

	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	BK	GCS	AA	120	PR	CN	0001	V02	

طرح نگهداشت و افزایش تولید 27 مخزن

Thermal/Mechanical Calculation Book

نگهداشت و افزایش تولید میدان نفتی بینک

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IFA: Issued For Approval

IFI: Issued For Information

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 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							 	
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REVISION RECORD SHEET

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1.0 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:	Executer 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.

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2.0 THERMALCALCULATION BOOK

		API 661 Air-Cooled Heat Exchanger - Specification Sheet			
		Job No. _____		Item No. 2101 (summer)	
		Page _____		By _____	
		Date 5/8/2024		Revision V02 (Totally Revised)	
		Proposal No. _____		Contract No. _____	
Inquiry No. _____		Order No. _____			
Manufacturer _____ Model no. _____ Customer PEDCO/NISOC Plant location BINAK Oilfield Service 1st stage Gas Compression Cool Type draft INDUCED Bay size (WxL) (m) 1.9x 3.8 No. of bays/items 1		Heat exchanged (MegaWatts) 0.3913 Surface/Item-Finned tube (m2) 721.45 Bare tube (m2) 31.536 MTD, Eff. (Deg. C) 28.7 Transfer rate-Finned (W/m2-K) 19.111 Bare tube, service (W/m2-K) 437.22 Bare tube, clean (W/m2-K) 491.43			
Basic design data					
Pressure design code _____		Structural code _____			
Tube bundle code stamped _____		Flammable service _____			
Heating coil code stamped _____		Lethal/toxic service _____			
Performance Data - Tube Side					
Fluid name Hydrocarbon		In _____ Out _____			
Total fluid entering (kg/hr)	9530.4	Total flow rate (Liq/Vap) (kg/hr)	/ 9530.4	/ 9530.4	
Dew /bubble point (Deg. C)	/	Water/Steam (kg/hr)	/	/ 0	
(Deg. C)		Noncondensables (kg/hr)	/	/ 0	
Latent heat (kJ/kg)		Molecular Wt. (Vap/Non-cond)	/	/	
Inlet pressure (barG)	18	Density (Liq/Vap) (kg/m3)	/ 14.571	/ 18.177	
Pressure drop (All/Calc) (bar)	0.7 / 0.453	Specific heat (Liq/Vap) (kJ/kg-C)	/ 2.23	/ 2.06	
Velocity (Allow /Calc) (m/s)	/ 16.41	Thermal cond. (Liq/Vap) (W/m-K)	/ 0.0422	/ 0.0331	
Inside fouling resistance (m2-K/W)	0.0002	Viscosity (Liq/Vap) (mN-s/m2)	/ 0.0149	/ 0.0126	
Temperature (Deg. C)	In 129 Out 60				
Performance Data - Air Side					
Air inlet temperature (Deg. C)	50.26	Face velocity (m/s)	2.96		
Air flow rate/item (m3/s)	24.188	Minimum design ambient temp. (Deg. C)	5		
Mass velocity (kg/s-m2)		Altitude (m)	12.5		
Air outlet temperature (Deg. C)	65.72	Static pressure (Pa)	152.81		
Air flow rate/fan (m3/s)	12.094				
Design, Material, and Construction					
Design pressure (barG)	22	Heating Coil NO			
Test pressure (barG)	28.6	No. of tubes			
Design temperature (Deg. C)	155	Tube outside diameter (mm)			
Min. design metal temp. (Deg. C)		Tube material			
Tube bundle		Fin material and type			
Size (WxL) (m)	1.86X 3.8	Fin thickness (mm)			
No./Bay	1	ASME Code, Sec. VIII, Div. 1			
Number of tube row s	4	Heating fluid			
Bundles in parallel	1	Heating fluid flow rate (kg/hr)			
Bundles in series		Temperature (In/Out) (Deg. C)	/		
Structure mounting		Inlet pressure (barG)			
Pipe rack beams		Pressure drop (All/Calc) (kPa)	/		
Ladders, w alkways, platforms		Design temperature (Deg. C)			
Structure surface prep.		Design pressure (barG)			
Header surface prep.		Inlet/Outlet nozzle	/		
Louver	YES	Header			
Material		Type	Plug		
Action control	Manual	Material	SA-240 TP316L		
Action type		Corrosion Allow ance (mm)	0		
		No. of passes	4		

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	API 661 Air-Cooled Heat Exchanger - Specification Sheet				
	Job No.			Item No.	2101 (summer)
	Page	Page 2		By	
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	Proposal No.			Contract No.	
	Inquiry No.			Order No.	
Design, Material, and Construction (continued)					
Header (continued)			No./Bundle 104		
Slope 1% ON LAST PASS			Length (m) 3.8		
Plug material SA 182 F316L			Pitch (mm) 61		
Gasket material Solid metal			Layout Triangular		
Nozzle			Fin		
No.	Size, (In)	Rating/Facing	Type	Extruded	
Inlet 1	6	300 RF	Material	Aluminum Alloy 1060 - O	
Outlet 1	6	300 RF	Thickness (mm)	0.48	
Vent 1	2	300 RF	Selection temp. (C)		
Drain 1	2	300 RF	Outside diameter (mm)	57.15	
Chemical Cleaning			Fin density (fin/in)	11	
Min. Wall Thk.			ASME Code, Sec. VIII, Div. 1		
Tube	SA-213 TP316L Tube (S) S31603		Customer Specifications		
Material					
Tube outside diameter (mm)	25.4				
w all thickness (mm)	1.651				
Mechanical Equipment					
Fan			RPM 1500		
Manufacturer			Service factor	1	
No./Bay	2		Enclosure	EEExd, IIB T3 (IP55)	
RPM (Revs/min.)	696		Voltage	400	
Diameter (mm)	1372		Phase	3	
No. of blades	5		Cycle	50	
Angle (degrees)			Fan noise level (dB)	≤85	
Pitch adjustment	50% Auto		Speed Reducer		
Blade material	AL		Type	V-BELT	
Hub material	ALU/Steel		Manufacturer		
@design temp	3.4		No./Bay	2	
@min. ambient temp	4.5		Service factor		
Tip speed			Speed ratio		
Driver			Support		
Type			Vib. Switch	YES, EEExd, IIB T3 (IP65)	
Manufacturer			Enclosure		
No./Bay	2				
Driver (kW)	5.5				
Controls - Air Side					
Air recirculation	NO		Louvers		
Degree control of outlet process temp. (Max. Cooling), +/-			Positioner		
Action on control signal failure			Signal air pressure (barG)		
Fan pitch			From	To	
Louvers			From	To	
Actuator air supply			Supply air pressure (barG)		
Fan			From	To	
			From	To	
Shipping					
Plot area (WxL) (m)	1.9 x 3.8		Total (kg)	9028	
Bundle weight (kg)	2247		Shipping (kg)		
Bay (kg)					
Note: 1) Reported duty and flow rates include a user-specified multiplier of 1.10 2- Max allow able nozzle load = 3xAPI 3-Material will be meet requirements of NACE MR0175/ISO1516 and specification for material requirments in sour service (BK-GNRL-PEDCO-000-PI-SP-0008) 4-HTRI Weight is reported					

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		API 661 Air-Cooled Heat Exchanger - Specification Sheet			
		Job No. _____ Page _____ Page 1 Date _____ 8/5/2024 Proposal No. _____ Inquiry No. _____	Item No. _____ 2101 (w inter) By _____ Revision _____ v02 Contract No. _____ Order No. _____		
Manufacturer _____ Model no. _____ Customer _____ PEDCO/NISOC Plant location _____ Binak oilfield Service _____ 1st stage Gas Compression Cooler Type draft _____ INDUCED Bay size (WxL) _____ (m) 1.9 x 3.8 No. of bays/items _____ 1	Heat exchanged (MegaWatts) _____ 0.2831 Surface/Item-Finned tube (m2) _____ 721.45 Bare tube (m2) _____ 31.536 MTD, Eff. (Deg. C) _____ 26.1 Transfer rate-Finned (W/m2-K) _____ 18.458 Bare tube, service (W/m2-K) _____ 422.28 Bare tube, clean (W/m2-K) _____ 472.63				
Basic design data					
Pressure design code _____ Tube bundle code stamped _____ Heating coil code stamped _____		Structural code _____ Flammable service _____ Lethal/toxic service _____			
Performance Data - Tube Side					
Fluid name _____ HYDROCARBON Total fluid entering (kg/hr) _____ 8343.5 Dew/bubble point (Deg. C) _____ / _____ Latent heat (kJ/kg) _____ Inlet pressure (barG) _____ 18 Pressure drop (All/Calc) (bar) _____ 0.7 / 0.4 Velocity (Allow /Calc) (m/s) _____ / 16.22 Inside fouling resistance (m2-K/W) _____ 0.0002 Temperature (Deg. C) _____ In 116 Out 60		Total flow rate (Liq/Vap) (kg/hr) _____ / 8343.5 _____ / 8343.5 Water/Steam (kg/hr) _____ / _____ Noncondensables (kg/hr) _____ Molecular Wt. (Vap/Non-cond) _____ / _____ Density (Liq/Vap) (kg/m3) _____ / 13.169 _____ / 15.723 Specific heat (Liq/Vap) (kJ/kg-C) _____ / 2.2498 _____ / 2.1161 Thermal cond. (Liq/Vap) (W/m-K) _____ / 0.0428 _____ / 0.0351 Viscosity (Liq/Vap) (mN-s/m2) _____ / 0.0145 _____ / 0.0127			
Performance Data - Air Side					
Air inlet temperature (Deg. C) _____ 50.26 Air flow rate/item (m3/s) _____ 23.88 Mass velocity (kg/s-m2) _____ Air outlet temperature (Deg. C) _____ 61.44 Air flow rate/fan (m3/s) _____ 11.94		Face velocity (m/s) _____ 2.96 Minimum design ambient temp. (Deg. C) _____ 5 Altitude (m) _____ 12.5 Static pressure (Pa) _____ 151.35			
Design, Material, and Construction					
Design pressure (barG) _____ 22 Test pressure (barG) _____ 28.6 Design temperature (Deg. C) _____ 155 Min. design metal temp. (Deg. C) _____ Tube bundle Size (WxL) _____ (m) 1.86X 3.80 No./Bay _____ 1 Number of tube rows _____ 4 Bundles in parallel _____ 1 Bundles in series _____ Structure mounting _____ Pipe rack beams _____ Ladders, walkways, platforms _____ Structure surface prep. _____ Header surface prep. _____ Louver Material _____ YES Action control _____ Manual Action type _____		Heating Coil _____ NO No. of tubes _____ Tube outside diameter (mm) _____ Tube material _____ Fin material and type _____ Fin thickness (mm) _____ ASME Code, Sec. VIII, Div. 1 _____ Heating fluid _____ Heating fluid flow rate (kg/hr) _____ Temperature (In/Out) (Deg. C) _____ / _____ Inlet pressure (barG) _____ Pressure drop (All/Calc) (kPa) _____ / _____ Design temperature (Deg. C) _____ Design pressure (barG) _____ Inlet/Outlet nozzle _____ / _____ Header Type _____ plug Material _____ SA-240 TP316L Corrosion Allowance (mm) _____ 0 No. of passes _____ 4			

