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| **طرح نگهداشت و افزایش تولید 27 مخزن** |
| **Thermal/Mechanical Calculation Book****نگهداشت و افزایش تولید میدان نفتی بینک** |
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**REVISION RECORD SHEET**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **5** | X | X | X |  |  | **70** |  |  | X |  |  |
| **6** | X | X | X |  |  | **71** |  |  | X |  |  |
| **7** | X | X | X |  |  | **72** |  |  | X |  |  |
| **8** | X | X | X |  |  | **73** |  |  | X |  |  |
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| **11** |  |  | X |  |  | **76** |  |  | X |  |  |
| **12** |  |  | X |  |  | **77** |  |  | X |  |  |
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| **19** |  |  | X |  |  | **84** |  |  | X |  |  |
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| **24** |  |  | X |  |  | **89** |  |  | X |  |  |
| **25** |  |  | X |  |  | **90** |  |  | X |  |  |
| **26** |  |  | X |  |  | **91** |  |  | X |  |  |
| **27** |  |  | X |  |  | **92** |  |  | X |  |  |
| **28** |  |  | X |  |  | **93** |  |  | X |  |  |
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| **30** |  |  | X |  |  | **95** |  |  |  |  |  |
| **31** |  |  | X |  |  | **96** |  |  |  |  |  |
| **32** |  |  | X |  |  | **97** |  |  |  |  |  |
| **33** |  |  | X |  |  | **98** |  |  |  |  |  |
| **34** |  |  | X |  |  | **99** |  |  |  |  |  |
| **35** |  |  | X |  |  | **100** |  |  |  |  |  |
| **36** |  |  | X |  |  | **101** |  |  |  |  |  |
| **37** |  |  | X |  |  | **102** |  |  |  |  |  |
| **38** |  |  | X |  |  | **103** |  |  |  |  |  |
| **39** |  |  | X |  |  | **104** |  |  |  |  |  |
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| **45** |  |  | X |  |  | **110** |  |  |  |  |  |
| **46** |  |  | X |  |  | **111** |  |  |  |  |  |
| **47** |  |  | X |  |  | **112** |  |  |  |  |  |
| **48** |  |  | X |  |  | **113** |  |  |  |  |  |
| **49** |  |  | X |  |  | **114** |  |  |  |  |  |
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1. **INTRODUCTION**

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

**GENERAL DEFINITION**

The following terms shall be used in this document.

|  |  |
| --- | --- |
| CLIENT:  | National Iranian South Oilfields Company (NISOC)  |
| PROJECT: | Binak Oilfield Development – Manufacturing (w/Engineering & Material Supply) of Air Coolers |
| EPD/EPC CONTRACTOR (GC):  | Petro Iran Development Company (PEDCO) |
| OWNER:  | OWNER is collectively refer to National Iranian South Oil Company (NISOC) and Petro Iran Development Company (PEDCO) |
| EPC CONTRACTOR: | Joint Venture of : Hirgan Energy – Design & Inspection(D&I) Companies |
| VENDOR: | Aban Air Cooler (AAC) |
| EXECUTOR:  | Executor is the party which carries out all or part of construction and/or commissioning for the project. |
| THIRD PARTY INSPECTOR (TPI): | Third Party Inspector |
| SHALL: | Is used where a provision is mandatory. |
| SHOULD: | Is used where a provision is advisory only. |
| WILL:  | Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR. |
| MAY:  | Is used where a provision is completely discretionary. |
|  |  |
|  |  |

1. **ThermalCalculation Book**

















**Mechanical Calculation**

1. **Mechanical Calculation Book**

## Stationary Header Calculation @ Design Pressure for ae-2101.

**Input Echo, COMPONENT 1, Description: St.AE-2101**

 Figure Number Analyzed A8

 Design Internal Pressure P 22.0000 bars

 Design Temperature Temp 155.0000 C

 VESSEL MATERIAL DATA:

 Material Specification SA-240 316L

 Shell Allowable Stress at Design Temp S 114.3898 N./mm^2

 Shell Allowable Stress at Ambient SA 115.1465 N./mm^2

 Shell Yield Stress at Design Temperature Sy 129.8699 N./mm^2

 SHORT-SIDE VESSEL DATA:

 Short-side Length Dimension H 160.0000 mm.

 Minimum Thickness of Short-side Plates t1 15.0000 mm.

 Mid-side Joint Efficiency on Short-side E 0.8500

 Corner Joint Efficiency on Short-side EC 0.8500

 LONG-SIDE VESSEL DATA:

 Long-side Length Dimension h 122.0000 mm.

 Minimum Thickness of Long-side Plates t2 20.0000 mm.

 Mid-side Joint Efficiency on Long-side E 0.8500

 ADDITIONAL VESSEL DATA:

 Minimum Thickness of End Plate t5 20.0000 mm.

 C-Factor for End Plate Cf\_Epl 0.2000

 Long-side Plate # 1,

 Pitch Distance p 61.0000 mm.

 Uniform Hole Diameter d0 25.6500 mm.

 Depth of Holes T0 20.0000 mm.

 Long-side Plate # 2,

 Pitch Distance p 61.0000 mm.

 # 1: Hole Diameter d0 36.3000 mm.

 Hole Depth T0 2.7000 mm.

 # 2: Hole Diameter d1 28.5750 mm.

 Hole Depth T1 17.3000 mm.

 STAY PLATE MATERIAL DATA:

 Stay Material Specification SA-240 316L

 Stay Allowable Stress at Design Temp Sr 114.3898 N./mm^2

 Stay Allowable Stress at Ambient SA 115.1465 N./mm^2

 Stay Yield Stress at Design Temp Sy 129.8699 N./mm^2

 STAY PLATE DATA:

 Minimum Thickness of Stay t3 10.0000 mm.

 Minimum Thickness of Stay t4 10.0000 mm.

 The Stay(s) Are Not Welded to the End Plate

**Rectangular Vessel Results, Item number 1, Desc: St.AE-2101**

**ASME Code, Section VIII, Division 1, 2019 App. 13**

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

***Short-side 1 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 15.000 - 0.000 / 2

 = 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 15.000 - 0.000 ) / 2

 = -7.500 mm.

***Short-side 2 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 15.000 - 0.000 / 2

 = 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 15.000 - 0.000 ) / 2

 = -7.500 mm.

***Long-side 1 Calculations***

Effective Diameter [De]: 25.700 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 61.000 - 25.700 / 61.000

 = 0.579

Bending Ligament Efficiency [Eb]:

*As diameter holes are uniform Eb = Em*

 = 0.579

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 2 Calculations***

Effective Diameter [De]:

 = ( d0 \* T0 + d1 \* T1 + d2 \* T2 ) / ( t1 - CA )

 = ( 36.30 \* 2.70 + 28.57 \* 17.30 + 0.00 \* 0.00 ) /

 ( 20.00 - 0.00 )

 = 29.618 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 61.000 - 29.618 / 61.000

 = 0.514

Dist from Neutral axis of c/s to extreme fibers [Ci & Co]:

*Calculation of Xbar:*

 = (( b0 \* T0 \* ( T0/2 + T1 + T2 )) + ( b1 \* T1 \*

 ( T1/2 + T2 )) + ( b2 \* T2 \* ( T2/2 ))) /

 ( b0 \* T0 + b1 \* T1 + b2 \* T2 )

 = (( 0.97 \* 2.70 \* ( 2.70 /2 + 17.30 + 0.00 )) + ( 1.28\* 17.30 \*

 ( 17.30 /2 + 0.00 )) + ( 2.40 \* 0.00 \* ( 0.00 /2 ))) /

 ( 0.97 \* 2.70 + 1.28 \* 17.30 + 2.40 \* 0.00 )

 = 9.713 mm.

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 *Ci = Xbar*

 = 9.713 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t - CA - Xbar )

 = -( 20.000 - 0.000 - 9.713 )

 = -10.287 mm.

Moment of Inertia (Section 13-6, Equation (5)) [I]:

 = 0.079 cm\*\*4

Effective Diameter [De]:

 = Pitch - (( 6 \* I ) / (( t - CA)^2 \* (-Co)))

 = 61.00 - (( 6 \* 0.08 ) / ((20.00 - 0.00 )^2 \* (10.29 )))

 = 31.851 mm.

Bending Ligament Efficiency [Eb]:

 = Pitch - De / Pitch

 = 61.000 - 31.851 / 61.000

 = 0.478

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

 Em Eb Ci Co

 Short-side 1 0.850 0.850 7.500 -7.500

 2 0.850 0.850 7.500 -7.500

 Long-side 1 0.579 0.579 10.000 -10.000

 2 0.514 0.478 9.713 -10.287

**Moment of Inertia of a Strip of the Vessel Wall:**

 Thickness t1, I1 = 0.0281 cm\*\*4

 Thickness t2, I2 = 0.0667 cm\*\*4

**Rectangular Vessel Parameters:**

 Alpha = H / h = 1.3115

 K = (I2/I1)\*Alpha = 3.1087

**Membrane Stress Calculations per Section 13-9**

***Membrane Stresses at Short-side 1***

Membrane Stress at Short-side 1 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 22.00 \* 122.00 / ( 2 \* 15.00 ) \* { 3- [( 6 + 3.11 \*

 ( 11 - 1.312) / ( 3 + 5 \* 3.11 )]}

 = 10.03 N./mm^2

***Membrane Stresses at Short-side 2***

Membrane Stress at Short-side 2 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 22.00 \* 122.00 / ( 2 \* 15.00 ) \* { 3- [( 6 + 3.11 \*

 ( 11 - 1.312) / ( 3 + 5 \* 3.11 )]}

 = 10.03 N./mm^2

***Membrane Stresses at Long-side 1***

Membrane Stress at Long-side 1 at A [Sml]:

 = P \* H / 2 \* t2

 = 22.00 \* 160.00 / 2 \* 20.00

 = 8.80 N./mm^2

 *If Em( 0.579 ) < E( 0.850 ) and Eb( 0.579 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 8.80 / 0.58

 = 15.21 N./mm^2

***Membrane Stresses at Long-side 2***

Membrane Stress at Long-side 2 at A [Sml]:

 = P \* H / 2 \* t2

 = 22.00 \* 160.00 / 2 \* 20.00

 = 8.80 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 8.80 / 0.51

 = 17.11 N./mm^2

***Membrane Stresses at Stay Plate***

Membrane Stress at Stay Plate [t3]:

 = P \* h / ( 2 \* t3 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 22.00 \* 122.00 / ( 2 \* 10.00 ) \* [( 6 + 3.11 \* ( 11 -

 1.312) / ( 3 + 5 \* 3.11 )]

 = 25.22 N./mm^2

Membrane Stress at Stay Plate [t4]:

 = P \* h / ( 2 \* t4 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 22.00 \* 122.00 / ( 2 \* 10.00 ) \* [( 6 + 3.11 \* ( 11 -

 1.312) / ( 3 + 5 \* 3.11 )]

 = 25.22 N./mm^2

**MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9,**

 **Equations (13-15). (N./mm^2) :**

 STRESS LOCATIONS Actual Allowable

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

 Short-side 1 10.03 97.23

 Short-side 2 10.03 97.23

 Short-side Corner 10.03 97.23

 Long-side 1 at A 15.21 114.39

 Long-side 2 at A 17.11 114.39

 Long-side Corner 8.80 97.23

 Stay Plate (t3) 25.22 114.39

 Stay Plate (t4) 25.22 114.39

**Bending Stress Calculations per Section 13-9**

***Bending Stresses at Short-side 1***

Bending Stress at Short-side 1 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 22.00 \* 7.50 / ( 24 \* 0.03 ) \* [ -3 \* 160.002 + 2 \* 122.002 \*

 (( 3 + 5 \* 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))]

 = -71.06 N./mm^2

Bending Stress at Short-side 1 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 22.00 \* -7.50 /( 24 \* 0.03 ) \* [ -3 \* 160.002 + 2 \* 122.002 \*

 (( 3 + 5 \* 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))]

 = 71.06 N./mm^2

Bending Stress at Short-side 1 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 22.00 \* 122.002 \* 7.50 / ( 12 \* 0.03 ) \* (( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))

 = 116.69 N./mm^2

Bending Stress at Short-side 1 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 22.00 \* 122.002 \* -7.50 / ( 12 \* 0.03 ) \* (( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))

 = -116.69 N./mm^2

***Bending Stresses at Short-side 2***

Bending Stress at Short-side 2 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 22.00 \* 7.50 / ( 24 \* 0.03 ) \* [ -3 \* 160.002 + 2 \* 122.002 \*

 (( 3 + 5 \* 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))]

 = -71.06 N./mm^2

Bending Stress at Short-side 2 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 22.00 \* -7.50 /( 24 \* 0.03 ) \* [ -3 \* 160.002 + 2 \* 122.002 \*

 (( 3 + 5 \* 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))]

 = 71.06 N./mm^2

Bending Stress at Short-side 2 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 22.00 \* 122.002 \* 7.50 / ( 12 \* 0.03 ) \* (( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))

 = 116.69 N./mm^2

Bending Stress at Short-side 2 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 22.00 \* 122.002 \* -7.50 / ( 12 \* 0.03 ) \* (( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))

 = -116.69 N./mm^2

***Bending Stresses at Long-side 1***

Bending Stress at Long-side 1 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 22.00 \* 122.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 3.11 \*

 ( 6 - 1.312)) / ( 3 + 5 \* 3.11 )]

 = 35.99 N./mm^2

 *If Em( 0.579 ) < E( 0.850 ) and Eb( 0.579 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 35.99 / 0.58

 = 62.20 N./mm^2

Bending Stress at Long-side 1 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 22.00 \* 122.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 3.11 \*

 ( 6 - 1.312)) / ( 3 + 5 \* 3.11 )]

 = -35.99 N./mm^2

 *If Em( 0.579 ) < E( 0.850 ) and Eb( 0.579 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -35.99 / 0.58

 = -62.20 N./mm^2

Bending Stress at Long-side 1 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 22.00 \* 122.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 )]

 = 65.64 N./mm^2

Bending Stress at Long-side 1 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 22.00 \* 122.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 )]

 = -65.64 N./mm^2

***Bending Stresses at Long-side 2***

Bending Stress at Long-side 2 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 22.00 \* 122.002 \* 9.71 / ( 12 \* 0.07 ) \* [( 3 + 3.11 \*

 ( 6 - 1.312)) / ( 3 + 5 \* 3.11 )]

 = 34.96 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 34.96 / 0.48

 = 73.16 N./mm^2

Bending Stress at Long-side 2 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 22.00 \* 122.002 \* -10.29 / ( 12 \* 0.07 ) \* [( 3 + 3.11 \*

 ( 6 - 1.312)) / ( 3 + 5 \* 3.11 )]

 = -37.03 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -37.03 / 0.48

 = -77.49 N./mm^2

Bending Stress at Long-side 2 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 22.00 \* 122.002 \* 9.71 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 )]

 = 63.75 N./mm^2

Bending Stress at Long-side 2 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 22.00 \* 122.002 \* -10.29 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 )]

 = -67.52 N./mm^2

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,**

 **Equations (16-19). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -71.06 71.06 145.85

 at Q 116.69 -116.69 145.85

 Short-side 2 at N -71.06 71.06 145.85

 at Q 116.69 -116.69 145.85

 Long-side 1 at M 62.20 -62.20 171.58

 at Q 65.64 -65.64 145.85

 Long-side 2 at M 73.16 -77.49 171.58

 at Q 63.75 -67.52 145.85

**Total Stress Calculations per Section 13-9**

***Total Stresses at Short-side 1***

Total Stress at short side 1 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 10.03 + -71.06

 = -61.03 N./mm^2

Total Stress at short side 1 at N outer [STS\_No]:

 = Sms + SbsNo

 = 10.03 + 71.06

 = 81.08 N./mm^2

Total Stress at short side 1 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 10.03 + 116.69

 = 126.71 N./mm^2

Total Stress at short side 1 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 10.03 + -116.69

 = -106.66 N./mm^2

***Total Stresses at Short-side 2***

Total Stress at short side 2 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 10.03 + -71.06

 = -61.03 N./mm^2

Total Stress at short side 2 at N outer [STS\_No]:

 = Sms + SbsNo

 = 10.03 + 71.06

 = 81.08 N./mm^2

Total Stress at short side 2 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 10.03 + 116.69

 = 126.71 N./mm^2

Total Stress at short side 2 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 10.03 + -116.69

 = -106.66 N./mm^2

***Total Stresses at Long-side 1***

Total Stress at long side 1 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 15.21 + 62.20

 = 77.40 N./mm^2

Total Stress at long side 1 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 15.21 + -62.20

 = -46.99 N./mm^2

Total Stress at long side 1 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 8.80 + 65.64

 = 74.44 N./mm^2

Total Stress at long side 1 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 8.80 + -65.64

 = -56.84 N./mm^2

***Total Stresses at Long-side 2***

Total Stress at long side 2 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 17.11 + 73.16

 = 90.26 N./mm^2

Total Stress at long side 2 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 17.11 + -77.49

 = -60.38 N./mm^2

Total Stress at long side 2 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 8.80 + 63.75

 = 72.55 N./mm^2

Total Stress at long side 2 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 8.80 + -67.52

 = -58.72 N./mm^2

**TOTAL STRESSES: Total Stress Calculations per Section 13-9,**

 **Equations (20-24). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -61.03 81.08 145.85

 at Q 126.71 -106.66 145.85

 Short-side 2 at N -61.03 81.08 145.85

 at Q 126.71 -106.66 145.85

 Long-side 1 at M 77.40 -46.99 171.58

 at Q 74.44 -56.84 145.85

 Long-side 2 at M 90.26 -60.38 171.58

 at Q 72.55 -58.72 145.85

**End Plate Stresses (N./mm^2):**

 Actual Allowable

 End Plate 67.73 114.39

**Required End Plate thickness due to Internal Pressure [trEP]:**

 = d \* sqrt( Z \* C \* P / ( SE ) ) + ca

 = 160.000 \* sqrt( 2.405 \* 0.200 \* 22.000 / ( 114.390 ) ) + 0.000

 = 15.390 mm.

