= K2 \* T / ( Rm \* t )

= 1.1707 \* 10009.89/( 30.4331 \* 0.8661 )

= 444.57 psi

Decay Length (4.15.22) [x1,x2]:

= 0.78 \* sqrt( Rm \* t )

= 0.78 \* sqrt( 30.433 \* 0.866 )

= 4.005 in

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

= -K5 \* Q \* k / ( t \* ( b + X1 + X2 ) )

= -0.7603 \* 15756 \* 0.1/( 0.866 \* ( 7.25 + 4.00 + 4.00 ) )

= -90.63 psi

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.25) [sigma7\*]:

= -Q/(4\*t\*(b+X1+X2)) - 12\*K7\*Q\*Rm/(L\*t2)

= -15756/(4\*0.866 \*(7.250 +4.005 +4.005 )) -

12 \* 0.028 \* 15756 \* 30.433/(12.500 \* 0.8662)

= -1744.05 psi

Effective reinforcing plate width (4.15.1) [B1]:

= min( b + 1.56 \* sqrt( Rm \* t ), 2a )

= min( 7.25 + 1.56 \* sqrt( 30.433 \* 0.866 ), 2 \* 21.000 )

= 15.26 in

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Results for Vessel Ribs, Web and Base:** | | | | |
| Baseplate Length | Bplen | | 54.0000 | in |
| Baseplate Thickness | Bpthk | | 0.6299 | in |
| Baseplate Width | Bpwid | | 8.0000 | in |
| Number of Ribs ( inc. outside ribs ) | | Nribs |  | 4 |
| Rib Thickness | Ribtk | | 0.5512 | in |
| Web Thickness | Webtk | | 0.5512 | in |
| Web Location | Webloc | | Center |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **FileName :** | **D4470** |  | | |
| **Horizontal Vessel Analysis (Test) :** | **Step:** | **13** | **1:43p Apr** | **4,2014** |

Moment of Inertia of Saddle - Lateral Direction

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Y | | A | AY | Io |
| Shell | 0. | 17. | 7. | 4. |
| Wearplate | 1. | 6. | 6. | 7. |
| Web | 5. | 4. | 24. | 149. |
| BasePlate | 10. | 5. | 49. | 470. |
| Totals | 17. | 32. | 86. | 630. |

|  |  |  |  |
| --- | --- | --- | --- |
| Value | C1 = Sumof(Ay)/Sumof(A) | = | 3. in |
| Value | I = Sumof(Io) - C1\*Sumof(Ay) | = | 401. in\*\*4 |
| Value | As = Sumof(A) - Ashell | = | 15. in^2 |

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

Fh = K1 \* Q = 0.2035 \* 15756.307 = 3206.7505 lbf

Tension Stress, St = ( Fh/As ) = 213.3715 psi Allowed Stress, Sa = 0.6 \* Yield Str = 20880.0000 psi

|  |  |  |
| --- | --- | --- |
| d = B - R\*Sin(theta) / theta | = | 15.1589 in |
| Bending Moment, M = Fh \* d | = | 4050.9138 ft-lbf |

Bending Stress, Sb = ( M \* C1 / I ) = 323.0436 psi Allowed Stress, Sa = 2/3 \* Yield Str = 23200.0000 psi

# Minimum Thickness of Baseplate per Moss :

= ( 3 \* ( Q + Saddle\_Wt ) \* BasePlateWidth / ( 4 \* BasePlateLength \* AllStress )).5

= ( 3 \* (15756 + 551 ) \* 8.00/( 4 \* 54.000 \* 23200.000 )).5

= 0.279 in

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

= ( Bplen - Clearance ) / ( Nribs - 1)

= ( 54.0000 - 1.0 )/( 4 - 1 ) = 17.6667 in

Baseplate Pressure Area [Ap]:

= e \* Bpwid / 2

= 17.6667 \* 8.0000/2 = 70.6667 in^2

Axial Load [P]:

= Ap \* Bp

= 70.7 \* 36.47 = 2577.4 lbf

**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

Area of the Rib and Web [Ar]:

= ( Bpwid - Clearance - Webtk ) \* Ribtk + e/2 \* Webtk

= ( 8.000 - 1.0 - 0.551 ) \* 0.551 + 17.6667/2 \* 0.551

= 8.423 in^2

Compressive Stress [Sc]:

= P/Ar

= 2577.4/8.4232 = 305.9895 psi

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y | A | AY | Ay2 | Io |  |
| Rib | 3.6 | 3.6 | 13.1 | 0.0 |  | 16.6 |
| Web | 3.6 | 4.9 | 17.6 | 0.0 |  | 0.2 |
| Values | 3.6 | 8.5 | 30.8 | 0.0 |  | 16.9 |

Bending Moment [Rm]:

= Fl /( 2 \* Bplen ) \* e \* rl / 2

= 0.0/( 2 \* 54.00 ) \* 17.667 \* 24.54/2

= 0.000 ft-lbf

KL/R < Cc ( 17.3422 < 128.2548 ) per AISC E2-1

Sca = (1-(Klr)2/(2\*Cc2))\*Fy/(5/3+3\*(Klr)/(8\*Cc)-(Klr3)/(8\*Cc3)

Sca = ( 1-( 17.34 )2/(2 \* 128.252 )) \* 34800/

( 5/3+3\*(17.34 )/(8\* 128.25 )-( 17.343)/(8\*128.253)

Sca = 20081.88 psi

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

Check = Sc/Sca + (Rm/Z)/Sba

Check = 305.99/20081.88 + (0.00/4.651 )/23200.00

Check = 0.02

Check of Inside Ribs

Inertia of Saddle, Inner Ribs - Axial Direction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y | A | AY | Ay2 | Io |  |
| Rib | 3.5 | 3.6 | 12.4 | 0.0 |  | 15.8 |
| Web | 3.5 | 9.7 | 34.1 | 0.0 |  | 0.2 |
| Values | 3.5 | 13.3 | 46.5 | 0.0 |  | 16.0 |

KL/R < Cc ( 9.0239 < 128.2548 ) per AISC E2-1

Sca = (1-(Klr)2/(2\*Cc2))\*Fy/(5/3+3\*(Klr)/(8\*Cc)-(Klr3)/(8\*Cc3)

Sca = ( 1-( 9.02 )2/(2 \* 128.252 )) \* 34800/

( 5/3+3\*(9.02 )/(8\* 128.25 )-( 9.023)/(8\*128.253)

Sca = 20504.26 psi

**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

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

Check = Sc/Sca + (Rm/Z)/Sba

Check = 387.82/20504.26 + ( 0.00/4.572 )/23200.00

Check = 0.02

**Input Data for Base Plate Bolting Calculations:**

Total Number of Bolts per BasePlate Nbolts 8

Total Number of Bolts in Tension/Baseplate Nbt 4

Bolt Material Specification SA-307 B Bolt Allowable Stress Stba 7000.00 psi

Bolt Corrosion Allowance Bca 0.1180 in Distance from Bolts to Edge Edgedis 4.1650 in Nominal Bolt Diameter Bnd 0.8750 in Thread Series Series UNC BasePlate Allowable Stress S 13800.00 psi Area Available in a Single Bolt BltArea 0.1920 in^2 Saddle Load QO (Weight) QO 16307.6 lbf Saddle Load QL (Wind/Seismic contribution) QL 0.0 lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Maximum Transverse Force | Ft | 0.0 | lbf |
| Maximum Longitudinal Force | Fl | 0.0 | lbf |
| Saddle Bolted to Steel Foundation  **Bolt Area Calculation per Dennis R. Moss** |  | No |  |

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)

= 0.00/(7000.00 \* 8.00 )

= 0.0000 in^2

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:

= B \* Ft + Sum of X Moments

= 3.58 \* 0.00 + 0.00

= 0.00 ft-lbf

Eccentricity (e):

= Rmom / QO

= 0.00/16307.61

= 0.00 in < Bplen/6 --> No Uplift in Transverse direction

**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

Bolt Area due to Transverse Load [Bltareart]:

= 0 (No Uplift)

Required of a Single Bolt [Bltarear]

= max[Bltarearl, Bltarears, Bltareart]

= max[0.0000 , 0.0000 , 0.0000 ]

= 0.0000 in^2

# ASME Horizontal Vessel Analysis: Stresses for the Right Saddle

(per ASME Sec. VIII Div. 2 based on the Zick method.)

Note: Wear Pad Width (11.81) 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( 7.250 + 1.56\*sqrt( 30.4331 \* 0.8661 ), 2 \* 21.000 )

= 15.2593 in

# Input and Calculated Values:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Vessel Mean Radius | Rm | 30.43 | in | |
| Stiffened Vessel Length per 4.15.6 | L | 12.50 | | ft |
| Distance from Saddle to Vessel tangent | a | 21.00 | | in |

|  |  |  |  |
| --- | --- | --- | --- |
| Saddle | Width | b | 7.25 in |
| Saddle | Bearing Angle | theta | 120.00 degrees |

Inside Depth of Head h2 1.25 ft

|  |  |  |
| --- | --- | --- |
| Shell Allowable Stress used in Calculation | 22500.00 | psi |
| Head Allowable Stress used in Calculation | 22500.00 | psi |
| Circumferential Efficiency in Plane of Saddle | 1.00 |  |
| Circumferential Efficiency at Mid-Span | 1.00 |  |

Saddle Force Q, Test Case, no Ext. Forces 15336.48 lbf

# Horizontal Vessel Analysis Results: Actual Allowable

Long. Stress at Top of Midspan 8825.77 22500.00 psi Long. Stress at Bottom of Midspan 8998.00 22500.00 psi Long. Stress at Top of Saddles 9083.27 22500.00 psi Long. Stress at Bottom of Saddles 8816.89 22500.00 psi

Tangential Shear in Shell 432.72 13500.00 psi

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **FileName Horizontal Vessel Analysis (Test)** | | **: D4470**  **: Step:** | **13** | **1:43p** | **Apr** | **4,2014** |
| Circ. Stress at Horn of Saddle | 1697.58 | 33750.00 | psi | | | |
| Circ. Compressive Stress in Shell | 88.22 | 22500.00 | psi | | | |

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

= Saddle Load + Max( Fwl, Fwt, Fsl, Fst )

= 15336 + Max( 0 , 0 , 0 , 0 )

= 15336.5 lbf

**Summary of Loads at the base of this Saddle:**

Vertical Load (including saddle weight) 15887.78 lbf Transverse Shear Load Saddle 0.00 lbf

Longitudinal Shear Load Saddle 0.00 lbf

Hydrostatic Test Pressure at center of Vessel: 507.274 psig **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 = 0.0283 | 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)]

= -15336\*1.75[1-(1-1.75/12.50+(2.5362-1.2502)/ (2\*1.75\*12.50))/(1+(4\*1.25)/(3\*12.50))]

= -3837.2 ft-lbf

Moment per Equation 4.15.4 [M2]:

= Q\*L/4(1+2(R2-h22)/(L2))/(1+(4h2)/( 3L))-4a/L

= 15336\*12.5/4(1+2(2.5362-1.2502)/(12.502))/(1+(4\*1.250)/ (3\*12.500))-4\*1.75/12.50

= 18084.9 ft-lbf

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

= P \* Rm/(2t) - M2/(pi\*Rm2t)

= 507.274 \* 30.433/(2\*0.866 ) - 217018.8/(pi\*30.42\*0.866 )

= 8825.77 psi

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

= P \* Rm/(2t) + M2/(pi \* Rm2 \* t)

= 507.274 \* 30.433/(2 \* 0.866 ) + 217018.8/(pi \* 30.42 \* 0.866 )

**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

= 8998.00 psi

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

= P \* Rm/(2t) - M1/(K1\*pi\*Rm2t)

= 507.274\*30.433/(2\*0.866)--46046.8/(0.1066\*pi\*30.42\*0.866)

= 9083.27 psi

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

= P \* Rm/(2t) + M1/(K1\* \* pi \* Rm2 \* t)

= 507.274\*30.433/(2\*0.866)+-46046.8/(0.1923\*pi\*30.42\*0.866)

= 8816.89 psi

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

= Q(L-2a)/(L+(4\*h2/3))

= 15336 ( 12.50 - 2 \* 1.75 )/(12.50 + ( 4 \* 1.25/3))

= 9743.2 lbf

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

= K2 \* T / ( Rm \* t )

= 1.1707 \* 9743.17/( 30.4331 \* 0.8661 )

= 432.72 psi

Decay Length (4.15.22) [x1,x2]:

= 0.78 \* sqrt( Rm \* t )

= 0.78 \* sqrt( 30.433 \* 0.866 )

= 4.005 in

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

= -K5 \* Q \* k / ( t \* ( b + X1 + X2 ) )

= -0.7603 \* 15336 \* 0.1/( 0.866 \* ( 7.25 + 4.00 + 4.00 ) )

= -88.22 psi

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.25) [sigma7\*]:

= -Q/(4\*t\*(b+X1+X2)) - 12\*K7\*Q\*Rm/(L\*t2)

= -15336/(4\*0.866 \*(7.250 +4.005 +4.005 )) -

12 \* 0.028 \* 15336 \* 30.433/(12.500 \* 0.8662)

= -1697.58 psi

Effective reinforcing plate width (4.15.1) [B1]:

= min( b + 1.56 \* sqrt( Rm \* t ), 2a )

= min( 7.25 + 1.56 \* sqrt( 30.433 \* 0.866 ), 2 \* 21.000 )

= 15.26 in

**Results for Vessel Ribs, Web and Base**

Baseplate Length Bplen 54.0000 in

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **FileName :** | **D4470** |  | | | |
| **Horizontal** | **Vessel** | **Analysis (Test) :** | **Step:** | **13** | **1:43p** | **Apr** | **4,2014** |

Baseplate Thickness Bpthk 0.6299 in

Baseplate Width Bpwid 8.0000 in Number of Ribs ( inc. outside ribs ) Nribs 4

Rib Thickness Ribtk 0.5512 in

Web Thickness Webtk 0.5512 in

Web Location Webloc Center

Moment of Inertia of Saddle - Lateral Direction

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Y | | A | AY | Io |
| Shell | 0. | 17. | 7. | 4. |
| Wearplate | 1. | 6. | 6. | 7. |
| Web | 5. | 4. | 24. | 149. |
| BasePlate | 10. | 5. | 49. | 470. |
| Totals | 17. | 32. | 86. | 630. |

|  |  |  |  |
| --- | --- | --- | --- |
| Value | C1 = Sumof(Ay)/Sumof(A) | = | 3. in |
| Value | I = Sumof(Io) - C1\*Sumof(Ay) | = | 401. in\*\*4 |
| Value | As = Sumof(A) - Ashell | = | 15. in^2 |

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

Fh = K1 \* Q = 0.2035 \* 15336.477 = 3121.3059 lbf

Tension Stress, St = ( Fh/As ) = 207.6862 psi Allowed Stress, Sa = 0.6 \* Yield Str = 20880.0000 psi

|  |  |  |
| --- | --- | --- |
| d = B - R\*Sin(theta) / theta | = | 15.1589 in |
| Bending Moment, M = Fh \* d | = | 3942.9763 ft-lbf |

Bending Stress, Sb = ( M \* C1 / I ) = 314.4361 psi Allowed Stress, Sa = 2/3 \* Yield Str = 23200.0000 psi

# Minimum Thickness of Baseplate per Moss :

= ( 3 \* ( Q + Saddle\_Wt ) \* BasePlateWidth / ( 4 \* BasePlateLength \* AllStress )).5

= ( 3 \* (15336 + 551 ) \* 8.00/( 4 \* 54.000 \* 23200.000 )).5

= 0.276 in

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

= ( Bplen - Clearance ) / ( Nribs - 1)

= ( 54.0000 - 1.0 )/( 4 - 1 ) = 17.6667 in

Baseplate Pressure Area [Ap]:

**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

= e \* Bpwid / 2

= 17.6667 \* 8.0000/2 = 70.6667 in^2

Axial Load [P]:

= Ap \* Bp

= 70.7 \* 35.50 = 2508.7 lbf

Area of the Rib and Web [Ar]:

= ( Bpwid - Clearance - Webtk ) \* Ribtk + e/2 \* Webtk

= ( 8.000 - 1.0 - 0.551 ) \* 0.551 + 17.6667/2 \* 0.551

= 8.423 in^2

Compressive Stress [Sc]:

= P/Ar

= 2508.7/8.4232 = 297.8363 psi

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y | A | AY | Ay2 | Io |  |
| Rib | 3.6 | 3.6 | 13.1 | 0.0 |  | 16.6 |
| Web | 3.6 | 4.9 | 17.6 | 0.0 |  | 0.2 |
| Values | 3.6 | 8.5 | 30.8 | 0.0 |  | 16.9 |

Bending Moment [Rm]:

= Fl /( 2 \* Bplen ) \* e \* rl / 2

= 0.0/( 2 \* 54.00 ) \* 17.667 \* 24.54/2

= 0.000 ft-lbf

KL/R < Cc ( 17.3422 < 128.2548 ) per AISC E2-1

Sca = (1-(Klr)2/(2\*Cc2))\*Fy/(5/3+3\*(Klr)/(8\*Cc)-(Klr3)/(8\*Cc3)

Sca = ( 1-( 17.34 )2/(2 \* 128.252 )) \* 34800/

( 5/3+3\*(17.34 )/(8\* 128.25 )-( 17.343)/(8\*128.253)

Sca = 20081.88 psi

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

Check = Sc/Sca + (Rm/Z)/Sba

Check = 297.84/20081.88 + (0.00/4.651 )/23200.00

Check = 0.01

Check of Inside Ribs

Inertia of Saddle, Inner Ribs - Axial Direction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y | A | AY | Ay2 | Io |  |
| Rib | 3.5 | 3.6 | 12.4 | 0.0 |  | 15.8 |
| Web | 3.5 | 9.7 | 34.1 | 0.0 |  | 0.2 |
| Values | 3.5 | 13.3 | 46.5 | 0.0 |  | 16.0 |

**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

KL/R < Cc ( 9.0239 < 128.2548 ) per AISC E2-1

Sca = (1-(Klr)2/(2\*Cc2))\*Fy/(5/3+3\*(Klr)/(8\*Cc)-(Klr3)/(8\*Cc3)

Sca = ( 1-( 9.02 )2/(2 \* 128.252 )) \* 34800/

( 5/3+3\*(9.02 )/(8\* 128.25 )-( 9.023)/(8\*128.253)