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Design, Material, and Construction (continued)					
Header (continued)		Design, Material, and Construction (continued)			
Slope <u>1% ON LAST PASS</u>		No./Bundle <u>104</u>			
Plug material <u>SA 182 F316L</u>		Length (m) <u>3.8</u>			
Gasket material <u>Solid Metal</u>		Pitch (mm) <u>61</u>			
Nozzle		Layout <u>Triangular</u>			
No.	Size, (In)	Rating/Facing	Fin		
Inlet <u>1</u>	<u>6</u>	<u>300 RF</u>	Type <u>EXTRUDED</u>		
Outlet <u>1</u>	<u>6</u>	<u>300RF</u>	Material <u>Aluminum Alloy 1060 - O</u>		
Vent <u>1</u>	<u>2</u>	<u>300RF</u>	Thickness (mm) <u>0.48</u>		
Drain <u>1</u>	<u>2</u>	<u>300RF</u>	Selection temp. (C) _____		
Chemical Cleaning _____			Outside diameter (mm) <u>57.15</u>		
Min. Wall Thk. _____			Fin density (fin/in) <u>11</u>		
Tube		ASME Code, Sec. VIII, Div. 1 _____			
Material <u>SA-213 TP316L Tube (S) S31603</u>	Customer Specifications _____				
Tube outside diameter (mm) <u>25.4</u>					
w all thickness (mm) <u>1.651</u>					
Mechanical Equipment					
Fan		RPM <u>1500</u>			
Manufacturer _____	Service factor <u>1</u>		Enclosure <u>EEExd, IIB T3 (IP 55)</u>		
No./Bay <u>2</u>	RPM (Revs/min.) <u>696</u>		Voltage <u>400</u>		
Diameter (MM) <u>1372</u>	Phase <u>3</u>		Cycle <u>50</u>		
No. of blades <u>4</u>	Fan noise level (dB) <u><85</u>		Speed Reducer		
Angle (degrees) _____	Pitch adjustment <u>50% Auto</u>		Type <u>V-Belt</u>		
Pitch adjustment _____	Blade material <u>AL</u>		Manufacturer _____		
Blade material _____	Hub material <u>Alu/Steel</u>		No./Bay <u>2</u>		
Hub material _____	@design temp <u>3.4</u>		Service factor <u>1.8</u>		
@min. ambient temp <u>4.5</u>	Tip speed _____		Speed ratio _____		
Tip speed _____	Driver		Support _____		
Type _____	Type _____		Vib. sw itch <u>YES EEExd, IIB T3 (IP 55)</u>		
Manufacturer _____	No./Bay <u>2</u>		Enclosure _____		
No./Bay _____	Driver (kW) <u>5.5</u>				
Driver _____					
Controls - Air Side					
Air recirculation <u>NO</u>		Louvers _____			
Degree control of outlet process temp. _____		Positioner _____			
(Max. Cooling), +/- _____ / _____		Signal air pressure (barG) _____			
Action on control signal failure _____		From _____ To _____			
Fan pitch _____		From _____ To _____			
Louvers _____		Supply air pressure (barG) _____			
Actuator air supply _____		From _____ To _____			
Fan _____		From _____ To _____			
Shipping					
Plot area (WxL) (m) <u>1.86 x 3.8</u>	Total (Note 4) (kg) <u>9028</u>				
Bundle weight (Note 4) (kg) <u>2247</u>	Shipping (kg) _____				
Bay (kg) _____					
Note:1- Reported duty and flow rates include a user-specified multiplier of 1.10 2-Maximum allowable nozzle load = 3 x API. 3-Material will be meet requirements of NACE MR0175/ISO1516 and specification for material requirements in sour service (BK-GNRL-PEDCO-000-PI-SP-0008) 4-HTRI Weight is reported					

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							  
	Thermal/Mechanical Calculation Book							شماره صفحه : 9 از 93
شماره پیمان : 053 - 073 - 9184	پروژه BK	بسته کاری GCS	صادر کننده AA	تسهیلات 120	رشته PR	نوع مدرک CN	سریال 0001	نسخه V02

		API 661 Air-Cooled Heat Exchanger - Specification Sheet			
		Job No. _____ Page _____ Page 1 Date _____ 8/5/2024 Proposal No. _____ Inquiry No. _____	Item No. _____ 2102 (Summer) By _____ Revision v02 (Totally Revised) Contract No. _____ Order No. _____		
Manufacturer _____ Model no. _____ Customer PEDCO/NISOC Plant location BINAK oilfield Service 2st Stage Gas Compression Cooler Type draft INDUCED Bay size (WxL) (m) 2.12 x 3.900 No. of bays/items 1	Heat exchanged (MegaWatts) 0.582 Surface/Item-Finned tube (m2) 1106.8 Bare tube (m2) 48.548 MTD, Eff. (Deg. C) 30.7 Transfer rate-Finned (W/m2-K) 17.28 Bare tube, service (W/m2-K) 393.97 Bare tube, clean (W/m2-K) 437.61				
Basic design data					
Pressure design code _____ Tube bundle code stamped _____ Heating coil code stamped _____	Structural code _____ Flammable service _____ Lethal/toxic service _____				
Performance Data - Tube Side					
Fluid name HYDROCARBON Total fluid entering (kg/hr) 9530.4 Dew /bubble point (Deg. C) / Latent heat (kJ/kg) Inlet pressure (barG) 54.9 Pressure drop (All/Calc) (bar) 0.7 / 0.097 Velocity (Allow/Calc) (m/s) / 3.57 Inside fouling resistance (m2-K/W) 0.0002 Temperature (Deg. C) In 148 Out 60	Total flow rate (Liq/Vap) (kg/hr) / 9530.4 Water/Steam (kg/hr) / Noncondensables (kg/hr) Molecular Wt. (Vap/Non-cond) / Density (Liq/Vap) (kg/m3) / 42.042 Specific heat (Liq/Vap) (kJ/kg-C) / 2.4255 Thermal cond. (Liq/Vap) (W/m-K) / 0.0474 Viscosity (Liq/Vap) (mN-s/m2) / 0.0164 In 41.362 / 9489.1 Out 981.96 / 60.168 2.4071 0.0371 0.0142				
Performance Data - Air Side					
Air inlet temperature (Deg. C) 50.26 Air flow rate/item (m3/s) 29.468 Mass velocity (kg/s-m2) Air outlet temperature (Deg. C) 69.32 Air flow rate/fan (m3/s) 14.734	Face velocity (m/s) 3.14 Minimum design ambient temp. (Deg. C) 5 Altitude (m) 12.5 Static pressure (Pa) 173.1				
Design, Material, and Construction					
Design pressure (barG) 62 Test pressure (barG) 80.6 Design temperature (Deg. C) 175 Min. design metal temp. (Deg. C) 5 Tube bundle Size (WxL) (m) 2.06 X 3.900 No./Bay 1 Number of tube row s 6 Bundles in parallel 1 Bundles in series Structure mounting Pipe rack beams Ladders, walkways, platforms Structure surface prep. Header surface prep. Louver Material YES Action control Manual Action type	Heating Coil NO No. of tubes Tube outside diameter (mm) Tube material Fin material and type Fin thickness (mm) ASME Code, Sec. VIII, Div. 1 Heating fluid Heating fluid flow rate (kg/hr) Temperature (In/Out) (Deg. C) / Inlet pressure (barG) Pressure drop (All/Calc) (kPa) / Design temperature (Deg. C) Design pressure (barG) Inlet/Outlet nozzle / Header Type PLUG Material SA-240 TP316L Corrosion Allowance (mm) 0 No. of passes 4				

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 - 073 - 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 10 از 93	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