**End Plate MAWP at given Thickness [MAWPEP]:**

 = ((T-ca)/d)^2 \* ((SE)/(C\*Z)) per UG-34 (c)(3)

 = ((20.0000-0.0000)/160.0000)^2\*((114)/(.20\*2.41))

 = 37.154 bars

 *where Z is:*

 = min( 3.4 - 2.4( d/D ), 2.5 )

 = min( 3.4 - 2.4( 160.000 / 386.000 ), 2.5 )

 = 2.405

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 25.22 N./mm^2

 High Stress Percentage 22.05 %

 M.A.W.P. for Membrane Stresses 99.78 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -116.69 N./mm^2

 High Stress Percentage 80.01 %

 M.A.W.P. for Bending Stresses 27.50 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 126.71 N./mm^2

 High Stress Percentage 86.88 %

 M.A.W.P. for Total Stresses 25.32 bars

**Rectangular Vessel Results For Item 1 : A8**

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 25.22 N./mm^2

 High Stress Percentage 22.05 %

 M.A.W.P. for Membrane Stresses 99.78 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -116.69 N./mm^2

 High Stress Percentage 80.01 %

 M.A.W.P. for Bending Stresses 27.50 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 126.71 N./mm^2

 High Stress Percentage 86.88 %

 M.A.W.P. for Total Stresses 25.32 bars

## Stationary Header Calculation @ test Pressure for ae-2101.

**Input Echo, COMPONENT 1, Description: St.AE-2101**

 Figure Number Analyzed A8

 Design Internal Pressure P 28.6000 bars

 Design Temperature Temp 25.0000 C

 VESSEL MATERIAL DATA:

 Material Specification SA-240 316L

 Shell Allowable Stress at Design Temp S 155.0000 N./mm^2

 Shell Allowable Stress at Ambient SA 155.0000 N./mm^2

 Shell Yield Stress at Design Temperature Sy 172.3750 N./mm^2

 SHORT-SIDE VESSEL DATA:

 Short-side Length Dimension H 160.0000 mm.

 Minimum Thickness of Short-side Plates t1 15.0000 mm.

 Mid-side Joint Efficiency on Short-side E 0.8500

 Corner Joint Efficiency on Short-side EC 0.8500

 LONG-SIDE VESSEL DATA:

 Long-side Length Dimension h 122.0000 mm.

 Minimum Thickness of Long-side Plates t2 20.0000 mm.

 Mid-side Joint Efficiency on Long-side E 0.8500

 ADDITIONAL VESSEL DATA:

 Minimum Thickness of End Plate t5 20.0000 mm.

 C-Factor for End Plate Cf\_Epl 0.2000

 Long-side Plate # 1,

 Pitch Distance p 61.0000 mm.

 Uniform Hole Diameter d0 25.6500 mm.

 Depth of Holes T0 20.0000 mm.

 Long-side Plate # 2,

 Pitch Distance p 61.0000 mm.

 # 1: Hole Diameter d0 36.3000 mm.

 Hole Depth T0 2.7000 mm.

 # 2: Hole Diameter d1 28.5750 mm.

 Hole Depth T1 17.3000 mm.

 STAY PLATE MATERIAL DATA:

 Stay Material Specification SA-240 316L

 Stay Allowable Stress at Design Temp Sr 114.3898 N./mm^2

 Stay Allowable Stress at Ambient SA 115.1465 N./mm^2

 Stay Yield Stress at Design Temp Sy 129.8699 N./mm^2

 STAY PLATE DATA:

 Minimum Thickness of Stay t3 10.0000 mm.

 Minimum Thickness of Stay t4 10.0000 mm.

 The Stay(s) Are Not Welded to the End Plate

**Rectangular Vessel Results, Item number 1, Desc: St.AE-2101**

**ASME Code, Section VIII, Division 1, 2019 App. 13**

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

***Short-side 1 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 15.000 - 0.000 / 2

 = 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 15.000 - 0.000 ) / 2

 = -7.500 mm.

***Short-side 2 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 15.000 - 0.000 / 2

 = 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 15.000 - 0.000 ) / 2

 = -7.500 mm.

***Long-side 1 Calculations***

Effective Diameter [De]: 25.650 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 61.000 - 25.650 / 61.000

 = 0.580

Bending Ligament Efficiency [Eb]:

*As diameter holes are uniform Eb = Em*

 = 0.580

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 2 Calculations***

Effective Diameter [De]:

 = ( d0 \* T0 + d1 \* T1 + d2 \* T2 ) / ( t1 - CA )

 = ( 36.30 \* 2.70 + 28.57 \* 17.30 + 0.00 \* 0.00 ) /

 ( 20.00 - 0.00 )

 = 29.618 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 61.000 - 29.618 / 61.000

 = 0.514

Dist from Neutral axis of c/s to extreme fibers [Ci & Co]:

*Calculation of Xbar:*

 = (( b0 \* T0 \* ( T0/2 + T1 + T2 )) + ( b1 \* T1 \*

 ( T1/2 + T2 )) + ( b2 \* T2 \* ( T2/2 ))) /

 ( b0 \* T0 + b1 \* T1 + b2 \* T2 )

 = (( 0.97 \* 2.70 \* ( 2.70 /2 + 17.30 + 0.00 )) + ( 1.28\* 17.30 \*

 ( 17.30 /2 + 0.00 )) + ( 2.40 \* 0.00 \* ( 0.00 /2 ))) /

 ( 0.97 \* 2.70 + 1.28 \* 17.30 + 2.40 \* 0.00 )

 = 9.713 mm.

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 *Ci = Xbar*

 = 9.713 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t - CA - Xbar )

 = -( 20.000 - 0.000 - 9.713 )

 = -10.287 mm.

Moment of Inertia (Section 13-6, Equation (5)) [I]:

 = 0.079 cm\*\*4

Effective Diameter [De]:

 = Pitch - (( 6 \* I ) / (( t - CA)^2 \* (-Co)))

 = 61.00 - (( 6 \* 0.08 ) / ((20.00 - 0.00 )^2 \* (10.29 )))

 = 31.851 mm.

Bending Ligament Efficiency [Eb]:

 = Pitch - De / Pitch

 = 61.000 - 31.851 / 61.000

 = 0.478

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

 Em Eb Ci Co

 Short-side 1 0.850 0.850 7.500 -7.500

 2 0.850 0.850 7.500 -7.500

 Long-side 1 0.580 0.580 10.000 -10.000

 2 0.514 0.478 9.713 -10.287

**Moment of Inertia of a Strip of the Vessel Wall:**

 Thickness t1, I1 = 0.0281 cm\*\*4

 Thickness t2, I2 = 0.0667 cm\*\*4

**Rectangular Vessel Parameters:**

 Alpha = H / h = 1.3115

 K = (I2/I1)\*Alpha = 3.1087

**Membrane Stress Calculations per Section 13-9**

***Membrane Stresses at Short-side 1***

Membrane Stress at Short-side 1 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 28.60 \* 122.00 / ( 2 \* 15.00 ) \* { 3- [( 6 + 3.11 \*

 ( 11 - 1.312) / ( 3 + 5 \* 3.11 )]}

 = 13.04 N./mm^2

***Membrane Stresses at Short-side 2***

Membrane Stress at Short-side 2 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 28.60 \* 122.00 / ( 2 \* 15.00 ) \* { 3- [( 6 + 3.11 \*

 ( 11 - 1.312) / ( 3 + 5 \* 3.11 )]}

 = 13.04 N./mm^2

***Membrane Stresses at Long-side 1***

Membrane Stress at Long-side 1 at A [Sml]:

 = P \* H / 2 \* t2

 = 28.60 \* 160.00 / 2 \* 20.00

 = 11.44 N./mm^2

 *If Em( 0.580 ) < E( 0.850 ) and Eb( 0.580 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 11.44 / 0.58

 = 19.74 N./mm^2

***Membrane Stresses at Long-side 2***

Membrane Stress at Long-side 2 at A [Sml]:

 = P \* H / 2 \* t2

 = 28.60 \* 160.00 / 2 \* 20.00

 = 11.44 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 11.44 / 0.51

 = 22.24 N./mm^2

***Membrane Stresses at Stay Plate***

Membrane Stress at Stay Plate [t3]:

 = P \* h / ( 2 \* t3 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 28.60 \* 122.00 / ( 2 \* 10.00 ) \* [( 6 + 3.11 \* ( 11 -

 1.312) / ( 3 + 5 \* 3.11 )]

 = 32.79 N./mm^2

Membrane Stress at Stay Plate [t4]:

 = P \* h / ( 2 \* t4 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 28.60 \* 122.00 / ( 2 \* 10.00 ) \* [( 6 + 3.11 \* ( 11 -

 1.312) / ( 3 + 5 \* 3.11 )]

 = 32.79 N./mm^2

**MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9,**

 **Equations (13-15). (N./mm^2) :**

 STRESS LOCATIONS Actual Allowable

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

 Short-side 1 13.04 131.75

 Short-side 2 13.04 131.75

 Short-side Corner 13.04 131.75

 Long-side 1 at A 19.74 155.00

 Long-side 2 at A 22.24 155.00

 Long-side Corner 11.44 131.75

 Stay Plate (t3) 32.79 114.39

 Stay Plate (t4) 32.79 114.39

**Bending Stress Calculations per Section 13-9**

***Bending Stresses at Short-side 1***

Bending Stress at Short-side 1 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 28.60 \* 7.50 / ( 24 \* 0.03 ) \* [ -3 \* 160.002 + 2 \* 122.002 \*

 (( 3 + 5 \* 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))]

 = -92.37 N./mm^2

Bending Stress at Short-side 1 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 28.60 \* -7.50 /( 24 \* 0.03 ) \* [ -3 \* 160.002 + 2 \* 122.002 \*

 (( 3 + 5 \* 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))]

 = 92.37 N./mm^2

Bending Stress at Short-side 1 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 28.60 \* 122.002 \* 7.50 / ( 12 \* 0.03 ) \* (( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))

 = 151.69 N./mm^2

Bending Stress at Short-side 1 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 28.60 \* 122.002 \* -7.50 / ( 12 \* 0.03 ) \* (( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))

 = -151.69 N./mm^2

***Bending Stresses at Short-side 2***

Bending Stress at Short-side 2 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 28.60 \* 7.50 / ( 24 \* 0.03 ) \* [ -3 \* 160.002 + 2 \* 122.002 \*

 (( 3 + 5 \* 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))]

 = -92.37 N./mm^2

Bending Stress at Short-side 2 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 28.60 \* -7.50 /( 24 \* 0.03 ) \* [ -3 \* 160.002 + 2 \* 122.002 \*

 (( 3 + 5 \* 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))]

 = 92.37 N./mm^2

Bending Stress at Short-side 2 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 28.60 \* 122.002 \* 7.50 / ( 12 \* 0.03 ) \* (( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))

 = 151.69 N./mm^2

Bending Stress at Short-side 2 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 28.60 \* 122.002 \* -7.50 / ( 12 \* 0.03 ) \* (( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 ))

 = -151.69 N./mm^2

***Bending Stresses at Long-side 1***

Bending Stress at Long-side 1 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 28.60 \* 122.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 3.11 \*

 ( 6 - 1.312)) / ( 3 + 5 \* 3.11 )]

 = 46.79 N./mm^2

 *If Em( 0.580 ) < E( 0.850 ) and Eb( 0.580 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 46.79 / 0.58

 = 80.74 N./mm^2

Bending Stress at Long-side 1 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 28.60 \* 122.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 3.11 \*

 ( 6 - 1.312)) / ( 3 + 5 \* 3.11 )]

 = -46.79 N./mm^2

 *If Em( 0.580 ) < E( 0.850 ) and Eb( 0.580 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -46.79 / 0.58

 = -80.74 N./mm^2

Bending Stress at Long-side 1 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 28.60 \* 122.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 )]

 = 85.33 N./mm^2

Bending Stress at Long-side 1 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 28.60 \* 122.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 )]

 = -85.33 N./mm^2

***Bending Stresses at Long-side 2***

Bending Stress at Long-side 2 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 28.60 \* 122.002 \* 9.71 / ( 12 \* 0.07 ) \* [( 3 + 3.11 \*

 ( 6 - 1.312)) / ( 3 + 5 \* 3.11 )]

 = 45.45 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 45.45 / 0.48

 = 95.10 N./mm^2

Bending Stress at Long-side 2 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 28.60 \* 122.002 \* -10.29 / ( 12 \* 0.07 ) \* [( 3 + 3.11 \*

 ( 6 - 1.312)) / ( 3 + 5 \* 3.11 )]

 = -48.14 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -48.14 / 0.48

 = -100.73 N./mm^2

Bending Stress at Long-side 2 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 28.60 \* 122.002 \* 9.71 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 )]

 = 82.87 N./mm^2

Bending Stress at Long-side 2 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 28.60 \* 122.002 \* -10.29 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.312 \* 3.11 ) / ( 3 + 5 \* 3.11 )]

 = -87.78 N./mm^2

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,**

 **Equations (16-19). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -92.37 92.37 197.62

 at Q 151.69 -151.69 197.62

 Short-side 2 at N -92.37 92.37 197.62

 at Q 151.69 -151.69 197.62

 Long-side 1 at M 80.74 -80.74 232.50

 at Q 85.33 -85.33 197.62

 Long-side 2 at M 95.10 -100.73 232.50

 at Q 82.87 -87.78 197.62

**Total Stress Calculations per Section 13-9**

***Total Stresses at Short-side 1***

Total Stress at short side 1 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 13.04 + -92.37

 = -79.34 N./mm^2

Total Stress at short side 1 at N outer [STS\_No]:

 = Sms + SbsNo

 = 13.04 + 92.37

 = 105.41 N./mm^2

Total Stress at short side 1 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 13.04 + 151.69

 = 164.73 N./mm^2

Total Stress at short side 1 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 13.04 + -151.69

 = -138.66 N./mm^2

***Total Stresses at Short-side 2***

Total Stress at short side 2 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 13.04 + -92.37

 = -79.34 N./mm^2

Total Stress at short side 2 at N outer [STS\_No]:

 = Sms + SbsNo

 = 13.04 + 92.37

 = 105.41 N./mm^2

Total Stress at short side 2 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 13.04 + 151.69

 = 164.73 N./mm^2

Total Stress at short side 2 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 13.04 + -151.69

 = -138.66 N./mm^2

***Total Stresses at Long-side 1***

Total Stress at long side 1 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 19.74 + 80.74

 = 100.48 N./mm^2

Total Stress at long side 1 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 19.74 + -80.74

 = -61.00 N./mm^2

Total Stress at long side 1 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 11.44 + 85.33

 = 96.77 N./mm^2

Total Stress at long side 1 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 11.44 + -85.33

 = -73.89 N./mm^2

***Total Stresses at Long-side 2***

Total Stress at long side 2 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 22.24 + 95.10

 = 117.34 N./mm^2

Total Stress at long side 2 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 22.24 + -100.73

 = -78.49 N./mm^2

Total Stress at long side 2 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 11.44 + 82.87

 = 94.32 N./mm^2

Total Stress at long side 2 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 11.44 + -87.78

 = -76.34 N./mm^2

**TOTAL STRESSES: Total Stress Calculations per Section 13-9,**

 **Equations (20-24). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -79.34 105.41 197.62

 at Q 164.73 -138.66 197.62

 Short-side 2 at N -79.34 105.41 197.62

 at Q 164.73 -138.66 197.62

 Long-side 1 at M 100.48 -61.00 232.50

 at Q 96.77 -73.89 197.62

 Long-side 2 at M 117.34 -78.49 232.50

 at Q 94.32 -76.34 197.62

**End Plate Stresses (N./mm^2):**

 Actual Allowable

 End Plate 88.05 155.00

**Required End Plate thickness due to Internal Pressure [trEP]:**

 = d \* sqrt( Z \* C \* P / ( SE ) ) + ca

 = 160.000 \* sqrt( 2.405 \* 0.200 \* 28.600 / ( 155.000 ) ) + 0.000

 = 15.074 mm.