Sca = 20504.26 psi

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

Check = Sc/Sca + (Rm/Z)/Sba

Check = 377.48/20504.26 + ( 0.00/4.572 )/23200.00

Check = 0.02

**Input Data for Base Plate Bolting Calculations:**

Total Number of Bolts per BasePlate Nbolts 8

Total Number of Bolts in Tension/Baseplate Nbt 4

Bolt Material Specification SA-307 B Bolt Allowable Stress Stba 7000.00 psi

Bolt Corrosion Allowance Bca 0.1180 in Distance from Bolts to Edge Edgedis 4.1650 in Nominal Bolt Diameter Bnd 0.8750 in Thread Series Series UNC BasePlate Allowable Stress S 13800.00 psi Area Available in a Single Bolt BltArea 0.1920 in^2 Saddle Load QO (Weight) QO 15887.8 lbf Saddle Load QL (Wind/Seismic contribution) QL 0.0 lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Maximum Transverse Force | Ft | 0.0 | lbf |
| Maximum Longitudinal Force | Fl | 0.0 | lbf |
| Saddle Bolted to Steel Foundation  **Bolt Area Calculation per Dennis R. Moss** |  | No |  |

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)

= 0.00/(7000.00 \* 8.00 )

= 0.0000 in^2

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:

= B \* Ft + Sum of X Moments

= 3.58 \* 0.00 + 0.00

**FileName : D4470**

**Horizontal Vessel Analysis (Test) : Step: 13 1:43p Apr 4,2014**

= 0.00 ft-lbf

Eccentricity (e):

= Rmom / QO

= 0.00/15887.78

= 0.00 in < Bplen/6 --> No Uplift in Transverse direction

Bolt Area due to Transverse Load [Bltareart]:

= 0 (No Uplift)

Required of a Single Bolt [Bltarear]

= max[Bltarearl, Bltarears, Bltareart]

= max[0.0000 , 0.0000 , 0.0000 ]

= 0.0000 in^2

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**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: F1 From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.000 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 0.8320 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 4.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 25.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

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: F1** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 4.500 in. Actual Thickness Used in Calculation 0.337 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.00\*30.0000)/(16700\*1.00-0.6\*363.00)

= 0.6607 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*2.2500)/(16700\*1.00+0.4\*363.00)

= 0.0485 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0303 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 7.6520 in

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

Parallel to Vessel Wall, opening length d 3.8260 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.8425 in

Weld Strength Reduction Factor [fr1]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr2]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr3]:

= min( fr2, fr4 )

= min( 1.0 , 1.0 )

= 1.000

# Results of Nozzle Reinforcement Area Calculations:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| AREA AVAILABLE, A1 to A5 | | | | | | | Design | External | Mapnc | | | | |
| Area Required | | Ar | | | | | NA | 0.573 | NA | in^2 | | | |
| Area in Shell | | A1 | | | | | NA | 2.168 | NA | in^2 | | | |
| Area in Nozzle Wall | | | | | A2 | | NA | 0.517 | NA | | | in^2 | |
| Area in Inward Nozzle | | | | | | A3 | NA | 0.000 | NA | | | | in^2 |
| Area in Welds | A41+A42+A43 | | | | | | NA | 0.155 | NA | | | | in^2 |
| Area in Element | | | A5 | | | | NA | 0.000 | NA | | in^2 | | |
| TOTAL AREA AVAILABLE | | | | Atot | | | NA | 2.840 | NA | | | | in^2 |

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

= 0.5( d \* tr\*F + 2 \* tn \* tr\*F \* (1-fr1) ) per UG-37(d) or UG-39

= 0.5(3.8260\*0.2994\*1+2\*0.3370\*0.2994\*1\*(1-1.00))

= 0.573 in^2

# Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

= d( E1\*t - F\*tr ) - 2 \* tn( E1\*t - F\*tr ) \* ( 1 - fr1 )

= 3.826 ( 1.00 \* 0.8661 - 1.0 \* 0.299 ) - 2 \* 0.337

( 1.00 \* 0.8661 - 1.0 \* 0.2994 ) \* ( 1 - 1.000 )

= 2.168 in^2

Area Available in Nozzle Projecting Outward [A2]:

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

= ( 2 \* tlnp ) \* ( tn - trn ) \* fr2

= ( 2 \* 0.843 ) \* ( 0.3370 - 0.0303 ) \* 1.0000

= 0.517 in^2

Area Available in Inward Weld + Outward Weld [A41 + A43]:

= Wo2 \* fr2 + ( Wi-can/0.707 )2 \* fr2

= 0.39372 \* 1.0000 + ( 0.0000 )2 \* 1.0000

= 0.155 in^2

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

Wall Thickness for Internal/External pressures ta = 0.0485 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6607 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6607 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.2070 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.207 , max( 0.6607 , 0.0625 ) ]

= 0.2070 in

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

= max( ta, tb )

= max( 0.0485 , 0.2070 )

= 0.2070 in

Available Nozzle Neck Thickness = 0.875 \* 0.337 = 0.295 in --> 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 : 6397.0, Allowable : 16700.0 psi Passed Expansion : 0.0, Allowable : 35353.0 psi Passed Occasional : 946.9, Allowable : 22211.0 psi Passed Shear : 3629.6, Allowable : 11690.0 psi Passed

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

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

**Nozzle Calculations per App. 1-10: Internal Pressure Case:**

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

Thickness of Nozzle [tn]:

= thickness - corrosion allowance

= 0.337 - 0.000

= 0.337 in

Effective Pressure Radius [Reff]:

= Di/2 + corrosion allowance

= 60.000/2 + 0.000

= 30.000 in

Effective Length of Vessel Wall [LR]:

= 8 \* t

= 8 \* 0.866

= 6.929 in

Thickness Limit Candidate [LH1]:

= t + 0.78 \* sqrt( Rn \* tn )

= 0.866 + 0.78 \* sqrt( 1.913 \* 0.337 )

= 1.492 in

Thickness Limit Candidate [LH2]:

= Lpr1 + T

= 25.000 + 0.866

= 25.866 in

Thickness Limit Candidate [LH3]:

= 8( t + te )

= 8( 0.866 + 0.000 )

= 6.929 in

Effective Nozzle Wall Length Outside the Vessel [LH]:

= min[ LH1, LH2, LH3 ]

= min[ 1.492 , 25.866 , 6.929 )

= 1.492 in

Effective Vessel Thickness [teff]:

= t

= 0.866 in

Determine Parameter [Lamda]:

= min( 10, ( Dn + Tn )/( sqrt( ( Di + teff ) \* teff )) )

= min( 10, (3.83 + 0.337 )/( sqrt((60.00 + 0.866 ) \* 0.866 )) )

= 0.573

**Compute Areas A1-A43 (No Pad) or A1-A5 (With Pad) :**

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

Area Contributed by the Vessel Wall [A1]:

= t \* LR \* max( Lamda/4, 1 )

= 0.866 \* 6.929 \* max( 0.573/4, 1 )

= 6.002 in^2

Area Contributed by the Nozzle Outside the Vessel Wall [A2]:

= tn \* LH

= 0.337 \* 1.492

= 0.503 in^2

Area Contributed by the Outside Fillet Weld [A41]:

= 0.5 \* Leg412

= 0.5 \* 0.3942

= 0.078 in^2

The total area contributed by A1 through A43 [AT]:

= A1 + frn( A2 + A3 ) + A41 + A42 + A43

= 6.002+1.000(0.503+0.000)+0.078+0.000+0.000

= 6.582 in^2

Allowable Local Primary Membrane Stress [Sallow]:

= 1.5 \* S \* E

= 1.5 \* 16700.000 \* 1.000

= 25050.0 psi

Determine Force acting on the Nozzle [fN]:

= P \* Rn( LH - t )

= 363.000 \* 1.913 ( 1.492 - 0.866 )

= 434.9 lbf

Determine Force acting on the Shell [fS]:

= P \* Reff( LR + tn )

= 363.000 \* 30.000 ( 6.929 + 0.337 )

= 79128.2 lbf

Discontinuity Force from Internal Pressure [fY]:

= P \* Reff \* Rnc

= 363.000 \* 30.000 \* 1.913

= 20832.6 lbf

Area Resisting Internal Pressure [Ap]:

= Rn( LH - t ) + Reff( LR + tn + Rnc )

= 1.913 ( 1.492 - 0.866 ) + 30.000 ( 6.929 + 0.337 + 1.913 )

= 276.6 in^2

Maximum Allowable Working Pressure Candidate [Pmax1]:

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

= Sallow /( 2 \* Ap/AT - Rxs/teff )

= 25050.000/( 2 \* 276.572/6.582 - 30.000/0.866 )

= 507.1 psig

Maximum Allowable Working Pressure Candidate [Pmax2]:

= S[t/Reff]

= 16700.000 [0.866/30.000 ]

= 482.2 psig

Maximum Allowable Working Pressure [Pmax]:

= min( Pmax1, Pmax2 )

= min( 507.066 , 482.152 )

= 482.152 psig

Average Primary Membrane Stress [SigmaAvg]:

= ( fN + fS + fY ) / AT

= ( 434.899 + 79128.195 + 20832.570 )/6.582

= 15252.930 psi

General Primary Membrane Stress [SigmaCirc]:

= P \* Reff / teff

= 363.000 \* 30.000/0.866

= 12573.0 psi

Maximum Local Primary Membrane Stress [PL]:

= max( 2 \* SigmaAvg - SigmaCirc, SigmaCirc )

= max( 2 \* 15252.930 - 12573.000 , 12573.000 )

= 17932.9 psi

# Summary of Nozzle Pressure/Stress Results:

Allowed Local Primary Membrane Stress Sallow 25050.00 psi Local Primary Membrane Stress PL 17932.86 psi Maximum Allowable Working Pressure Pmax 482.15 psig

# Strength of Nozzle Attachment Welds per 1-10 and U-2(g)

Discontinuity Force Factor [ky]:

= ( Rnc + tn ) / Rnc

= ( 1.913 + 0.337 )/1.913

= 1.176 For set-in Nozzles

Weld Length of Nozzle to Shell Weld [Ltau]:

= pi/2 \* ( Rn + tn )

= pi/2 \* ( 1.913 + 0.337 )

= 3.534 in

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

Weld Throat Dimensions, (0.7071\*Leg Dimensions) [L41T, L42T, L43T]:

= 0.278, 0.000, 0.000, in

Weld Load Value [fwelds]:

= min( fy \* ky, 1.5 \* Sn( A2 + A3 ), pi/4\*P\*Rn^2\*ky^2 )

= min(20832\*1.18,1.5\*16700.0(0.503+0.000),pi/4\*363.0\*1.91^2\*1.18^2)

= 1443.316 lbf

Weld Stress Value [tau]:

= fwelds/(Ltau(0.49\*L41T + 0.6\*tw1 + 0.49\*L43T ) )

= 1443.316/(3.534 (0.49\*0.278 + 0.6\*0.787 + 0.49\*0.000 ) )

= 670.731 < or = to 16700.000 Weld Size is OK

Weld Size Calculations, Description: F1

Intermediate Calc. for nozzle/shell Welds Tmin 0.3370 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.2359 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.091 psig

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

Nozzle is O.K. for the External Pressure 14.500 psig

The Drop for this Nozzle is : 0.0845 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 25.9506 in

# Input Echo, WRC107/537 Item 1, Description: F1 :

|  |  |  |  |
| --- | --- | --- | --- |
| Diameter Basis for Vessel | Vbasis | ID | |
| Cylindrical or Spherical Vessel | Cylsph | Cylindrical | |
| Internal Corrosion Allowance | Cas | 0.0000 in | |
| Vessel Diameter | Dv | 60.000 | in |
| Vessel Thickness | Tv | 0.866 | in |

Design Temperature 248.00 癋

Vessel Material SA-240 304L

Vessel Cold S.I. Allowable Smc 16700.00 psi

Vessel Hot S.I. Allowable Smh 16700.00 psi

Attachment Type Type Round

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

|  |  |  |
| --- | --- | --- |
| Diameter Basis for Nozzle | Nbasis | OD |
| Corrosion Allowance for Nozzle | Can | 0.0000 in |
| Nozzle Diameter | Dn | 4.500 in |
| Nozzle Thickness | Tn | 0.337 in |
| Nozzle Material | SA-312 | TP304L |
| Nozzle Cold S.I. Allowable | SNmc | 16700.00 psi |
| Nozzle Hot S.I. Allowable | SNmh | 16700.00 psi |

Design Internal Pressure Dp 363.000 psig Include Pressure Thrust No

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS) P 967.0 lbf

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Longitudinal Shear | (SUS) | Vl | 1079.0 | lbf |
| Circumferential Shear | (SUS) | Vc | 787.0 | lbf |
| Circumferential Moment | (SUS) | Mc | 1033.0 | ft-lbf |
| Longitudinal Moment | (SUS) | Ml | 1549.0 | ft-lbf |
| Torsional Moment | (SUS) | Mt | 1918.0 | ft-lbf |

|  |  |  |  |
| --- | --- | --- | --- |
| Use Interactive Control |  | No |  |
| WRC107 Version | Version | March | 1979 |

Include Pressure Stress Indices per Div. 2 No

Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load P 967.0 lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Circumferential Shear | VC | 787.0 | lbf |
| Longitudinal Shear | VL | 1079.0 | lbf |
| Circumferential Moment | MC | 1033.0 | ft-lbf |
| Longitudinal Moment | ML | 1549.0 | ft-lbf |
| Torsional Moment | MT | 1918.0 | ft-lbf |

Dimensionless Parameters used : Gamma = 35.14

# Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.065 | 4C | 6.483 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.065 | 3C | 6.251 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.065 | 2C1 | 0.132 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.065 | 1C | 0.169 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.065 3A 0.616 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.065 1A 0.103 (A,B,C,D)

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.065 3B 2.227 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.065 1B 0.054 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.065 | 3C | 6.251 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.065 | 4C | 6.483 | (C,D) |
| M(x) | / | ( P ) |  | 0.065 | 1C1 | 0.174 | (A,B) |
| M(x) | / | ( P ) |  | 0.065 | 2C | 0.132 | (C,D) |
| N(x) / ( MC/(Rm\*\*2 \* Beta) ) 0.065 | | | | | 4A | 0.805 | (A,B,C,D) |
| M(x) / ( MC/(Rm \* Beta) ) 0.065 | | | | | 2A | 0.060 | (A,B,C,D) |
| N(x) / ( ML/(Rm\*\*2 \* Beta) ) 0.065 | | | | | 4B | 0.633 | (A,B,C,D) |
| M(x) / ( ML/(Rm \* Beta) ) 0.065 | | | | | 2B | 0.091 | (A,B,C,D) |

Stress Concentration Factors Kn = 1.00, Kb = 1.00

# Stresses in the Vessel at the Attachment Junction

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

-237 -229 -229 -229 -229

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Circ. | Memb. | P | | -237 | -237 | -237 |
| Circ. | Bend. | P | | -1021 | 1021 | -1021 |

1021 -1309 1309 -1309 1309

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Memb. | MC | | | 0 | 0 | 0 | 0 -147 | | -147 147 147 | | | |
| Circ. | Bend. | MC | | | 0 | 0 | 0 | 0 -5169 | | 5169 5169 -5169 | | | |
| Circ. | Memb. | ML | | | -797 | -797 | 797 | 797 | | 0 | 0 | 0 | 0 |
| Circ. | Bend. | ML | | | -4112 | 4112 | 4112 | -4112 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |
| Tot. Circ. Str.| -6169 | | | | | 4098 | 3650 | -2530 -6856 6103 3777 -3941 | | | | | |
| Long. | Memb. | P | | | -229 | -229 | -229 | -229 | -237 | | -237 | -237 | -237 |
| Long. | Bend. | P | | | -1348 | 1348 | -1348 | 1348 | -1023 | | 1023 | -1023 | 1023 |
| Long. | Memb. | MC | | | 0 | 0 | 0 | 0 | -192 |  | -192 | 192 | 192 |
| Long. | Bend. | MC | | | 0 | 0 | 0 | 0 -3015 | |  | 3015 | 3015 | -3015 |
| Long. | Memb. | ML | | | -226 | -226 | 226 | 226 | | 0 | 0 | 0 | 0 |
| Long. | Bend. | ML | | | -6852 | 6852 | 6852 | -6852 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |

Tot. Long. Str.| -8656 7744 5501 -5506 -4469 3608 1946 -2038

Shear VC | Shear VL | Shear MT |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 128 128 -128 -128 0 0 | | | | | | 0 | 0 |
| 0 0 0 0 -176 -176 | | | | | | 176 | 176 |
| 835 | 835 | 835 | 835 | 835 | 835 | 835 | 835 |
| 963 | 963 | 706 | 706 | 659 | 659 | 1011 | 1011 |

| Tot. Shear|

**FileName : D4470**

**Nozzle Calcs. : F1 Nozl: 14 1:43p Apr 4,2014**

Str. Int. | 8986 7983 5740 5666 7025 6266 4226 4379

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Attachment Junction**

Type of | Stress Values at Stress Int. | (psi )

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pm (SUS) | | 12394 | 12757 | 12394 | 12757 | 12394 | 12757 | 12394 | 12757 |
| Circ. | Pl (SUS) | | -1035 | -1035 | 560 | 560 | -376 | -376 | -82 | -82 |
| Circ. | Q (SUS) | | -5133 | 5133 | 3090 | -3090 | -6479 | 6479 | 3859 | -3859 |
| Long. | Pm (SUS) | | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 |
| Long. | Pl (SUS) | | -456 | -456 | -2 | -2 | -430 | -430 | -45 | -45 |
| Long. | Q (SUS) | | -8200 | 8200 | 5504 | -5504 | -4038 | 4038 | 1992 | -1992 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Pl (SUS) | | 128 | 128 | -128 | -128 | -176 | -176 | 176 | 176 |
| Shear Q (SUS) | | 835 | 835 | 835 | 835 | 835 | 835 | 835 | 835 |

Pm (SUS) | 12394 12757 12394 12757 12394 12757 12394 12757

Pm+Pl (SUS) | 11361 11724 12956 13319 12022 12385 12316 12679

Pm+Pl+Q (Total)| 8895 17145 16157 10278 5648 18907 16297 9025

|  |  |  |  |
| --- | --- | --- | --- |
| Type of | | Max. | S.I. S.I. Allowable | | Result |
| Stress Int. | |  | psi | |  |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 12757 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 13319 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 18907 50100 | Passed

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**FileName : D4470**

**Nozzle Calcs. : Y Nozl: 15 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: Y From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.000 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 1.8320 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 2.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 25.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : Y Nozl: 15 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

The Pressure Design option was Design Pressure + static head.