		API 661 Air-Cooled Heat Exchanger - Specification Sheet																
		Job No. _____	Item No. <u>2102 (Summer)</u>															
		Page <u>2</u>	By _____															
		Date _____	Revision <u>v02 (Totally revised)</u>															
Proposal No. _____ Inquiry No. _____		Contract No. _____ Order No. _____																
Design, Material, and Construction (continued)																		
Header (continued) Slope <u>1% ON LAST PASS</u> Plug material <u>SA-182 F316 L</u> Gasket material <u>Solid METAL</u>		No./Bundle <u>156</u> Length (m) <u>3.9</u> Pitch (mm) <u>69</u> Layout <u>Triangular</u>																
Nozzle <table border="1"> <tr> <th>No.</th> <th>Size, (in)</th> <th>Rating/Facing</th> </tr> <tr> <td>Inlet <u>1</u></td> <td><u>4</u></td> <td><u>600 RF</u></td> </tr> <tr> <td>Outlet <u>1</u></td> <td><u>4</u></td> <td><u>600 RF</u></td> </tr> <tr> <td>Vent <u>1</u></td> <td><u>2</u></td> <td><u>600 RF</u></td> </tr> <tr> <td>Drain <u>1</u></td> <td><u>2</u></td> <td><u>600 RF</u></td> </tr> </table> Chemical Cleaning _____ Min. Wall Thk. _____		No.	Size, (in)	Rating/Facing	Inlet <u>1</u>	<u>4</u>	<u>600 RF</u>	Outlet <u>1</u>	<u>4</u>	<u>600 RF</u>	Vent <u>1</u>	<u>2</u>	<u>600 RF</u>	Drain <u>1</u>	<u>2</u>	<u>600 RF</u>	Fin Type <u>Extruded</u> Material <u>Aluminum Alloy 1060 - O</u> Thickness (mm) <u>0.48</u> Selection temp. (C) _____ Outside diameter (mm) <u>57.15</u> Fin density (fin/in) <u>11</u> ASME Code, Sec. VIII, Div. 1 _____ Customer Specifications _____	
No.	Size, (in)	Rating/Facing																
Inlet <u>1</u>	<u>4</u>	<u>600 RF</u>																
Outlet <u>1</u>	<u>4</u>	<u>600 RF</u>																
Vent <u>1</u>	<u>2</u>	<u>600 RF</u>																
Drain <u>1</u>	<u>2</u>	<u>600 RF</u>																
Tube Material <u>SA-213 TP316L Tube (S) S31603</u> Tube outside diameter (mm) <u>25.4</u> w all thickness (mm) <u>1.651</u>																		
Mechanical Equipment																		
Fan Manufacturer _____ No./Bay <u>2</u> RPM (Revs/min.) <u>658.6</u> Diameter (mm) <u>1450</u> No. of blades <u>5</u> Angle (degrees) _____ Pitch adjustment <u>50% Auto</u> Blade material <u>Al</u> Hub material <u>steel/Alu</u> @design temp <u>4.8</u> @min. ambient temp <u>6.7</u> Tip speed _____		RPM <u>1500</u> Service factor <u>1</u> Enclosure <u>EEExd, IIB T3 (IP 55)</u> Voltage <u>400</u> Phase <u>3</u> Cycle <u>50</u> Fan noise level (dB) <u><85</u> Speed Reducer Type <u>V-Belt</u> Manufacturer _____ No./Bay <u>2</u> Service factor <u>1.8</u> Speed ratio <u>2.28</u> Support _____ Vib. sw itch _____ Enclosure _____																
Driver Type _____ Manufacturer _____ No./Bay <u>2</u> Driver (kW) <u>7.5</u>																		
Controls - Air Side																		
Air recirculation <u>NO</u> Degree control of outlet process temp. _____ (Max. Cooling), +/- _____ / _____ Action on control signal failure _____ Fan pitch _____ Louvers _____ Actuator air supply _____ Fan _____		Louvers _____ Positioner _____ Signal air pressure (barG) _____ From _____ To _____ From _____ To _____ Supply air pressure (barG) _____ From _____ To _____ From _____ To _____																
Shipping																		
Plot area (WxL) (m) <u>2.12 x 3.900</u> Bundle weight (Note 4) (kg) <u>3329.2</u> Bay (kg) _____		Total (kg) <u>10528</u> Shipping (kg) _____																
Note: 1-Reported duty and flow rates include a user-specified multiplier of 1.10 2-Maximum allowable nozzle load = 3 x API 3-Material will be meet requirements of NACE MR0175/ISO1516 and specification for material requirements in sour service (BK-GNRL-PEDCO-000-PI-SP-0008) 4- HTRI Weights are reported																		

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 11 از 93	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

		API 661 Air-Cooled Heat Exchanger - Specification Sheet																														
		Job No. _____		Item No. 2102 (w inter)																												
		Page Page 1		By _____																												
		Date 8/5/2024		Revision V02 Totally Revised																												
		Proposal No. _____		Contract No. _____																												
Inquiry No. _____		Order No. _____																														
Manufacturer _____ Model no. _____ Customer PEDCO/NISOC Plant location BINAK oilfield Service 2st Stage Gas Compression Cooler Type draft INDUCED Bay size (WxL) (m) 2.12 x 3.900 No. of bays/items 1		Heat exchanged (MegaWatts) 0.496 Surface/Item-Finned tube (m2) 1106.8 Bare tube (m2) 48.548 MTD, Eff. (Deg. C) 33.7 Transfer rate-Finned (W/m2-K) 15.921 Bare tube, service (W/m2-K) 362.98 Bare tube, clean (W/m2-K) 399.72																														
Basic design data																																
Pressure design code _____ Tube bundle code stamped _____ Heating coil code stamped _____		Structural code _____ Flammable service _____ Lethal/toxic service _____																														
Performance Data - Tube Side																																
Fluid name HYDROCARBON Total fluid entering (kg/hr) 8343.5 Dew /bubble point (Deg. C) _____ Latent heat (kJ/kg) _____ Inlet pressure (barG) 54.9 Pressure drop (All/Calc) (bar) 0.7 / 0.081 Velocity (Allow /Calc) (m/s) _____ / 3.69 Inside fouling resistance (m2-K/W) 0.0002 Temperature (Deg. C) In 149 Out 60		<table border="1"> <thead> <tr> <th></th> <th>In</th> <th>Out</th> </tr> </thead> <tbody> <tr> <td>Total flow rate (Liq/Vap) (kg/hr)</td> <td>8343.5</td> <td>8343.5</td> </tr> <tr> <td>Water/Steam (kg/hr)</td> <td>/</td> <td>/</td> </tr> <tr> <td>Noncondensables (kg/hr)</td> <td>/</td> <td>/</td> </tr> <tr> <td>Molecular Wt. (Vap/Non-cond)</td> <td>/</td> <td>/</td> </tr> <tr> <td>Density (Liq/Vap) (kg/m3)</td> <td>36.099</td> <td>50.026</td> </tr> <tr> <td>Specific heat (Liq/Vap) (kJ/kg-C)</td> <td>2.46</td> <td>2.38</td> </tr> <tr> <td>Thermal cond. (Liq/Vap) (W/m-K)</td> <td>0.05</td> <td>0.0387</td> </tr> <tr> <td>Viscosity (Liq/Vap) (mN-s/m2)</td> <td>0.0163</td> <td>0.0139</td> </tr> </tbody> </table>					In	Out	Total flow rate (Liq/Vap) (kg/hr)	8343.5	8343.5	Water/Steam (kg/hr)	/	/	Noncondensables (kg/hr)	/	/	Molecular Wt. (Vap/Non-cond)	/	/	Density (Liq/Vap) (kg/m3)	36.099	50.026	Specific heat (Liq/Vap) (kJ/kg-C)	2.46	2.38	Thermal cond. (Liq/Vap) (W/m-K)	0.05	0.0387	Viscosity (Liq/Vap) (mN-s/m2)	0.0163	0.0139
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Performance Data - Air Side																																
Air inlet temperature (Deg. C) 50.26 Air flow rate/item (m3/s) 29.226 Mass velocity (kg/s-m2) _____ Air outlet temperature (Deg. C) 66.5 Air flow rate/fan (m3/s) 14.613		Face velocity (m/s) 3.14 Minimum design ambient temp. (Deg. C) 5 Altitude (m) 12.5 Static pressure (Pa) 172.09																														
Design, Material, and Construction																																
Design pressure (barG) 62 Test pressure (barG) 80.6 Design temperature (Deg. C) 175 Min. design metal temp. (Deg. C) _____ Tube bundle Size (WxL) (m) 2.058 X 3.900 No./Bay 1 Number of tube rows 6 Bundles in parallel 1 Bundles in series _____ Structure mounting _____ Pipe rack beams _____ Ladders, w alkways, platforms _____ Structure surface prep. _____ Header surface prep. _____ Louver Material YES Action control Manual Action type _____		Heating Coil NO No. of tubes _____ Tube outside diameter (mm) _____ Tube material _____ Fin material and type _____ Fin thickness (mm) _____ ASME Code, Sec. VIII, Div. 1 _____ Heating fluid _____ Heating fluid flow rate (kg/hr) _____ Temperature (In/Out) (Deg. C) _____ / _____ Inlet pressure (barG) _____ Pressure drop (All/Calc) (kPa) _____ / _____ Design temperature (Deg. C) _____ Design pressure (barG) _____ Inlet/Outlet nozzle _____ / _____ Header Type PLUG Material SA-240 TP316L Corrosion Allowance (mm) 0 No. of passes 4																														

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)		  																
	شماره پیمان: 053 - 073 - 9184		شماره صفحه : 12 از 93																
Thermal/Mechanical Calculation Book		<table border="1"> <tr> <td>پروژه</td> <td>بسته کاری</td> <td>صادر کننده</td> <td>تسهيلات</td> <td>رشته</td> <td>نوع مدرک</td> <td>سریال</td> <td>نسخه</td> </tr> <tr> <td>BK</td> <td>GCS</td> <td>AA</td> <td>120</td> <td>PR</td> <td>CN</td> <td>0001</td> <td>V02</td> </tr> </table>		پروژه	بسته کاری	صادر کننده	تسهيلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	AA	120	PR	CN	0001	V02
پروژه	بسته کاری	صادر کننده	تسهيلات	رشته	نوع مدرک	سریال	نسخه												
BK	GCS	AA	120	PR	CN	0001	V02												