**End Plate MAWP at given Thickness [MAWPEP]:**

 = ((T-ca)/d)^2 \* ((SE)/(C\*Z)) per UG-34 (c)(3)

 = ((20.0000-0.0000)/160.0000)^2\*((155)/(.20\*2.41))

 = 50.344 bars

 *where Z is:*

 = min( 3.4 - 2.4( d/D ), 2.5 )

 = min( 3.4 - 2.4( 160.000 / 386.000 ), 2.5 )

 = 2.405

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 32.79 N./mm^2

 High Stress Percentage 28.66 %

 M.A.W.P. for Membrane Stresses 99.78 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -151.69 N./mm^2

 High Stress Percentage 76.76 %

 M.A.W.P. for Bending Stresses 37.26 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 164.73 N./mm^2

 High Stress Percentage 83.35 %

 M.A.W.P. for Total Stresses 34.31 bars

**Rectangular Vessel Results For Item 1 : A8**

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 32.79 N./mm^2

 High Stress Percentage 28.66 %

 M.A.W.P. for Membrane Stresses 99.78 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -151.69 N./mm^2

 High Stress Percentage 76.76 %

 M.A.W.P. for Bending Stresses 37.26 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 164.73 N./mm^2

 High Stress Percentage 83.35 %

 M.A.W.P. for Total Stresses 34.31 bars

## floating Header Calculation @ Design Pressure for ae-2101.

**Input Echo, COMPONENT 1, Description: Fl.AE-2101**

 Figure Number Analyzed A7

 Design Internal Pressure P 22.0000 bars

 Design Temperature Temp 155.0000 C

 VESSEL MATERIAL DATA:

 Material Specification SA-240 316L

 Shell Allowable Stress at Design Temp S 114.3898 N./mm^2

 Shell Allowable Stress at Ambient SA 115.1465 N./mm^2

 Shell Yield Stress at Design Temperature Sy 129.8699 N./mm^2

 SHORT-SIDE VESSEL DATA:

 Short-side Length Dimension H 100.0000 mm.

 Minimum Thickness of Short-side Plates t1 15.0000 mm.

 Mid-side Joint Efficiency on Short-side E 0.8500

 Corner Joint Efficiency on Short-side EC 0.8500

 LONG-SIDE VESSEL DATA:

 Long-side Length Dimension h 122.0000 mm.

 Minimum Thickness of Long-side Plates t2 20.0000 mm.

 Mid-side Joint Efficiency on Long-side E 0.8500

 ADDITIONAL VESSEL DATA:

 Minimum Thickness of End Plate t5 20.0000 mm.

 C-Factor for End Plate Cf\_Epl 0.2000

 Long-side Plate # 1,

 Pitch Distance p 61.0000 mm.

 Uniform Hole Diameter d0 25.6500 mm.

 Depth of Holes T0 20.0000 mm.

 Long-side Plate # 2,

 Pitch Distance p 61.0000 mm.

 # 1: Hole Diameter d0 36.3000 mm.

 Hole Depth T0 2.7000 mm.

 # 2: Hole Diameter d1 28.5750 mm.

 Hole Depth T1 17.3000 mm.

 STAY PLATE MATERIAL DATA:

 Stay Material Specification SA-240 316L

 Stay Allowable Stress at Design Temp Sr 114.3898 N./mm^2

 Stay Allowable Stress at Ambient SA 115.1465 N./mm^2

 Stay Yield Stress at Design Temp Sy 129.8699 N./mm^2

 STAY PLATE DATA:

 Minimum Thickness of Stay t3 10.0000 mm.

 The Stay(s) Are Not Welded to the End Plate

**Rectangular Vessel Results, Item number 1, Desc: Fl.AE-2101**

**ASME Code, Section VIII, Division 1, 2019 App. 13**

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

***Short-side 1 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 15.000 - 0.000 / 2

 = 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 15.000 - 0.000 ) / 2

 = -7.500 mm.

***Short-side 2 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 15.000 - 0.000 / 2

 = 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 15.000 - 0.000 ) / 2

 = -7.500 mm.

***Long-side 1 Calculations***

Effective Diameter [De]: 25.700 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 61.000 - 25.700 / 61.000

 = 0.579

Bending Ligament Efficiency [Eb]:

*As diameter holes are uniform Eb = Em*

 = 0.579

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 2 Calculations***

Effective Diameter [De]:

 = ( d0 \* T0 + d1 \* T1 + d2 \* T2 ) / ( t1 - CA )

 = ( 36.30 \* 2.70 + 28.57 \* 17.30 + 0.00 \* 0.00 ) /

 ( 20.00 - 0.00 )

 = 29.618 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 61.000 - 29.618 / 61.000

 = 0.514

Dist from Neutral axis of c/s to extreme fibers [Ci & Co]:

*Calculation of Xbar:*

 = (( b0 \* T0 \* ( T0/2 + T1 + T2 )) + ( b1 \* T1 \*

 ( T1/2 + T2 )) + ( b2 \* T2 \* ( T2/2 ))) /

 ( b0 \* T0 + b1 \* T1 + b2 \* T2 )

 = (( 0.97 \* 2.70 \* ( 2.70 /2 + 17.30 + 0.00 )) + ( 1.28\* 17.30 \*

 ( 17.30 /2 + 0.00 )) + ( 2.40 \* 0.00 \* ( 0.00 /2 ))) /

 ( 0.97 \* 2.70 + 1.28 \* 17.30 + 2.40 \* 0.00 )

 = 9.713 mm.

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 *Ci = Xbar*

 = 9.713 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t - CA - Xbar )

 = -( 20.000 - 0.000 - 9.713 )

 = -10.287 mm.

Moment of Inertia (Section 13-6, Equation (5)) [I]:

 = 0.079 cm\*\*4

Effective Diameter [De]:

 = Pitch - (( 6 \* I ) / (( t - CA)^2 \* (-Co)))

 = 61.00 - (( 6 \* 0.08 ) / ((20.00 - 0.00 )^2 \* (10.29 )))

 = 31.851 mm.

Bending Ligament Efficiency [Eb]:

 = Pitch - De / Pitch

 = 61.000 - 31.851 / 61.000

 = 0.478

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

 Em Eb Ci Co

 Short-side 1 0.850 0.850 7.500 -7.500

 2 0.850 0.850 7.500 -7.500

 Long-side 1 0.579 0.579 10.000 -10.000

 2 0.514 0.478 9.713 -10.287

**Moment of Inertia of a Strip of the Vessel Wall:**

 Thickness t1, I1 = 0.0281 cm\*\*4

 Thickness t2, I2 = 0.0667 cm\*\*4

**Rectangular Vessel Parameters:**

 Alpha = H / h = 0.8197

 K = (I2/I1)\*Alpha = 1.9429

**Membrane Stress Calculations per Section 13-9**

***Membrane Stresses at Short-side 1***

Membrane Stress at Short-side 1 [Sms]:

 = p \* h / ( 4 \* t1 ) \* { 4 - [( 2 + K \*

 ( 5 - alpha2)) / ( 1 + 2 \* K )]}

 = 22.00 \* 122.00 / ( 4 \* 15.00 ) \* { 4 - [( 2 + 1.94 \*

 ( 5 - 0.822)) / ( 1 + 2 \* 1.94 )]}

 = 8.36 N./mm^2

***Membrane Stresses at Short-side 2***

Membrane Stress at Short-side 2 [Sms]:

 = p \* h / ( 4 \* t1 ) \* { 4 - [( 2 + K \*

 ( 5 - alpha2)) / ( 1 + 2 \* K )]}

 = 22.00 \* 122.00 / ( 4 \* 15.00 ) \* { 4 - [( 2 + 1.94 \*

 ( 5 - 0.822)) / ( 1 + 2 \* 1.94 )]}

 = 8.36 N./mm^2

***Membrane Stresses at Long-side 1***

Membrane Stress at Long-side 1 at A [Sml]:

 = P \* H / 2 \* t2

 = 22.00 \* 100.00 / 2 \* 20.00

 = 5.50 N./mm^2

 *If Em( 0.579 ) < E( 0.850 ) and Eb( 0.579 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 5.50 / 0.58

 = 9.50 N./mm^2

***Membrane Stresses at Long-side 2***

Membrane Stress at Long-side 2 at A [Sml]:

 = P \* H / 2 \* t2

 = 22.00 \* 100.00 / 2 \* 20.00

 = 5.50 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 5.50 / 0.51

 = 10.69 N./mm^2

***Membrane Stresses at Stay Plate***

Membrane Stress at Stay Plate [Smsp]:

 = P \* h / ( 2 \* t3 ) \* [( 2 + K \* ( 5 -

 alpha2)) / ( 1 + 2 \* K )]

 = 22.00 \* 122.00 / ( 2 \* 10.00 ) \* [( 2 + 1.94 \* ( 5 -

 0.822)) / ( 1 + 2 \* 1.94 )]

 = 28.59 N./mm^2

**MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9,**

 **Equations (1-3). (N./mm^2) :**

 STRESS LOCATIONS Actual Allowable

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

 Short-side 1 8.36 97.23

 Short-side 2 8.36 97.23

 Short-side Corner 8.36 97.23

 Long-side 1 at A 9.50 114.39

 Long-side 2 at A 10.69 114.39

 Long-side Corner 5.50 97.23

 Stay Plate (t3) 28.59 114.39

**Bending Stress Calculations per Section 13-9**

***Bending Stresses at Short-side 1***

Bending Stress at Short-side 1 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 1 + 2 \* Alpha2 \* K ) / ( 1 + 2 \* K ))]

 = 22.00 \* 7.50 / ( 24 \* 0.03 ) \* [ -3 \* 100.002 + 2 \* 122.002 \*

 (( 1 + 2 \* 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))]

 = -19.56 N./mm^2

Bending Stress at Short-side 1 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 1 + 2 \* Alpha2 \* K ) / ( 1 + 2 \* K ))]

 = 22.00 \* -7.50 / ( 24 \* 0.03 ) \* [ -3 \* 100.002 + 2 \* 122.002 \*

 (( 1 + 2 \* 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))]

 = 19.56 N./mm^2

Bending Stress at Short-side 1 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K ))

 = 22.00 \* 122.002 \* 7.50 / ( 12 \* 0.03 ) \* (( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))

 = 53.78 N./mm^2

Bending Stress at Short-side 1 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K ))

 = 22.00 \* 122.002 \* -7.50 / ( 12 \* 0.03 ) \* (( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))

 = -53.78 N./mm^2

***Bending Stresses at Short-side 2***

Bending Stress at Short-side 2 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 1 + 2 \* Alpha2 \* K ) / ( 1 + 2 \* K ))]

 = 22.00 \* 7.50 / ( 24 \* 0.03 ) \* [ -3 \* 100.002 + 2 \* 122.002 \*

 (( 1 + 2 \* 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))]

 = -19.56 N./mm^2

Bending Stress at Short-side 2 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 1 + 2 \* Alpha2 \* K ) / ( 1 + 2 \* K ))]

 = 22.00 \* -7.50 / ( 24 \* 0.03 ) \* [ -3 \* 100.002 + 2 \* 122.002 \*

 (( 1 + 2 \* 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))]

 = 19.56 N./mm^2

Bending Stress at Short-side 2 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K ))

 = 22.00 \* 122.002 \* 7.50 / ( 12 \* 0.03 ) \* (( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))

 = 53.78 N./mm^2

Bending Stress at Short-side 2 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K ))

 = 22.00 \* 122.002 \* -7.50 / ( 12 \* 0.03 ) \* (( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))

 = -53.78 N./mm^2

***Bending Stresses at Long-side 1***

Bending Stress at Long-side 1 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + K \*

 ( 3 - Alpha2)) / ( 1 + 2 \* K )]

 = 22.00 \* 122.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 1 + 1.94 \*

 ( 3 - 0.822)) / ( 1 + 2 \* 1.94 )]

 = 46.27 N./mm^2

 *If Em( 0.579 ) < E( 0.850 ) and Eb( 0.579 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 46.27 / 0.58

 = 79.96 N./mm^2

Bending Stress at Long-side 1 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + K \*

 ( 3 - Alpha2)) / ( 1 + 2 \* K )]

 = 22.00 \* 122.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 1 + 1.94 \*

 ( 3 - 0.822)) / ( 1 + 2 \* 1.94 )]

 = -46.27 N./mm^2

 *If Em( 0.579 ) < E( 0.850 ) and Eb( 0.579 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -46.27 / 0.58

 = -79.96 N./mm^2

Bending Stress at Long-side 1 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K )]

 = 22.00 \* 122.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 )]

 = 30.25 N./mm^2

Bending Stress at Long-side 1 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K )]

 = 22.00 \* 122.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 )]

 = -30.25 N./mm^2

***Bending Stresses at Long-side 2***

Bending Stress at Long-side 2 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + K \*

 ( 3 - Alpha2)) / ( 1 + 2 \* K )]

 = 22.00 \* 122.002 \* 9.71 / ( 12 \* 0.07 ) \* [( 1 + 1.94 \*

 ( 3 - 0.822)) / ( 1 + 2 \* 1.94 )]

 = 44.94 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 44.94 / 0.48

 = 94.05 N./mm^2

Bending Stress at Long-side 2 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + K \*

 ( 3 - Alpha2)) / ( 1 + 2 \* K )]

 = 22.00 \* 122.002 \* -10.29 / ( 12 \* 0.07 ) \* [( 1 + 1.94 \*

 ( 3 - 0.822)) / ( 1 + 2 \* 1.94 )]

 = -47.60 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -47.60 / 0.48

 = -99.62 N./mm^2

Bending Stress at Long-side 2 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K )]

 = 22.00 \* 122.002 \* 9.71 / ( 12 \* 0.07 ) \* [( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 )]

 = 29.38 N./mm^2

Bending Stress at Long-side 2 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K )]

 = 22.00 \* 122.002 \* -10.29 / ( 12 \* 0.07 ) \* [( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 )]

 = -31.12 N./mm^2

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,**

 **Equations (4-7). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -19.56 19.56 145.85

 at Q 53.78 -53.78 145.85

 Short-side 2 at N -19.56 19.56 145.85

 at Q 53.78 -53.78 145.85

 Long-side 1 at M 79.96 -79.96 171.58

 at Q 30.25 -30.25 145.85

 Long-side 2 at M 94.05 -99.62 171.58

 at Q 29.38 -31.12 145.85

**Total Stress Calculations per Section 13-9**

***Total Stresses at Short-side 1***

Total Stress at short side 1 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 8.36 + -19.56

 = -11.20 N./mm^2

Total Stress at short side 1 at N outer [STS\_No]:

 = Sms + SbsNo

 = 8.36 + 19.56

 = 27.92 N./mm^2

Total Stress at short side 1 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 8.36 + 53.78

 = 62.14 N./mm^2

Total Stress at short side 1 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 8.36 + -53.78

 = -45.42 N./mm^2

***Total Stresses at Short-side 2***

Total Stress at short side 2 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 8.36 + -19.56

 = -11.20 N./mm^2

Total Stress at short side 2 at N outer [STS\_No]:

 = Sms + SbsNo

 = 8.36 + 19.56

 = 27.92 N./mm^2

Total Stress at short side 2 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 8.36 + 53.78

 = 62.14 N./mm^2

Total Stress at short side 2 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 8.36 + -53.78

 = -45.42 N./mm^2

***Total Stresses at Long-side 1***

Total Stress at long side 1 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 9.50 + 79.96

 = 89.47 N./mm^2

Total Stress at long side 1 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 9.50 + -79.96

 = -70.46 N./mm^2

Total Stress at long side 1 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 5.50 + 30.25

 = 35.75 N./mm^2

Total Stress at long side 1 at Q outer [STL\_Qo]:

 = Sml + SblQo

 = 5.50 + -30.25

 = -24.75 N./mm^2

***Total Stresses at Long-side 2***

Total Stress at long side 2 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 10.69 + 94.05

 = 104.75 N./mm^2

Total Stress at long side 2 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 10.69 + -99.62

 = -88.93 N./mm^2

Total Stress at long side 2 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 5.50 + 29.38

 = 34.88 N./mm^2

Total Stress at long side 2 at Q outer [STL\_Qo]:

 = Sml + SblQo

 = 5.50 + -31.12

 = -25.62 N./mm^2

**TOTAL STRESSES: Total Stress Calculations per Section 13-9,**

 **Equations (8-12). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -11.20 27.92 145.85

 at Q 62.14 -45.42 145.85

 Short-side 2 at N -11.20 27.92 145.85

 at Q 62.14 -45.42 145.85

 Long-side 1 at M 89.47 -70.46 171.58

 at Q 35.75 -24.75 145.85

 Long-side 2 at M 104.75 -88.93 171.58

 at Q 34.88 -25.62 145.85

**End Plate Stresses (N./mm^2):**

 Actual Allowable

 End Plate 30.85 114.39

**Required End Plate thickness due to Internal Pressure [trEP]:**

 = d \* sqrt( Z \* C \* P / ( SE ) ) + ca

 = 110.000 \* sqrt( 2.318 \* 0.200 \* 22.000 / ( 114.390 ) ) + 0.000

 = 10.387 mm.