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

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**Insert/Set-in Nozzle No Pad, no Inside projection Reinforcement CALCULATION, Description: Y** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in. Actual Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.00\*30.0000)/(16700\*1.00-0.6\*363.00)

= 0.6607 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*1.1875)/(16700\*1.00+0.4\*363.00)

= 0.0256 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0204 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 4.1073 in

**FileName : D4470**

**Nozzle Calcs. : Y Nozl: 15 1:43p Apr 4,2014**

Parallel to Vessel Wall Rn+tn+t 2.0536 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5450 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: Y.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

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

Wall Thickness for Internal/External pressures ta = 0.0256 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6607 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6607 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1346 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.135 , max( 0.6607 , 0.0625 ) ]

= 0.1346 in

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

= max( ta, tb )

= max( 0.0256 , 0.1346 )

= 0.1346 in

Available Nozzle Neck Thickness = 0.875 \* 0.218 = 0.191 in --> OK

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

Weld Size Calculations, Description: Y

Intermediate Calc. for nozzle/shell Welds Tmin 0.2180 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1526 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

**FileName : D4470**

**Nozzle Calcs. : Y Nozl: 15 1:43p Apr 4,2014**

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.091 psig

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

The Drop for this Nozzle is : 0.0235 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 25.8897 in

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**FileName : D4470**

**Nozzle Calcs. : L4 Nozl: 16 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: L4 From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.000 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 2.8320 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 2.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 25.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : L4 Nozl: 16 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

The Pressure Design option was Design Pressure + static head.

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

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**Insert/Set-in Nozzle No Pad, no Inside projection Reinforcement CALCULATION, Description: L4** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in. Actual Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.00\*30.0000)/(16700\*1.00-0.6\*363.00)

= 0.6607 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*1.1875)/(16700\*1.00+0.4\*363.00)

= 0.0256 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0204 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 4.1073 in

**FileName : D4470**

**Nozzle Calcs. : L4 Nozl: 16 1:43p Apr 4,2014**

Parallel to Vessel Wall Rn+tn+t 2.0536 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5450 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: L4.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

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

Wall Thickness for Internal/External pressures ta = 0.0256 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6607 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6607 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1346 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.135 , max( 0.6607 , 0.0625 ) ]

= 0.1346 in

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

= max( ta, tb )

= max( 0.0256 , 0.1346 )

= 0.1346 in

Available Nozzle Neck Thickness = 0.875 \* 0.218 = 0.191 in --> OK

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

Weld Size Calculations, Description: L4

Intermediate Calc. for nozzle/shell Welds Tmin 0.2180 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1526 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

**FileName : D4470**

**Nozzle Calcs. : L4 Nozl: 16 1:43p Apr 4,2014**

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.091 psig

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

The Drop for this Nozzle is : 0.0235 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 25.8897 in

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**FileName : D4470**

**Nozzle Calcs. : P Nozl: 17 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: P From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.000 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 3.8320 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 2.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 25.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : P Nozl: 17 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

The Pressure Design option was Design Pressure + static head.

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

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**Insert/Set-in Nozzle No Pad, no Inside projection Reinforcement CALCULATION, Description: P** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in. Actual Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.00\*30.0000)/(16700\*1.00-0.6\*363.00)

= 0.6607 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*1.1875)/(16700\*1.00+0.4\*363.00)

= 0.0256 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0204 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 4.1073 in

**FileName : D4470**

**Nozzle Calcs. : P Nozl: 17 1:43p Apr 4,2014**

Parallel to Vessel Wall Rn+tn+t 2.0536 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5450 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: P.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

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

Wall Thickness for Internal/External pressures ta = 0.0256 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6607 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6607 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1346 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.135 , max( 0.6607 , 0.0625 ) ]

= 0.1346 in

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

= max( ta, tb )

= max( 0.0256 , 0.1346 )

= 0.1346 in

Available Nozzle Neck Thickness = 0.875 \* 0.218 = 0.191 in --> OK

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

Weld Size Calculations, Description: P

Intermediate Calc. for nozzle/shell Welds Tmin 0.2180 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1526 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

**FileName : D4470**

**Nozzle Calcs. : P Nozl: 17 1:43p Apr 4,2014**

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.091 psig

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

The Drop for this Nozzle is : 0.0235 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 25.8897 in

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**FileName : D4470**

**Nozzle Calcs. : V Nozl: 18 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: V From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.000 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 4.8320 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 2.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 25.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : V Nozl: 18 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

The Pressure Design option was Design Pressure + static head.

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

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**Insert/Set-in Nozzle No Pad, no Inside projection Reinforcement CALCULATION, Description: V** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in. Actual Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.00\*30.0000)/(16700\*1.00-0.6\*363.00)

= 0.6607 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*1.1875)/(16700\*1.00+0.4\*363.00)

= 0.0256 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0204 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 4.1073 in

**FileName : D4470**

**Nozzle Calcs. : V Nozl: 18 1:43p Apr 4,2014**

Parallel to Vessel Wall Rn+tn+t 2.0536 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5450 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: V.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

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

Wall Thickness for Internal/External pressures ta = 0.0256 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6607 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6607 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1346 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.135 , max( 0.6607 , 0.0625 ) ]

= 0.1346 in

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

= max( ta, tb )

= max( 0.0256 , 0.1346 )

= 0.1346 in

Available Nozzle Neck Thickness = 0.875 \* 0.218 = 0.191 in --> 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 : 8832.1, Allowable : 16700.0 psi Passed Expansion : 0.0, Allowable : 32917.9 psi Passed Occasional : 725.6, Allowable : 22211.0 psi Passed Shear : 6806.2, Allowable : 11690.0 psi Passed

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

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

**FileName : D4470**

**Nozzle Calcs. : V Nozl: 18 1:43p Apr 4,2014**

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

Weld Size Calculations, Description: V

Intermediate Calc. for nozzle/shell Welds Tmin 0.2180 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1526 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.091 psig

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

The Drop for this Nozzle is : 0.0235 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 25.8897 in

# Input Echo, WRC107/537 Item 1, Description: V :

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Diameter Basis for Vessel | Vbasis | ID | | |
| Cylindrical or Spherical Vessel | Cylsph | Cylindrical | | |
| Internal Corrosion Allowance | Cas | 0.0000 | | in |
| Vessel Diameter | Dv | 60.000 | in | |
| Vessel Thickness | Tv | 0.866 | in | |

Design Temperature 248.00 癋

Vessel Material SA-240 304L

Vessel Cold S.I. Allowable Smc 16700.00 psi

Vessel Hot S.I. Allowable Smh 16700.00 psi

|  |  |  |  |
| --- | --- | --- | --- |
| Attachment Type | Type | Round |  |
| Diameter Basis for Nozzle | Nbasis | OD |
| Corrosion Allowance for Nozzle | Can | 0.0000 | in |
| Nozzle Diameter | Dn | 2.375 in | |
| Nozzle Thickness Nozzle Material  Nozzle Cold S.I. Allowable | Tn  SA-312  SNmc | 0.218 in TP304L  16700.00 psi | |
| Nozzle Hot S.I. Allowable | SNmh | 16700.00 | psi |
| Design Internal Pressure | Dp | 363.000 | psig |

**FileName : D4470**

**Nozzle Calcs. : V Nozl: 18 1:43p Apr 4,2014**

Include Pressure Thrust No

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS) P 517.0 lbf

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Longitudinal Shear | (SUS) | Vl | 697.0 | lbf |
| Circumferential Shear | (SUS) | Vc | 517.0 | lbf |
| Circumferential Moment | (SUS) | Mc | 295.0 | ft-lbf |
| Longitudinal Moment | (SUS) | Ml | 369.0 | ft-lbf |
| Torsional Moment | (SUS) | Mt | 590.0 | ft-lbf |

|  |  |  |  |
| --- | --- | --- | --- |
| Use Interactive Control |  | No |  |
| WRC107 Version | Version | March | 1979 |

Include Pressure Stress Indices per Div. 2 No

Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load P 517.0 lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Circumferential Shear | VC | 517.0 | lbf |
| Longitudinal Shear | VL | 697.0 | lbf |
| Circumferential Moment | MC | 295.0 | ft-lbf |
| Longitudinal Moment | ML | 369.0 | ft-lbf |
| Torsional Moment | MT | 590.0 | ft-lbf |

Dimensionless Parameters used : Gamma = 35.14

# Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.034 | 4C | 6.715 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.034 | 3C | 6.866 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.034 | 2C1 | 0.185 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.034 | 1C | 0.233 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.034 3A 0.262 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.034 1A 0.104 (A,B,C,D) N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.034 3B 0.987 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.034 1B 0.063 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.034 | 3C | 6.866 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.034 | 4C | 6.715 | (C,D) |
| M(x) | / | ( P ) |  | 0.034 | 1C1 | 0.236 | (A,B) |
| M(x) | / | ( P ) |  | 0.034 | 2C | 0.186 | (C,D) |

N(x) / ( MC/(Rm\*\*2 \* Beta) ) 0.034 4A 0.317 (A,B,C,D)

M(x) / ( MC/(Rm \* Beta) ) 0.034 2A 0.063 (A,B,C,D)

**FileName : D4470**

**Nozzle Calcs. : V Nozl: 18 1:43p Apr 4,2014**

N(x) / ( ML/(Rm\*\*2 \* Beta) ) 0.034 4B 0.271 (A,B,C,D)

M(x) / ( ML/(Rm \* Beta) ) 0.034 2B 0.105 (A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

# Stresses in the Vessel at the Attachment Junction

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Memb. | P | | | -131 | -131 | -131 | -131 | -134 | | -134 | -134 | -134 |
| Circ.  Circ. | Bend.  Memb. | P |  MC | | | -765  0 | 765  0 | -765  0 | 765  0 | -961  -33 | | 961  -33 | -961  33 | 961  33 |
| Circ. | Bend. | MC | | | 0 | 0 | 0 | 0 -2845 | |  | 2845 | 2845 | -2845 |
| Circ. | Memb. | ML | | | -159 | -159 | 159 | 159 | | 0 | 0 | 0 | 0 |
| Circ. | Bend. | ML | | | -2136 | 2136 | 2136 | -2136 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |
| Tot. Circ. Str.| -3193 | | | | | 2610 | 1398 | -1342 | -3975 3638 1782 -1984 | | | | |
| Long. | Memb. | P | | | -134 | -134 | -134 | -134 | -131 | | -131 | -131 | -131 |
| Long. | Bend. | P | | | -977 | 977 | -977 | 977 | -770 | | 770 | -770 | 770 |

0 -40

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long. | Memb. | MC | | | 0 | 0 | 0 |
| Long. | Bend. | MC | | | 0 | 0 | 0 |
| Long. | Memb. | ML | | | -43 | -43 | 43 |
| Long. | Bend. | ML | | | -3594 | 3594 | 3594 |
|  |  | | |  |  |  |  |

|  |  |  |
| --- | --- | --- |
| -40 | 40 | 40 |
| 1704 | 1704 | -1704 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |

0 -1704

43 0

-3594 0

Tot. Long. Str.| -4750 4394 2526 -2708 -2647 2302 842 -1024

|  |  |  |
| --- | --- | --- |
| 0 0 | 0 | 0 |
| -215 | 215 | 215 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear | VC | | | 159 | 159 | -159 -159 | | | | | |
| Shear | VL | | | 0 | 0 | 0 0 -215 | | | | | |
| Shear | MT | | | 922 | 922 | 922 922 922 922 922 922 | | | | | |
|  | | |  |  |  |  | | | | | |
| Tot. Shear| | | | 1082 | 1082 | 762 | 762 | 706 | 706 | 1138 | 1138 |
| Str. Int. | | | | 5305 | 4904 | 2910 | 3049 | 4280 | 3942 | 2544 | 2739 |

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Attachment Junction**

Type of | Stress Values at Stress Int. | (psi )

**FileName : D4470**

**Nozzle Calcs. : V Nozl: 18 1:43p Apr 4,2014**

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|-------------------------------------------------------- Circ. Pm (SUS) | 12394 12757 12394 12757 12394 12757 12394 12757

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pl (SUS) | | -291 | -291 | 27 | 27 | -168 | -168 | -100 | -100 |
| Circ. | Q (SUS) | | -2902 | 2902 | 1370 | -1370 | -3806 | 3806 | 1883 | -1883 |
| Long. | Pm (SUS) | | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 |
| Long. | Pl (SUS) | | -178 | -178 | -90 | -90 | -172 | -172 | -90 | -90 |
| Long. | Q (SUS) | | -4572 | 4572 | 2617 | -2617 | -2474 | 2474 | 933 | -933 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Pl (SUS) | | 159 | 159 | -159 | -159 | -215 | -215 | 215 | 215 |
| Shear Q (SUS) | | 922 | 922 | 922 | 922 | 922 | 922 | 922 | 922 |

Pm (SUS) | 12394 12757 12394 12757 12394 12757 12394 12757

Pm+Pl (SUS) | 12106 12469 12426 12788 12233 12595 12300 12663

Pm+Pl+Q (Total)| 9349 15601 13905 11486 8519 16457 14353 10995

|  |  |  |  |
| --- | --- | --- | --- |
| Type of | | Max. | S.I. S.I. Allowable | | Result |
| Stress Int. | |  | psi | |  |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 12757 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 12788 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 16457 50100 | Passed

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**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: A From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.000 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 12.0820 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 3.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 25.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

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: A** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 3.500 in. Actual Thickness Used in Calculation 0.300 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.00\*30.0000)/(16700\*1.00-0.6\*363.00)

= 0.6607 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*1.7500)/(16700\*1.00+0.4\*363.00)

= 0.0377 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0263 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 5.8000 in

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

Parallel to Vessel Wall, opening length d 2.9000 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.7500 in

Weld Strength Reduction Factor [fr1]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr2]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr3]:

= min( fr2, fr4 )

= min( 1.0 , 1.0 )

= 1.000

# Results of Nozzle Reinforcement Area Calculations:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| AREA AVAILABLE, A1 to A5 | | | | | | | Design | External | Mapnc | | | | |
| Area Required | | Ar | | | | | NA | 0.434 | NA | in^2 | | | |
| Area in Shell | | A1 | | | | | NA | 1.643 | NA | in^2 | | | |
| Area in Nozzle Wall | | | | | A2 | | NA | 0.410 | NA | | | in^2 | |
| Area in Inward Nozzle | | | | | | A3 | NA | 0.000 | NA | | | | in^2 |
| Area in Welds | A41+A42+A43 | | | | | | NA | 0.155 | NA | | | | in^2 |
| Area in Element | | | A5 | | | | NA | 0.000 | NA | | in^2 | | |
| TOTAL AREA AVAILABLE | | | | Atot | | | NA | 2.209 | NA | | | | in^2 |

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

= 0.5( d \* tr\*F + 2 \* tn \* tr\*F \* (1-fr1) ) per UG-37(d) or UG-39

= 0.5(2.9000\*0.2994\*1+2\*0.3000\*0.2994\*1\*(1-1.00))

= 0.434 in^2

# Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

= d( E1\*t - F\*tr ) - 2 \* tn( E1\*t - F\*tr ) \* ( 1 - fr1 )

= 2.900 ( 1.00 \* 0.8661 - 1.0 \* 0.299 ) - 2 \* 0.300

( 1.00 \* 0.8661 - 1.0 \* 0.2994 ) \* ( 1 - 1.000 )

= 1.643 in^2

Area Available in Nozzle Projecting Outward [A2]:

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

= ( 2 \* tlnp ) \* ( tn - trn ) \* fr2

= ( 2 \* 0.750 ) \* ( 0.3000 - 0.0263 ) \* 1.0000

= 0.410 in^2

Area Available in Inward Weld + Outward Weld [A41 + A43]:

= Wo2 \* fr2 + ( Wi-can/0.707 )2 \* fr2

= 0.39372 \* 1.0000 + ( 0.0000 )2 \* 1.0000

= 0.155 in^2

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

Wall Thickness for Internal/External pressures ta = 0.0377 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6607 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6607 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1890 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.189 , max( 0.6607 , 0.0625 ) ]

= 0.1890 in

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

= max( ta, tb )

= max( 0.0377 , 0.1890 )

= 0.1890 in

Available Nozzle Neck Thickness = 0.875 \* 0.300 = 0.263 in --> 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 : 7673.4, Allowable : 16700.0 psi Passed Expansion : 0.0, Allowable : 34076.6 psi Passed Occasional : 795.0, Allowable : 22211.0 psi Passed Shear : 4856.8, Allowable : 11690.0 psi Passed

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

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

**Nozzle Calculations per App. 1-10: Internal Pressure Case:**

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

Thickness of Nozzle [tn]:

= thickness - corrosion allowance

= 0.300 - 0.000

= 0.300 in

Effective Pressure Radius [Reff]:

= Di/2 + corrosion allowance

= 60.000/2 + 0.000

= 30.000 in

Effective Length of Vessel Wall [LR]:

= 8 \* t

= 8 \* 0.866

= 6.929 in

Thickness Limit Candidate [LH1]:

= t + 0.78 \* sqrt( Rn \* tn )

= 0.866 + 0.78 \* sqrt( 1.450 \* 0.300 )

= 1.381 in

Thickness Limit Candidate [LH2]:

= Lpr1 + T

= 25.000 + 0.866

= 25.866 in

Thickness Limit Candidate [LH3]:

= 8( t + te )

= 8( 0.866 + 0.000 )

= 6.929 in

Effective Nozzle Wall Length Outside the Vessel [LH]:

= min[ LH1, LH2, LH3 ]

= min[ 1.381 , 25.866 , 6.929 )

= 1.381 in

Effective Vessel Thickness [teff]:

= t

= 0.866 in

Determine Parameter [Lamda]:

= min( 10, ( Dn + Tn )/( sqrt( ( Di + teff ) \* teff )) )

= min( 10, (2.90 + 0.300 )/( sqrt((60.00 + 0.866 ) \* 0.866 )) )

= 0.441

**Compute Areas A1-A43 (No Pad) or A1-A5 (With Pad) :**

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

Area Contributed by the Vessel Wall [A1]:

= t \* LR \* max( Lamda/4, 1 )

= 0.866 \* 6.929 \* max( 0.441/4, 1 )

= 6.002 in^2

Area Contributed by the Nozzle Outside the Vessel Wall [A2]:

= tn \* LH

= 0.300 \* 1.381

= 0.414 in^2

Area Contributed by the Outside Fillet Weld [A41]:

= 0.5 \* Leg412

= 0.5 \* 0.3942

= 0.078 in^2

The total area contributed by A1 through A43 [AT]:

= A1 + frn( A2 + A3 ) + A41 + A42 + A43

= 6.002+1.000(0.414+0.000)+0.078+0.000+0.000

= 6.493 in^2

Allowable Local Primary Membrane Stress [Sallow]:

= 1.5 \* S \* E

= 1.5 \* 16700.000 \* 1.000

= 25050.0 psi

Determine Force acting on the Nozzle [fN]:

= P \* Rn( LH - t )

= 363.000 \* 1.450 ( 1.381 - 0.866 )

= 270.8 lbf

Determine Force acting on the Shell [fS]:

= P \* Reff( LR + tn )

= 363.000 \* 30.000 ( 6.929 + 0.300 )

= 78725.3 lbf

Discontinuity Force from Internal Pressure [fY]:

= P \* Reff \* Rnc

= 363.000 \* 30.000 \* 1.450

= 15790.5 lbf

Area Resisting Internal Pressure [Ap]:

= Rn( LH - t ) + Reff( LR + tn + Rnc )

= 1.450 ( 1.381 - 0.866 ) + 30.000 ( 6.929 + 0.300 + 1.450 )

= 261.1 in^2

Maximum Allowable Working Pressure Candidate [Pmax1]:

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

= Sallow /( 2 \* Ap/AT - Rxs/teff )

= 25050.000/( 2 \* 261.120/6.493 - 30.000/0.866 )

= 547.0 psig

Maximum Allowable Working Pressure Candidate [Pmax2]:

= S[t/Reff]

= 16700.000 [0.866/30.000 ]

= 482.2 psig

Maximum Allowable Working Pressure [Pmax]:

= min( Pmax1, Pmax2 )

= min( 547.047 , 482.152 )

= 482.152 psig

Average Primary Membrane Stress [SigmaAvg]:

= ( fN + fS + fY ) / AT

= ( 270.778 + 78725.266 + 15790.501 )/6.493

= 14597.618 psi

General Primary Membrane Stress [SigmaCirc]:

= P \* Reff / teff

= 363.000 \* 30.000/0.866

= 12573.0 psi

Maximum Local Primary Membrane Stress [PL]:

= max( 2 \* SigmaAvg - SigmaCirc, SigmaCirc )

= max( 2 \* 14597.618 - 12573.000 , 12573.000 )

= 16622.2 psi

# Summary of Nozzle Pressure/Stress Results:

Allowed Local Primary Membrane Stress Sallow 25050.00 psi Local Primary Membrane Stress PL 16622.24 psi Maximum Allowable Working Pressure Pmax 482.15 psig

# Strength of Nozzle Attachment Welds per 1-10 and U-2(g)

Discontinuity Force Factor [ky]:

= ( Rnc + tn ) / Rnc

= ( 1.450 + 0.300 )/1.450

= 1.207 For set-in Nozzles

Weld Length of Nozzle to Shell Weld [Ltau]:

= pi/2 \* ( Rn + tn )

= pi/2 \* ( 1.450 + 0.300 )

= 2.749 in

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

Weld Throat Dimensions, (0.7071\*Leg Dimensions) [L41T, L42T, L43T]:

= 0.278, 0.000, 0.000, in

Weld Load Value [fwelds]:

= min( fy \* ky, 1.5 \* Sn( A2 + A3 ), pi/4\*P\*Rn^2\*ky^2 )

= min(15790\*1.21,1.5\*16700.0(0.414+0.000),pi/4\*363.0\*1.45^2\*1.21^2)

= 873.117 lbf

Weld Stress Value [tau]:

= fwelds/(Ltau(0.49\*L41T + 0.6\*tw1 + 0.49\*L43T ) )

= 873.117/(2.749 (0.49\*0.278 + 0.6\*0.787 + 0.49\*0.000 ) )

= 521.680 < or = to 16700.000 Weld Size is OK

Weld Size Calculations, Description: A

Intermediate Calc. for nozzle/shell Welds Tmin 0.3000 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.2100 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.091 psig

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

Nozzle is O.K. for the External Pressure 14.500 psig

The Drop for this Nozzle is : 0.0511 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 25.9172 in

# Input Echo, WRC107/537 Item 1, Description: A :

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Diameter Basis for Vessel | Vbasis | ID | | |
| Cylindrical or Spherical Vessel | Cylsph | Cylindrical | | |
| Internal Corrosion Allowance | Cas | 0.0000 | | in |
| Vessel Diameter | Dv | 60.000 | in | |
| Vessel Thickness | Tv | 0.866 | in | |

Design Temperature 248.00 癋

Vessel Material SA-240 304L

Vessel Cold S.I. Allowable Smc 16700.00 psi

Vessel Hot S.I. Allowable Smh 16700.00 psi

Attachment Type Type Round

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

|  |  |  |
| --- | --- | --- |
| Diameter Basis for Nozzle | Nbasis | OD |
| Corrosion Allowance for Nozzle | Can | 0.0000 in |
| Nozzle Diameter | Dn | 3.500 in |
| Nozzle Thickness | Tn | 0.300 in |
| Nozzle Material | SA-312 | TP304L |
| Nozzle Cold S.I. Allowable | SNmc | 16700.00 psi |
| Nozzle Hot S.I. Allowable | SNmh | 16700.00 psi |

Design Internal Pressure Dp 363.000 psig Include Pressure Thrust No

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS) P 787.0 lbf

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Longitudinal Shear | (SUS) | Vl | 922.0 | lbf |
| Circumferential Shear | (SUS) | Vc | 674.0 | lbf |
| Circumferential Moment | (SUS) | Mc | 664.0 | ft-lbf |
| Longitudinal Moment | (SUS) | Ml | 1032.0 | ft-lbf |
| Torsional Moment | (SUS) | Mt | 1328.0 | ft-lbf |

|  |  |  |  |
| --- | --- | --- | --- |
| Use Interactive Control |  | No |  |
| WRC107 Version | Version | March | 1979 |

Include Pressure Stress Indices per Div. 2 No

Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load P 787.0 lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Circumferential Shear | VC | 674.0 | lbf |
| Longitudinal Shear | VL | 922.0 | lbf |
| Circumferential Moment | MC | 664.0 | ft-lbf |
| Longitudinal Moment | ML | 1032.0 | ft-lbf |
| Torsional Moment | MT | 1328.0 | ft-lbf |

Dimensionless Parameters used : Gamma = 35.14

# Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.050 | 4C | 6.605 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.050 | 3C | 6.567 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.050 | 2C1 | 0.152 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.050 | 1C | 0.194 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.050 3A 0.453 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.050 1A 0.104 (A,B,C,D)

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.050 3B 1.684 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.050 1B 0.058 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.050 | 3C | 6.567 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.050 | 4C | 6.605 | (C,D) |
| M(x) | / | ( P ) |  | 0.050 | 1C1 | 0.196 | (A,B) |
| M(x) | / | ( P ) |  | 0.050 | 2C | 0.152 | (C,D) |
| N(x) / ( MC/(Rm\*\*2 \* Beta) ) 0.050 | | | | | 4A | 0.575 | (A,B,C,D) |
| M(x) / ( MC/(Rm \* Beta) ) 0.050 | | | | | 2A | 0.062 | (A,B,C,D) |
| N(x) / ( ML/(Rm\*\*2 \* Beta) ) 0.050 | | | | | 4B | 0.465 | (A,B,C,D) |
| M(x) / ( ML/(Rm \* Beta) ) 0.050 | | | | | 2B | 0.097 | (A,B,C,D) |

Stress Concentration Factors Kn = 1.00, Kb = 1.00

# Stresses in the Vessel at the Attachment Junction

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Memb. | P | | | -197 | -197 | -197 | -197 | -196 | | -196 | -196 | -196 |
| Circ.  Circ. | Bend.  Memb. | P |  MC | | | -953  0 | 953  0 | -953  0 | 953  0 | -1219  -89 | | 1219  -89 | -1219  89 | 1219  89 |
| Circ. | Bend. | MC | | | 0 | 0 | 0 | 0 -4315 | |  | 4315 | 4315 | -4315 |
| Circ. | Memb. | ML | | | -516 | -516 | 516 | 516 | | 0 | 0 | 0 | 0 |
| Circ. | Bend. | ML | | | -3763 | 3763 | 3763 | -3763 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |

Tot. Circ. Str.| -5431 4003 3129 -2490 -5820 5249 2988 -3202

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Memb. | P | | | -196 | -196 | -196 | -196 | -197 | | -197 | -197 | -197 |
| Long. | Bend. | P | | | -1235 | 1235 | -1235 | 1235 | -957 | | 957 | -957 | 957 |
| Long. Memb. MC | 0 0 0 0 -113 -113 113 113 | | | | | | | | | | | | |
| Long. | Bend. | MC | | | 0 | 0 | 0 | 0 -2562 | |  | 2562 | 2562 | -2562 |
| Long. | Memb. | ML | | | -142 | -142 | 142 | 142 | | 0 | 0 | 0 | 0 |
| Long. | Bend. | ML | | | -6306 | 6306 | 6306 | -6306 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |

Tot. Long. Str.| -7879 7202 5017 -5124 -3831 3209 1521 -1688

Shear VC | Shear VL | Shear MT |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 141 141 -141 -141 0 0 | | | | | | 0 | 0 |
| 0 0 0 0 -193 -193 | | | | | | 193 | 193 |
| 956 | 956 | 956 | 956 | 956 | 956 | 956 | 956 |
| 1097 | 1097 | 814 | 814 | 762 | 762 | 1149 | 1149 |

| Tot. Shear|

**FileName : D4470**

**Nozzle Calcs. : A Nozl: 19 1:43p Apr 4,2014**

Str. Int. | 8300 7543 5320 5355 6078 5502 3618 3821

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Attachment Junction**

Type of | Stress Values at Stress Int. | (psi )

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pm (SUS) | | 12394 | 12757 | 12394 | 12757 | 12394 | 12757 | 12394 | 12757 |
| Circ. | Pl (SUS) | | -713 | -713 | 319 | 319 | -285 | -285 | -106 | -106 |
| Circ. | Q (SUS) | | -4717 | 4717 | 2809 | -2809 | -5534 | 5534 | 3095 | -3095 |
| Long. | Pm (SUS) | | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 |
| Long. | Pl (SUS) | | -338 | -338 | -53 | -53 | -310 | -310 | -83 | -83 |
| Long. | Q (SUS) | | -7541 | 7541 | 5070 | -5070 | -3520 | 3520 | 1604 | -1604 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Pl (SUS) | | 141 | 141 | -141 | -141 | -193 | -193 | 193 | 193 |
| Shear Q (SUS) | | 956 | 956 | 956 | 956 | 956 | 956 | 956 | 956 |

Pm (SUS) | 12394 12757 12394 12757 12394 12757 12394 12757

Pm+Pl (SUS) | 11683 12046 12716 13079 12114 12477 12293 12656

Pm+Pl+Q (Total)| 8919 17087 15672 10338 6707 18073 15551 9804

|  |  |  |  |
| --- | --- | --- | --- |
| Type of | | Max. | S.I. S.I. Allowable | | Result |
| Stress Int. | |  | psi | |  |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 12757 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 13079 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 18073 50100 | Passed

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**FileName : D4470**

**Nozzle Calcs. : M Nozl: 20 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: M From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.000 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 8.5820 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-240 304L

Material UNS Number S30403

Material Specification/Type Plate Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 24.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Actual |
| Actual Thickness |  | tn | 0.3937 in |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 25.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.4724 in

**FileName : D4470**

**Nozzle Calcs. : M Nozl: 20 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in

Pad Material SA-240 304L

Pad Allowable Stress at Temperature Pad Allowable Stress At Ambient Diameter of Pad along vessel surface Thickness of Pad

Sp Spa

Dp

te

16700.00 psi

16700.00 psi

38.5827 in

0.6299 in

Weld leg size between Pad and Shell Wp 0.5118 in Groove weld depth between Pad and Nozzle Wgpn 0.5512 in Reinforcing Pad Width 7.2913 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

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, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 24.000 in. Actual Thickness Used in Calculation 0.394 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.00\*30.0000)/(16700\*1.00-0.6\*363.00)

= 0.6607 in

**FileName : D4470**

**Nozzle Calcs. : M Nozl: 20 1:43p Apr 4,2014**

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*12.0000)/(16700\*1.00+0.4\*363.00)

= 0.2586 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0798 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 46.4252 in Parallel to Vessel Wall, opening length d 23.2126 in Normal to Vessel Wall (Thickness Limit), pad side Tlwp 1.6142 in

Weld Strength Reduction Factor [fr1]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr2]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr4]:

= min( 1, Sp/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr3]:

= min( fr2, fr4 )

= min( 1.0 , 1.0 )

= 1.000

# Results of Nozzle Reinforcement Area Calculations:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| AREA AVAILABLE, A1 to A5 | | | | | | | Design | External | Mapnc | | | | | |
| Area Required | | Ar | | | | | NA | 3.475 | NA | in^2 | | | | |
| Area in Shell | | A1 | | | | | NA | 13.155 | NA | in^2 | | | | |
| Area in Nozzle Wall | | | | | A2 | | NA | 1.013 | NA | | | in^2 | | |
| Area in Inward Nozzle | | | | | | A3 | NA | 0.000 | NA | | | | in^2 | |
| Area in Welds | A41+A42+A43 | | | | | | NA | 0.485 | NA | | | | in^2 | |
| Area in Element | | | A5 | | | | NA | 6.889 | NA | | in^2 | | | |
| TOTAL AREA AVAILABLE | | | | Atot | | | NA | 21.543 | NA | | | | | in^2 |

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

The area available with the given pad is Sufficient.

**FileName : D4470**

**Nozzle Calcs. : M Nozl: 20 1:43p Apr 4,2014**

Area Required [A]:

= 0.5( d \* tr\*F + 2 \* tn \* tr\*F \* (1-fr1) ) per UG-37(d) or UG-39

= 0.5(23.2126\*0.2994\*1+2\*0.3937\*0.2994\*1\*(1-1.00))

= 3.475 in^2

# Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

= d( E1\*t - F\*tr ) - 2 \* tn( E1\*t - F\*tr ) \* ( 1 - fr1 )

= 23.213 ( 1.00 \* 0.8661 - 1.0 \* 0.299 ) - 2 \* 0.394

( 1.00 \* 0.8661 - 1.0 \* 0.2994 ) \* ( 1 - 1.000 )

= 13.155 in^2

Area Available in Nozzle Wall Projecting Outward [A2]:

= ( 2 \* Tlwp ) \* ( tn - trn ) \* fr2

= ( 2 \* 1.614 ) \* ( 0.3937 - 0.0798 ) \* 1.0000

= 1.013 in^2

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

= Wo2\*fr3+(Wi-can/0.707)2\*fr2+Wp2\*fr4

= 0.47242 \*1.00 + (0.0000 )2 \*1.00 + 0.51182 \* 1.00

= 0.485 in^2

Area Available in Element [A5]:

= (min(Dp,DL)-(Nozzle OD))\*(min(tp,Tlwp,te))\*fr4

= ( 38.5827 - 24.0000 ) \* 0.6299 \* 1.0000

= 6.889 in^2

Note: Per user request, A5 multiplied by 0.75, see UG-37(h).

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

Wall Thickness for Internal/External pressures ta = 0.2586 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6607 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6607 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.3280 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.328 , max( 0.6607 , 0.0625 ) ]

= 0.3280 in

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

**FileName : D4470**

**Nozzle Calcs. : M Nozl: 20 1:43p Apr 4,2014**

= max( ta, tb )

= max( 0.2586 , 0.3280 )

= 0.3280 in

Available Nozzle Neck Thickness = 0.3937 in --> OK

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

# Nozzle Calculations per App. 1-10: Internal Pressure Case:

Thickness of Nozzle [tn]:

= thickness - corrosion allowance

= 0.394 - 0.000

= 0.394 in

Effective Pressure Radius [Reff]:

= Di/2 + corrosion allowance

= 60.000/2 + 0.000

= 30.000 in

Effective Length of Vessel Wall [LR]:

Note : Pad Thk >= 0.5T and Pad Width < 8(Shell Thk + Pad Thk)

= 10 \* t

= 10 \* 0.866

= 8.661 in

Thickness Limit Candidate [LH1]:

= t + 0.78 \* sqrt( Rn \* tn )

= 0.866 + 0.78 \* sqrt( 11.606 \* 0.394 )

= 2.533 in

Thickness Limit Candidate [LH2]:

= Lpr1 + T

= 25.000 + 0.866

= 25.866 in

Thickness Limit Candidate [LH3]:

= 8( t + te )

= 8( 0.866 + 0.630 )

= 11.969 in

Effective Nozzle Wall Length Outside the Vessel [LH]:

= min[ LH1, LH2, LH3 ]

= min[ 2.533 , 25.866 , 11.969 )

= 2.533 in

**FileName : D4470**

**Nozzle Calcs. : M Nozl: 20 1:43p Apr 4,2014**

Effective Vessel Thickness [teff]:

= t

= 0.866 in

Determine Parameter [Lamda]:

= min( 10, ( Dn + Tn )/( sqrt( ( Di + teff ) \* teff )) )

= min( 10, (23.21 + 0.394 )/( sqrt((60.00 + 0.866 ) \* 0.866 )) )

= 3.251

# Compute Areas A1-A43 (No Pad) or A1-A5 (With Pad) :

Area Contributed by the Vessel Wall [A1]:

= t \* LR \* max( Lamda/4, 1 )

= 0.866 \* 8.661 \* max( 3.251/4, 1 )

= 7.502 in^2

Area Contributed by the Nozzle Outside the Vessel Wall [A2]:

= tn \* LH

= 0.394 \* 2.533

= 0.997 in^2

Area Contributed by the Pad Fillet Weld [A42]:

= 0.5 \* Leg422

= 0.5 \* 0.5122

= 0.131 in^2

Area Contributed by the Outside Fillet Weld [A41]:

= 0.5 \* Leg412

= 0.5 \* 0.4722

= 0.112 in^2

Area Contributed by the Reinforcing Pad [A5]:

= min( W \* te , LR \* te )

= min( 7.291 \* 0.630 , 8.661 \* 0.630 )

= 4.593 in^2

The total area contributed by A1 through A5 [AT]:

= A1 + frn( A2 + A3 ) + A41 + A42 + A43 + frp( A5 )

= 7.502+1.000(0.997+0.000)+0.112+0.131+0.000+1.000(4.593)

= 13.335 in^2

Allowable Local Primary Membrane Stress [Sallow]:

= 1.5 \* S \* E

= 1.5 \* 16700.000 \* 1.000

= 25050.0 psi

**FileName : D4470**

**Nozzle Calcs. : M Nozl: 20 1:43p Apr 4,2014**

Determine Force acting on the Nozzle [fN]:

= P \* Rn( LH - t )

= 363.000 \* 11.606 ( 2.533 - 0.866 )

= 7024.7 lbf

Determine Force acting on the Shell [fS]:

= P \* Reff( LR + tn )

= 363.000 \* 30.000 ( 8.661 + 0.394 )

= 98610.2 lbf

Discontinuity Force from Internal Pressure [fY]:

= P \* Reff \* Rnc

= 363.000 \* 30.000 \* 11.606

= 126392.6 lbf

Area Resisting Internal Pressure [Ap]:

= Rn( LH - t ) + Reff( LR + tn + Rnc )

= 11.606 ( 2.533 - 0.866 ) + 30.000 ( 8.661 + 0.394 + 11.606 )

= 639.2 in^2

Maximum Allowable Working Pressure Candidate [Pmax1]:

= Sallow /( 2 \* Ap/AT - Rxs/teff )

= 25050.000/( 2 \* 639.194/13.335 - 30.000/0.866 )

= 409.1 psig

Maximum Allowable Working Pressure Candidate [Pmax2]:

= S[t/Reff]

= 16700.000 [0.866/30.000 ]

= 482.2 psig

Maximum Allowable Working Pressure [Pmax]:

= min( Pmax1, Pmax2 )

= min( 409.108 , 482.152 )

= 409.108 psig

Average Primary Membrane Stress [SigmaAvg]:

= ( fN + fS + fY ) / AT

= ( 7024.657 + 98610.234 + 126392.602 )/13.335

= 17399.889 psi

General Primary Membrane Stress [SigmaCirc]:

= P \* Reff / teff

= 363.000 \* 30.000/0.866

= 12573.0 psi

Maximum Local Primary Membrane Stress [PL]:

**FileName : D4470**

**Nozzle Calcs. : M Nozl: 20 1:43p Apr 4,2014**

= max( 2 \* SigmaAvg - SigmaCirc, SigmaCirc )

= max( 2 \* 17399.889 - 12573.000 , 12573.000 )

= 22226.8 psi

# Summary of Nozzle Pressure/Stress Results:

Allowed Local Primary Membrane Stress Sallow 25050.00 psi Local Primary Membrane Stress PL 22226.78 psi Maximum Allowable Working Pressure Pmax 409.11 psig

# Strength of Nozzle Attachment Welds per 1-10 and U-2(g)

Discontinuity Force Factor [ky]:

= ( Rnc + tn ) / Rnc

= ( 11.606 + 0.394 )/11.606

= 1.034 For set-in Nozzles

Weld Length of Nozzle to Shell Weld [Ltau]:

= pi/2 \* ( Rn + tn )

= pi/2 \* ( 11.606 + 0.394 )

= 18.850 in

Weld Length of Pad to Shell Weld [LtauP]:

= pi/2 \* ( Rn + tn + W )

= pi/2 \* ( 11.606 + 0.394 + 7.291 )

= 30.303 in

Weld Throat Dimensions, (0.7071\*Leg Dimensions) [L41T, L42T, L43T]:

= 0.334, 0.362, 0.000, in

Weld Load Value [fwelds]:

= min( fy \* ky, 1.5 \* Sn( A2 + A3 ), pi/4\*P\*Rn^2\*ky^2 )

= min(126392\*1.03,1.5\*16700.0(0.997+0.000),pi/4\*363.0\*11.61^2\*1.03^2)

= 24985.750 lbf

Discontinuity Force [fws]:

= fwelds \* t \* S/( t \* S + te \* Sp )

= 24985.8\*0.87\*16700/(0.866\*16700+0.630\*16700)

= 14465.437 lbf

Discontinuity Force [fwp]:

= fwelds \* te \* Sp / ( t \* S + te \* Sp )

= 24985.8\*0.63\*16700/(0.866\*16700+0.630\*16700)

= 10520.313 lbf

Shear Stress [tau1]:

= fws / ( Ltau \* ( 0.6 \* tw1 + 0.49 \* L43T ) )

**FileName : D4470**

**Nozzle Calcs. : M Nozl: 20 1:43p Apr 4,2014**

= 14465.437/( 18.850 \* ( 0.6 \* 0.787 + 0.49 \* 0.000 ) )

= 1624.361 psi

Shear Stress [tau2]:

= fwp / ( Ltau \* ( 0.6 \* tw2 + 0.49 \* L41T ) )

= 10520.313/( 18.850 \* ( 0.6 \* 0.551 + 0.49 \* 0.334 ) )

= 1128.884 psi

Shear Stress [tau3]:

= fwp / ( Ltau \* ( 0.49 \* L42T ) )

= 10520.313/( 30.303 \* ( 0.49 \* 0.362 ) )

= 1957.761 psi

Maximum Shear Stress in the Welds:

= max( tau1, tau2, tau3 )

= max( 1624.361 , 1128.884 , 1957.761 )

= 1957.8 must be less than or equal to 16700.0 psi

Weld Size Calculations, Description: M

|  |  |  |  |
| --- | --- | --- | --- |
| Intermediate Calc. for nozzle/shell Welds | | Tmin | 0.3937 in |
| Intermediate Calc. for pad/shell Welds | TminPad | | 0.6299 in |
| **Results Per UW-16.1:** |  | |  |

Required Thickness Actual Thickness Nozzle Weld 0.2756 = 0.7 \* tmin. 0.3340 = 0.7 \* Wo in Pad Weld 0.3150 = 0.5\*TminPad 0.3619 = 0.7 \* Wp in

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.091 psig

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

Nozzle is O.K. for the External Pressure 14.500 psig

The Drop for this Nozzle is : 2.5045 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 28.3707 in

# Percent Elongation Calculations:

Percent Elongation per UHA-44 (50\*tnom/Rf)\*(1-Rf/Ro) 1.668 %

Note: Please Check Requirements of Table UHA-44 for Elongation limits.

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**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: R1 From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.000 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 5.8320 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 4.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 25.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

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: R1** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 4.500 in. Actual Thickness Used in Calculation 0.337 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.00\*30.0000)/(16700\*1.00-0.6\*363.00)

= 0.6607 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*2.2500)/(16700\*1.00+0.4\*363.00)

= 0.0485 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0303 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 7.6520 in

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

Parallel to Vessel Wall, opening length d 3.8260 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.8425 in

Weld Strength Reduction Factor [fr1]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr2]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr3]:

= min( fr2, fr4 )

= min( 1.0 , 1.0 )

= 1.000

# Results of Nozzle Reinforcement Area Calculations:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| AREA AVAILABLE, A1 to A5 | | | | | | | Design | External | Mapnc | | | | |
| Area Required | | Ar | | | | | NA | 0.573 | NA | in^2 | | | |
| Area in Shell | | A1 | | | | | NA | 2.168 | NA | in^2 | | | |
| Area in Nozzle Wall | | | | | A2 | | NA | 0.517 | NA | | | in^2 | |
| Area in Inward Nozzle | | | | | | A3 | NA | 0.000 | NA | | | | in^2 |
| Area in Welds | A41+A42+A43 | | | | | | NA | 0.155 | NA | | | | in^2 |
| Area in Element | | | A5 | | | | NA | 0.000 | NA | | in^2 | | |
| TOTAL AREA AVAILABLE | | | | Atot | | | NA | 2.840 | NA | | | | in^2 |

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

= 0.5( d \* tr\*F + 2 \* tn \* tr\*F \* (1-fr1) ) per UG-37(d) or UG-39

= 0.5(3.8260\*0.2994\*1+2\*0.3370\*0.2994\*1\*(1-1.00))

= 0.573 in^2

# Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

= d( E1\*t - F\*tr ) - 2 \* tn( E1\*t - F\*tr ) \* ( 1 - fr1 )

= 3.826 ( 1.00 \* 0.8661 - 1.0 \* 0.299 ) - 2 \* 0.337

( 1.00 \* 0.8661 - 1.0 \* 0.2994 ) \* ( 1 - 1.000 )

= 2.168 in^2

Area Available in Nozzle Projecting Outward [A2]:

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

= ( 2 \* tlnp ) \* ( tn - trn ) \* fr2

= ( 2 \* 0.843 ) \* ( 0.3370 - 0.0303 ) \* 1.0000

= 0.517 in^2

Area Available in Inward Weld + Outward Weld [A41 + A43]:

= Wo2 \* fr2 + ( Wi-can/0.707 )2 \* fr2

= 0.39372 \* 1.0000 + ( 0.0000 )2 \* 1.0000

= 0.155 in^2

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

Wall Thickness for Internal/External pressures ta = 0.0485 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6607 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6607 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.2070 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.207 , max( 0.6607 , 0.0625 ) ]

= 0.2070 in

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

= max( ta, tb )

= max( 0.0485 , 0.2070 )

= 0.2070 in

Available Nozzle Neck Thickness = 0.875 \* 0.337 = 0.295 in --> 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 : 6397.0, Allowable : 16700.0 psi Passed Expansion : 0.0, Allowable : 35353.0 psi Passed Occasional : 946.9, Allowable : 22211.0 psi Passed Shear : 3629.6, Allowable : 11690.0 psi Passed

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

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

**Nozzle Calculations per App. 1-10: Internal Pressure Case:**

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

Thickness of Nozzle [tn]:

= thickness - corrosion allowance

= 0.337 - 0.000

= 0.337 in

Effective Pressure Radius [Reff]:

= Di/2 + corrosion allowance

= 60.000/2 + 0.000

= 30.000 in

Effective Length of Vessel Wall [LR]:

= 8 \* t

= 8 \* 0.866

= 6.929 in

Thickness Limit Candidate [LH1]:

= t + 0.78 \* sqrt( Rn \* tn )

= 0.866 + 0.78 \* sqrt( 1.913 \* 0.337 )

= 1.492 in

Thickness Limit Candidate [LH2]:

= Lpr1 + T

= 25.000 + 0.866

= 25.866 in

Thickness Limit Candidate [LH3]:

= 8( t + te )

= 8( 0.866 + 0.000 )

= 6.929 in

Effective Nozzle Wall Length Outside the Vessel [LH]:

= min[ LH1, LH2, LH3 ]

= min[ 1.492 , 25.866 , 6.929 )

= 1.492 in

Effective Vessel Thickness [teff]:

= t

= 0.866 in

Determine Parameter [Lamda]:

= min( 10, ( Dn + Tn )/( sqrt( ( Di + teff ) \* teff )) )

= min( 10, (3.83 + 0.337 )/( sqrt((60.00 + 0.866 ) \* 0.866 )) )

= 0.573

**Compute Areas A1-A43 (No Pad) or A1-A5 (With Pad) :**

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

Area Contributed by the Vessel Wall [A1]:

= t \* LR \* max( Lamda/4, 1 )

= 0.866 \* 6.929 \* max( 0.573/4, 1 )

= 6.002 in^2

Area Contributed by the Nozzle Outside the Vessel Wall [A2]:

= tn \* LH

= 0.337 \* 1.492

= 0.503 in^2

Area Contributed by the Outside Fillet Weld [A41]:

= 0.5 \* Leg412

= 0.5 \* 0.3942

= 0.078 in^2

The total area contributed by A1 through A43 [AT]:

= A1 + frn( A2 + A3 ) + A41 + A42 + A43

= 6.002+1.000(0.503+0.000)+0.078+0.000+0.000

= 6.582 in^2

Allowable Local Primary Membrane Stress [Sallow]:

= 1.5 \* S \* E

= 1.5 \* 16700.000 \* 1.000

= 25050.0 psi

Determine Force acting on the Nozzle [fN]:

= P \* Rn( LH - t )

= 363.000 \* 1.913 ( 1.492 - 0.866 )

= 434.9 lbf

Determine Force acting on the Shell [fS]:

= P \* Reff( LR + tn )

= 363.000 \* 30.000 ( 6.929 + 0.337 )

= 79128.2 lbf

Discontinuity Force from Internal Pressure [fY]:

= P \* Reff \* Rnc

= 363.000 \* 30.000 \* 1.913

= 20832.6 lbf

Area Resisting Internal Pressure [Ap]:

= Rn( LH - t ) + Reff( LR + tn + Rnc )

= 1.913 ( 1.492 - 0.866 ) + 30.000 ( 6.929 + 0.337 + 1.913 )

= 276.6 in^2

Maximum Allowable Working Pressure Candidate [Pmax1]:

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

= Sallow /( 2 \* Ap/AT - Rxs/teff )

= 25050.000/( 2 \* 276.572/6.582 - 30.000/0.866 )

= 507.1 psig

Maximum Allowable Working Pressure Candidate [Pmax2]:

= S[t/Reff]

= 16700.000 [0.866/30.000 ]

= 482.2 psig

Maximum Allowable Working Pressure [Pmax]:

= min( Pmax1, Pmax2 )

= min( 507.066 , 482.152 )

= 482.152 psig

Average Primary Membrane Stress [SigmaAvg]:

= ( fN + fS + fY ) / AT

= ( 434.899 + 79128.195 + 20832.570 )/6.582

= 15252.930 psi

General Primary Membrane Stress [SigmaCirc]:

= P \* Reff / teff

= 363.000 \* 30.000/0.866

= 12573.0 psi

Maximum Local Primary Membrane Stress [PL]:

= max( 2 \* SigmaAvg - SigmaCirc, SigmaCirc )

= max( 2 \* 15252.930 - 12573.000 , 12573.000 )

= 17932.9 psi

# Summary of Nozzle Pressure/Stress Results:

Allowed Local Primary Membrane Stress Sallow 25050.00 psi Local Primary Membrane Stress PL 17932.86 psi Maximum Allowable Working Pressure Pmax 482.15 psig

# Strength of Nozzle Attachment Welds per 1-10 and U-2(g)

Discontinuity Force Factor [ky]:

= ( Rnc + tn ) / Rnc

= ( 1.913 + 0.337 )/1.913

= 1.176 For set-in Nozzles

Weld Length of Nozzle to Shell Weld [Ltau]:

= pi/2 \* ( Rn + tn )

= pi/2 \* ( 1.913 + 0.337 )

= 3.534 in

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

Weld Throat Dimensions, (0.7071\*Leg Dimensions) [L41T, L42T, L43T]:

= 0.278, 0.000, 0.000, in

Weld Load Value [fwelds]:

= min( fy \* ky, 1.5 \* Sn( A2 + A3 ), pi/4\*P\*Rn^2\*ky^2 )

= min(20832\*1.18,1.5\*16700.0(0.503+0.000),pi/4\*363.0\*1.91^2\*1.18^2)

= 1443.316 lbf

Weld Stress Value [tau]:

= fwelds/(Ltau(0.49\*L41T + 0.6\*tw1 + 0.49\*L43T ) )

= 1443.316/(3.534 (0.49\*0.278 + 0.6\*0.787 + 0.49\*0.000 ) )

= 670.731 < or = to 16700.000 Weld Size is OK

Weld Size Calculations, Description: R1

Intermediate Calc. for nozzle/shell Welds Tmin 0.3370 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.2359 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.091 psig

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

Nozzle is O.K. for the External Pressure 14.500 psig

The Drop for this Nozzle is : 0.0845 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 25.9506 in

# Input Echo, WRC107/537 Item 1, Description: R1 :

|  |  |  |  |
| --- | --- | --- | --- |
| Diameter Basis for Vessel | Vbasis | ID | |
| Cylindrical or Spherical Vessel | Cylsph | Cylindrical | |
| Internal Corrosion Allowance | Cas | 0.0000 in | |
| Vessel Diameter | Dv | 60.000 | in |
| Vessel Thickness | Tv | 0.866 | in |

Design Temperature 248.00 癋

Vessel Material SA-240 304L

Vessel Cold S.I. Allowable Smc 16700.00 psi

Vessel Hot S.I. Allowable Smh 16700.00 psi

Attachment Type Type Round

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

|  |  |  |
| --- | --- | --- |
| Diameter Basis for Nozzle | Nbasis | OD |
| Corrosion Allowance for Nozzle | Can | 0.0000 in |
| Nozzle Diameter | Dn | 4.500 in |
| Nozzle Thickness | Tn | 0.337 in |
| Nozzle Material | SA-312 | TP304L |
| Nozzle Cold S.I. Allowable | SNmc | 16700.00 psi |
| Nozzle Hot S.I. Allowable | SNmh | 16700.00 psi |

Design Internal Pressure Dp 363.000 psig Include Pressure Thrust No

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS) P 967.0 lbf

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Longitudinal Shear | (SUS) | Vl | 1079.0 | lbf |
| Circumferential Shear | (SUS) | Vc | 787.0 | lbf |
| Circumferential Moment | (SUS) | Mc | 1033.0 | ft-lbf |
| Longitudinal Moment | (SUS) | Ml | 1549.0 | ft-lbf |
| Torsional Moment | (SUS) | Mt | 1918.0 | ft-lbf |

|  |  |  |  |
| --- | --- | --- | --- |
| Use Interactive Control |  | No |  |
| WRC107 Version | Version | March | 1979 |

Include Pressure Stress Indices per Div. 2 No

Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load P 967.0 lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Circumferential Shear | VC | 787.0 | lbf |
| Longitudinal Shear | VL | 1079.0 | lbf |
| Circumferential Moment | MC | 1033.0 | ft-lbf |
| Longitudinal Moment | ML | 1549.0 | ft-lbf |
| Torsional Moment | MT | 1918.0 | ft-lbf |

Dimensionless Parameters used : Gamma = 35.14

# Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.065 | 4C | 6.483 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.065 | 3C | 6.251 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.065 | 2C1 | 0.132 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.065 | 1C | 0.169 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.065 3A 0.616 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.065 1A 0.103 (A,B,C,D)

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.065 3B 2.227 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.065 1B 0.054 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.065 | 3C | 6.251 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.065 | 4C | 6.483 | (C,D) |
| M(x) | / | ( P ) |  | 0.065 | 1C1 | 0.174 | (A,B) |
| M(x) | / | ( P ) |  | 0.065 | 2C | 0.132 | (C,D) |
| N(x) / ( MC/(Rm\*\*2 \* Beta) ) 0.065 | | | | | 4A | 0.805 | (A,B,C,D) |
| M(x) / ( MC/(Rm \* Beta) ) 0.065 | | | | | 2A | 0.060 | (A,B,C,D) |
| N(x) / ( ML/(Rm\*\*2 \* Beta) ) 0.065 | | | | | 4B | 0.633 | (A,B,C,D) |
| M(x) / ( ML/(Rm \* Beta) ) 0.065 | | | | | 2B | 0.091 | (A,B,C,D) |

Stress Concentration Factors Kn = 1.00, Kb = 1.00

# Stresses in the Vessel at the Attachment Junction

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

-237 -229 -229 -229 -229

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Circ. | Memb. | P | | -237 | -237 | -237 |
| Circ. | Bend. | P | | -1021 | 1021 | -1021 |