		API 661 Air-Cooled Heat Exchanger - Specification Sheet	
		Job No. _____ Page _____ Page 2 Date _____ Proposal No. _____ Inquiry No. _____	Item No. 2102 (w inter) By _____ Revision v02 Totally Revised Contract No. _____ Order No. _____
Design, Material, and Construction (continued)			
Header (continued)		No./Bundle 156 Length (m) 3.9 Pitch (mm) 69 Layout Triangular	
Slope 1% ON LAST PASS Plug material SA-182 F316 L Gasket material Solid METAL		Fin Type Extruded Material Aluminum Alloy 1060 - O Thickness (mm) 0.48 Selection temp. (C) _____ Outside diameter (mm) 57.15 Fin density (fin/in) 11 ASME Code, Sec. VIII, Div. 1 _____ Customer Specifications _____	
Nozzle		Tube	
No.	Size, (in)	Rating/Facing	
Inlet 1	4	600 RF	
Outlet 1	4	600 RF	
Vent 1	2	600 RF	
Drain 1	2	600 RF	
Chemical Cleaning			
Min. Wall Thk.			
Material SA-213 TP316L Tube (S) S31603 Tube outside diameter (mm) 25.4 w all thickness (mm) 1.651			
Mechanical Equipment			
Fan		Speed Reducer	
Manufacturer		RPM	1500
No./Bay	2	Service factor	1
RPM (Revs/min.)	658.6	Enclosure	EExd, IIB T3 (IP 55)
Diameter (mm)	1450	Voltage	400
No. of blades	5	Phase	3
Angle (degrees)		Cycle	50
Pitch adjustment	50% Auto	Fan noise level (dB)	<85
Blade material	Al	Type	V-Belt
Hub material	steel/Alu	Manufacturer	
@design temp	4.8	No./Bay	2
@min. ambient temp	6.7	Service factor	1.8
Tip speed		Speed ratio	2.28
Driver		Support	
Type		Vib. sw itch	YES, EExd, IIB T3 (IP 65)
Manufacturer		Enclosure	
No./Bay	2		
Driver (kW)	7.5		
Controls - Air Side			
Air recirculation NO Degree control of outlet process temp. _____ (Max. Cooling), +/- _____ / _____ Action on control signal failure _____ Fan pitch _____ Louvers _____ Actuator air supply _____ Fan _____		Louvers _____ Positioner _____ Signal air pressure (barG) From _____ To _____ From _____ To _____ Supply air pressure (barG) From _____ To _____ From _____ To _____	
Shipping			
Plot area (WxL)	(m)	2.12 x 3.900	Total (kg)
Bundle weight (Note 4)	(kg)	3329.2	Shipping (kg)
Bay	(kg)		
Note: 1-Reported duty and flow rates include a user-specified multiplier of 1.10 2-Maximum allowable nozzle load = 3 x API. 3-Material will be meet requirements of NACE MR0175/ISO1516 and specification for material requirements in sour service (BK-GNRL-PEDCO-000-PI-SP-0008) 4- HTRI Weights are reported			

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 13 از 93
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	AA	120	PR	CN	0001	V02

Mechanical Calculation

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 14 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

3.0 MECHANICAL CALCULATION BOOK

3.1 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./mm²
Shell Allowable Stress at Ambient SA 115.1465 N./mm²
Shell Yield Stress at Design Temperature Sy 129.8699 N./mm²

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./mm²
Stay Allowable Stress at Ambient SA 115.1465 N./mm²
Stay Yield Stress at Design Temp Sy 129.8699 N./mm²

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 - 073 - 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 15 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

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 vessel [Ci]:
= $t_1 - CA / 2$
= $15.000 - 0.000 / 2$
= 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(15.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $15.000 - 0.000 / 2$
= 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(15.000 - 0.000) / 2$
= -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 $E_b = E_m$
= 0.579

Dist from Neutral axis of c/s to inside surface of the vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 16 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

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

$$\begin{aligned}
 &= -(t_1 - CA) / 2 \\
 &= -(20.000 - 0.000) / 2 \\
 &= -10.000 \text{ mm.}
 \end{aligned}$$

Long-side 2 Calculations

Effective Diameter [De]:

$$\begin{aligned}
 &= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA) \\
 &= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / \\
 &\quad (20.00 - 0.00) \\
 &= 29.618 \text{ mm.}
 \end{aligned}$$

Membrane Ligament Efficiency [Em]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 61.000 - 29.618 / 61.000 \\
 &= 0.514
 \end{aligned}$$

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

Calculation of Xbar:

$$\begin{aligned}
 &= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * \\
 &\quad (T_1/2 + T_2)) + (b_2 * T_2 * (T_2/2))) / \\
 &\quad (b_0 * T_0 + b_1 * T_1 + b_2 * T_2) \\
 &= ((0.97 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.28 * 17.30 * \\
 &\quad (17.30/2 + 0.00)) + (2.40 * 0.00 * (0.00/2))) / \\
 &\quad (0.97 * 2.70 + 1.28 * 17.30 + 2.40 * 0.00) \\
 &= 9.713 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 Ci &= Xbar \\
 &= 9.713 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= -(t - CA - Xbar) \\
 &= -(20.000 - 0.000 - 9.713) \\
 &= -10.287 \text{ mm.}
 \end{aligned}$$

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

$$= 0.079 \text{ cm}^4$$

Effective Diameter [De]:

$$\begin{aligned}
 &= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co))) \\
 &= 61.00 - ((6 * 0.08) / ((20.00 - 0.00)^2 * (10.29))) \\
 &= 31.851 \text{ mm.}
 \end{aligned}$$

Bending Ligament Efficiency [Eb]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 61.000 - 31.851 / 61.000 \\
 &= 0.478
 \end{aligned}$$

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

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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]:

$$= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \}$$

$$= 22.00 * 122.00 / (2 * 15.00) * \{ 3 - [(6 + 3.11 * (11 - 1.31^2) / (3 + 5 * 3.11))] \}$$

$$= 10.03 \text{ N./mm}^2$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \}$$

$$= 22.00 * 122.00 / (2 * 15.00) * \{ 3 - [(6 + 3.11 * (11 - 1.31^2) / (3 + 5 * 3.11))] \}$$

$$= 10.03 \text{ N./mm}^2$$

Membrane Stresses at Long-side 1

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

$$= P * H / 2 * t2$$

$$= 22.00 * 160.00 / 2 * 20.00$$

$$= 8.80 \text{ N./mm}^2$$

If $E_m(0.579) < E(0.850)$ and $E_b(0.579) < E(0.850)$ then

$$S_{ml} = S_{ml} / E_m$$

$$= 8.80 / 0.58$$

$$= 15.21 \text{ N./mm}^2$$

Membrane Stresses at Long-side 2

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

$$= P * H / 2 * t2$$

$$= 22.00 * 160.00 / 2 * 20.00$$

$$= 8.80 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$S_{ml} = S_{ml} / E_m$$

$$= 8.80 / 0.51$$

$$= 17.11 \text{ N./mm}^2$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$= P * h / (2 * t3) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))]$$

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$$= 22.00 * 122.00 / (2 * 10.00) * [(6 + 3.11 * (11 - 1.31^2) / (3 + 5 * 3.11))]$$

$$= 25.22 \text{ N./mm}^2$$

Membrane Stress at Stay Plate [t4]:

$$= P * h / (2 * t_4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))]$$

$$= 22.00 * 122.00 / (2 * 10.00) * [(6 + 3.11 * (11 - 1.31^2) / (3 + 5 * 3.11))]$$

$$= 25.22 \text{ N./mm}^2$$

MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9, Equations (13-15). (N./mm²) :

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]:

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 22.00 * 7.50 / (24 * 0.03) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))]$$

$$= -71.06 \text{ N./mm}^2$$

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

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 22.00 * -7.50 / (24 * 0.03) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))]$$

$$= 71.06 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 22.00 * 122.00^2 * 7.50 / (12 * 0.03) * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))$$

$$= 116.69 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 22.00 * 122.00^2 * -7.50 / (12 * 0.03) * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))$$

$$= -116.69 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							
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Bending Stresses at Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 22.00 * 7.50 / (24 * 0.03) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))]$$

$$= -71.06 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 22.00 * -7.50 / (24 * 0.03) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))]$$

$$= 71.06 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 22.00 * 122.00^2 * 7.50 / (12 * 0.03) * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))$$

$$= 116.69 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 22.00 * 122.00^2 * -7.50 / (12 * 0.03) * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))$$

$$= -116.69 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * [(3 + 3.11 * (6 - 1.31^2)) / (3 + 5 * 3.11)]$$

$$= 35.99 \text{ N./mm}^2$$

If $E_m(0.579) < E(0.850)$ and $E_b(0.579) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 35.99 / 0.58$$

$$= 62.20 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * -10.00 / (12 * 0.07) * [(3 + 3.11 * (6 - 1.31^2)) / (3 + 5 * 3.11)]$$

$$= -35.99 \text{ N./mm}^2$$

If $E_m(0.579) < E(0.850)$ and $E_b(0.579) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -35.99 / 0.58$$

$$= -62.20 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11)]$$

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$$= 1.31^2 * 3.11 / (3 + 5 * 3.11)]$$

$$= 65.64 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * -10.00 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11)]$$

$$= -65.64 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - \text{Alpha}^2)) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * 9.71 / (12 * 0.07) * [(3 + 3.11 * (6 - 1.31^2)) / (3 + 5 * 3.11)]$$

$$= 34.96 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$SblMi = SblMi / E_b$$

$$= 34.96 / 0.48$$

$$= 73.16 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - \text{Alpha}^2)) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * -10.29 / (12 * 0.07) * [(3 + 3.11 * (6 - 1.31^2)) / (3 + 5 * 3.11)]$$

$$= -37.03 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$SblMo = SblMo / E_b$$

$$= -37.03 / 0.48$$

$$= -77.49 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * 9.71 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11)]$$

$$= 63.75 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * -10.29 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11)]$$

$$= -67.52 \text{ N./mm}^2$$

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**BENDING STRESSES: Bending Stress Calculations per Section 13-9,
Equations (16-19). (N./mm²) :**