**End Plate MAWP at given Thickness [MAWPEP]:**

 = ((T-ca)/d)^2 \* ((SE)/(C\*Z)) per UG-34 (c)(3)

 = ((20.0000-0.0000)/110.0000)^2\*((114)/(.20\*2.32))

 = 81.562 bars

 *where Z is:*

 = min( 3.4 - 2.4( d/D ), 2.5 )

 = min( 3.4 - 2.4( 110.000 / 244.000 ), 2.5 )

 = 2.318

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 28.59 N./mm^2

 High Stress Percentage 25.00 %

 M.A.W.P. for Membrane Stresses 88.01 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -99.62 N./mm^2

 High Stress Percentage 58.06 %

 M.A.W.P. for Bending Stresses 37.89 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 104.75 N./mm^2

 High Stress Percentage 61.05 %

 M.A.W.P. for Total Stresses 36.04 bars

**Rectangular Vessel Results For Item 1 : A7**

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 28.59 N./mm^2

 High Stress Percentage 25.00 %

 M.A.W.P. for Membrane Stresses 88.01 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -99.62 N./mm^2

 High Stress Percentage 58.06 %

 M.A.W.P. for Bending Stresses 37.89 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 104.75 N./mm^2

 High Stress Percentage 61.05 %

 M.A.W.P. for Total Stresses 36.04 bars

## floating Header Calculation @ test Pressure for ae-2101.

**Input Echo, COMPONENT 1, Description: Fl.AE-2101**

 Figure Number Analyzed A7

 Design Internal Pressure P 28.6000 bars

 Design Temperature Temp 25.0000 C

 VESSEL MATERIAL DATA:

 Material Specification SA-240 316L

 Shell Allowable Stress at Design Temp S 155.0000 N./mm^2

 Shell Allowable Stress at Ambient SA 155.0000 N./mm^2

 Shell Yield Stress at Design Temperature Sy 172.3750 N./mm^2

 SHORT-SIDE VESSEL DATA:

 Short-side Length Dimension H 100.0000 mm.

 Minimum Thickness of Short-side Plates t1 15.0000 mm.

 Mid-side Joint Efficiency on Short-side E 0.8500

 Corner Joint Efficiency on Short-side EC 0.8500

 LONG-SIDE VESSEL DATA:

 Long-side Length Dimension h 122.0000 mm.

 Minimum Thickness of Long-side Plates t2 20.0000 mm.

 Mid-side Joint Efficiency on Long-side E 0.8500

 ADDITIONAL VESSEL DATA:

 Minimum Thickness of End Plate t5 20.0000 mm.

 C-Factor for End Plate Cf\_Epl 0.2000

 Long-side Plate # 1,

 Pitch Distance p 61.0000 mm.

 Uniform Hole Diameter d0 25.6500 mm.

 Depth of Holes T0 20.0000 mm.

 Long-side Plate # 2,

 Pitch Distance p 61.0000 mm.

 # 1: Hole Diameter d0 36.3000 mm.

 Hole Depth T0 2.7000 mm.

 # 2: Hole Diameter d1 28.5750 mm.

 Hole Depth T1 17.3000 mm.

 STAY PLATE MATERIAL DATA:

 Stay Material Specification SA-240 316L

 Stay Allowable Stress at Design Temp Sr 114.3898 N./mm^2

 Stay Allowable Stress at Ambient SA 115.1465 N./mm^2

 Stay Yield Stress at Design Temp Sy 129.8699 N./mm^2

 STAY PLATE DATA:

 Minimum Thickness of Stay t3 10.0000 mm.

 The Stay(s) Are Not Welded to the End Plate

**Rectangular Vessel Results, Item number 1, Desc: Fl.AE-2101**

**ASME Code, Section VIII, Division 1, 2019 App. 13**

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

***Short-side 1 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 15.000 - 0.000 / 2

 = 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 15.000 - 0.000 ) / 2

 = -7.500 mm.

***Short-side 2 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 15.000 - 0.000 / 2

 = 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 15.000 - 0.000 ) / 2

 = -7.500 mm.

***Long-side 1 Calculations***

Effective Diameter [De]: 25.650 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 61.000 - 25.650 / 61.000

 = 0.580

Bending Ligament Efficiency [Eb]:

*As diameter holes are uniform Eb = Em*

 = 0.580

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 2 Calculations***

Effective Diameter [De]:

 = ( d0 \* T0 + d1 \* T1 + d2 \* T2 ) / ( t1 - CA )

 = ( 36.30 \* 2.70 + 28.57 \* 17.30 + 0.00 \* 0.00 ) /

 ( 20.00 - 0.00 )

 = 29.618 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 61.000 - 29.618 / 61.000

 = 0.514

Dist from Neutral axis of c/s to extreme fibers [Ci & Co]:

*Calculation of Xbar:*

 = (( b0 \* T0 \* ( T0/2 + T1 + T2 )) + ( b1 \* T1 \*

 ( T1/2 + T2 )) + ( b2 \* T2 \* ( T2/2 ))) /

 ( b0 \* T0 + b1 \* T1 + b2 \* T2 )

 = (( 0.97 \* 2.70 \* ( 2.70 /2 + 17.30 + 0.00 )) + ( 1.28\* 17.30 \*

 ( 17.30 /2 + 0.00 )) + ( 2.40 \* 0.00 \* ( 0.00 /2 ))) /

 ( 0.97 \* 2.70 + 1.28 \* 17.30 + 2.40 \* 0.00 )

 = 9.713 mm.

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 *Ci = Xbar*

 = 9.713 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t - CA - Xbar )

 = -( 20.000 - 0.000 - 9.713 )

 = -10.287 mm.

Moment of Inertia (Section 13-6, Equation (5)) [I]:

 = 0.079 cm\*\*4

Effective Diameter [De]:

 = Pitch - (( 6 \* I ) / (( t - CA)^2 \* (-Co)))

 = 61.00 - (( 6 \* 0.08 ) / ((20.00 - 0.00 )^2 \* (10.29 )))

 = 31.851 mm.

Bending Ligament Efficiency [Eb]:

 = Pitch - De / Pitch

 = 61.000 - 31.851 / 61.000

 = 0.478

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

 Em Eb Ci Co

 Short-side 1 0.850 0.850 7.500 -7.500

 2 0.850 0.850 7.500 -7.500

 Long-side 1 0.580 0.580 10.000 -10.000

 2 0.514 0.478 9.713 -10.287

**Moment of Inertia of a Strip of the Vessel Wall:**

 Thickness t1, I1 = 0.0281 cm\*\*4

 Thickness t2, I2 = 0.0667 cm\*\*4

**Rectangular Vessel Parameters:**

 Alpha = H / h = 0.8197

 K = (I2/I1)\*Alpha = 1.9429

**Membrane Stress Calculations per Section 13-9**

***Membrane Stresses at Short-side 1***

Membrane Stress at Short-side 1 [Sms]:

 = p \* h / ( 4 \* t1 ) \* { 4 - [( 2 + K \*

 ( 5 - alpha2)) / ( 1 + 2 \* K )]}

 = 28.60 \* 122.00 / ( 4 \* 15.00 ) \* { 4 - [( 2 + 1.94 \*

 ( 5 - 0.822)) / ( 1 + 2 \* 1.94 )]}

 = 10.87 N./mm^2

***Membrane Stresses at Short-side 2***

Membrane Stress at Short-side 2 [Sms]:

 = p \* h / ( 4 \* t1 ) \* { 4 - [( 2 + K \*

 ( 5 - alpha2)) / ( 1 + 2 \* K )]}

 = 28.60 \* 122.00 / ( 4 \* 15.00 ) \* { 4 - [( 2 + 1.94 \*

 ( 5 - 0.822)) / ( 1 + 2 \* 1.94 )]}

 = 10.87 N./mm^2

***Membrane Stresses at Long-side 1***

Membrane Stress at Long-side 1 at A [Sml]:

 = P \* H / 2 \* t2

 = 28.60 \* 100.00 / 2 \* 20.00

 = 7.15 N./mm^2

 *If Em( 0.580 ) < E( 0.850 ) and Eb( 0.580 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 7.15 / 0.58

 = 12.34 N./mm^2

***Membrane Stresses at Long-side 2***

Membrane Stress at Long-side 2 at A [Sml]:

 = P \* H / 2 \* t2

 = 28.60 \* 100.00 / 2 \* 20.00

 = 7.15 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 7.15 / 0.51

 = 13.90 N./mm^2

***Membrane Stresses at Stay Plate***

Membrane Stress at Stay Plate [Smsp]:

 = P \* h / ( 2 \* t3 ) \* [( 2 + K \* ( 5 -

 alpha2)) / ( 1 + 2 \* K )]

 = 28.60 \* 122.00 / ( 2 \* 10.00 ) \* [( 2 + 1.94 \* ( 5 -

 0.822)) / ( 1 + 2 \* 1.94 )]

 = 37.17 N./mm^2

**MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9,**

 **Equations (1-3). (N./mm^2) :**

 STRESS LOCATIONS Actual Allowable

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

 Short-side 1 10.87 131.75

 Short-side 2 10.87 131.75

 Short-side Corner 10.87 131.75

 Long-side 1 at A 12.34 155.00

 Long-side 2 at A 13.90 155.00

 Long-side Corner 7.15 131.75

 Stay Plate (t3) 37.17 114.39

**Bending Stress Calculations per Section 13-9**

***Bending Stresses at Short-side 1***

Bending Stress at Short-side 1 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 1 + 2 \* Alpha2 \* K ) / ( 1 + 2 \* K ))]

 = 28.60 \* 7.50 / ( 24 \* 0.03 ) \* [ -3 \* 100.002 + 2 \* 122.002 \*

 (( 1 + 2 \* 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))]

 = -25.43 N./mm^2

Bending Stress at Short-side 1 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 1 + 2 \* Alpha2 \* K ) / ( 1 + 2 \* K ))]

 = 28.60 \* -7.50 / ( 24 \* 0.03 ) \* [ -3 \* 100.002 + 2 \* 122.002 \*

 (( 1 + 2 \* 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))]

 = 25.43 N./mm^2

Bending Stress at Short-side 1 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K ))

 = 28.60 \* 122.002 \* 7.50 / ( 12 \* 0.03 ) \* (( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))

 = 69.91 N./mm^2

Bending Stress at Short-side 1 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K ))

 = 28.60 \* 122.002 \* -7.50 / ( 12 \* 0.03 ) \* (( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))

 = -69.91 N./mm^2

***Bending Stresses at Short-side 2***

Bending Stress at Short-side 2 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 1 + 2 \* Alpha2 \* K ) / ( 1 + 2 \* K ))]

 = 28.60 \* 7.50 / ( 24 \* 0.03 ) \* [ -3 \* 100.002 + 2 \* 122.002 \*

 (( 1 + 2 \* 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))]

 = -25.43 N./mm^2

Bending Stress at Short-side 2 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 1 + 2 \* Alpha2 \* K ) / ( 1 + 2 \* K ))]

 = 28.60 \* -7.50 / ( 24 \* 0.03 ) \* [ -3 \* 100.002 + 2 \* 122.002 \*

 (( 1 + 2 \* 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))]

 = 25.43 N./mm^2

Bending Stress at Short-side 2 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K ))

 = 28.60 \* 122.002 \* 7.50 / ( 12 \* 0.03 ) \* (( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))

 = 69.91 N./mm^2

Bending Stress at Short-side 2 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K ))

 = 28.60 \* 122.002 \* -7.50 / ( 12 \* 0.03 ) \* (( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 ))

 = -69.91 N./mm^2

***Bending Stresses at Long-side 1***

Bending Stress at Long-side 1 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + K \*

 ( 3 - Alpha2)) / ( 1 + 2 \* K )]

 = 28.60 \* 122.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 1 + 1.94 \*

 ( 3 - 0.822)) / ( 1 + 2 \* 1.94 )]

 = 60.16 N./mm^2

 *If Em( 0.580 ) < E( 0.850 ) and Eb( 0.580 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 60.16 / 0.58

 = 103.81 N./mm^2

Bending Stress at Long-side 1 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + K \*

 ( 3 - Alpha2)) / ( 1 + 2 \* K )]

 = 28.60 \* 122.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 1 + 1.94 \*

 ( 3 - 0.822)) / ( 1 + 2 \* 1.94 )]

 = -60.16 N./mm^2

 *If Em( 0.580 ) < E( 0.850 ) and Eb( 0.580 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -60.16 / 0.58

 = -103.81 N./mm^2

Bending Stress at Long-side 1 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K )]

 = 28.60 \* 122.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 )]

 = 39.33 N./mm^2

Bending Stress at Long-side 1 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K )]

 = 28.60 \* 122.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 )]

 = -39.33 N./mm^2

***Bending Stresses at Long-side 2***

Bending Stress at Long-side 2 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + K \*

 ( 3 - Alpha2)) / ( 1 + 2 \* K )]

 = 28.60 \* 122.002 \* 9.71 / ( 12 \* 0.07 ) \* [( 1 + 1.94 \*

 ( 3 - 0.822)) / ( 1 + 2 \* 1.94 )]

 = 58.43 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 58.43 / 0.48

 = 122.27 N./mm^2

Bending Stress at Long-side 2 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + K \*

 ( 3 - Alpha2)) / ( 1 + 2 \* K )]

 = 28.60 \* 122.002 \* -10.29 / ( 12 \* 0.07 ) \* [( 1 + 1.94 \*

 ( 3 - 0.822)) / ( 1 + 2 \* 1.94 )]

 = -61.89 N./mm^2

 *If Em( 0.514 ) < E( 0.850 ) and Eb( 0.478 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -61.89 / 0.48

 = -129.51 N./mm^2

Bending Stress at Long-side 2 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K )]

 = 28.60 \* 122.002 \* 9.71 / ( 12 \* 0.07 ) \* [( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 )]

 = 38.20 N./mm^2

Bending Stress at Long-side 2 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 1 + 2 \*

 Alpha2 \* K ) / ( 1 + 2 \* K )]

 = 28.60 \* 122.002 \* -10.29 / ( 12 \* 0.07 ) \* [( 1 + 2 \*

 0.822 \* 1.94 ) / ( 1 + 2 \* 1.94 )]

 = -40.46 N./mm^2

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,**

 **Equations (4-7). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -25.43 25.43 197.62

 at Q 69.91 -69.91 197.62

 Short-side 2 at N -25.43 25.43 197.62

 at Q 69.91 -69.91 197.62

 Long-side 1 at M 103.81 -103.81 232.50

 at Q 39.33 -39.33 197.62

 Long-side 2 at M 122.27 -129.51 232.50

 at Q 38.20 -40.46 197.62

**Total Stress Calculations per Section 13-9**

***Total Stresses at Short-side 1***

Total Stress at short side 1 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 10.87 + -25.43

 = -14.55 N./mm^2

Total Stress at short side 1 at N outer [STS\_No]:

 = Sms + SbsNo

 = 10.87 + 25.43

 = 36.30 N./mm^2

Total Stress at short side 1 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 10.87 + 69.91

 = 80.79 N./mm^2

Total Stress at short side 1 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 10.87 + -69.91

 = -59.04 N./mm^2

***Total Stresses at Short-side 2***

Total Stress at short side 2 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 10.87 + -25.43

 = -14.55 N./mm^2

Total Stress at short side 2 at N outer [STS\_No]:

 = Sms + SbsNo

 = 10.87 + 25.43

 = 36.30 N./mm^2

Total Stress at short side 2 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 10.87 + 69.91

 = 80.79 N./mm^2

Total Stress at short side 2 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 10.87 + -69.91

 = -59.04 N./mm^2

***Total Stresses at Long-side 1***

Total Stress at long side 1 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 12.34 + 103.81

 = 116.15 N./mm^2

Total Stress at long side 1 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 12.34 + -103.81

 = -91.47 N./mm^2

Total Stress at long side 1 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 7.15 + 39.33

 = 46.48 N./mm^2

Total Stress at long side 1 at Q outer [STL\_Qo]:

 = Sml + SblQo

 = 7.15 + -39.33

 = -32.18 N./mm^2

***Total Stresses at Long-side 2***

Total Stress at long side 2 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 13.90 + 122.27

 = 136.17 N./mm^2

Total Stress at long side 2 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 13.90 + -129.51

 = -115.61 N./mm^2

Total Stress at long side 2 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 7.15 + 38.20

 = 45.35 N./mm^2

Total Stress at long side 2 at Q outer [STL\_Qo]:

 = Sml + SblQo

 = 7.15 + -40.46

 = -33.31 N./mm^2

**TOTAL STRESSES: Total Stress Calculations per Section 13-9,**

 **Equations (8-12). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -14.55 36.30 197.62

 at Q 80.79 -59.04 197.62

 Short-side 2 at N -14.55 36.30 197.62

 at Q 80.79 -59.04 197.62

 Long-side 1 at M 116.15 -91.47 232.50

 at Q 46.48 -32.18 197.62

 Long-side 2 at M 136.17 -115.61 232.50

 at Q 45.35 -33.31 197.62

**End Plate Stresses (N./mm^2):**

 Actual Allowable

 End Plate 40.11 155.00

**Required End Plate thickness due to Internal Pressure [trEP]:**

 = d \* sqrt( Z \* C \* P / ( SE ) ) + ca

 = 110.000 \* sqrt( 2.318 \* 0.200 \* 28.600 / ( 155.000 ) ) + 0.000

 = 10.174 mm.