1021 -1309 1309 -1309 1309

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Memb. | MC | | | 0 | 0 | 0 | 0 -147 | | -147 147 147 | | | |
| Circ. | Bend. | MC | | | 0 | 0 | 0 | 0 -5169 | | 5169 5169 -5169 | | | |
| Circ. | Memb. | ML | | | -797 | -797 | 797 | 797 | | 0 | 0 | 0 | 0 |
| Circ. | Bend. | ML | | | -4112 | 4112 | 4112 | -4112 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |
| Tot. Circ. Str.| -6169 | | | | | 4098 | 3650 | -2530 -6856 6103 3777 -3941 | | | | | |
| Long. | Memb. | P | | | -229 | -229 | -229 | -229 | -237 | | -237 | -237 | -237 |
| Long. | Bend. | P | | | -1348 | 1348 | -1348 | 1348 | -1023 | | 1023 | -1023 | 1023 |
| Long. | Memb. | MC | | | 0 | 0 | 0 | 0 | -192 |  | -192 | 192 | 192 |
| Long. | Bend. | MC | | | 0 | 0 | 0 | 0 -3015 | |  | 3015 | 3015 | -3015 |
| Long. | Memb. | ML | | | -226 | -226 | 226 | 226 | | 0 | 0 | 0 | 0 |
| Long. | Bend. | ML | | | -6852 | 6852 | 6852 | -6852 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |

Tot. Long. Str.| -8656 7744 5501 -5506 -4469 3608 1946 -2038

Shear VC | Shear VL | Shear MT |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 128 128 -128 -128 0 0 | | | | | | 0 | 0 |
| 0 0 0 0 -176 -176 | | | | | | 176 | 176 |
| 835 | 835 | 835 | 835 | 835 | 835 | 835 | 835 |
| 963 | 963 | 706 | 706 | 659 | 659 | 1011 | 1011 |

| Tot. Shear|

**FileName : D4470**

**Nozzle Calcs. : R1 Nozl: 21 1:43p Apr 4,2014**

Str. Int. | 8986 7983 5740 5666 7025 6266 4226 4379

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Attachment Junction**

Type of | Stress Values at Stress Int. | (psi )

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pm (SUS) | | 12394 | 12757 | 12394 | 12757 | 12394 | 12757 | 12394 | 12757 |
| Circ. | Pl (SUS) | | -1035 | -1035 | 560 | 560 | -376 | -376 | -82 | -82 |
| Circ. | Q (SUS) | | -5133 | 5133 | 3090 | -3090 | -6479 | 6479 | 3859 | -3859 |
| Long. | Pm (SUS) | | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 | 6197 |
| Long. | Pl (SUS) | | -456 | -456 | -2 | -2 | -430 | -430 | -45 | -45 |
| Long. | Q (SUS) | | -8200 | 8200 | 5504 | -5504 | -4038 | 4038 | 1992 | -1992 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Pl (SUS) | | 128 | 128 | -128 | -128 | -176 | -176 | 176 | 176 |
| Shear Q (SUS) | | 835 | 835 | 835 | 835 | 835 | 835 | 835 | 835 |

Pm (SUS) | 12394 12757 12394 12757 12394 12757 12394 12757

Pm+Pl (SUS) | 11361 11724 12956 13319 12022 12385 12316 12679

Pm+Pl+Q (Total)| 8895 17145 16157 10278 5648 18907 16297 9025

|  |  |  |  |
| --- | --- | --- | --- |
| Type of | | Max. | S.I. S.I. Allowable | | Result |
| Stress Int. | |  | psi | |  |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 12757 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 13319 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 18907 50100 | Passed

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**FileName : D4470**

**Nozzle Calcs. : W1 Nozl: 22 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: W1 From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.760 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 4.0820 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 180.00 deg

Diameter 2.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 9.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : W1 Nozl: 22 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

The Pressure Design option was Design Pressure + static head.

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

**| |**

**| |**

**| |**

**| |**

**/| |**

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**| \ | |**

**| \| |**

**Insert/Set-in Nozzle No Pad, no Inside projection Reinforcement CALCULATION, Description: W1** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in. Actual Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.76\*30.0000)/(16700\*1.00-0.6\*363.76)

= 0.6621 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.76\*1.1875)/(16700\*1.00+0.4\*363.76)

= 0.0256 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0134 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 4.1073 in

**FileName : D4470**

**Nozzle Calcs. : W1 Nozl: 22 1:43p Apr 4,2014**

Parallel to Vessel Wall Rn+tn+t 2.0536 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5450 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: W1.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

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

Wall Thickness for Internal/External pressures ta = 0.0256 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6621 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6621 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1346 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.135 , max( 0.6621 , 0.0625 ) ]

= 0.1346 in

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

= max( ta, tb )

= max( 0.0256 , 0.1346 )

= 0.1346 in

Available Nozzle Neck Thickness = 0.875 \* 0.218 = 0.191 in --> 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 : 8833.6, Allowable : 16700.0 psi Passed Expansion : 0.0, Allowable : 32916.4 psi Passed Occasional : 727.1, Allowable : 22211.0 psi Passed Shear : 6806.2, Allowable : 11690.0 psi Passed

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

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

**FileName : D4470**

**Nozzle Calcs. : W1 Nozl: 22 1:43p Apr 4,2014**

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

Weld Size Calculations, Description: W1

Intermediate Calc. for nozzle/shell Welds Tmin 0.2180 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1526 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.851 psig

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

The Drop for this Nozzle is : 0.0235 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 9.8897 in

# Input Echo, WRC107/537 Item 1, Description: W1 :

|  |  |  |  |
| --- | --- | --- | --- |
| Diameter Basis for Vessel | Vbasis | ID | |
| Cylindrical or Spherical Vessel | Cylsph | Cylindrical | |
| Internal Corrosion Allowance | Cas | 0.0000 in | |
| Vessel Diameter | Dv | 60.000 | in |
| Vessel Thickness | Tv | 0.866 | in |

Design Temperature 248.00 癋

Vessel Material SA-240 304L

Vessel Cold S.I. Allowable Smc 16700.00 psi

Vessel Hot S.I. Allowable Smh 16700.00 psi

|  |  |  |  |
| --- | --- | --- | --- |
| Attachment Type | Type | Round |  |
| Diameter Basis for Nozzle | Nbasis | OD |
| Corrosion Allowance for Nozzle | Can | 0.0000 | in |
| Nozzle Diameter | Dn | 2.375 in | |
| Nozzle Thickness Nozzle Material  Nozzle Cold S.I. Allowable | Tn  SA-312  SNmc | 0.218 in TP304L  16700.00 psi | |
| Nozzle Hot S.I. Allowable | SNmh | 16700.00 | psi |
| Design Internal Pressure | Dp | 363.760 | psig |

**FileName : D4470**

**Nozzle Calcs. : W1 Nozl: 22 1:43p Apr 4,2014**

Include Pressure Thrust No

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS) P 517.0 lbf

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Longitudinal Shear | (SUS) | Vl | 697.0 | lbf |
| Circumferential Shear | (SUS) | Vc | 517.0 | lbf |
| Circumferential Moment | (SUS) | Mc | 295.0 | ft-lbf |
| Longitudinal Moment | (SUS) | Ml | 369.0 | ft-lbf |
| Torsional Moment | (SUS) | Mt | 590.0 | ft-lbf |

|  |  |  |  |
| --- | --- | --- | --- |
| Use Interactive Control |  | No |  |
| WRC107 Version | Version | March | 1979 |

Include Pressure Stress Indices per Div. 2 No

Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load P 517.0 lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Circumferential Shear | VC | 517.0 | lbf |
| Longitudinal Shear | VL | 697.0 | lbf |
| Circumferential Moment | MC | 295.0 | ft-lbf |
| Longitudinal Moment | ML | 369.0 | ft-lbf |
| Torsional Moment | MT | 590.0 | ft-lbf |

Dimensionless Parameters used : Gamma = 35.14

# Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.034 | 4C | 6.715 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.034 | 3C | 6.866 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.034 | 2C1 | 0.185 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.034 | 1C | 0.233 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.034 3A 0.262 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.034 1A 0.104 (A,B,C,D) N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.034 3B 0.987 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.034 1B 0.063 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.034 | 3C | 6.866 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.034 | 4C | 6.715 | (C,D) |
| M(x) | / | ( P ) |  | 0.034 | 1C1 | 0.236 | (A,B) |
| M(x) | / | ( P ) |  | 0.034 | 2C | 0.186 | (C,D) |

N(x) / ( MC/(Rm\*\*2 \* Beta) ) 0.034 4A 0.317 (A,B,C,D)

M(x) / ( MC/(Rm \* Beta) ) 0.034 2A 0.063 (A,B,C,D)

**FileName : D4470**

**Nozzle Calcs. : W1 Nozl: 22 1:43p Apr 4,2014**

N(x) / ( ML/(Rm\*\*2 \* Beta) ) 0.034 4B 0.271 (A,B,C,D)

M(x) / ( ML/(Rm \* Beta) ) 0.034 2B 0.105 (A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

# Stresses in the Vessel at the Attachment Junction

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Memb. | P | | | -131 | -131 | -131 | -131 | -134 | | -134 | -134 | -134 |
| Circ.  Circ. | Bend.  Memb. | P |  MC | | | -765  0 | 765  0 | -765  0 | 765  0 | -961  -33 | | 961  -33 | -961  33 | 961  33 |
| Circ. | Bend. | MC | | | 0 | 0 | 0 | 0 -2845 | |  | 2845 | 2845 | -2845 |
| Circ. | Memb. | ML | | | -159 | -159 | 159 | 159 | | 0 | 0 | 0 | 0 |
| Circ. | Bend. | ML | | | -2136 | 2136 | 2136 | -2136 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |
| Tot. Circ. Str.| -3193 | | | | | 2610 | 1398 | -1342 | -3975 3638 1782 -1984 | | | | |
| Long. | Memb. | P | | | -134 | -134 | -134 | -134 | -131 | | -131 | -131 | -131 |
| Long. | Bend. | P | | | -977 | 977 | -977 | 977 | -770 | | 770 | -770 | 770 |

0 -40

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Long. | Memb. | MC | | | 0 | 0 | 0 |
| Long. | Bend. | MC | | | 0 | 0 | 0 |
| Long. | Memb. | ML | | | -43 | -43 | 43 |
| Long. | Bend. | ML | | | -3594 | 3594 | 3594 |
|  |  | | |  |  |  |  |

|  |  |  |
| --- | --- | --- |
| -40 | 40 | 40 |
| 1704 | 1704 | -1704 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |

0 -1704

43 0

-3594 0

Tot. Long. Str.| -4750 4394 2526 -2708 -2647 2302 842 -1024

|  |  |  |
| --- | --- | --- |
| 0 0 | 0 | 0 |
| -215 | 215 | 215 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear | VC | | | 159 | 159 | -159 -159 | | | | | |
| Shear | VL | | | 0 | 0 | 0 0 -215 | | | | | |
| Shear | MT | | | 922 | 922 | 922 922 922 922 922 922 | | | | | |
|  | | |  |  |  |  | | | | | |
| Tot. Shear| | | | 1082 | 1082 | 762 | 762 | 706 | 706 | 1138 | 1138 |
| Str. Int. | | | | 5305 | 4904 | 2910 | 3049 | 4280 | 3942 | 2544 | 2739 |

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Attachment Junction**

Type of | Stress Values at Stress Int. | (psi )

**FileName : D4470**

**Nozzle Calcs. : W1 Nozl: 22 1:43p Apr 4,2014**

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|-------------------------------------------------------- Circ. Pm (SUS) | 12420 12783 12420 12783 12420 12783 12420 12783

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pl (SUS) | | -291 | -291 | 27 | 27 | -168 | -168 | -100 | -100 |
| Circ. | Q (SUS) | | -2902 | 2902 | 1370 | -1370 | -3806 | 3806 | 1883 | -1883 |
| Long. | Pm (SUS) | | 6210 | 6210 | 6210 | 6210 | 6210 | 6210 | 6210 | 6210 |
| Long. | Pl (SUS) | | -178 | -178 | -90 | -90 | -172 | -172 | -90 | -90 |
| Long. | Q (SUS) | | -4572 | 4572 | 2617 | -2617 | -2474 | 2474 | 933 | -933 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Pl (SUS) | | 159 | 159 | -159 | -159 | -215 | -215 | 215 | 215 |
| Shear Q (SUS) | | 922 | 922 | 922 | 922 | 922 | 922 | 922 | 922 |

Pm (SUS) | 12420 12783 12420 12783 12420 12783 12420 12783

Pm+Pl (SUS) | 12132 12496 12451 12815 12259 12622 12326 12690

Pm+Pl+Q (Total)| 9374 15627 13930 11513 8545 16484 14379 11021

|  |  |  |  |
| --- | --- | --- | --- |
| Type of | | Max. | S.I. S.I. Allowable | | Result |
| Stress Int. | |  | psi | |  |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 12783 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 12815 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 16484 50100 | Passed

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**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: B From : 20

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.760 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

Inside Diameter of Cylindrical Shell D 60.0000 in Design Length of Section L 160.0000 in

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Shell | Finished | (Minimum) | Thickness | t | 0.8661 | in |
| Shell | Internal | Corrosion | Allowance | c | 0.0000 | in |
| Shell | External | Corrosion | Allowance | co | 0.0000 | in |

Distance from Bottom/Left Tangent 12.0820 ft

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 180.00 deg

Diameter 3.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 9.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7874 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

The Pressure Design option was Design Pressure + static head.

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

**| |**

**| |**

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**| \| |**

**Insert/Set-in Nozzle No Pad, no Inside projection Reinforcement CALCULATION, Description: B** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 3.500 in. Actual Thickness Used in Calculation 0.300 in.

Nozzle input data check completed without errors.

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

= (P\*R)/(S\*E-0.6\*P) per UG-27 (c)(1)

= (363.76\*30.0000)/(16700\*1.00-0.6\*363.76)

= 0.6621 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.76\*1.7500)/(16700\*1.00+0.4\*363.76)

= 0.0378 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0169 in

# UG-40, Limits of Reinforcement : [External Pressure]

Parallel to Vessel Wall (Diameter Limit) Dl 5.8000 in

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

Parallel to Vessel Wall, opening length d 2.9000 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.7500 in

Weld Strength Reduction Factor [fr1]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr2]:

= min( 1, Sn/S )

= min( 1, 16700.0/16700.0 )

= 1.000

Weld Strength Reduction Factor [fr3]:

= min( fr2, fr4 )

= min( 1.0 , 1.0 )

= 1.000

# Results of Nozzle Reinforcement Area Calculations:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| AREA AVAILABLE, A1 to A5 | | | | | | | Design | External | Mapnc | | | | |
| Area Required | | Ar | | | | | NA | 0.434 | NA | in^2 | | | |
| Area in Shell | | A1 | | | | | NA | 1.643 | NA | in^2 | | | |
| Area in Nozzle Wall | | | | | A2 | | NA | 0.425 | NA | | | in^2 | |
| Area in Inward Nozzle | | | | | | A3 | NA | 0.000 | NA | | | | in^2 |
| Area in Welds | A41+A42+A43 | | | | | | NA | 0.155 | NA | | | | in^2 |
| Area in Element | | | A5 | | | | NA | 0.000 | NA | | in^2 | | |
| TOTAL AREA AVAILABLE | | | | Atot | | | NA | 2.223 | NA | | | | in^2 |

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

= 0.5( d \* tr\*F + 2 \* tn \* tr\*F \* (1-fr1) ) per UG-37(d) or UG-39

= 0.5(2.9000\*0.2994\*1+2\*0.3000\*0.2994\*1\*(1-1.00))

= 0.434 in^2

# Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

= d( E1\*t - F\*tr ) - 2 \* tn( E1\*t - F\*tr ) \* ( 1 - fr1 )

= 2.900 ( 1.00 \* 0.8661 - 1.0 \* 0.299 ) - 2 \* 0.300

( 1.00 \* 0.8661 - 1.0 \* 0.2994 ) \* ( 1 - 1.000 )

= 1.643 in^2

Area Available in Nozzle Projecting Outward [A2]:

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

= ( 2 \* tlnp ) \* ( tn - trn ) \* fr2

= ( 2 \* 0.750 ) \* ( 0.3000 - 0.0169 ) \* 1.0000

= 0.425 in^2

Area Available in Inward Weld + Outward Weld [A41 + A43]:

= Wo2 \* fr2 + ( Wi-can/0.707 )2 \* fr2

= 0.39372 \* 1.0000 + ( 0.0000 )2 \* 1.0000

= 0.155 in^2

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

Wall Thickness for Internal/External pressures ta = 0.0378 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6621 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6621 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1890 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.189 , max( 0.6621 , 0.0625 ) ]

= 0.1890 in

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

= max( ta, tb )

= max( 0.0378 , 0.1890 )

= 0.1890 in

Available Nozzle Neck Thickness = 0.875 \* 0.300 = 0.263 in --> 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 : 7675.0, Allowable : 16700.0 psi Passed Expansion : 0.0, Allowable : 34075.0 psi Passed Occasional : 796.7, Allowable : 22211.0 psi Passed Shear : 4856.8, Allowable : 11690.0 psi Passed

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

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

**Nozzle Calculations per App. 1-10: Internal Pressure Case:**

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

Thickness of Nozzle [tn]:

= thickness - corrosion allowance

= 0.300 - 0.000

= 0.300 in

Effective Pressure Radius [Reff]:

= Di/2 + corrosion allowance

= 60.000/2 + 0.000

= 30.000 in

Effective Length of Vessel Wall [LR]:

= 8 \* t

= 8 \* 0.866

= 6.929 in

Thickness Limit Candidate [LH1]:

= t + 0.78 \* sqrt( Rn \* tn )

= 0.866 + 0.78 \* sqrt( 1.450 \* 0.300 )

= 1.381 in

Thickness Limit Candidate [LH2]:

= Lpr1 + T

= 9.000 + 0.866

= 9.866 in

Thickness Limit Candidate [LH3]:

= 8( t + te )

= 8( 0.866 + 0.000 )

= 6.929 in

Effective Nozzle Wall Length Outside the Vessel [LH]:

= min[ LH1, LH2, LH3 ]

= min[ 1.381 , 9.866 , 6.929 )

= 1.381 in

Effective Vessel Thickness [teff]:

= t

= 0.866 in

Determine Parameter [Lamda]:

= min( 10, ( Dn + Tn )/( sqrt( ( Di + teff ) \* teff )) )

= min( 10, (2.90 + 0.300 )/( sqrt((60.00 + 0.866 ) \* 0.866 )) )

= 0.441

**Compute Areas A1-A43 (No Pad) or A1-A5 (With Pad) :**

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

Area Contributed by the Vessel Wall [A1]:

= t \* LR \* max( Lamda/4, 1 )

= 0.866 \* 6.929 \* max( 0.441/4, 1 )

= 6.002 in^2

Area Contributed by the Nozzle Outside the Vessel Wall [A2]:

= tn \* LH

= 0.300 \* 1.381

= 0.414 in^2

Area Contributed by the Outside Fillet Weld [A41]:

= 0.5 \* Leg412

= 0.5 \* 0.3942

= 0.078 in^2

The total area contributed by A1 through A43 [AT]:

= A1 + frn( A2 + A3 ) + A41 + A42 + A43

= 6.002+1.000(0.414+0.000)+0.078+0.000+0.000

= 6.493 in^2

Allowable Local Primary Membrane Stress [Sallow]:

= 1.5 \* S \* E

= 1.5 \* 16700.000 \* 1.000

= 25050.0 psi

Determine Force acting on the Nozzle [fN]:

= P \* Rn( LH - t )

= 363.760 \* 1.450 ( 1.381 - 0.866 )

= 271.3 lbf

Determine Force acting on the Shell [fS]:

= P \* Reff( LR + tn )

= 363.760 \* 30.000 ( 6.929 + 0.300 )

= 78890.1 lbf

Discontinuity Force from Internal Pressure [fY]:

= P \* Reff \* Rnc

= 363.760 \* 30.000 \* 1.450

= 15823.6 lbf

Area Resisting Internal Pressure [Ap]:

= Rn( LH - t ) + Reff( LR + tn + Rnc )

= 1.450 ( 1.381 - 0.866 ) + 30.000 ( 6.929 + 0.300 + 1.450 )

= 261.1 in^2

Maximum Allowable Working Pressure Candidate [Pmax1]:

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

= Sallow /( 2 \* Ap/AT - Rxs/teff )

= 25050.000/( 2 \* 261.120/6.493 - 30.000/0.866 )

= 547.0 psig

Maximum Allowable Working Pressure Candidate [Pmax2]:

= S[t/Reff]

= 16700.000 [0.866/30.000 ]

= 482.2 psig

Maximum Allowable Working Pressure [Pmax]:

= min( Pmax1, Pmax2 )

= min( 547.047 , 482.152 )

= 482.152 psig

Average Primary Membrane Stress [SigmaAvg]:

= ( fN + fS + fY ) / AT

= ( 271.345 + 78890.117 + 15823.564 )/6.493

= 14628.186 psi

General Primary Membrane Stress [SigmaCirc]:

= P \* Reff / teff

= 363.760 \* 30.000/0.866

= 12599.3 psi

Maximum Local Primary Membrane Stress [PL]:

= max( 2 \* SigmaAvg - SigmaCirc, SigmaCirc )

= max( 2 \* 14628.186 - 12599.327 , 12599.327 )

= 16657.0 psi

# Summary of Nozzle Pressure/Stress Results:

Allowed Local Primary Membrane Stress Sallow 25050.00 psi Local Primary Membrane Stress PL 16657.04 psi Maximum Allowable Working Pressure Pmax 482.15 psig

# Strength of Nozzle Attachment Welds per 1-10 and U-2(g)

Discontinuity Force Factor [ky]:

= ( Rnc + tn ) / Rnc

= ( 1.450 + 0.300 )/1.450

= 1.207 For set-in Nozzles

Weld Length of Nozzle to Shell Weld [Ltau]:

= pi/2 \* ( Rn + tn )

= pi/2 \* ( 1.450 + 0.300 )

= 2.749 in

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

Weld Throat Dimensions, (0.7071\*Leg Dimensions) [L41T, L42T, L43T]:

= 0.278, 0.000, 0.000, in

Weld Load Value [fwelds]:

= min( fy \* ky, 1.5 \* Sn( A2 + A3 ), pi/4\*P\*Rn^2\*ky^2 )

= min(15823\*1.21,1.5\*16700.0(0.414+0.000),pi/4\*363.8\*1.45^2\*1.21^2)

= 874.946 lbf

Weld Stress Value [tau]:

= fwelds/(Ltau(0.49\*L41T + 0.6\*tw1 + 0.49\*L43T ) )

= 874.946/(2.749 (0.49\*0.278 + 0.6\*0.787 + 0.49\*0.000 ) )

= 522.772 < or = to 16700.000 Weld Size is OK

Weld Size Calculations, Description: B

Intermediate Calc. for nozzle/shell Welds Tmin 0.3000 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.2100 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 402.851 psig

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

Nozzle is O.K. for the External Pressure 14.500 psig

The Drop for this Nozzle is : 0.0511 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 9.9172 in

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Diameter Basis for Vessel | Vbasis | ID | | |
| Cylindrical or Spherical Vessel | Cylsph | Cylindrical | | |
| Internal Corrosion Allowance | Cas | 0.0000 | | in |
| Vessel Diameter | Dv | 60.000 | in | |
| Vessel Thickness | Tv | 0.866 | in | |

Design Temperature 248.00 癋

Vessel Material SA-240 304L

Vessel Cold S.I. Allowable Smc 16700.00 psi

Vessel Hot S.I. Allowable Smh 16700.00 psi

Attachment Type Type Round

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

|  |  |  |
| --- | --- | --- |
| Diameter Basis for Nozzle | Nbasis | OD |
| Corrosion Allowance for Nozzle | Can | 0.0000 in |
| Nozzle Diameter | Dn | 3.500 in |
| Nozzle Thickness | Tn | 0.300 in |
| Nozzle Material | SA-312 | TP304L |
| Nozzle Cold S.I. Allowable | SNmc | 16700.00 psi |
| Nozzle Hot S.I. Allowable | SNmh | 16700.00 psi |

Design Internal Pressure Dp 363.760 psig Include Pressure Thrust No

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS) P 787.0 lbf

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Longitudinal Shear | (SUS) | Vl | 922.0 | lbf |
| Circumferential Shear | (SUS) | Vc | 674.0 | lbf |
| Circumferential Moment | (SUS) | Mc | 664.0 | ft-lbf |
| Longitudinal Moment | (SUS) | Ml | 1032.0 | ft-lbf |
| Torsional Moment | (SUS) | Mt | 1328.0 | ft-lbf |

|  |  |  |  |
| --- | --- | --- | --- |
| Use Interactive Control |  | No |  |
| WRC107 Version | Version | March | 1979 |

Include Pressure Stress Indices per Div. 2 No

Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load P 787.0 lbf

|  |  |  |  |
| --- | --- | --- | --- |
| Circumferential Shear | VC | 674.0 | lbf |
| Longitudinal Shear | VL | 922.0 | lbf |
| Circumferential Moment | MC | 664.0 | ft-lbf |
| Longitudinal Moment | ML | 1032.0 | ft-lbf |
| Torsional Moment | MT | 1328.0 | ft-lbf |

Dimensionless Parameters used : Gamma = 35.14

# Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 Beta Figure Value Location

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(PHI) | / | ( P/Rm | ) | 0.050 | 4C | 6.605 | (A,B) |
| N(PHI) | / | ( P/Rm | ) | 0.050 | 3C | 6.567 | (C,D) |
| M(PHI) | / | ( P ) |  | 0.050 | 2C1 | 0.152 | (A,B) |
| M(PHI) | / | ( P ) |  | 0.050 | 1C | 0.194 | (C,D) |

N(PHI) / ( MC/(Rm\*\*2 \* Beta) ) 0.050 3A 0.453 (A,B,C,D) M(PHI) / ( MC/(Rm \* Beta) ) 0.050 1A 0.104 (A,B,C,D)

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) 0.050 3B 1.684 (A,B,C,D) M(PHI) / ( ML/(Rm \* Beta) ) 0.050 1B 0.058 (A,B,C,D)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N(x) | / | ( P/Rm | ) | 0.050 | 3C | 6.567 | (A,B) |
| N(x) | / | ( P/Rm | ) | 0.050 | 4C | 6.605 | (C,D) |
| M(x) | / | ( P ) |  | 0.050 | 1C1 | 0.196 | (A,B) |
| M(x) | / | ( P ) |  | 0.050 | 2C | 0.152 | (C,D) |
| N(x) / ( MC/(Rm\*\*2 \* Beta) ) 0.050 | | | | | 4A | 0.575 | (A,B,C,D) |
| M(x) / ( MC/(Rm \* Beta) ) 0.050 | | | | | 2A | 0.062 | (A,B,C,D) |
| N(x) / ( ML/(Rm\*\*2 \* Beta) ) 0.050 | | | | | 4B | 0.465 | (A,B,C,D) |
| M(x) / ( ML/(Rm \* Beta) ) 0.050 | | | | | 2B | 0.097 | (A,B,C,D) |

Stress Concentration Factors Kn = 1.00, Kb = 1.00

# Stresses in the Vessel at the Attachment Junction

| Stress Values at

Type of | (psi )

---------------|--------------------------------------------------------

Stress Load| Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Memb. | P | | | -197 | -197 | -197 | -197 | -196 | | -196 | -196 | -196 |
| Circ.  Circ. | Bend.  Memb. | P |  MC | | | -953  0 | 953  0 | -953  0 | 953  0 | -1219  -89 | | 1219  -89 | -1219  89 | 1219  89 |
| Circ. | Bend. | MC | | | 0 | 0 | 0 | 0 -4315 | |  | 4315 | 4315 | -4315 |
| Circ. | Memb. | ML | | | -516 | -516 | 516 | 516 | | 0 | 0 | 0 | 0 |
| Circ. | Bend. | ML | | | -3763 | 3763 | 3763 | -3763 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |

Tot. Circ. Str.| -5431 4003 3129 -2490 -5820 5249 2988 -3202

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long. | Memb. | P | | | -196 | -196 | -196 | -196 | -197 | | -197 | -197 | -197 |
| Long. | Bend. | P | | | -1235 | 1235 | -1235 | 1235 | -957 | | 957 | -957 | 957 |
| Long. Memb. MC | 0 0 0 0 -113 -113 113 113 | | | | | | | | | | | | |
| Long. | Bend. | MC | | | 0 | 0 | 0 | 0 -2562 | |  | 2562 | 2562 | -2562 |
| Long. | Memb. | ML | | | -142 | -142 | 142 | 142 | | 0 | 0 | 0 | 0 |
| Long. | Bend. | ML | | | -6306 | 6306 | 6306 | -6306 | | 0 | 0 | 0 | 0 |
|  |  | | |  |  |  |  |  | |  |  |  |  |

Tot. Long. Str.| -7879 7202 5017 -5124 -3831 3209 1521 -1688

Shear VC | Shear VL | Shear MT |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 141 141 -141 -141 0 0 | | | | | | 0 | 0 |
| 0 0 0 0 -193 -193 | | | | | | 193 | 193 |
| 956 | 956 | 956 | 956 | 956 | 956 | 956 | 956 |
| 1097 | 1097 | 814 | 814 | 762 | 762 | 1149 | 1149 |

| Tot. Shear|

**FileName : D4470**

**Nozzle Calcs. : B Nozl: 23 1:43p Apr 4,2014**

Str. Int. | 8300 7543 5320 5355 6078 5502 3618 3821

# WRC 107/537 Stress Summations:

**Vessel Stress Summation at Attachment Junction**

Type of | Stress Values at Stress Int. | (psi )

---------------|--------------------------------------------------------

Location | Au Al Bu Bl Cu Cl Du Dl

---------------|--------------------------------------------------------

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Circ. | Pm (SUS) | | 12420 | 12783 | 12420 | 12783 | 12420 | 12783 | 12420 | 12783 |
| Circ. | Pl (SUS) | | -713 | -713 | 319 | 319 | -285 | -285 | -106 | -106 |
| Circ. | Q (SUS) | | -4717 | 4717 | 2809 | -2809 | -5534 | 5534 | 3095 | -3095 |
| Long. | Pm (SUS) | | 6210 | 6210 | 6210 | 6210 | 6210 | 6210 | 6210 | 6210 |
| Long. | Pl (SUS) | | -338 | -338 | -53 | -53 | -310 | -310 | -83 | -83 |
| Long. | Q (SUS) | | -7541 | 7541 | 5070 | -5070 | -3520 | 3520 | 1604 | -1604 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear Pm (SUS) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shear Pl (SUS) | | 141 | 141 | -141 | -141 | -193 | -193 | 193 | 193 |
| Shear Q (SUS) | | 956 | 956 | 956 | 956 | 956 | 956 | 956 | 956 |

Pm (SUS) | 12420 12783 12420 12783 12420 12783 12420 12783

Pm+Pl (SUS) | 11709 12073 12742 13106 12140 12504 12319 12682

Pm+Pl+Q (Total)| 8932 17113 15697 10365 6733 18100 15577 9830

|  |  |  |  |
| --- | --- | --- | --- |
| Type of | | Max. | S.I. S.I. Allowable | | Result |
| Stress Int. | |  | psi | |  |

---------------|--------------------------------------------------------

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pm (SUS) | | | 12783 | 16700 | | | Passed |
| Pm+Pl (SUS) | | | 13106 | 25050 | | | Passed |

Pm+Pl+Q (TOTAL)| 18100 50100 | Passed

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**FileName : D4470**

**Nozzle Calcs. : L2 Nozl: 24 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: L2 From : 30

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.000 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

|  |  |  |  |
| --- | --- | --- | --- |
| Inside Diameter of Elliptical Head | D | 60.0000 | in |
| Aspect Ratio of Elliptical Head | Ar | 2.00 |  |
| Head Finished (Minimum) Thickness | t | 0.8268 | in |
| Head Internal Corrosion Allowance | c | 0.0000 | in |
| Head External Corrosion Allowance | co | 0.0000 | in |

Distance from Head Centerline L1 24.0000 in

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 2.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 10.3090 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : L2 Nozl: 24 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7480 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

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: L2** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in. Actual Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

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

= (P\*D\*K)/(2\*S\*E-0.2\*P) Appendix 1-4(c)

= (363.00\*60.0000\*1.000)/( 2\*16700.00\*1.00-0.2\*363.00)

= 0.6535 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*1.1875)/(16700\*1.00+0.4\*363.00)

= 0.0256 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0143 in

**FileName : D4470**

**Nozzle Calcs. : L2 Nozl: 24 1:43p Apr 4,2014**

**UG-40, Limits of Reinforcement : [Internal Pressure]** Parallel to Vessel Wall (Diameter Limit) Parallel to Vessel Wall, opening length

Dl 4.6678 in

d 2.3339 in

Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5450 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: L2.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

Weld Size Calculations, Description: L2

Intermediate Calc. for nozzle/shell Welds Tmin 0.2180 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1526 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 389.366 psig

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

Note : Checking Nozzle in the Latitudinal direction. **Reinforcement CALCULATION, Description: L2** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in. Actual Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

**FileName : D4470**

**Nozzle Calcs. : L2 Nozl: 24 1:43p Apr 4,2014**

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

= (P\*D\*K)/(2\*S\*E-0.2\*P) Appendix 1-4(c)

= (363.00\*60.0000\*1.000)/( 2\*16700.00\*1.00-0.2\*363.00)

= 0.6535 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.00\*1.1875)/(16700\*1.00+0.4\*363.00)

= 0.0256 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0143 in

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

Parallel to Vessel Wall (Diameter Limit) Dl 4.0285 in Parallel to Vessel Wall Rn+tn+t 2.0143 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5450 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: L2.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

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

Wall Thickness for Internal/External pressures ta = 0.0256 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6535 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6535 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1346 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.135 , max( 0.6535 , 0.0625 ) ]

= 0.1346 in

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

= max( ta, tb )

= max( 0.0256 , 0.1346 )

= 0.1346 in

**FileName : D4470**

**Nozzle Calcs. : L2 Nozl: 24 1:43p Apr 4,2014**

Available Nozzle Neck Thickness = 0.875 \* 0.218 = 0.191 in --> OK

Weld Size Calculations, Description: L2

Intermediate Calc. for nozzle/shell Welds Tmin 0.2180 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1526 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 389.366 psig

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

The Drop for this Nozzle is : 0.5983 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 11.8259 in

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**FileName : D4470**

**Nozzle Calcs. : L1 Nozl: 25 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: L1 From : 30

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.633 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

|  |  |  |  |
| --- | --- | --- | --- |
| Inside Diameter of Elliptical Head | D | 60.0000 | in |
| Aspect Ratio of Elliptical Head | Ar | 2.00 |  |
| Head Finished (Minimum) Thickness | t | 0.8268 | in |
| Head Internal Corrosion Allowance | c | 0.0000 | in |
| Head External Corrosion Allowance | co | 0.0000 | in |

Distance from Head Centerline L1 24.0000 in

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 180.00 deg

Diameter 2.0000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 10.3090 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : L1 Nozl: 25 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7480 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

The Pressure Design option was Design Pressure + static head.

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

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**Insert/Set-in Nozzle No Pad, no Inside projection** Note : Checking Nozzle in the Meridional direction. **Reinforcement CALCULATION, Description: L1** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in. Actual Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

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

= (P\*D\*K)/(2\*S\*E-0.2\*P) Appendix 1-4(c)

= (363.63\*60.0000\*1.000)/( 2\*16700.00\*1.00-0.2\*363.63)

= 0.6547 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.63\*1.1875)/(16700\*1.00+0.4\*363.63)

= 0.0256 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0143 in

**FileName : D4470**

**Nozzle Calcs. : L1 Nozl: 25 1:43p Apr 4,2014**

**UG-40, Limits of Reinforcement : [Internal Pressure]** Parallel to Vessel Wall (Diameter Limit) Parallel to Vessel Wall, opening length

Dl 4.6678 in

d 2.3339 in

Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5450 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: L1.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

Weld Size Calculations, Description: L1

Intermediate Calc. for nozzle/shell Welds Tmin 0.2180 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1526 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 389.999 psig

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

Note : Checking Nozzle in the Latitudinal direction. **Reinforcement CALCULATION, Description: L1** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in. Actual Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

**FileName : D4470**

**Nozzle Calcs. : L1 Nozl: 25 1:43p Apr 4,2014**

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

= (P\*D\*K)/(2\*S\*E-0.2\*P) Appendix 1-4(c)

= (363.63\*60.0000\*1.000)/( 2\*16700.00\*1.00-0.2\*363.63)

= 0.6547 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.63\*1.1875)/(16700\*1.00+0.4\*363.63)

= 0.0256 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0143 in

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

Parallel to Vessel Wall (Diameter Limit) Dl 4.0285 in Parallel to Vessel Wall Rn+tn+t 2.0143 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5450 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: L1.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

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

Wall Thickness for Internal/External pressures ta = 0.0256 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6547 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6547 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1346 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.135 , max( 0.6547 , 0.0625 ) ]

= 0.1346 in

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

= max( ta, tb )

= max( 0.0256 , 0.1346 )

= 0.1346 in

**FileName : D4470**

**Nozzle Calcs. : L1 Nozl: 25 1:43p Apr 4,2014**

Available Nozzle Neck Thickness = 0.875 \* 0.218 = 0.191 in --> OK

Weld Size Calculations, Description: L1

Intermediate Calc. for nozzle/shell Welds Tmin 0.2180 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1526 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 389.999 psig

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

The Drop for this Nozzle is : 0.5983 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 11.8259 in

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**FileName : D4470**

**Nozzle Calcs. : T Nozl: 26 1:43p Apr 4,2014**

# INPUT VALUES, Nozzle Description: T From : 30

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure for Reinforcement Calculations P | | 363.125 psig | |
| Temperature for Internal Pressure | Temp | 248 | F |
| Design External Pressure | Pext | 14.50 | psig |
| Temperature for External Pressure | Tempex | 248 | F |

Shell Material SA-240 304L

Shell Allowable Stress at Temperature S 16700.00 psi Shell Allowable Stress At Ambient Sa 16700.00 psi

|  |  |  |  |
| --- | --- | --- | --- |
| Inside Diameter of Elliptical Head | D | 60.0000 | in |
| Aspect Ratio of Elliptical Head | Ar | 2.00 |  |
| Head Finished (Minimum) Thickness | t | 0.8268 | in |
| Head Internal Corrosion Allowance | c | 0.0000 | in |
| Head External Corrosion Allowance | co | 0.0000 | in |

Distance from Head Centerline L1 0.1000 in

User Entered Minimum Design Metal Temperature 0.00 F

## Type of Element Connected to the Shell : Nozzle

Material SA-312 TP304L

Material UNS Number S30403

Material Specification/Type Smls. & wld. pipe Allowable Stress at Temperature Sn 16700.00 psi

Allowable Stress At Ambient Sna 16700.00 psi

Diameter Basis (for tr calc only) OD Layout Angle 0.00 deg

Diameter 1.5000 in.

|  |  |  |  |
| --- | --- | --- | --- |
| Size and Thickness | Basis |  | Nominal |
| Nominal Thickness |  | tn | 80S |

Flange Material SA-182 F304

Flange Type Weld Neck Flange

Corrosion Allowance can 0.0000 in Joint Efficiency of Shell Seam at Nozzle E1 1.00

Joint Efficiency of Nozzle Neck En 1.00

Outside Projection ho 10.0000 in Weld leg size between Nozzle and Pad/Shell Wo 0.3937 in

**FileName : D4470**

**Nozzle Calcs. : T Nozl: 26 1:43p Apr 4,2014**

Groove weld depth between Nozzle and Vessel Wgnv 0.7480 in Inside Projection h 0.0000 in

Weld leg size, Inside Element to Shell Wi 0.0000 in ASME Code Weld Type per UW-16 None

Class of attached Flange 300

Grade of attached Flange GR 2.1

The Pressure Design option was Design Pressure + static head.