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]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 10.03 + -71.06 \\
 &= -61.03 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 10.03 + 71.06 \\
 &= 81.08 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 10.03 + 116.69 \\
 &= 126.71 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 10.03 + -116.69 \\
 &= -106.66 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 10.03 + -71.06 \\
 &= -61.03 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 10.03 + 71.06 \\
 &= 81.08 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 10.03 + 116.69 \\
 &= 126.71 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 10.03 + -116.69 \\
 &= -106.66 \text{ N./mm}^2
 \end{aligned}$$

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Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 15.21 + 62.20 \\
 &= 77.40 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 15.21 + -62.20 \\
 &= -46.99 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 8.80 + 65.64 \\
 &= 74.44 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 8.80 + -65.64 \\
 &= -56.84 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 17.11 + 73.16 \\
 &= 90.26 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 17.11 + -77.49 \\
 &= -60.38 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 8.80 + 63.75 \\
 &= 72.55 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 8.80 + -67.52 \\
 &= -58.72 \text{ N./mm}^2
 \end{aligned}$$

TOTAL STRESSES: Total Stress Calculations per Section 13-9, Equations (20-24). (N./mm²) :

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	67.73	114.39

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

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

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

$$= 15.390 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/160.0000)^2 * ((114)/(0.20*2.41))$$

$$= 37.154 \text{ bars}$$

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

3.2 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			

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
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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 vessel [Ci]:
= $t_1 - CA / 2$
= $15.000 - 0.000 / 2$
= 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(15.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $15.000 - 0.000 / 2$
= 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(15.000 - 0.000) / 2$
= -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 $E_b = E_m$
= 0.580

Dist from Neutral axis of c/s to inside surface of the vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

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

$$\begin{aligned}
 &= -(t_1 - CA) / 2 \\
 &= -(20.000 - 0.000) / 2 \\
 &= -10.000 \text{ mm.}
 \end{aligned}$$

Long-side 2 Calculations

Effective Diameter [De]:

$$\begin{aligned}
 &= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA) \\
 &= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / \\
 &\quad (20.00 - 0.00) \\
 &= 29.618 \text{ mm.}
 \end{aligned}$$

Membrane Ligament Efficiency [Em]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 61.000 - 29.618 / 61.000 \\
 &= 0.514
 \end{aligned}$$

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

Calculation of Xbar:

$$\begin{aligned}
 &= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * \\
 &\quad (T_1/2 + T_2)) + (b_2 * T_2 * (T_2/2))) / \\
 &\quad (b_0 * T_0 + b_1 * T_1 + b_2 * T_2) \\
 &= ((0.97 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.28 * 17.30 * \\
 &\quad (17.30/2 + 0.00)) + (2.40 * 0.00 * (0.00/2))) / \\
 &\quad (0.97 * 2.70 + 1.28 * 17.30 + 2.40 * 0.00) \\
 &= 9.713 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 Ci &= Xbar \\
 &= 9.713 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= -(t - CA - Xbar) \\
 &= -(20.000 - 0.000 - 9.713) \\
 &= -10.287 \text{ mm.}
 \end{aligned}$$

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

$$= 0.079 \text{ cm}^4$$

Effective Diameter [De]:

$$\begin{aligned}
 &= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co))) \\
 &= 61.00 - ((6 * 0.08) / ((20.00 - 0.00)^2 * (10.29))) \\
 &= 31.851 \text{ mm.}
 \end{aligned}$$

Bending Ligament Efficiency [Eb]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 61.000 - 31.851 / 61.000 \\
 &= 0.478
 \end{aligned}$$

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V02

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]:

$$= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \}$$

$$= 28.60 * 122.00 / (2 * 15.00) * \{ 3 - [(6 + 3.11 * (11 - 1.31^2) / (3 + 5 * 3.11))] \}$$

$$= 13.04 \text{ N./mm}^2$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \}$$

$$= 28.60 * 122.00 / (2 * 15.00) * \{ 3 - [(6 + 3.11 * (11 - 1.31^2) / (3 + 5 * 3.11))] \}$$

$$= 13.04 \text{ N./mm}^2$$

Membrane Stresses at Long-side 1

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

$$= P * H / 2 * t2$$

$$= 28.60 * 160.00 / 2 * 20.00$$

$$= 11.44 \text{ N./mm}^2$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.580) < E(0.850)$ then

$$S_{ml} = S_{ml} / E_m$$

$$= 11.44 / 0.58$$

$$= 19.74 \text{ N./mm}^2$$

Membrane Stresses at Long-side 2

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

$$= P * H / 2 * t2$$

$$= 28.60 * 160.00 / 2 * 20.00$$

$$= 11.44 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$S_{ml} = S_{ml} / E_m$$

$$= 11.44 / 0.51$$

$$= 22.24 \text{ N./mm}^2$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$= P * h / (2 * t3) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))]$$

$$= 28.60 * 122.00 / (2 * 10.00) * [(6 + 3.11 * (11 - \alpha^2) / (3 + 5 * 3.11))]$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	BK	GCS	AA	120	PR	CN	0001	V02	

$$= 1.31^2 / (3 + 5 * 3.11)]$$

$$= 32.79 \text{ N./mm}^2$$

Membrane Stress at Stay Plate [t4]:

$$= P * h / (2 * t_4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))]$$

$$= 28.60 * 122.00 / (2 * 10.00) * [(6 + 3.11 * (11 - 1.31^2) / (3 + 5 * 3.11))]$$

$$= 32.79 \text{ N./mm}^2$$

MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9, Equations (13-15). (N./mm²) :

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]:

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 28.60 * 7.50 / (24 * 0.03) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))]$$

$$= -92.37 \text{ N./mm}^2$$

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

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 28.60 * -7.50 / (24 * 0.03) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))]$$

$$= 92.37 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 28.60 * 122.00^2 * 7.50 / (12 * 0.03) * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))$$

$$= 151.69 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 28.60 * 122.00^2 * -7.50 / (12 * 0.03) * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))$$

$$= -151.69 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	BK	GCS	AA	120	PR	CN	0001	V02	

Bending Stresses at Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 28.60 * 7.50 / (24 * 0.03) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))]$$

$$= -92.37 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 28.60 * -7.50 / (24 * 0.03) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))]$$

$$= 92.37 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 28.60 * 122.00^2 * 7.50 / (12 * 0.03) * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))$$

$$= 151.69 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 28.60 * 122.00^2 * -7.50 / (12 * 0.03) * ((3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11))$$

$$= -151.69 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 28.60 * 122.00^2 * 10.00 / (12 * 0.07) * [(3 + 3.11 * (6 - 1.31^2)) / (3 + 5 * 3.11)]$$

$$= 46.79 \text{ N./mm}^2$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.580) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 46.79 / 0.58$$

$$= 80.74 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 28.60 * 122.00^2 * -10.00 / (12 * 0.07) * [(3 + 3.11 * (6 - 1.31^2)) / (3 + 5 * 3.11)]$$

$$= -46.79 \text{ N./mm}^2$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.580) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -46.79 / 0.58$$

$$= -80.74 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 28.60 * 122.00^2 * 10.00 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11)]$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

$$= 1.31^2 * 3.11 / (3 + 5 * 3.11) \\ = 85.33 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I^2) * [(3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)] \\ = 28.60 * 122.00^2 * -10.00 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11)] \\ = -85.33 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

$$= P * h^2 * c / (12 * I^2) * [(3 + K * (6 - \text{Alpha}^2)) / (3 + 5 * K)] \\ = 28.60 * 122.00^2 * 9.71 / (12 * 0.07) * [(3 + 3.11 * (6 - 1.31^2)) / (3 + 5 * 3.11)] \\ = 45.45 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$\text{SblMi} = \text{SblMi} / E_b \\ = 45.45 / 0.48 \\ = 95.10 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I^2) * [(3 + K * (6 - \text{Alpha}^2)) / (3 + 5 * K)] \\ = 28.60 * 122.00^2 * -10.29 / (12 * 0.07) * [(3 + 3.11 * (6 - 1.31^2)) / (3 + 5 * 3.11)] \\ = -48.14 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$\text{SblMo} = \text{SblMo} / E_b \\ = -48.14 / 0.48 \\ = -100.73 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I^2) * [(3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)] \\ = 28.60 * 122.00^2 * 9.71 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11)] \\ = 82.87 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I^2) * [(3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)] \\ = 28.60 * 122.00^2 * -10.29 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 3.11) / (3 + 5 * 3.11)] \\ = -87.78 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,
Equations (16-19). (N./mm²) :**

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]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 13.04 + -92.37 \\
 &= -79.34 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 13.04 + 92.37 \\
 &= 105.41 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 13.04 + 151.69 \\
 &= 164.73 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 13.04 + -151.69 \\
 &= -138.66 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 13.04 + -92.37 \\
 &= -79.34 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 13.04 + 92.37 \\
 &= 105.41 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 13.04 + 151.69 \\
 &= 164.73 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 13.04 + -151.69 \\
 &= -138.66 \text{ N./mm}^2
 \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 19.74 + 80.74 \\
 &= 100.48 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 19.74 + -80.74 \\
 &= -61.00 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 11.44 + 85.33 \\
 &= 96.77 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 11.44 + -85.33 \\
 &= -73.89 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 22.24 + 95.10 \\
 &= 117.34 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 22.24 + -100.73 \\
 &= -78.49 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 11.44 + 82.87 \\
 &= 94.32 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 11.44 + -87.78 \\
 &= -76.34 \text{ N./mm}^2
 \end{aligned}$$