**End Plate MAWP at given Thickness [MAWPEP]:**

 = ((T-ca)/d)^2 \* ((SE)/(C\*Z)) per UG-34 (c)(3)

 = ((20.0000-0.0000)/110.0000)^2\*((155)/(.20\*2.32))

 = 110.518 bars

 *where Z is:*

 = min( 3.4 - 2.4( d/D ), 2.5 )

 = min( 3.4 - 2.4( 110.000 / 244.000 ), 2.5 )

 = 2.318

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 37.17 N./mm^2

 High Stress Percentage 32.49 %

 M.A.W.P. for Membrane Stresses 88.01 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -129.51 N./mm^2

 High Stress Percentage 55.70 %

 M.A.W.P. for Bending Stresses 51.34 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 136.17 N./mm^2

 High Stress Percentage 58.57 %

 M.A.W.P. for Total Stresses 48.83 bars

**Rectangular Vessel Results For Item 1 : A7**

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 37.17 N./mm^2

 High Stress Percentage 32.49 %

 M.A.W.P. for Membrane Stresses 88.01 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -129.51 N./mm^2

 High Stress Percentage 55.70 %

 M.A.W.P. for Bending Stresses 51.34 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 136.17 N./mm^2

 High Stress Percentage 58.57 %

 M.A.W.P. for Total Stresses 48.83 bars

## Stationary Header Calculation @ Design Pressure for ae-2102.

**Input Echo, COMPONENT 1, Description: St.AE-2102**

 Figure Number Analyzed A8

 Design Internal Pressure P 62.0000 bars

 Design Temperature Temp 175.0000 C

 VESSEL MATERIAL DATA:

 Material Specification SA-240 316L

 Shell Allowable Stress at Design Temp S 111.9078 N./mm^2

 Shell Allowable Stress at Ambient SA 115.1465 N./mm^2

 Shell Yield Stress at Design Temperature Sy 126.1469 N./mm^2

 SHORT-SIDE VESSEL DATA:

 Short-side Length Dimension H 110.0000 mm.

 Minimum Thickness of Short-side Plates t1 20.0000 mm.

 Mid-side Joint Efficiency on Short-side E 0.8500

 Corner Joint Efficiency on Short-side EC 0.8500

 LONG-SIDE VESSEL DATA:

 Long-side Length Dimension h 95.0000 mm.

 Minimum Thickness of Long-side Plates t2 20.0000 mm.

 Mid-side Joint Efficiency on Long-side E 0.8500

 ADDITIONAL VESSEL DATA:

 Minimum Thickness of End Plate t5 20.0000 mm.

 C-Factor for End Plate Cf\_Epl 0.2000

 Long-side Plate # 1,

 Pitch Distance p 69.0000 mm.

 Uniform Hole Diameter d0 25.6500 mm.

 Depth of Holes T0 20.0000 mm.

 Long-side Plate # 2,

 Pitch Distance p 69.0000 mm.

 # 1: Hole Diameter d0 36.3000 mm.

 Hole Depth T0 2.7000 mm.

 # 2: Hole Diameter d1 28.5750 mm.

 Hole Depth T1 17.3000 mm.

 STAY PLATE MATERIAL DATA:

 Stay Material Specification SA-240 316L

 Stay Allowable Stress at Design Temp Sr 114.3898 N./mm^2

 Stay Allowable Stress at Ambient SA 115.1465 N./mm^2

 Stay Yield Stress at Design Temp Sy 129.8699 N./mm^2

 STAY PLATE DATA:

 Minimum Thickness of Stay t3 10.0000 mm.

 Minimum Thickness of Stay t4 10.0000 mm.

 The Stay(s) Are Not Welded to the End Plate

**Rectangular Vessel Results, Item number 1, Desc: St.AE-2102**

**ASME Code, Section VIII, Division 1, 2019 App. 13**

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

***Short-side 1 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Short-side 2 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 1 Calculations***

Effective Diameter [De]: 25.650 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 69.000 - 25.650 / 69.000

 = 0.628

Bending Ligament Efficiency [Eb]:

*As diameter holes are uniform Eb = Em*

 = 0.628

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 2 Calculations***

Effective Diameter [De]:

 = ( d0 \* T0 + d1 \* T1 + d2 \* T2 ) / ( t1 - CA )

 = ( 36.30 \* 2.70 + 28.57 \* 17.30 + 0.00 \* 0.00 ) /

 ( 20.00 - 0.00 )

 = 29.618 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 69.000 - 29.618 / 69.000

 = 0.571

Dist from Neutral axis of c/s to extreme fibers [Ci & Co]:

*Calculation of Xbar:*

 = (( b0 \* T0 \* ( T0/2 + T1 + T2 )) + ( b1 \* T1 \*

 ( T1/2 + T2 )) + ( b2 \* T2 \* ( T2/2 ))) /

 ( b0 \* T0 + b1 \* T1 + b2 \* T2 )

 = (( 1.29 \* 2.70 \* ( 2.70 /2 + 17.30 + 0.00 )) + ( 1.59\* 17.30 \*

 ( 17.30 /2 + 0.00 )) + ( 2.72 \* 0.00 \* ( 0.00 /2 ))) /

 ( 1.29 \* 2.70 + 1.59 \* 17.30 + 2.72 \* 0.00 )

 = 9.771 mm.

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 *Ci = Xbar*

 = 9.771 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t - CA - Xbar )

 = -( 20.000 - 0.000 - 9.771 )

 = -10.229 mm.

Moment of Inertia (Section 13-6, Equation (5)) [I]:

 = 0.100 cm\*\*4

Effective Diameter [De]:

 = Pitch - (( 6 \* I ) / (( t - CA)^2 \* (-Co)))

 = 69.00 - (( 6 \* 0.10 ) / ((20.00 - 0.00 )^2 \* (10.23 )))

 = 31.848 mm.

Bending Ligament Efficiency [Eb]:

 = Pitch - De / Pitch

 = 69.000 - 31.848 / 69.000

 = 0.538

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

 Em Eb Ci Co

 Short-side 1 0.850 0.850 10.000 -10.000

 2 0.850 0.850 10.000 -10.000

 Long-side 1 0.628 0.628 10.000 -10.000

 2 0.571 0.538 9.771 -10.229

**Moment of Inertia of a Strip of the Vessel Wall:**

 Thickness t1, I1 = 0.0667 cm\*\*4

 Thickness t2, I2 = 0.0667 cm\*\*4

**Rectangular Vessel Parameters:**

 Alpha = H / h = 1.1579

 K = (I2/I1)\*Alpha = 1.1579

**Membrane Stress Calculations per Section 13-9**

***Membrane Stresses at Short-side 1***

Membrane Stress at Short-side 1 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 62.00 \* 95.00 / ( 2 \* 20.00 ) \* { 3- [( 6 + 1.16 \*

 ( 11 - 1.162) / ( 3 + 5 \* 1.16 )]}

 = 15.39 N./mm^2

***Membrane Stresses at Short-side 2***

Membrane Stress at Short-side 2 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 62.00 \* 95.00 / ( 2 \* 20.00 ) \* { 3- [( 6 + 1.16 \*

 ( 11 - 1.162) / ( 3 + 5 \* 1.16 )]}

 = 15.39 N./mm^2

***Membrane Stresses at Long-side 1***

Membrane Stress at Long-side 1 at A [Sml]:

 = P \* H / 2 \* t2

 = 62.00 \* 110.00 / 2 \* 20.00

 = 17.05 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 17.05 / 0.63

 = 27.14 N./mm^2

***Membrane Stresses at Long-side 2***

Membrane Stress at Long-side 2 at A [Sml]:

 = P \* H / 2 \* t2

 = 62.00 \* 110.00 / 2 \* 20.00

 = 17.05 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 17.05 / 0.57

 = 29.87 N./mm^2

***Membrane Stresses at Stay Plate***

Membrane Stress at Stay Plate [t3]:

 = P \* h / ( 2 \* t3 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 62.00 \* 95.00 / ( 2 \* 10.00 ) \* [( 6 + 1.16 \* ( 11 -

 1.162) / ( 3 + 5 \* 1.16 )]

 = 57.58 N./mm^2

Membrane Stress at Stay Plate [t4]:

 = P \* h / ( 2 \* t4 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 62.00 \* 95.00 / ( 2 \* 10.00 ) \* [( 6 + 1.16 \* ( 11 -

 1.162) / ( 3 + 5 \* 1.16 )]

 = 57.58 N./mm^2

**MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9,**

 **Equations (13-15). (N./mm^2) :**

 STRESS LOCATIONS Actual Allowable

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

 Short-side 1 15.39 95.12

 Short-side 2 15.39 95.12

 Short-side Corner 15.39 95.12

 Long-side 1 at A 27.14 111.91

 Long-side 2 at A 29.87 111.91

 Long-side Corner 17.05 95.12

 Stay Plate (t3) 57.58 114.39

 Stay Plate (t4) 57.58 114.39

**Bending Stress Calculations per Section 13-9**

***Bending Stresses at Short-side 1***

Bending Stress at Short-side 1 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 62.00 \* 10.00 / ( 24 \* 0.07 ) \* [ -3 \* 110.002 + 2 \* 95.002 \*

 (( 3 + 5 \* 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))]

 = -55.02 N./mm^2

Bending Stress at Short-side 1 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 62.00 \* -10.00 /( 24 \* 0.07 ) \* [ -3 \* 110.002 + 2 \* 95.002 \*

 (( 3 + 5 \* 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))]

 = 55.02 N./mm^2

Bending Stress at Short-side 1 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 62.00 \* 95.002 \* 10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))

 = 85.65 N./mm^2

Bending Stress at Short-side 1 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 62.00 \* 95.002 \* -10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))

 = -85.65 N./mm^2

***Bending Stresses at Short-side 2***

Bending Stress at Short-side 2 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 62.00 \* 10.00 / ( 24 \* 0.07 ) \* [ -3 \* 110.002 + 2 \* 95.002 \*

 (( 3 + 5 \* 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))]

 = -55.02 N./mm^2

Bending Stress at Short-side 2 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 62.00 \* -10.00 /( 24 \* 0.07 ) \* [ -3 \* 110.002 + 2 \* 95.002 \*

 (( 3 + 5 \* 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))]

 = 55.02 N./mm^2

Bending Stress at Short-side 2 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 62.00 \* 95.002 \* 10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))

 = 85.65 N./mm^2

Bending Stress at Short-side 2 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 62.00 \* 95.002 \* -10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))

 = -85.65 N./mm^2

***Bending Stresses at Long-side 1***

Bending Stress at Long-side 1 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 62.00 \* 95.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 1.16 \*

 ( 6 - 1.162)) / ( 3 + 5 \* 1.16 )]

 = 66.81 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 66.81 / 0.63

 = 106.34 N./mm^2

Bending Stress at Long-side 1 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 62.00 \* 95.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 1.16 \*

 ( 6 - 1.162)) / ( 3 + 5 \* 1.16 )]

 = -66.81 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -66.81 / 0.63

 = -106.34 N./mm^2

Bending Stress at Long-side 1 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 62.00 \* 95.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 )]

 = 85.65 N./mm^2

Bending Stress at Long-side 1 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 62.00 \* 95.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 )]

 = -85.65 N./mm^2

***Bending Stresses at Long-side 2***

Bending Stress at Long-side 2 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 62.00 \* 95.002 \* 9.77 / ( 12 \* 0.07 ) \* [( 3 + 1.16 \*

 ( 6 - 1.162)) / ( 3 + 5 \* 1.16 )]

 = 65.28 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 65.28 / 0.54

 = 121.24 N./mm^2

Bending Stress at Long-side 2 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 62.00 \* 95.002 \* -10.23 / ( 12 \* 0.07 ) \* [( 3 + 1.16 \*

 ( 6 - 1.162)) / ( 3 + 5 \* 1.16 )]

 = -68.34 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -68.34 / 0.54

 = -126.92 N./mm^2

Bending Stress at Long-side 2 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 62.00 \* 95.002 \* 9.77 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 )]

 = 83.68 N./mm^2

Bending Stress at Long-side 2 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 62.00 \* 95.002 \* -10.23 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 )]

 = -87.61 N./mm^2

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,**

 **Equations (16-19). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -55.02 55.02 142.68

 at Q 85.65 -85.65 142.68

 Short-side 2 at N -55.02 55.02 142.68

 at Q 85.65 -85.65 142.68

 Long-side 1 at M 106.34 -106.34 167.86

 at Q 85.65 -85.65 142.68

 Long-side 2 at M 121.24 -126.92 167.86

 at Q 83.68 -87.61 142.68

**Total Stress Calculations per Section 13-9**

***Total Stresses at Short-side 1***

Total Stress at short side 1 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 15.39 + -55.02

 = -39.64 N./mm^2

Total Stress at short side 1 at N outer [STS\_No]:

 = Sms + SbsNo

 = 15.39 + 55.02

 = 70.41 N./mm^2

Total Stress at short side 1 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 15.39 + 85.65

 = 101.03 N./mm^2

Total Stress at short side 1 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 15.39 + -85.65

 = -70.26 N./mm^2

***Total Stresses at Short-side 2***

Total Stress at short side 2 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 15.39 + -55.02

 = -39.64 N./mm^2

Total Stress at short side 2 at N outer [STS\_No]:

 = Sms + SbsNo

 = 15.39 + 55.02

 = 70.41 N./mm^2

Total Stress at short side 2 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 15.39 + 85.65

 = 101.03 N./mm^2

Total Stress at short side 2 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 15.39 + -85.65

 = -70.26 N./mm^2

***Total Stresses at Long-side 1***

Total Stress at long side 1 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 27.14 + 106.34

 = 133.48 N./mm^2

Total Stress at long side 1 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 27.14 + -106.34

 = -79.20 N./mm^2

Total Stress at long side 1 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 17.05 + 85.65

 = 102.70 N./mm^2

Total Stress at long side 1 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 17.05 + -85.65

 = -68.59 N./mm^2

***Total Stresses at Long-side 2***

Total Stress at long side 2 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 29.87 + 121.24

 = 151.11 N./mm^2

Total Stress at long side 2 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 29.87 + -126.92

 = -97.05 N./mm^2

Total Stress at long side 2 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 17.05 + 83.68

 = 100.74 N./mm^2

Total Stress at long side 2 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 17.05 + -87.61

 = -70.56 N./mm^2

**TOTAL STRESSES: Total Stress Calculations per Section 13-9,**

 **Equations (20-24). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -39.64 70.41 142.68

 at Q 101.03 -70.26 142.68

 Short-side 2 at N -39.64 70.41 142.68

 at Q 101.03 -70.26 142.68

 Long-side 1 at M 133.48 -79.20 167.86

 at Q 102.70 -68.59 142.68

 Long-side 2 at M 151.11 -97.05 167.86

 at Q 100.74 -70.56 142.68

**End Plate Stresses (N./mm^2):**

 Actual Allowable

 End Plate 93.78 111.91

**Required End Plate thickness due to Internal Pressure [trEP]:**

 = d \* sqrt( Z \* C \* P / ( SE ) ) + ca

 = 110.000 \* sqrt( 2.500 \* 0.200 \* 62.000 / ( 111.908 ) ) + 0.000

 = 18.309 mm.