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

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**Insert/Set-in Nozzle No Pad, no Inside projection** Note : Checking Nozzle in the Meridional direction. **Reinforcement CALCULATION, Description: T** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 1.900 in. Actual Thickness Used in Calculation 0.200 in.

Nozzle input data check completed without errors.

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

= (P\*K1\*D))/(2\*S\*E-0.2\*P) per UG-37(a)(3)

= (363.12\*0.900\*60.0000)/(2 \*16700.00\*1.00-0.2\*363.12)

= 0.5884 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.12\*0.9500)/(16700\*1.00+0.4\*363.12)

= 0.0205 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0125 in

**FileName : D4470**

**Nozzle Calcs. : T Nozl: 26 1:43p Apr 4,2014**

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

Parallel to Vessel Wall (Diameter Limit) Dl 3.5536 in Parallel to Vessel Wall Rn+tn+t 1.7768 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5000 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: T.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

*SA-240 304L, Min Metal Temp without impact per UHA-51: -320 F*

*SA-312 TP304L, Min Metal Temp without impact per UHA-51: -320 F*

Weld Size Calculations, Description: T

Intermediate Calc. for nozzle/shell Welds Tmin 0.2000 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1400 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 389.490 psig

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

Note : Checking Nozzle in the Latitudinal direction. **Reinforcement CALCULATION, Description: T** ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 1.900 in. Actual Thickness Used in Calculation 0.200 in.

Nozzle input data check completed without errors.

**FileName : D4470**

**Nozzle Calcs. : T Nozl: 26 1:43p Apr 4,2014**

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

= (P\*K1\*D))/(2\*S\*E-0.2\*P) per UG-37(a)(3)

= (363.12\*0.900\*60.0000)/(2 \*16700.00\*1.00-0.2\*363.12)

= 0.5884 in

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

= (P\*Ro)/(S\*E+0.4\*P) per Appendix 1-1 (a)(1)

= (363.12\*0.9500)/(16700\*1.00+0.4\*363.12)

= 0.0205 in

Required Nozzle thickness under External Pressure per UG-28 : 0.0125 in

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

Parallel to Vessel Wall (Diameter Limit) Dl 3.5535 in Parallel to Vessel Wall Rn+tn+t 1.7768 in Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.5000 in

*Note:*

*Taking a UG-36(c)(3)(a) exemption for nozzle: T.*

*This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration*

*and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.*

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

Wall Thickness for Internal/External pressures ta = 0.0205 in Wall Thickness per UG16(b), tr16b = 0.0625 in Wall Thickness, shell/head, internal pressure trb1 = 0.6537 in Wall Thickness tb1 = max(trb1, tr16b) = 0.6537 in Wall Thickness, shell/head, external pressure trb2 = 0.0261 in Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in Wall Thickness per table UG-45 tb3 = 0.1268 in

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]

= min[ 0.127 , max( 0.6537 , 0.0625 ) ]

= 0.1268 in

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

= max( ta, tb )

= max( 0.0205 , 0.1268 )

= 0.1268 in

**FileName : D4470**

**Nozzle Calcs. : T Nozl: 26 1:43p Apr 4,2014**

Available Nozzle Neck Thickness = 0.875 \* 0.200 = 0.175 in --> OK

Weld Size Calculations, Description: T

Intermediate Calc. for nozzle/shell Welds Tmin 0.2000 in

# Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 0.1400 = 0.7 \* tmin. 0.2783 = 0.7 \* Wo in

NOTE : Skipping the nozzle attachment weld strength calculations.

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

# Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 389.490 psig

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

The Drop for this Nozzle is : 0.0100 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 10.8368 in

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**FileName : D4470**

**Nozzle Schedule : Step: 27 1:43p Apr 4,2014**

# Nozzle Schedule:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Nominal Flange | | | | Noz. | Wall | | Re-Pad | | | Cut | |
| Description | Size | | Sch/Type | O/Dia | | Thk | ODia | | Thick | | Length |
| in. | | Cls | | in. | in | in | | in | | in | |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| T | 1.500 | 80S | WNF | 1.900 | 0.200 | - - | 10.84 |
| Y | 2.000 | 80S | WNF | 2.375 | 0.218 | - - | 25.89 |
| L4 | 2.000 | 80S | WNF | 2.375 | 0.218 | - - | 25.89 |
| P | 2.000 | 80S | WNF | 2.375 | 0.218 | - - | 25.89 |
| V | 2.000 | 80S | WNF | 2.375 | 0.218 | - - | 25.89 |
| W1 | 2.000 | 80S | WNF | 2.375 | 0.218 | - - | 9.89 |
| L2 | 2.000 | 80S | WNF | 2.375 | 0.218 | - - | 11.83 |
| L1 | 2.000 | 80S | WNF | 2.375 | 0.218 | - - | 11.83 |
| A | 3.000 | 80S | WNF | 3.500 | 0.300 | - - | 25.92 |
| B | 3.000 | 80S | WNF | 3.500 | 0.300 | - - | 9.92 |
| F1 | 4.000 | 80S | WNF | 4.500 | 0.337 | - - | 25.95 |
| R1 | 4.000 | 80S | WNF | 4.500 | 0.337 | - - | 25.95 |
| M | 24.000 | 300 | WNF | 24.000 | 0.394 | 38.58 0.630 | 28.37 |

*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:

Shl Grve Noz Shl/Pad Pad OD Pad Grve Inside

Nozzle Material Weld Weld Weld Weld Weld in in in in in

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| T | SA-312 TP304L | 0.748 | 0.394 | - - - |
| Y | SA-312 TP304L | 0.787 | 0.394 | - - - |
| L4 | SA-312 TP304L | 0.787 | 0.394 | - - - |
| P | SA-312 TP304L | 0.787 | 0.394 | - - - |
| V | SA-312 TP304L | 0.787 | 0.394 | - - - |
| W1 | SA-312 TP304L | 0.787 | 0.394 | - - - |
| L2 | SA-312 TP304L | 0.748 | 0.394 | - - - |

**FileName : D4470**

**Nozzle Schedule : Step: 27 1:43p Apr 4,2014**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| L1 | SA-312 TP304L | 0.748 | 0.394 | - | - - |
| A | SA-312 TP304L | 0.787 | 0.394 | - | - - |
| B | SA-312 TP304L | 0.787 | 0.394 | - | - - |
| F1 | SA-312 TP304L | 0.787 | 0.394 | - | - - |
| R1 | SA-312 TP304L | 0.787 | 0.394 | - | - - |
| M | SA-240 304L | 0.787 | 0.472 | 0.512 | 0.551 - |

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

# Nozzle Miscellaneous Data:

Elevation/Distance Layout Projection Installed In Nozzle From Datum Angle Outside Inside Component

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | ft | deg. | in | in |  |
| T |  | 0.00 | 10.00 | 0.00 | right head |
| Y | 1.750 | 0.00 | 25.00 | 0.00 | shell |
| L4 | 2.750 | 0.00 | 25.00 | 0.00 | shell |
| P | 3.750 | 0.00 | 25.00 | 0.00 | shell |
| V | 4.750 | 0.00 | 25.00 | 0.00 | shell |
| W1 | 4.000 | 180.00 | 9.00 | 0.00 | shell |
| L2 |  | 0.00 | 10.31 | 0.00 | right head |
| L1 |  | 180.00 | 10.31 | 0.00 | right head |
| A | 12.000 | 0.00 | 25.00 | 0.00 | shell |
| B | 12.000 | 180.00 | 9.00 | 0.00 | shell |
| F1 | 0.750 | 0.00 | 25.00 | 0.00 | shell |
| R1 | 5.750 | 0.00 | 25.00 | 0.00 | shell |
| M | 8.500 | 0.00 | 25.00 | 0.00 | shell |

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**FileName : D4470**

**Nozzle Summary : Step: 28 1:43p Apr 4,2014**

# Nozzle Calculation Summary:

Description MAWP Ext MAPNC UG45 [tr] Weld Areas or psig psig Path Stresses

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| F1 | 402.09 | OK | 0.00 | OK 0.207 | OK | Passed |
| Y | 402.09 | ... | ... | OK 0.135 | OK | NoCalc[\*] |
| L4 | 402.09 | ... | ... | OK 0.135 | OK | NoCalc[\*] |
| P | 402.09 | ... | ... | OK 0.135 | OK | NoCalc[\*] |
| V | 402.09 | ... | ... | OK 0.135 | OK | NoCalc[\*] |
| A | 402.09 | OK | 0.00 | OK 0.189 | OK | Passed |
| M | 402.09 | OK | 0.00 | OK 0.328 | OK | Passed |
| R1 | 402.09 | OK | 0.00 | OK 0.207 | OK | Passed |
| W1 | 402.09 | ... | ... | OK 0.135 | OK | NoCalc[\*] |
| B | 402.09 | OK | 0.00 | OK 0.189 | OK | Passed |
| L2 | 389.37 | ... | ... | OK 0.135 | OK | NoCalc[\*] |
| L2 | 389.37 | ... | ... | OK 0.135 | OK | NoCalc[\*] |
| L1 | 389.37 | ... | ... | OK 0.135 | OK | NoCalc[\*] |
| L1 | 389.37 | ... | ... | OK 0.135 | OK | NoCalc[\*] |
| T | 389.37 | ... | ... | OK 0.127 | OK | NoCalc[\*] |
| T | 389.37 | ... | ... | OK 0.127 | OK | NoCalc[\*] |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Min. - Nozzles | 389.37 | T | 0.00 | B |
| Min. Shell&Flgs | 389.37 | 30 | 40 390.12 |  |

Computed Vessel M.A.W.P. 389.37 psig

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

Note: MAWPs (Internal Case) shown above are at the High Point. Check the Spatial Relationship between the Nozzles

From Node Nozzle Description X Coordinate, Layout Angle, Dia. Limit

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 20 | F1 | 9.984 | 0.000 | 18.358 |
| 20 | Y | 21.984 | 0.000 | 4.107 |
| 20 | L4 | 33.984 | 0.000 | 4.107 |
| 20 | P | 45.984 | 0.000 | 4.107 |
| 20 | V | 57.984 | 0.000 | 4.107 |
| 20 | A | 144.984 | 0.000 | 17.358 |
| 20 | M | 102.984 | 0.000 | 46.425 |
| 20 | R1 | 69.984 | 0.000 | 18.358 |
| 20 | W1 | 48.984 | 180.000 | 4.107 |

**FileName : D4470**

**Nozzle Summary : Step: 28 1:43p Apr 4,2014**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 20 | B | 144.984 | 180.000 | 17.358 |
| 30 | L2 | 0.000 | 0.000 | 4.029 |
| 30 | L1 | 0.000 | 180.000 | 4.029 |
| 30 | T | 0.000 | 0.000 | 3.554 |

# The nozzle spacing is computed by the following:

= Sqrt( ll2 + lc2 ) where

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

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

No interference violations have been detected !

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**FileName : D4470**

**MDMT Summary : Step: 29 1:43p Apr 4,2014**

# Minimum Design Metal Temperature Results Summary :

Curve Basic Reduced UG-20(f) Thickness Gov E\* Description MDMT MDMT MDMT ratio Thk

Notes F F F in

|  |  |  |
| --- | --- | --- |
| left head | [16] | -320 |
| shell | [16] | -320 |
| right head | [16] | -320 |
| F1 | [15] | -320 |
| Y | [15] | -320 |
| L4 | [15] | -320 |
| P | [15] | -320 |
| V | [15] | -320 |
| A | [15] | -320 |
| M | [15] | -320 |
| R1 | [15] | -320 |
| W1 | [15] | -320 |
| B | [15] | -320 |
| L2 | [15] | -320 |
| L1 | [15] | -320 |
| T | [15] | -320 |

Required Minimum Design Metal Temperature 0 F Warmest Computed Minimum Design Metal Temperature -320 F

# 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.

1. - Calculations in the Knuckle Portion of the Head.
2. - Calculated (Body Flange) Flange MDMT.
3. - Calculated Flat Head MDMT per UCS-66.3
4. - Tubesheet MDMT, shell side, if applicable
5. - Tubesheet MDMT, tube side, if applicable
6. - Nozzle Material
7. - Shell or Head Material

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

**FileName : D4470**

**MDMT Summary : Step: 29 1:43p Apr 4,2014**

UCS-66(i) was not considered.

Notes:

Impact test temps were not entered in and not considered in the analysis. UCS-66(i) applies to impact tested materials not by specification and

UCS-66(g) applies to materials impact tested per UG-84.1 General Note (c). The Basic MDMT includes the (30F) PWHT credit if applicable.

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**FileName : D4470**

**Vessel Design Summary : Step: 30 1:43p Apr 4,2014**

# ASME Code, Section VIII, Division 1, 2013

Diameter Spec : 60.000 in ID

Vessel Design Length, Tangent to Tangent 12.50 ft

Specified Datum Line Distance 0.08 ft

Shell Material SA-240 304L

Nozzle Material SA-312 TP304L

Nozzle Material SA-240 304L

Re-Pad Material SA-240 304L

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Internal | Design | Temperature | 248 | F |
| Internal | Design | Pressure | 363.000 | psig |
| External | Design | Temperature | 248 | F |
| External | Design | Pressure | 14.500 | psig |

Maximum Allowable Working Pressure 389.366 psig External Max. Allowable Working Pressure 121.393 psig Hydrostatic Test Pressure 506.175 psig

Required Minimum Design Metal Temperature 0 F Warmest Computed Minimum Design Metal Temperature -320 F

Wind Design Code ASCE 7-05

Earthquake Design Code ASCE 7-05

**Element Pressures and MAWP: psig**

Element Desc | Design Pres. | External | M.A.W.P | Corrosion

| + Stat. head | Pressure | | Allowance

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| left head | 363.760 | 14.500 | 389.366 | 0.0000 |
| shell | 363.760 | 14.500 | 402.091 | 0.0000 |
| right head | 363.760 | 14.500 | 389.366 | 0.0000 |

Liquid Level: 3.00 ft Dens.: 36.485 lb/ft^3 Sp. Gr.: 0.585

Element "To" Elev Length Element Thk R e q d T h k Joint Eff Type ft ft in Int. Ext. Long Circ

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Ellipse | 0.00 | 0.082 | 0.945 | 0.771 | 0.163 | 0.85 | 0.85 |
| Cylinder | 12.34 | 12.336 | 0.866 | 0.781 | 0.299 | 0.85 | 0.85 |
| Ellipse | 12.42 | 0.082 | 0.945 | 0.771 | 0.163 | 0.85 | 0.85 |

**FileName : D4470**

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Element thicknesses are shown as Nominal if specified, otherwise are Minimum

# Saddle Parameters:

Saddle Width 7.250 in

Saddle Bearing Angle 120.000 deg.

Centerline Dimension 43.000 in

Wear Pad Width 11.811 in

Wear Pad Thickness 0.472 in

Wear Pad Bearing Angle 132.000 deg. Distance from Saddle to Tangent 21.000 in

Baseplate Length 54.000 in

Baseplate Thickness 0.630 in

Baseplate Width 8.000 in

Number of Ribs (including outside ribs) 4

Rib Thickness 0.551 in

Web Thickness 0.551 in

Height of Center Web 9.969 in

# Summary of Maximum Saddle Loads, Operating Case :

Maximum Vertical Saddle Load 13142.88 lbf Maximum Transverse Saddle Shear Load 989.19 lbf Maximum Longitudinal Saddle Shear Load 1160.64 lbf

# Summary of Maximum Saddle Loads, Hydrotest Case :

Maximum Vertical Saddle Load 16307.61 lbf Maximum Transverse Saddle Shear Load 0.00 lbf

Maximum Longitudinal Saddle Shear Load 0.00 lbf

**Weights:**

|  |  |  |
| --- | --- | --- |
| Fabricated - Bare W/O Removable Internals | 14485.0 | lbm |
| Shop Test - Fabricated + Water ( Full ) | 31842.3 | lbm |
| Shipping - Fab. + Rem. Intls.+ Shipping App. | 14838.1 | lbm |
| Erected - Fab. + Rem. Intls.+ Insul. (etc) | 14838.1 | lbm |
| Empty - Fab. + Intls. + Details + Wghts. | 14838.1 | lbm |
| Operating - Empty + Operating Liquid (No CA) | 21224.3 | lbm |
| Field Test - Empty Weight + Water (Full) | 32195.4 | lbm |

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