TOTAL STRESSES: Total Stress Calculations per Section 13-9, Equations (20-24). (N./mm²) :

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

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End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	88.05	155.00

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

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

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

$$= 15.074 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/160.0000)^2 * ((155)/(0.20*2.41))$$

$$= 50.344 \text{ bars}$$

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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3.3 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			

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Rectangular Vessel Results, Item number 1, Desc: FI.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 vessel [Ci]:
= $t_1 - CA / 2$
= $15.000 - 0.000 / 2$
= 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(15.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $15.000 - 0.000 / 2$
= 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(15.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

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

$$\begin{aligned}
 &= -(t_1 - CA) / 2 \\
 &= -(20.000 - 0.000) / 2 \\
 &= -10.000 \text{ mm.}
 \end{aligned}$$

Long-side 2 Calculations

Effective Diameter [De]:

$$\begin{aligned}
 &= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA) \\
 &= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / \\
 &\quad (20.00 - 0.00) \\
 &= 29.618 \text{ mm.}
 \end{aligned}$$

Membrane Ligament Efficiency [Em]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 61.000 - 29.618 / 61.000 \\
 &= 0.514
 \end{aligned}$$

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

Calculation of Xbar:

$$\begin{aligned}
 &= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * \\
 &\quad (T_1/2 + T_2)) + (b_2 * T_2 * (T_2/2))) / \\
 &\quad (b_0 * T_0 + b_1 * T_1 + b_2 * T_2) \\
 &= ((0.97 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.28 * 17.30 * \\
 &\quad (17.30/2 + 0.00)) + (2.40 * 0.00 * (0.00/2))) / \\
 &\quad (0.97 * 2.70 + 1.28 * 17.30 + 2.40 * 0.00) \\
 &= 9.713 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 Ci &= Xbar \\
 &= 9.713 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= -(t - CA - Xbar) \\
 &= -(20.000 - 0.000 - 9.713) \\
 &= -10.287 \text{ mm.}
 \end{aligned}$$

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

$$= 0.079 \text{ cm}^4$$

Effective Diameter [De]:

$$\begin{aligned}
 &= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co))) \\
 &= 61.00 - ((6 * 0.08) / ((20.00 - 0.00)^2 * (10.29))) \\
 &= 31.851 \text{ mm.}
 \end{aligned}$$

Bending Ligament Efficiency [Eb]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 61.000 - 31.851 / 61.000 \\
 &= 0.478
 \end{aligned}$$

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

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Moment of Inertia of a Strip of the Vessel Wall:

$$\begin{aligned} \text{Thickness } t_1, I_1 &= 0.0281 \text{ cm}^4 \\ \text{Thickness } t_2, I_2 &= 0.0667 \text{ cm}^4 \end{aligned}$$

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 0.8197 \\ K &= (I_2/I_1) * \text{Alpha} = 1.9429 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= p * h / (4 * t_1) * \{ 4 - [(2 + K * (5 - \alpha^2)) / (1 + 2 * K)] \} \\ &= 22.00 * 122.00 / (4 * 15.00) * \{ 4 - [(2 + 1.94 * (5 - 0.82^2)) / (1 + 2 * 1.94)] \} \\ &= 8.36 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= p * h / (4 * t_1) * \{ 4 - [(2 + K * (5 - \alpha^2)) / (1 + 2 * K)] \} \\ &= 22.00 * 122.00 / (4 * 15.00) * \{ 4 - [(2 + 1.94 * (5 - 0.82^2)) / (1 + 2 * 1.94)] \} \\ &= 8.36 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 22.00 * 100.00 / 2 * 20.00 \\ &= 5.50 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.579) < E(0.850)$ and $E_b(0.579) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 5.50 / 0.58 \\ &= 9.50 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 22.00 * 100.00 / 2 * 20.00 \\ &= 5.50 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 5.50 / 0.51 \\ &= 10.69 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [Smsp]:

$$\begin{aligned} &= P * h / (2 * t_3) * [(2 + K * (5 - \alpha^2)) / (1 + 2 * K)] \\ &= 22.00 * 122.00 / (2 * 10.00) * [(2 + 1.94 * (5 - \end{aligned}$$

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$$0.82^2) / (1 + 2 * 1.94)] \\ = 28.59 \text{ N./mm}^2$$

MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9, Equations (1-3). (N./mm²) :

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]:

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\ = 22.00 * 7.50 / (24 * 0.03) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))] \\ = -19.56 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\ = 22.00 * -7.50 / (24 * 0.03) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))] \\ = 19.56 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K)) \\ = 22.00 * 122.00^2 * 7.50 / (12 * 0.03) * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)) \\ = 53.78 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K)) \\ = 22.00 * 122.00^2 * -7.50 / (12 * 0.03) * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)) \\ = -53.78 \text{ N./mm}^2$$

Bending Stresses at Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\ = 22.00 * 7.50 / (24 * 0.03) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))] \\ = -19.56 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\ = 19.56 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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$$= 22.00 * -7.50 / (24 * 0.03) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))]$$

$$= 19.56 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))$$

$$= 22.00 * 122.00^2 * 7.50 / (12 * 0.03) * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))$$

$$= 53.78 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))$$

$$= 22.00 * 122.00^2 * -7.50 / (12 * 0.03) * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))$$

$$= -53.78 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

$$= P * h^2 * c / (12 * I2) * [(1 + K * (3 - Alpha^2)) / (1 + 2 * K)]$$

$$= 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * [(1 + 1.94 * (3 - 0.82^2)) / (1 + 2 * 1.94)]$$

$$= 46.27 \text{ N./mm}^2$$

If $E_m(0.579) < E(0.850)$ and $E_b(0.579) < E(0.850)$ then

$$SblMi = SblMi / E_b$$

$$= 46.27 / 0.58$$

$$= 79.96 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + K * (3 - Alpha^2)) / (1 + 2 * K)]$$

$$= 22.00 * 122.00^2 * -10.00 / (12 * 0.07) * [(1 + 1.94 * (3 - 0.82^2)) / (1 + 2 * 1.94)]$$

$$= -46.27 \text{ N./mm}^2$$

If $E_m(0.579) < E(0.850)$ and $E_b(0.579) < E(0.850)$ then

$$SblMo = SblMo / E_b$$

$$= -46.27 / 0.58$$

$$= -79.96 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + 2 * Alpha^2 * K) / (1 + 2 * K)]$$

$$= 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)]$$

$$= 30.25 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + 2 * Alpha^2 * K) / (1 + 2 * K)]$$

$$= 22.00 * 122.00^2 * -10.00 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)]$$

$$= -30.25 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	BK	GCS	AA	120	PR	CN	0001	V02	

Bending Stresses at Long-side 2

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

$$= P * h^2 * c / (12 * I2) * [(1 + K * (3 - Alpha^2)) / (1 + 2 * K)]$$

$$= 22.00 * 122.00^2 * 9.71 / (12 * 0.07) * [(1 + 1.94 * (3 - 0.82^2)) / (1 + 2 * 1.94)]$$

$$= 44.94 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 44.94 / 0.48$$

$$= 94.05 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + K * (3 - Alpha^2)) / (1 + 2 * K)]$$

$$= 22.00 * 122.00^2 * -10.29 / (12 * 0.07) * [(1 + 1.94 * (3 - 0.82^2)) / (1 + 2 * 1.94)]$$

$$= -47.60 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -47.60 / 0.48$$

$$= -99.62 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + 2 * Alpha^2 * K) / (1 + 2 * K)]$$

$$= 22.00 * 122.00^2 * 9.71 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)]$$

$$= 29.38 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + 2 * Alpha^2 * K) / (1 + 2 * K)]$$

$$= 22.00 * 122.00^2 * -10.29 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)]$$

$$= -31.12 \text{ N./mm}^2$$

BENDING STRESSES: Bending Stress Calculations per Section 13-9, Equations (4-7). (N./mm²) :

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
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Total Stress Calculations per Section 13-9

Total Stresses at Short-side 1

Total Stress at short side 1 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 8.36 + -19.56 \\
 &= -11.20 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 8.36 + 19.56 \\
 &= 27.92 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 8.36 + 53.78 \\
 &= 62.14 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 8.36 + -53.78 \\
 &= -45.42 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 8.36 + -19.56 \\
 &= -11.20 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 8.36 + 19.56 \\
 &= 27.92 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 8.36 + 53.78 \\
 &= 62.14 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 8.36 + -53.78 \\
 &= -45.42 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 9.50 + 79.96 \\
 &= 89.47 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{ml} + S_{blMo} \\
 &= 9.50 + -79.96 \\
 &= -70.46 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q inner [STL_Qi]:

$$= S_{ml} + S_{blQi}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
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$$= 5.50 + 30.25$$

$$= 35.75 \text{ N./mm}^2$$

Total Stress at long side 1 at Q outer [STL_Qo]:

$$= S_{m1} + S_{b1Qo}$$

$$= 5.50 + -30.25$$

$$= -24.75 \text{ N./mm}^2$$

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:

$$= S_{m1} + S_{b1Mi}$$

$$= 10.69 + 94.05$$

$$= 104.75 \text{ N./mm}^2$$

Total Stress at long side 2 at M outer [STL_Mo]:

$$= S_{m1} + S_{b1Mo}$$

$$= 10.69 + -99.62$$

$$= -88.93 \text{ N./mm}^2$$

Total Stress at long side 2 at Q inner [STL_Qi]:

$$= S_{m1} + S_{b1Qi}$$

$$= 5.50 + 29.38$$

$$= 34.88 \text{ N./mm}^2$$

Total Stress at long side 2 at Q outer [STL_Qo]:

$$= S_{m1} + S_{b1Qo}$$

$$= 5.50 + -31.12$$

$$= -25.62 \text{ N./mm}^2$$

TOTAL STRESSES: Total Stress Calculations per Section 13-9, Equations (8-12). (N./mm²) :