**End Plate MAWP at given Thickness [MAWPEP]:**

 = ((T-ca)/d)^2 \* ((SE)/(C\*Z)) per UG-34 (c)(3)

 = ((20.0000-0.0000)/110.0000)^2\*((111)/(.20\*2.50))

 = 73.984 bars

 *where Z is:*

 = min( 3.4 - 2.4( d/D ), 2.5 )

 = min( 3.4 - 2.4( 110.000 / 305.000 ), 2.5 )

 = 2.500

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 57.58 N./mm^2

 High Stress Percentage 50.34 %

 M.A.W.P. for Membrane Stresses 123.17 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -126.92 N./mm^2

 High Stress Percentage 75.61 %

 M.A.W.P. for Bending Stresses 82.00 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 151.11 N./mm^2

 High Stress Percentage 90.02 %

 M.A.W.P. for Total Stresses 68.87 bars

**Rectangular Vessel Results For Item 1 : A8**

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 57.58 N./mm^2

 High Stress Percentage 50.34 %

 M.A.W.P. for Membrane Stresses 123.17 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -126.92 N./mm^2

 High Stress Percentage 75.61 %

 M.A.W.P. for Bending Stresses 82.00 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 151.11 N./mm^2

 High Stress Percentage 90.02 %

 M.A.W.P. for Total Stresses 68.87 bars

## Stationary Header Calculation @ test Pressure for ae-2102.

**Input Echo, COMPONENT 1, Description: St.AE-2102-Test**

 Figure Number Analyzed A8

 Design Internal Pressure P 80.6000 bars

 Design Temperature Temp 25.0000 C

 VESSEL MATERIAL DATA:

 Material Specification SA-240 316L

 Shell Allowable Stress at Design Temp S 155.0000 N./mm^2

 Shell Allowable Stress at Ambient SA 155.0000 N./mm^2

 Shell Yield Stress at Design Temperature Sy 172.3750 N./mm^2

 SHORT-SIDE VESSEL DATA:

 Short-side Length Dimension H 110.0000 mm.

 Minimum Thickness of Short-side Plates t1 20.0000 mm.

 Mid-side Joint Efficiency on Short-side E 0.8500

 Corner Joint Efficiency on Short-side EC 0.8500

 LONG-SIDE VESSEL DATA:

 Long-side Length Dimension h 95.0000 mm.

 Minimum Thickness of Long-side Plates t2 20.0000 mm.

 Mid-side Joint Efficiency on Long-side E 0.8500

 ADDITIONAL VESSEL DATA:

 Minimum Thickness of End Plate t5 20.0000 mm.

 C-Factor for End Plate Cf\_Epl 0.2000

 Long-side Plate # 1,

 Pitch Distance p 69.0000 mm.

 Uniform Hole Diameter d0 25.6500 mm.

 Depth of Holes T0 20.0000 mm.

 Long-side Plate # 2,

 Pitch Distance p 69.0000 mm.

 # 1: Hole Diameter d0 36.3000 mm.

 Hole Depth T0 2.7000 mm.

 # 2: Hole Diameter d1 28.5750 mm.

 Hole Depth T1 17.3000 mm.

 STAY PLATE MATERIAL DATA:

 Stay Material Specification SA-240 316L

 Stay Allowable Stress at Design Temp Sr 114.3898 N./mm^2

 Stay Allowable Stress at Ambient SA 115.1465 N./mm^2

 Stay Yield Stress at Design Temp Sy 129.8699 N./mm^2

 STAY PLATE DATA:

 Minimum Thickness of Stay t3 10.0000 mm.

 Minimum Thickness of Stay t4 10.0000 mm.

 The Stay(s) Are Not Welded to the End Plate

**Rectangular Vessel Results, Item number 1, Desc: St.AE-2102-Test**

**ASME Code, Section VIII, Division 1, 2019 App. 13**

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

***Short-side 1 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Short-side 2 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 1 Calculations***

Effective Diameter [De]: 25.650 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 69.000 - 25.650 / 69.000

 = 0.628

Bending Ligament Efficiency [Eb]:

*As diameter holes are uniform Eb = Em*

 = 0.628

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 2 Calculations***

Effective Diameter [De]:

 = ( d0 \* T0 + d1 \* T1 + d2 \* T2 ) / ( t1 - CA )

 = ( 36.30 \* 2.70 + 28.57 \* 17.30 + 0.00 \* 0.00 ) /

 ( 20.00 - 0.00 )

 = 29.618 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 69.000 - 29.618 / 69.000

 = 0.571

Dist from Neutral axis of c/s to extreme fibers [Ci & Co]:

*Calculation of Xbar:*

 = (( b0 \* T0 \* ( T0/2 + T1 + T2 )) + ( b1 \* T1 \*

 ( T1/2 + T2 )) + ( b2 \* T2 \* ( T2/2 ))) /

 ( b0 \* T0 + b1 \* T1 + b2 \* T2 )

 = (( 1.29 \* 2.70 \* ( 2.70 /2 + 17.30 + 0.00 )) + ( 1.59\* 17.30 \*

 ( 17.30 /2 + 0.00 )) + ( 2.72 \* 0.00 \* ( 0.00 /2 ))) /

 ( 1.29 \* 2.70 + 1.59 \* 17.30 + 2.72 \* 0.00 )

 = 9.771 mm.

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 *Ci = Xbar*

 = 9.771 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t - CA - Xbar )

 = -( 20.000 - 0.000 - 9.771 )

 = -10.229 mm.

Moment of Inertia (Section 13-6, Equation (5)) [I]:

 = 0.100 cm\*\*4

Effective Diameter [De]:

 = Pitch - (( 6 \* I ) / (( t - CA)^2 \* (-Co)))

 = 69.00 - (( 6 \* 0.10 ) / ((20.00 - 0.00 )^2 \* (10.23 )))

 = 31.848 mm.

Bending Ligament Efficiency [Eb]:

 = Pitch - De / Pitch

 = 69.000 - 31.848 / 69.000

 = 0.538

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

 Em Eb Ci Co

 Short-side 1 0.850 0.850 10.000 -10.000

 2 0.850 0.850 10.000 -10.000

 Long-side 1 0.628 0.628 10.000 -10.000

 2 0.571 0.538 9.771 -10.229

**Moment of Inertia of a Strip of the Vessel Wall:**

 Thickness t1, I1 = 0.0667 cm\*\*4

 Thickness t2, I2 = 0.0667 cm\*\*4

**Rectangular Vessel Parameters:**

 Alpha = H / h = 1.1579

 K = (I2/I1)\*Alpha = 1.1579

**Membrane Stress Calculations per Section 13-9**

***Membrane Stresses at Short-side 1***

Membrane Stress at Short-side 1 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 80.60 \* 95.00 / ( 2 \* 20.00 ) \* { 3- [( 6 + 1.16 \*

 ( 11 - 1.162) / ( 3 + 5 \* 1.16 )]}

 = 20.00 N./mm^2

***Membrane Stresses at Short-side 2***

Membrane Stress at Short-side 2 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 80.60 \* 95.00 / ( 2 \* 20.00 ) \* { 3- [( 6 + 1.16 \*

 ( 11 - 1.162) / ( 3 + 5 \* 1.16 )]}

 = 20.00 N./mm^2

***Membrane Stresses at Long-side 1***

Membrane Stress at Long-side 1 at A [Sml]:

 = P \* H / 2 \* t2

 = 80.60 \* 110.00 / 2 \* 20.00

 = 22.17 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 22.17 / 0.63

 = 35.28 N./mm^2

***Membrane Stresses at Long-side 2***

Membrane Stress at Long-side 2 at A [Sml]:

 = P \* H / 2 \* t2

 = 80.60 \* 110.00 / 2 \* 20.00

 = 22.17 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 22.17 / 0.57

 = 38.84 N./mm^2

***Membrane Stresses at Stay Plate***

Membrane Stress at Stay Plate [t3]:

 = P \* h / ( 2 \* t3 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 80.60 \* 95.00 / ( 2 \* 10.00 ) \* [( 6 + 1.16 \* ( 11 -

 1.162) / ( 3 + 5 \* 1.16 )]

 = 74.86 N./mm^2

Membrane Stress at Stay Plate [t4]:

 = P \* h / ( 2 \* t4 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 80.60 \* 95.00 / ( 2 \* 10.00 ) \* [( 6 + 1.16 \* ( 11 -

 1.162) / ( 3 + 5 \* 1.16 )]

 = 74.86 N./mm^2

**MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9,**

 **Equations (13-15). (N./mm^2) :**

 STRESS LOCATIONS Actual Allowable

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

 Short-side 1 20.00 131.75

 Short-side 2 20.00 131.75

 Short-side Corner 20.00 131.75

 Long-side 1 at A 35.28 155.00

 Long-side 2 at A 38.84 155.00

 Long-side Corner 22.17 131.75

 Stay Plate (t3) 74.86 114.39

 Stay Plate (t4) 74.86 114.39

**Bending Stress Calculations per Section 13-9**

***Bending Stresses at Short-side 1***

Bending Stress at Short-side 1 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 80.60 \* 10.00 / ( 24 \* 0.07 ) \* [ -3 \* 110.002 + 2 \* 95.002 \*

 (( 3 + 5 \* 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))]

 = -71.53 N./mm^2

Bending Stress at Short-side 1 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 80.60 \* -10.00 /( 24 \* 0.07 ) \* [ -3 \* 110.002 + 2 \* 95.002 \*

 (( 3 + 5 \* 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))]

 = 71.53 N./mm^2

Bending Stress at Short-side 1 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 80.60 \* 95.002 \* 10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))

 = 111.34 N./mm^2

Bending Stress at Short-side 1 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 80.60 \* 95.002 \* -10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))

 = -111.34 N./mm^2

***Bending Stresses at Short-side 2***

Bending Stress at Short-side 2 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 80.60 \* 10.00 / ( 24 \* 0.07 ) \* [ -3 \* 110.002 + 2 \* 95.002 \*

 (( 3 + 5 \* 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))]

 = -71.53 N./mm^2

Bending Stress at Short-side 2 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 80.60 \* -10.00 /( 24 \* 0.07 ) \* [ -3 \* 110.002 + 2 \* 95.002 \*

 (( 3 + 5 \* 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))]

 = 71.53 N./mm^2

Bending Stress at Short-side 2 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 80.60 \* 95.002 \* 10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))

 = 111.34 N./mm^2

Bending Stress at Short-side 2 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 80.60 \* 95.002 \* -10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 ))

 = -111.34 N./mm^2

***Bending Stresses at Long-side 1***

Bending Stress at Long-side 1 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 80.60 \* 95.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 1.16 \*

 ( 6 - 1.162)) / ( 3 + 5 \* 1.16 )]

 = 86.85 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 86.85 / 0.63

 = 138.24 N./mm^2

Bending Stress at Long-side 1 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 80.60 \* 95.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 1.16 \*

 ( 6 - 1.162)) / ( 3 + 5 \* 1.16 )]

 = -86.85 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -86.85 / 0.63

 = -138.24 N./mm^2

Bending Stress at Long-side 1 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 80.60 \* 95.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 )]

 = 111.34 N./mm^2

Bending Stress at Long-side 1 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 80.60 \* 95.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 )]

 = -111.34 N./mm^2

***Bending Stresses at Long-side 2***

Bending Stress at Long-side 2 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 80.60 \* 95.002 \* 9.77 / ( 12 \* 0.07 ) \* [( 3 + 1.16 \*

 ( 6 - 1.162)) / ( 3 + 5 \* 1.16 )]

 = 84.86 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 84.86 / 0.54

 = 157.61 N./mm^2

Bending Stress at Long-side 2 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 80.60 \* 95.002 \* -10.23 / ( 12 \* 0.07 ) \* [( 3 + 1.16 \*

 ( 6 - 1.162)) / ( 3 + 5 \* 1.16 )]

 = -88.84 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -88.84 / 0.54

 = -165.00 N./mm^2

Bending Stress at Long-side 2 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 80.60 \* 95.002 \* 9.77 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 )]

 = 108.79 N./mm^2

Bending Stress at Long-side 2 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 80.60 \* 95.002 \* -10.23 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.162 \* 1.16 ) / ( 3 + 5 \* 1.16 )]

 = -113.89 N./mm^2

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,**

 **Equations (16-19). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -71.53 71.53 197.62

 at Q 111.34 -111.34 197.62

 Short-side 2 at N -71.53 71.53 197.62

 at Q 111.34 -111.34 197.62

 Long-side 1 at M 138.24 -138.24 232.50

 at Q 111.34 -111.34 197.62

 Long-side 2 at M 157.61 -165.00 232.50

 at Q 108.79 -113.89 197.62

**Total Stress Calculations per Section 13-9**

***Total Stresses at Short-side 1***

Total Stress at short side 1 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 20.00 + -71.53

 = -51.53 N./mm^2

Total Stress at short side 1 at N outer [STS\_No]:

 = Sms + SbsNo

 = 20.00 + 71.53

 = 91.53 N./mm^2

Total Stress at short side 1 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 20.00 + 111.34

 = 131.34 N./mm^2

Total Stress at short side 1 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 20.00 + -111.34

 = -91.34 N./mm^2

***Total Stresses at Short-side 2***

Total Stress at short side 2 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 20.00 + -71.53

 = -51.53 N./mm^2

Total Stress at short side 2 at N outer [STS\_No]:

 = Sms + SbsNo

 = 20.00 + 71.53

 = 91.53 N./mm^2

Total Stress at short side 2 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 20.00 + 111.34

 = 131.34 N./mm^2

Total Stress at short side 2 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 20.00 + -111.34

 = -91.34 N./mm^2

***Total Stresses at Long-side 1***

Total Stress at long side 1 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 35.28 + 138.24

 = 173.52 N./mm^2

Total Stress at long side 1 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 35.28 + -138.24

 = -102.96 N./mm^2

Total Stress at long side 1 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 22.17 + 111.34

 = 133.51 N./mm^2

Total Stress at long side 1 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 22.17 + -111.34

 = -89.17 N./mm^2

***Total Stresses at Long-side 2***

Total Stress at long side 2 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 38.84 + 157.61

 = 196.44 N./mm^2

Total Stress at long side 2 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 38.84 + -165.00

 = -126.16 N./mm^2

Total Stress at long side 2 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 22.17 + 108.79

 = 130.96 N./mm^2

Total Stress at long side 2 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 22.17 + -113.89

 = -91.72 N./mm^2

**TOTAL STRESSES: Total Stress Calculations per Section 13-9,**

 **Equations (20-24). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -51.53 91.53 197.62

 at Q 131.34 -91.34 197.62

 Short-side 2 at N -51.53 91.53 197.62

 at Q 131.34 -91.34 197.62

 Long-side 1 at M 173.52 -102.96 232.50

 at Q 133.51 -89.17 197.62

 Long-side 2 at M 196.44 -126.16 232.50

 at Q 130.96 -91.72 197.62

**End Plate Stresses (N./mm^2):**

 Actual Allowable

 End Plate 121.91 155.00

**Required End Plate thickness due to Internal Pressure [trEP]:**

 = d \* sqrt( Z \* C \* P / ( SE ) ) + ca

 = 110.000 \* sqrt( 2.500 \* 0.200 \* 80.600 / ( 155.000 ) ) + 0.000

 = 17.737 mm.

**End Plate MAWP at given Thickness [MAWPEP]:**

 = ((T-ca)/d)^2 \* ((SE)/(C\*Z)) per UG-34 (c)(3)

 = ((20.0000-0.0000)/110.0000)^2\*((155)/(.20\*2.50))

 = 102.473 bars

 *where Z is:*

 = min( 3.4 - 2.4( d/D ), 2.5 )

 = min( 3.4 - 2.4( 110.000 / 305.000 ), 2.5 )

 = 2.500

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 74.86 N./mm^2

 High Stress Percentage 65.44 %

 M.A.W.P. for Membrane Stresses 123.17 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -165.00 N./mm^2

 High Stress Percentage 70.97 %

 M.A.W.P. for Bending Stresses 113.58 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 196.44 N./mm^2

 High Stress Percentage 84.49 %

 M.A.W.P. for Total Stresses 95.39 bars

**Rectangular Vessel Results For Item 1 : A8**

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 74.86 N./mm^2

 High Stress Percentage 65.44 %

 M.A.W.P. for Membrane Stresses 123.17 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -165.00 N./mm^2

 High Stress Percentage 70.97 %

 M.A.W.P. for Bending Stresses 113.58 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 196.44 N./mm^2

 High Stress Percentage 84.49 %

 M.A.W.P. for Total Stresses 95.39 bars

## floating Header Calculation @ Design Pressure for ae-2102.

**Input Echo, COMPONENT 1, Description: Fl.AE-2101**

 Figure Number Analyzed A8

 Design Internal Pressure P 62.0000 bars

 Design Temperature Temp 175.0000 C

 VESSEL MATERIAL DATA:

 Material Specification SA-240 316L

 Shell Allowable Stress at Design Temp S 111.9078 N./mm^2

 Shell Allowable Stress at Ambient SA 115.1465 N./mm^2

 Shell Yield Stress at Design Temperature Sy 126.1469 N./mm^2

 SHORT-SIDE VESSEL DATA:

 Short-side Length Dimension H 100.0000 mm.

 Minimum Thickness of Short-side Plates t1 20.0000 mm.

 Mid-side Joint Efficiency on Short-side E 0.8500

 Corner Joint Efficiency on Short-side EC 0.8500

 LONG-SIDE VESSEL DATA:

 Long-side Length Dimension h 60.0000 mm.

 Minimum Thickness of Long-side Plates t2 20.0000 mm.

 Mid-side Joint Efficiency on Long-side E 0.8500

 ADDITIONAL VESSEL DATA:

 Minimum Thickness of End Plate t5 20.0000 mm.

 C-Factor for End Plate Cf\_Epl 0.2000

 Long-side Plate # 1,

 Pitch Distance p 69.0000 mm.

 Uniform Hole Diameter d0 25.6500 mm.

 Depth of Holes T0 20.0000 mm.

 Long-side Plate # 2,

 Pitch Distance p 69.0000 mm.

 # 1: Hole Diameter d0 36.3000 mm.

 Hole Depth T0 2.7000 mm.

 # 2: Hole Diameter d1 28.5750 mm.

 Hole Depth T1 17.3000 mm.

 STAY PLATE MATERIAL DATA:

 Stay Material Specification SA-240 316L

 Stay Allowable Stress at Design Temp Sr 114.3898 N./mm^2

 Stay Allowable Stress at Ambient SA 115.1465 N./mm^2

 Stay Yield Stress at Design Temp Sy 129.8699 N./mm^2

 STAY PLATE DATA:

 Minimum Thickness of Stay t3 10.0000 mm.

 Minimum Thickness of Stay t4 10.0000 mm.

 The Stay(s) Are Not Welded to the End Plate

**Rectangular Vessel Results, Item number 1, Desc: Fl.AE-2101**

**ASME Code, Section VIII, Division 1, 2019 App. 13**

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

***Short-side 1 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Short-side 2 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 1 Calculations***

Effective Diameter [De]: 25.650 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 69.000 - 25.650 / 69.000

 = 0.628

Bending Ligament Efficiency [Eb]:

*As diameter holes are uniform Eb = Em*

 = 0.628

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 2 Calculations***

Effective Diameter [De]:

 = ( d0 \* T0 + d1 \* T1 + d2 \* T2 ) / ( t1 - CA )

 = ( 36.30 \* 2.70 + 28.57 \* 17.30 + 0.00 \* 0.00 ) /

 ( 20.00 - 0.00 )

 = 29.618 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 69.000 - 29.618 / 69.000

 = 0.571

Dist from Neutral axis of c/s to extreme fibers [Ci & Co]:

*Calculation of Xbar:*

 = (( b0 \* T0 \* ( T0/2 + T1 + T2 )) + ( b1 \* T1 \*

 ( T1/2 + T2 )) + ( b2 \* T2 \* ( T2/2 ))) /

 ( b0 \* T0 + b1 \* T1 + b2 \* T2 )

 = (( 1.29 \* 2.70 \* ( 2.70 /2 + 17.30 + 0.00 )) + ( 1.59\* 17.30 \*

 ( 17.30 /2 + 0.00 )) + ( 2.72 \* 0.00 \* ( 0.00 /2 ))) /

 ( 1.29 \* 2.70 + 1.59 \* 17.30 + 2.72 \* 0.00 )

 = 9.771 mm.

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 *Ci = Xbar*

 = 9.771 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t - CA - Xbar )

 = -( 20.000 - 0.000 - 9.771 )

 = -10.229 mm.

Moment of Inertia (Section 13-6, Equation (5)) [I]:

 = 0.100 cm\*\*4

Effective Diameter [De]:

 = Pitch - (( 6 \* I ) / (( t - CA)^2 \* (-Co)))

 = 69.00 - (( 6 \* 0.10 ) / ((20.00 - 0.00 )^2 \* (10.23 )))

 = 31.848 mm.

Bending Ligament Efficiency [Eb]:

 = Pitch - De / Pitch

 = 69.000 - 31.848 / 69.000

 = 0.538

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

 Em Eb Ci Co

 Short-side 1 0.850 0.850 10.000 -10.000

 2 0.850 0.850 10.000 -10.000

 Long-side 1 0.628 0.628 10.000 -10.000

 2 0.571 0.538 9.771 -10.229

**Moment of Inertia of a Strip of the Vessel Wall:**

 Thickness t1, I1 = 0.0667 cm\*\*4

 Thickness t2, I2 = 0.0667 cm\*\*4

**Rectangular Vessel Parameters:**

 Alpha = H / h = 1.6667

 K = (I2/I1)\*Alpha = 1.6667

**Membrane Stress Calculations per Section 13-9**

***Membrane Stresses at Short-side 1***

Membrane Stress at Short-side 1 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 62.00 \* 60.00 / ( 2 \* 20.00 ) \* { 3- [( 6 + 1.67 \*

 ( 11 - 1.672) / ( 3 + 5 \* 1.67 )]}

 = 11.73 N./mm^2

***Membrane Stresses at Short-side 2***

Membrane Stress at Short-side 2 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 62.00 \* 60.00 / ( 2 \* 20.00 ) \* { 3- [( 6 + 1.67 \*

 ( 11 - 1.672) / ( 3 + 5 \* 1.67 )]}

 = 11.73 N./mm^2

***Membrane Stresses at Long-side 1***

Membrane Stress at Long-side 1 at A [Sml]:

 = P \* H / 2 \* t2

 = 62.00 \* 100.00 / 2 \* 20.00

 = 15.50 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 15.50 / 0.63

 = 24.67 N./mm^2

***Membrane Stresses at Long-side 2***

Membrane Stress at Long-side 2 at A [Sml]:

 = P \* H / 2 \* t2

 = 62.00 \* 100.00 / 2 \* 20.00

 = 15.50 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 15.50 / 0.57

 = 27.16 N./mm^2

***Membrane Stresses at Stay Plate***

Membrane Stress at Stay Plate [t3]:

 = P \* h / ( 2 \* t3 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 62.00 \* 60.00 / ( 2 \* 10.00 ) \* [( 6 + 1.67 \* ( 11 -

 1.672) / ( 3 + 5 \* 1.67 )]

 = 32.34 N./mm^2

Membrane Stress at Stay Plate [t4]:

 = P \* h / ( 2 \* t4 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 62.00 \* 60.00 / ( 2 \* 10.00 ) \* [( 6 + 1.67 \* ( 11 -

 1.672) / ( 3 + 5 \* 1.67 )]

 = 32.34 N./mm^2

**MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9,**

 **Equations (13-15). (N./mm^2) :**

 STRESS LOCATIONS Actual Allowable

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

 Short-side 1 11.73 95.12

 Short-side 2 11.73 95.12

 Short-side Corner 11.73 95.12

 Long-side 1 at A 24.67 111.91

 Long-side 2 at A 27.16 111.91

 Long-side Corner 15.50 95.12

 Stay Plate (t3) 32.34 114.39

 Stay Plate (t4) 32.34 114.39

**Bending Stress Calculations per Section 13-9**

***Bending Stresses at Short-side 1***

Bending Stress at Short-side 1 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 62.00 \* 10.00 / ( 24 \* 0.07 ) \* [ -3 \* 100.002 + 2 \* 60.002 \*

 (( 3 + 5 \* 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))]

 = -51.88 N./mm^2

Bending Stress at Short-side 1 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 62.00 \* -10.00 /( 24 \* 0.07 ) \* [ -3 \* 100.002 + 2 \* 60.002 \*

 (( 3 + 5 \* 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))]

 = 51.88 N./mm^2

Bending Stress at Short-side 1 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 62.00 \* 60.002 \* 10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))

 = 64.37 N./mm^2

Bending Stress at Short-side 1 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 62.00 \* 60.002 \* -10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))

 = -64.37 N./mm^2

***Bending Stresses at Short-side 2***

Bending Stress at Short-side 2 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 62.00 \* 10.00 / ( 24 \* 0.07 ) \* [ -3 \* 100.002 + 2 \* 60.002 \*

 (( 3 + 5 \* 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))]

 = -51.88 N./mm^2

Bending Stress at Short-side 2 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 62.00 \* -10.00 /( 24 \* 0.07 ) \* [ -3 \* 100.002 + 2 \* 60.002 \*

 (( 3 + 5 \* 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))]

 = 51.88 N./mm^2

Bending Stress at Short-side 2 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 62.00 \* 60.002 \* 10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))

 = 64.37 N./mm^2

Bending Stress at Short-side 2 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 62.00 \* 60.002 \* -10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))

 = -64.37 N./mm^2

***Bending Stresses at Long-side 1***

Bending Stress at Long-side 1 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 62.00 \* 60.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 1.67 \*

 ( 6 - 1.672)) / ( 3 + 5 \* 1.67 )]

 = 20.61 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 20.61 / 0.63

 = 32.80 N./mm^2

Bending Stress at Long-side 1 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 62.00 \* 60.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 1.67 \*

 ( 6 - 1.672)) / ( 3 + 5 \* 1.67 )]

 = -20.61 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -20.61 / 0.63

 = -32.80 N./mm^2

Bending Stress at Long-side 1 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 62.00 \* 60.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 )]

 = 64.37 N./mm^2

Bending Stress at Long-side 1 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 62.00 \* 60.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 )]

 = -64.37 N./mm^2

***Bending Stresses at Long-side 2***

Bending Stress at Long-side 2 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 62.00 \* 60.002 \* 9.77 / ( 12 \* 0.07 ) \* [( 3 + 1.67 \*

 ( 6 - 1.672)) / ( 3 + 5 \* 1.67 )]

 = 20.14 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 20.14 / 0.54

 = 37.40 N./mm^2

Bending Stress at Long-side 2 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 62.00 \* 60.002 \* -10.23 / ( 12 \* 0.07 ) \* [( 3 + 1.67 \*

 ( 6 - 1.672)) / ( 3 + 5 \* 1.67 )]

 = -21.08 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -21.08 / 0.54

 = -39.15 N./mm^2

Bending Stress at Long-side 2 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 62.00 \* 60.002 \* 9.77 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 )]

 = 62.90 N./mm^2

Bending Stress at Long-side 2 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 62.00 \* 60.002 \* -10.23 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 )]

 = -65.85 N./mm^2

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,**

 **Equations (16-19). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -51.88 51.88 142.68

 at Q 64.37 -64.37 142.68

 Short-side 2 at N -51.88 51.88 142.68

 at Q 64.37 -64.37 142.68

 Long-side 1 at M 32.80 -32.80 167.86

 at Q 64.37 -64.37 142.68

 Long-side 2 at M 37.40 -39.15 167.86

 at Q 62.90 -65.85 142.68

**Total Stress Calculations per Section 13-9**

***Total Stresses at Short-side 1***

Total Stress at short side 1 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 11.73 + -51.88

 = -40.15 N./mm^2

Total Stress at short side 1 at N outer [STS\_No]:

 = Sms + SbsNo

 = 11.73 + 51.88

 = 63.61 N./mm^2

Total Stress at short side 1 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 11.73 + 64.37

 = 76.11 N./mm^2

Total Stress at short side 1 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 11.73 + -64.37

 = -52.64 N./mm^2

***Total Stresses at Short-side 2***

Total Stress at short side 2 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 11.73 + -51.88

 = -40.15 N./mm^2

Total Stress at short side 2 at N outer [STS\_No]:

 = Sms + SbsNo

 = 11.73 + 51.88

 = 63.61 N./mm^2

Total Stress at short side 2 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 11.73 + 64.37

 = 76.11 N./mm^2

Total Stress at short side 2 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 11.73 + -64.37

 = -52.64 N./mm^2

***Total Stresses at Long-side 1***

Total Stress at long side 1 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 24.67 + 32.80

 = 57.47 N./mm^2

Total Stress at long side 1 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 24.67 + -32.80

 = -8.13 N./mm^2

Total Stress at long side 1 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 15.50 + 64.37

 = 79.88 N./mm^2

Total Stress at long side 1 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 15.50 + -64.37

 = -48.87 N./mm^2

***Total Stresses at Long-side 2***

Total Stress at long side 2 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 27.16 + 37.40

 = 64.55 N./mm^2

Total Stress at long side 2 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 27.16 + -39.15

 = -11.99 N./mm^2

Total Stress at long side 2 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 15.50 + 62.90

 = 78.40 N./mm^2

Total Stress at long side 2 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 15.50 + -65.85

 = -50.35 N./mm^2

**TOTAL STRESSES: Total Stress Calculations per Section 13-9,**

 **Equations (20-24). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -40.15 63.61 142.68

 at Q 76.11 -52.64 142.68

 Short-side 2 at N -40.15 63.61 142.68

 at Q 76.11 -52.64 142.68

 Long-side 1 at M 57.47 -8.13 167.86

 at Q 79.88 -48.87 142.68

 Long-side 2 at M 64.55 -11.99 167.86

 at Q 78.40 -50.35 142.68

**End Plate Stresses (N./mm^2):**

 Actual Allowable

 End Plate 68.20 111.91

**Required End Plate thickness due to Internal Pressure [trEP]:**

 = d \* sqrt( Z \* C \* P / ( SE ) ) + ca

 = 100.000 \* sqrt( 2.200 \* 0.200 \* 62.000 / ( 111.908 ) ) + 0.000

 = 15.614 mm.

**End Plate MAWP at given Thickness [MAWPEP]:**

 = ((T-ca)/d)^2 \* ((SE)/(C\*Z)) per UG-34 (c)(3)

 = ((20.0000-0.0000)/100.0000)^2\*((111)/(.20\*2.20))

 = 101.728 bars

 *where Z is:*

 = min( 3.4 - 2.4( d/D ), 2.5 )

 = min( 3.4 - 2.4( 100.000 / 200.000 ), 2.5 )

 = 2.200

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 32.34 N./mm^2

 High Stress Percentage 28.27 %

 M.A.W.P. for Membrane Stresses 219.31 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -65.85 N./mm^2

 High Stress Percentage 46.15 %

 M.A.W.P. for Bending Stresses 134.34 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 79.88 N./mm^2

 High Stress Percentage 55.98 %

 M.A.W.P. for Total Stresses 110.75 bars

**Rectangular Vessel Results For Item 1 : A8**

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 32.34 N./mm^2

 High Stress Percentage 28.27 %

 M.A.W.P. for Membrane Stresses 219.31 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -65.85 N./mm^2

 High Stress Percentage 46.15 %

 M.A.W.P. for Bending Stresses 134.34 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 79.88 N./mm^2

 High Stress Percentage 55.98 %

 M.A.W.P. for Total Stresses 110.75 bars

## floating Header Calculation @ test Pressure for ae-2102.

**Input Echo, COMPONENT 1, Description: Fl.AE-2101-Test**

 Figure Number Analyzed A8

 Design Internal Pressure P 80.6000 bars

 Design Temperature Temp 25.0000 C

 VESSEL MATERIAL DATA:

 Material Specification SA-240 316L

 Shell Allowable Stress at Design Temp S 155.0000 N./mm^2

 Shell Allowable Stress at Ambient SA 155.0000 N./mm^2

 Shell Yield Stress at Design Temperature Sy 172.3750 N./mm^2

 SHORT-SIDE VESSEL DATA:

 Short-side Length Dimension H 100.0000 mm.

 Minimum Thickness of Short-side Plates t1 20.0000 mm.

 Mid-side Joint Efficiency on Short-side E 0.8500

 Corner Joint Efficiency on Short-side EC 0.8500

 LONG-SIDE VESSEL DATA:

 Long-side Length Dimension h 60.0000 mm.

 Minimum Thickness of Long-side Plates t2 20.0000 mm.

 Mid-side Joint Efficiency on Long-side E 0.8500

 ADDITIONAL VESSEL DATA:

 Minimum Thickness of End Plate t5 20.0000 mm.

 C-Factor for End Plate Cf\_Epl 0.2000

 Long-side Plate # 1,

 Pitch Distance p 69.0000 mm.

 Uniform Hole Diameter d0 25.6500 mm.

 Depth of Holes T0 20.0000 mm.