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./mm²):

	Actual	Allowable
End Plate	30.85	114.39

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

$$= d * \sqrt{Z * C * P / (SE)} + c_a$$

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

$$= 10.387 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$= ((T - c_a) / d)^2 * ((SE) / (C * Z)) \text{ per UG-34 (c) (3)}$$

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

$$= 81.562 \text{ bars}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
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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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

3.4 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			

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	BK	GCS	AA	120	PR	CN	0001	V02	

Rectangular Vessel Results, Item number 1, Desc: FI.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 vessel [Ci]:
= $t_1 - CA / 2$
= $15.000 - 0.000 / 2$
= 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(15.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $15.000 - 0.000 / 2$
= 7.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(15.000 - 0.000) / 2$
= -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 $E_b = E_m$
= 0.580

Dist from Neutral axis of c/s to inside surface of the vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

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

$$\begin{aligned}
 &= -(t_1 - CA) / 2 \\
 &= -(20.000 - 0.000) / 2 \\
 &= -10.000 \text{ mm.}
 \end{aligned}$$

Long-side 2 Calculations

Effective Diameter [De]:

$$\begin{aligned}
 &= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA) \\
 &= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / \\
 &\quad (20.00 - 0.00) \\
 &= 29.618 \text{ mm.}
 \end{aligned}$$

Membrane Ligament Efficiency [Em]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 61.000 - 29.618 / 61.000 \\
 &= 0.514
 \end{aligned}$$

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

Calculation of Xbar:

$$\begin{aligned}
 &= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * \\
 &\quad (T_1/2 + T_2)) + (b_2 * T_2 * (T_2/2))) / \\
 &\quad (b_0 * T_0 + b_1 * T_1 + b_2 * T_2) \\
 &= ((0.97 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.28 * 17.30 * \\
 &\quad (17.30/2 + 0.00)) + (2.40 * 0.00 * (0.00/2))) / \\
 &\quad (0.97 * 2.70 + 1.28 * 17.30 + 2.40 * 0.00) \\
 &= 9.713 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 Ci &= Xbar \\
 &= 9.713 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= -(t - CA - Xbar) \\
 &= -(20.000 - 0.000 - 9.713) \\
 &= -10.287 \text{ mm.}
 \end{aligned}$$

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

$$= 0.079 \text{ cm}^4$$

Effective Diameter [De]:

$$\begin{aligned}
 &= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co))) \\
 &= 61.00 - ((6 * 0.08) / ((20.00 - 0.00)^2 * (10.29))) \\
 &= 31.851 \text{ mm.}
 \end{aligned}$$

Bending Ligament Efficiency [Eb]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 61.000 - 31.851 / 61.000 \\
 &= 0.478
 \end{aligned}$$

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V02

Moment of Inertia of a Strip of the Vessel Wall:

$$\begin{aligned} \text{Thickness } t_1, I_1 &= 0.0281 \text{ cm}^4 \\ \text{Thickness } t_2, I_2 &= 0.0667 \text{ cm}^4 \end{aligned}$$

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 0.8197 \\ K &= (I_2/I_1) * \text{Alpha} = 1.9429 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= p * h / (4 * t_1) * \{ 4 - [(2 + K * (5 - \alpha^2)) / (1 + 2 * K)] \} \\ &= 28.60 * 122.00 / (4 * 15.00) * \{ 4 - [(2 + 1.94 * (5 - 0.82^2)) / (1 + 2 * 1.94)] \} \\ &= 10.87 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= p * h / (4 * t_1) * \{ 4 - [(2 + K * (5 - \alpha^2)) / (1 + 2 * K)] \} \\ &= 28.60 * 122.00 / (4 * 15.00) * \{ 4 - [(2 + 1.94 * (5 - 0.82^2)) / (1 + 2 * 1.94)] \} \\ &= 10.87 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 28.60 * 100.00 / 2 * 20.00 \\ &= 7.15 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.580) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 7.15 / 0.58 \\ &= 12.34 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 28.60 * 100.00 / 2 * 20.00 \\ &= 7.15 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 7.15 / 0.51 \\ &= 13.90 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [Smsp]:

$$\begin{aligned} &= P * h / (2 * t_3) * [(2 + K * (5 - \alpha^2)) / (1 + 2 * K)] \\ &= 28.60 * 122.00 / (2 * 10.00) * [(2 + 1.94 * (5 - \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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$$0.82^2) / (1 + 2 * 1.94)] \\ = 37.17 \text{ N./mm}^2$$

MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9, Equations (1-3). (N./mm²) :

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]:

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\ = 28.60 * 7.50 / (24 * 0.03) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))] \\ = -25.43 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\ = 28.60 * -7.50 / (24 * 0.03) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))] \\ = 25.43 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K)) \\ = 28.60 * 122.00^2 * 7.50 / (12 * 0.03) * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)) \\ = 69.91 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K)) \\ = 28.60 * 122.00^2 * -7.50 / (12 * 0.03) * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)) \\ = -69.91 \text{ N./mm}^2$$

Bending Stresses at Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\ = 28.60 * 7.50 / (24 * 0.03) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))] \\ = -25.43 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\ = 28.60 * -7.50 / (24 * 0.03) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))] \\ = 25.43 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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$$= 28.60 * -7.50 / (24 * 0.03) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))]$$

$$= 25.43 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))$$

$$= 28.60 * 122.00^2 * 7.50 / (12 * 0.03) * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))$$

$$= 69.91 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))$$

$$= 28.60 * 122.00^2 * -7.50 / (12 * 0.03) * ((1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94))$$

$$= -69.91 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

$$= P * h^2 * c / (12 * I2) * [(1 + K * (3 - Alpha^2)) / (1 + 2 * K)]$$

$$= 28.60 * 122.00^2 * 10.00 / (12 * 0.07) * [(1 + 1.94 * (3 - 0.82^2)) / (1 + 2 * 1.94)]$$

$$= 60.16 \text{ N./mm}^2$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.580) < E(0.850)$ then

$$SblMi = SblMi / E_b$$

$$= 60.16 / 0.58$$

$$= 103.81 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + K * (3 - Alpha^2)) / (1 + 2 * K)]$$

$$= 28.60 * 122.00^2 * -10.00 / (12 * 0.07) * [(1 + 1.94 * (3 - 0.82^2)) / (1 + 2 * 1.94)]$$

$$= -60.16 \text{ N./mm}^2$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.580) < E(0.850)$ then

$$SblMo = SblMo / E_b$$

$$= -60.16 / 0.58$$

$$= -103.81 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + 2 * Alpha^2 * K) / (1 + 2 * K)]$$

$$= 28.60 * 122.00^2 * 10.00 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)]$$

$$= 39.33 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + 2 * Alpha^2 * K) / (1 + 2 * K)]$$

$$= 28.60 * 122.00^2 * -10.00 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)]$$

$$= -39.33 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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Bending Stresses at Long-side 2

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

$$= P * h^2 * c / (12 * I2) * [(1 + K * (3 - Alpha^2)) / (1 + 2 * K)]$$

$$= 28.60 * 122.00^2 * 9.71 / (12 * 0.07) * [(1 + 1.94 * (3 - 0.82^2)) / (1 + 2 * 1.94)]$$

$$= 58.43 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 58.43 / 0.48$$

$$= 122.27 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + K * (3 - Alpha^2)) / (1 + 2 * K)]$$

$$= 28.60 * 122.00^2 * -10.29 / (12 * 0.07) * [(1 + 1.94 * (3 - 0.82^2)) / (1 + 2 * 1.94)]$$

$$= -61.89 \text{ N./mm}^2$$

If $E_m(0.514) < E(0.850)$ and $E_b(0.478) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -61.89 / 0.48$$

$$= -129.51 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + 2 * Alpha^2 * K) / (1 + 2 * K)]$$

$$= 28.60 * 122.00^2 * 9.71 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)]$$

$$= 38.20 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(1 + 2 * Alpha^2 * K) / (1 + 2 * K)]$$

$$= 28.60 * 122.00^2 * -10.29 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 1.94) / (1 + 2 * 1.94)]$$

$$= -40.46 \text{ N./mm}^2$$

BENDING STRESSES: Bending Stress Calculations per Section 13-9, Equations (4-7). (N./mm²) :

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

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Total Stress Calculations per Section 13-9

Total Stresses at Short-side 1

Total Stress at short side 1 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 10.87 + -25.43 \\
 &= -14.55 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 10.87 + 25.43 \\
 &= 36.30 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 10.87 + 69.91 \\
 &= 80.79 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 10.87 + -69.91 \\
 &= -59.04 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 10.87 + -25.43 \\
 &= -14.55 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 10.87 + 25.43 \\
 &= 36.30 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 10.87 + 69.91 \\
 &= 80.79 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 10.87 + -69.91 \\
 &= -59.04 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 12.34 + 103.81 \\
 &= 116.15 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{ml} + S_{blMo} \\
 &= 12.34 + -103.81 \\
 &= -91.47 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q inner [STL_Qi]:

$$= S_{ml} + S_{blQi}$$

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$$= 7.15 + 39.33$$

$$= 46.48 \text{ N./mm}^2$$

Total Stress at long side 1 at Q outer [STL_Qo]:

$$= S_{m1} + S_{b1Qo}$$

$$= 7.15 + -39.33$$

$$= -32.18 \text{ N./mm}^2$$

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:

$$= S_{m1} + S_{b1Mi}$$

$$= 13.90 + 122.27$$

$$= 136.17 \text{ N./mm}^2$$

Total Stress at long side 2 at M outer [STL_Mo]:

$$= S_{m1} + S_{b1Mo}$$

$$= 13.90 + -129.51$$

$$= -115.61 \text{ N./mm}^2$$

Total Stress at long side 2 at Q inner [STL_Qi]:

$$= S_{m1} + S_{b1Qi}$$

$$= 7.15 + 38.20$$

$$= 45.35 \text{ N./mm}^2$$

Total Stress at long side 2 at Q outer [STL_Qo]:

$$= S_{m1} + S_{b1Qo}$$

$$= 7.15 + -40.46$$

$$= -33.31 \text{ N./mm}^2$$

TOTAL STRESSES: Total Stress Calculations per Section 13-9, Equations (8-12). (N./mm²) :