 Long-side Plate # 2,

 Pitch Distance p 69.0000 mm.

 # 1: Hole Diameter d0 36.3000 mm.

 Hole Depth T0 2.7000 mm.

 # 2: Hole Diameter d1 28.5750 mm.

 Hole Depth T1 17.3000 mm.

 STAY PLATE MATERIAL DATA:

 Stay Material Specification SA-240 316L

 Stay Allowable Stress at Design Temp Sr 114.3898 N./mm^2

 Stay Allowable Stress at Ambient SA 115.1465 N./mm^2

 Stay Yield Stress at Design Temp Sy 129.8699 N./mm^2

 STAY PLATE DATA:

 Minimum Thickness of Stay t3 10.0000 mm.

 Minimum Thickness of Stay t4 10.0000 mm.

 The Stay(s) Are Not Welded to the End Plate

**Rectangular Vessel Results, Item number 1, Desc: Fl.AE-2101-Test**

**ASME Code, Section VIII, Division 1, 2019 App. 13**

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

***Short-side 1 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Short-side 2 Calculations***

Membrane Ligament Efficiency [Em]:

 = 0.850

Bending Ligament Efficiency [Eb]:

 = 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 1 Calculations***

Effective Diameter [De]: 25.650 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 69.000 - 25.650 / 69.000

 = 0.628

Bending Ligament Efficiency [Eb]:

*As diameter holes are uniform Eb = Em*

 = 0.628

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 = t1 - CA / 2

 = 20.000 - 0.000 / 2

 = 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t1 - CA ) / 2

 = -( 20.000 - 0.000 ) / 2

 = -10.000 mm.

***Long-side 2 Calculations***

Effective Diameter [De]:

 = ( d0 \* T0 + d1 \* T1 + d2 \* T2 ) / ( t1 - CA )

 = ( 36.30 \* 2.70 + 28.57 \* 17.30 + 0.00 \* 0.00 ) /

 ( 20.00 - 0.00 )

 = 29.618 mm.

Membrane Ligament Efficiency [Em]:

 = Pitch - De / Pitch

 = 69.000 - 29.618 / 69.000

 = 0.571

Dist from Neutral axis of c/s to extreme fibers [Ci & Co]:

*Calculation of Xbar:*

 = (( b0 \* T0 \* ( T0/2 + T1 + T2 )) + ( b1 \* T1 \*

 ( T1/2 + T2 )) + ( b2 \* T2 \* ( T2/2 ))) /

 ( b0 \* T0 + b1 \* T1 + b2 \* T2 )

 = (( 1.29 \* 2.70 \* ( 2.70 /2 + 17.30 + 0.00 )) + ( 1.59\* 17.30 \*

 ( 17.30 /2 + 0.00 )) + ( 2.72 \* 0.00 \* ( 0.00 /2 ))) /

 ( 1.29 \* 2.70 + 1.59 \* 17.30 + 2.72 \* 0.00 )

 = 9.771 mm.

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:

 *Ci = Xbar*

 = 9.771 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:

 = -( t - CA - Xbar )

 = -( 20.000 - 0.000 - 9.771 )

 = -10.229 mm.

Moment of Inertia (Section 13-6, Equation (5)) [I]:

 = 0.100 cm\*\*4

Effective Diameter [De]:

 = Pitch - (( 6 \* I ) / (( t - CA)^2 \* (-Co)))

 = 69.00 - (( 6 \* 0.10 ) / ((20.00 - 0.00 )^2 \* (10.23 )))

 = 31.848 mm.

Bending Ligament Efficiency [Eb]:

 = Pitch - De / Pitch

 = 69.000 - 31.848 / 69.000

 = 0.538

**Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):**

 Em Eb Ci Co

 Short-side 1 0.850 0.850 10.000 -10.000

 2 0.850 0.850 10.000 -10.000

 Long-side 1 0.628 0.628 10.000 -10.000

 2 0.571 0.538 9.771 -10.229

**Moment of Inertia of a Strip of the Vessel Wall:**

 Thickness t1, I1 = 0.0667 cm\*\*4

 Thickness t2, I2 = 0.0667 cm\*\*4

**Rectangular Vessel Parameters:**

 Alpha = H / h = 1.6667

 K = (I2/I1)\*Alpha = 1.6667

**Membrane Stress Calculations per Section 13-9**

***Membrane Stresses at Short-side 1***

Membrane Stress at Short-side 1 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 80.60 \* 60.00 / ( 2 \* 20.00 ) \* { 3- [( 6 + 1.67 \*

 ( 11 - 1.672) / ( 3 + 5 \* 1.67 )]}

 = 15.25 N./mm^2

***Membrane Stresses at Short-side 2***

Membrane Stress at Short-side 2 [Sms]:

 = P \* h / ( 2 \* t1 ) \* { 3 - [( 6 + K \*

 ( 11 - alpha2) / ( 3 + 5 \* K )]}

 = 80.60 \* 60.00 / ( 2 \* 20.00 ) \* { 3- [( 6 + 1.67 \*

 ( 11 - 1.672) / ( 3 + 5 \* 1.67 )]}

 = 15.25 N./mm^2

***Membrane Stresses at Long-side 1***

Membrane Stress at Long-side 1 at A [Sml]:

 = P \* H / 2 \* t2

 = 80.60 \* 100.00 / 2 \* 20.00

 = 20.15 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 20.15 / 0.63

 = 32.07 N./mm^2

***Membrane Stresses at Long-side 2***

Membrane Stress at Long-side 2 at A [Sml]:

 = P \* H / 2 \* t2

 = 80.60 \* 100.00 / 2 \* 20.00

 = 20.15 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 Sml = Sml / Em

 = 20.15 / 0.57

 = 35.31 N./mm^2

***Membrane Stresses at Stay Plate***

Membrane Stress at Stay Plate [t3]:

 = P \* h / ( 2 \* t3 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 80.60 \* 60.00 / ( 2 \* 10.00 ) \* [( 6 + 1.67 \* ( 11 -

 1.672) / ( 3 + 5 \* 1.67 )]

 = 42.04 N./mm^2

Membrane Stress at Stay Plate [t4]:

 = P \* h / ( 2 \* t4 ) \* [( 6 + K \* ( 11 -

 alpha2) / ( 3 + 5 \* K )]

 = 80.60 \* 60.00 / ( 2 \* 10.00 ) \* [( 6 + 1.67 \* ( 11 -

 1.672) / ( 3 + 5 \* 1.67 )]

 = 42.04 N./mm^2

**MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9,**

 **Equations (13-15). (N./mm^2) :**

 STRESS LOCATIONS Actual Allowable

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

 Short-side 1 15.25 131.75

 Short-side 2 15.25 131.75

 Short-side Corner 15.25 131.75

 Long-side 1 at A 32.07 155.00

 Long-side 2 at A 35.31 155.00

 Long-side Corner 20.15 131.75

 Stay Plate (t3) 42.04 114.39

 Stay Plate (t4) 42.04 114.39

**Bending Stress Calculations per Section 13-9**

***Bending Stresses at Short-side 1***

Bending Stress at Short-side 1 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 80.60 \* 10.00 / ( 24 \* 0.07 ) \* [ -3 \* 100.002 + 2 \* 60.002 \*

 (( 3 + 5 \* 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))]

 = -67.45 N./mm^2

Bending Stress at Short-side 1 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 80.60 \* -10.00 /( 24 \* 0.07 ) \* [ -3 \* 100.002 + 2 \* 60.002 \*

 (( 3 + 5 \* 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))]

 = 67.45 N./mm^2

Bending Stress at Short-side 1 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 80.60 \* 60.002 \* 10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))

 = 83.69 N./mm^2

Bending Stress at Short-side 1 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 80.60 \* 60.002 \* -10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))

 = -83.69 N./mm^2

***Bending Stresses at Short-side 2***

Bending Stress at Short-side 2 at N Inner[SbsNi]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 80.60 \* 10.00 / ( 24 \* 0.07 ) \* [ -3 \* 100.002 + 2 \* 60.002 \*

 (( 3 + 5 \* 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))]

 = -67.45 N./mm^2

Bending Stress at Short-side 2 at N Outer[SbsNo]:

 = P \* c / ( 24 \* I1 ) \* [ -3 \* H2 + 2 \* h2 \*

 (( 3 + 5 \* Alpha2 \* K ) / ( 3 + 5 \* K ))]

 = 80.60 \* -10.00 /( 24 \* 0.07 ) \* [ -3 \* 100.002 + 2 \* 60.002 \*

 (( 3 + 5 \* 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))]

 = 67.45 N./mm^2

Bending Stress at Short-side 2 at Q Inner[SbsQi]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 80.60 \* 60.002 \* 10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))

 = 83.69 N./mm^2

Bending Stress at Short-side 2 at Q Outer[SbsQo]:

 = P \* h2 \* c / ( 12 \* I1 ) \* (( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K ))

 = 80.60 \* 60.002 \* -10.00 / ( 12 \* 0.07 ) \* (( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 ))

 = -83.69 N./mm^2

***Bending Stresses at Long-side 1***

Bending Stress at Long-side 1 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 80.60 \* 60.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 1.67 \*

 ( 6 - 1.672)) / ( 3 + 5 \* 1.67 )]

 = 26.79 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 26.79 / 0.63

 = 42.64 N./mm^2

Bending Stress at Long-side 1 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 80.60 \* 60.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 1.67 \*

 ( 6 - 1.672)) / ( 3 + 5 \* 1.67 )]

 = -26.79 N./mm^2

 *If Em( 0.628 ) < E( 0.850 ) and Eb( 0.628 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -26.79 / 0.63

 = -42.64 N./mm^2

Bending Stress at Long-side 1 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 80.60 \* 60.002 \* 10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 )]

 = 83.69 N./mm^2

Bending Stress at Long-side 1 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 80.60 \* 60.002 \* -10.00 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 )]

 = -83.69 N./mm^2

***Bending Stresses at Long-side 2***

Bending Stress at Long-side 2 at M Inner[SblMi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 80.60 \* 60.002 \* 9.77 / ( 12 \* 0.07 ) \* [( 3 + 1.67 \*

 ( 6 - 1.672)) / ( 3 + 5 \* 1.67 )]

 = 26.18 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 SblMi = SblMi / Eb

 = 26.18 / 0.54

 = 48.61 N./mm^2

Bending Stress at Long-side 2 at M Outer[SblMo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + K \*

 ( 6 - Alpha2)) / ( 3 + 5 \* K )]

 = 80.60 \* 60.002 \* -10.23 / ( 12 \* 0.07 ) \* [( 3 + 1.67 \*

 ( 6 - 1.672)) / ( 3 + 5 \* 1.67 )]

 = -27.40 N./mm^2

 *If Em( 0.571 ) < E( 0.850 ) and Eb( 0.538 ) < E( 0.850 ) then*

 SblMo = SblMo / Eb

 = -27.40 / 0.54

 = -50.89 N./mm^2

Bending Stress at Long-side 2 at Q Inner[SblQi]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 80.60 \* 60.002 \* 9.77 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 )]

 = 81.77 N./mm^2

Bending Stress at Long-side 2 at Q Outer[SblQo]:

 = P \* h2 \* c / ( 12 \* I2 ) \* [( 3 + 5 \*

 Alpha2 \* K ) / ( 3 + 5 \* K )]

 = 80.60 \* 60.002 \* -10.23 / ( 12 \* 0.07 ) \* [( 3 + 5 \*

 1.672 \* 1.67 ) / ( 3 + 5 \* 1.67 )]

 = -85.60 N./mm^2

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,**

 **Equations (16-19). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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

 Short-side 1 at N -67.45 67.45 197.62

 at Q 83.69 -83.69 197.62

 Short-side 2 at N -67.45 67.45 197.62

 at Q 83.69 -83.69 197.62

 Long-side 1 at M 42.64 -42.64 232.50

 at Q 83.69 -83.69 197.62

 Long-side 2 at M 48.61 -50.89 232.50

 at Q 81.77 -85.60 197.62

**Total Stress Calculations per Section 13-9**

***Total Stresses at Short-side 1***

Total Stress at short side 1 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 15.25 + -67.45

 = -52.20 N./mm^2

Total Stress at short side 1 at N outer [STS\_No]:

 = Sms + SbsNo

 = 15.25 + 67.45

 = 82.70 N./mm^2

Total Stress at short side 1 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 15.25 + 83.69

 = 98.94 N./mm^2

Total Stress at short side 1 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 15.25 + -83.69

 = -68.43 N./mm^2

***Total Stresses at Short-side 2***

Total Stress at short side 2 at N inner [STS\_Ni]:

 = Sms + SbsNi

 = 15.25 + -67.45

 = -52.20 N./mm^2

Total Stress at short side 2 at N outer [STS\_No]:

 = Sms + SbsNo

 = 15.25 + 67.45

 = 82.70 N./mm^2

Total Stress at short side 2 at Q inner [STS\_Qi]:

 = Sms + SbsQi

 = 15.25 + 83.69

 = 98.94 N./mm^2

Total Stress at short side 2 at Q outer [STS\_Qo]:

 = Sms + SbsQo

 = 15.25 + -83.69

 = -68.43 N./mm^2

***Total Stresses at Long-side 1***

Total Stress at long side 1 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 32.07 + 42.64

 = 74.71 N./mm^2

Total Stress at long side 1 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 32.07 + -42.64

 = -10.57 N./mm^2

Total Stress at long side 1 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 20.15 + 83.69

 = 103.84 N./mm^2

Total Stress at long side 1 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 20.15 + -83.69

 = -63.54 N./mm^2

***Total Stresses at Long-side 2***

Total Stress at long side 2 at M inner [STL\_Mi]:

 = Sml + SblMi

 = 35.31 + 48.61

 = 83.92 N./mm^2

Total Stress at long side 2 at M outer [STL\_Mo]:

 = Sml + SblMo

 = 35.31 + -50.89

 = -15.59 N./mm^2

Total Stress at long side 2 at Q inner [STL\_Qi]:

 = Sml + SblQi

 = 20.15 + 81.77

 = 101.92 N./mm^2

Total Stress at long side 2 at Q outer [STL\_Qo]:

 = SmlB + SblQo

 = 20.15 + -85.60

 = -65.45 N./mm^2

**TOTAL STRESSES: Total Stress Calculations per Section 13-9,**

 **Equations (20-24). (N./mm^2) :**

 STRESS LOCATIONS Inner Outer Allowable

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 Short-side 1 at N -52.20 82.70 197.62

 at Q 98.94 -68.43 197.62

 Short-side 2 at N -52.20 82.70 197.62

 at Q 98.94 -68.43 197.62

 Long-side 1 at M 74.71 -10.57 232.50

 at Q 103.84 -63.54 197.62

 Long-side 2 at M 83.92 -15.59 232.50

 at Q 101.92 -65.45 197.62

**End Plate Stresses (N./mm^2):**

 Actual Allowable

 End Plate 88.67 155.00

**Required End Plate thickness due to Internal Pressure [trEP]:**

 = d \* sqrt( Z \* C \* P / ( SE ) ) + ca

 = 100.000 \* sqrt( 2.200 \* 0.200 \* 80.600 / ( 155.000 ) ) + 0.000

 = 15.127 mm.

**End Plate MAWP at given Thickness [MAWPEP]:**

 = ((T-ca)/d)^2 \* ((SE)/(C\*Z)) per UG-34 (c)(3)

 = ((20.0000-0.0000)/100.0000)^2\*((155)/(.20\*2.20))

 = 140.901 bars

 *where Z is:*

 = min( 3.4 - 2.4( d/D ), 2.5 )

 = min( 3.4 - 2.4( 100.000 / 200.000 ), 2.5 )

 = 2.200

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 42.04 N./mm^2

 High Stress Percentage 36.75 %

 M.A.W.P. for Membrane Stresses 219.31 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -85.60 N./mm^2

 High Stress Percentage 43.32 %

 M.A.W.P. for Bending Stresses 186.07 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 103.84 N./mm^2

 High Stress Percentage 52.54 %

 M.A.W.P. for Total Stresses 153.40 bars

**Rectangular Vessel Results For Item 1 : A8**

**SUMMARY OF RESULTS:**

 MEMBRANE STRESS SUMMARY,

 High Stress (Highest % of Allowable) 42.04 N./mm^2

 High Stress Percentage 36.75 %

 M.A.W.P. for Membrane Stresses 219.31 bars

 BENDING STRESS SUMMARY,

 High Stress (Highest % of Allowable) -85.60 N./mm^2

 High Stress Percentage 43.32 %

 M.A.W.P. for Bending Stresses 186.07 bars

 TOTAL STRESS SUMMARY,

 High Stress (Highest % of Allowable) 103.84 N./mm^2

 High Stress Percentage 52.54 %

 M.A.W.P. for Total Stresses 153.40 bars