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./mm²):

	Actual	Allowable
End Plate	40.11	155.00

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

$$= d * \sqrt{Z * C * P / (SE)} + c_a$$

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

$$= 10.174 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$= ((T - c_a) / d)^2 * ((SE) / (C * Z)) \text{ per UG-34 (c) (3)}$$

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

$$= 110.518 \text{ bars}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							 	
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3.5 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./mm²
Shell Allowable Stress at Ambient SA 115.1465 N./mm²
Shell Yield Stress at Design Temperature Sy 126.1469 N./mm²

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./mm²
Stay Allowable Stress at Ambient SA 115.1465 N./mm²
Stay Yield Stress at Design Temp Sy 129.8699 N./mm²

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(20.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(20.000 - 0.000) / 2$
= -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 $E_b = E_m$
= 0.628

Dist from Neutral axis of c/s to inside surface of the vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

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

$$\begin{aligned}
 &= -(t_1 - CA) / 2 \\
 &= -(20.000 - 0.000) / 2 \\
 &= -10.000 \text{ mm.}
 \end{aligned}$$

Long-side 2 Calculations

Effective Diameter [De]:

$$\begin{aligned}
 &= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA) \\
 &= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / \\
 &\quad (20.00 - 0.00) \\
 &= 29.618 \text{ mm.}
 \end{aligned}$$

Membrane Ligament Efficiency [Em]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 69.000 - 29.618 / 69.000 \\
 &= 0.571
 \end{aligned}$$

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

Calculation of Xbar:

$$\begin{aligned}
 &= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * \\
 &\quad (T_1/2 + T_2)) + (b_2 * T_2 * (T_2/2))) / \\
 &\quad (b_0 * T_0 + b_1 * T_1 + b_2 * T_2) \\
 &= ((1.29 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.59 * 17.30 * \\
 &\quad (17.30/2 + 0.00)) + (2.72 * 0.00 * (0.00/2))) / \\
 &\quad (1.29 * 2.70 + 1.59 * 17.30 + 2.72 * 0.00) \\
 &= 9.771 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 Ci &= Xbar \\
 &= 9.771 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= -(t - CA - Xbar) \\
 &= -(20.000 - 0.000 - 9.771) \\
 &= -10.229 \text{ mm.}
 \end{aligned}$$

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

$$= 0.100 \text{ cm}^4$$

Effective Diameter [De]:

$$\begin{aligned}
 &= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co))) \\
 &= 69.00 - ((6 * 0.10) / ((20.00 - 0.00)^2 * (10.23))) \\
 &= 31.848 \text{ mm.}
 \end{aligned}$$

Bending Ligament Efficiency [Eb]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 69.000 - 31.848 / 69.000 \\
 &= 0.538
 \end{aligned}$$

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

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Moment of Inertia of a Strip of the Vessel Wall:

$$\begin{aligned} \text{Thickness } t_1, I_1 &= 0.0667 \text{ cm}^4 \\ \text{Thickness } t_2, I_2 &= 0.0667 \text{ cm}^4 \end{aligned}$$

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 1.1579 \\ K &= (I_2/I_1) * \text{Alpha} = 1.1579 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \} \\ &= 62.00 * 95.00 / (2 * 20.00) * \{ 3 - [(6 + 1.16 * (11 - 1.16^2)) / (3 + 5 * 1.16)] \} \\ &= 15.39 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \} \\ &= 62.00 * 95.00 / (2 * 20.00) * \{ 3 - [(6 + 1.16 * (11 - 1.16^2)) / (3 + 5 * 1.16)] \} \\ &= 15.39 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 62.00 * 110.00 / 2 * 20.00 \\ &= 17.05 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 17.05 / 0.63 \\ &= 27.14 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 62.00 * 110.00 / 2 * 20.00 \\ &= 17.05 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 17.05 / 0.57 \\ &= 29.87 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$\begin{aligned} &= P * h / (2 * t_3) * [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \\ &= 62.00 * 95.00 / (2 * 10.00) * [(6 + 1.16 * (11 - \end{aligned}$$

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$$1.16^2) / (3 + 5 * 1.16)]$$

$$= 57.58 \text{ N./mm}^2$$

Membrane Stress at Stay Plate [t4]:

$$= P * h / (2 * t_4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))]$$

$$= 62.00 * 95.00 / (2 * 10.00) * [(6 + 1.16 * (11 - 1.16^2) / (3 + 5 * 1.16))]$$

$$= 57.58 \text{ N./mm}^2$$

MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9, Equations (13-15). (N./mm²) :

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]:

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 95.00^2 * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))]$$

$$= -55.02 \text{ N./mm}^2$$

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

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 62.00 * -10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 95.00^2 * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))]$$

$$= 55.02 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 62.00 * 95.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))$$

$$= 85.65 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 62.00 * 95.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))$$

$$= -85.65 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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Bending Stresses at Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 95.00^2 * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))]$$

$$= -55.02 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 62.00 * -10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 95.00^2 * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))]$$

$$= 55.02 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 62.00 * 95.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))$$

$$= 85.65 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 62.00 * 95.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))$$

$$= -85.65 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 62.00 * 95.00^2 * 10.00 / (12 * 0.07) * [(3 + 1.16 * (6 - 1.16^2)) / (3 + 5 * 1.16)]$$

$$= 66.81 \text{ N./mm}^2$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 66.81 / 0.63$$

$$= 106.34 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 62.00 * 95.00^2 * -10.00 / (12 * 0.07) * [(3 + 1.16 * (6 - 1.16^2)) / (3 + 5 * 1.16)]$$

$$= -66.81 \text{ N./mm}^2$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -66.81 / 0.63$$

$$= -106.34 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 62.00 * 95.00^2 * 10.00 / (12 * 0.07) * [(3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)]$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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$$= 1.16^2 * 1.16 / (3 + 5 * 1.16) \\ = 85.65 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)] \\ = 62.00 * 95.00^2 * -10.00 / (12 * 0.07) * [(3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)] \\ = -85.65 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - \text{Alpha}^2)) / (3 + 5 * K)] \\ = 62.00 * 95.00^2 * 9.77 / (12 * 0.07) * [(3 + 1.16 * (6 - 1.16^2)) / (3 + 5 * 1.16)] \\ = 65.28 \text{ N./mm}^2$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$\text{SblMi} = \text{SblMi} / E_b \\ = 65.28 / 0.54 \\ = 121.24 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - \text{Alpha}^2)) / (3 + 5 * K)] \\ = 62.00 * 95.00^2 * -10.23 / (12 * 0.07) * [(3 + 1.16 * (6 - 1.16^2)) / (3 + 5 * 1.16)] \\ = -68.34 \text{ N./mm}^2$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$\text{SblMo} = \text{SblMo} / E_b \\ = -68.34 / 0.54 \\ = -126.92 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)] \\ = 62.00 * 95.00^2 * 9.77 / (12 * 0.07) * [(3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)] \\ = 83.68 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)] \\ = 62.00 * 95.00^2 * -10.23 / (12 * 0.07) * [(3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)] \\ = -87.61 \text{ N./mm}^2$$

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**BENDING STRESSES: Bending Stress Calculations per Section 13-9,
Equations (16-19). (N./mm²) :**

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]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 15.39 + -55.02 \\
 &= -39.64 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 15.39 + 55.02 \\
 &= 70.41 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 15.39 + 85.65 \\
 &= 101.03 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 15.39 + -85.65 \\
 &= -70.26 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 15.39 + -55.02 \\
 &= -39.64 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 15.39 + 55.02 \\
 &= 70.41 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 15.39 + 85.65 \\
 &= 101.03 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 15.39 + -85.65 \\
 &= -70.26 \text{ N./mm}^2
 \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 27.14 + 106.34 \\
 &= 133.48 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 27.14 + -106.34 \\
 &= -79.20 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 17.05 + 85.65 \\
 &= 102.70 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 17.05 + -85.65 \\
 &= -68.59 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 29.87 + 121.24 \\
 &= 151.11 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 29.87 + -126.92 \\
 &= -97.05 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 17.05 + 83.68 \\
 &= 100.74 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 17.05 + -87.61 \\
 &= -70.56 \text{ N./mm}^2
 \end{aligned}$$

TOTAL STRESSES: Total Stress Calculations per Section 13-9, Equations (20-24). (N./mm²) :

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V02

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	93.78	111.91

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

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

$$= 110.000 * \sqrt{2.500 * 0.200 * 62.000 / (111.908)} + 0.000$$

$$= 18.309 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/110.0000)^2 * ((111)/(0.20*2.50))$$

$$= 73.984 \text{ bars}$$

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 64 از 93	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

3.6 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			

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 65 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(20.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(20.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 66 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

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

$$\begin{aligned}
 &= -(t_1 - CA) / 2 \\
 &= -(20.000 - 0.000) / 2 \\
 &= -10.000 \text{ mm.}
 \end{aligned}$$

Long-side 2 Calculations

Effective Diameter [De]:

$$\begin{aligned}
 &= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA) \\
 &= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / \\
 &\quad (20.00 - 0.00) \\
 &= 29.618 \text{ mm.}
 \end{aligned}$$

Membrane Ligament Efficiency [Em]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 69.000 - 29.618 / 69.000 \\
 &= 0.571
 \end{aligned}$$

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

Calculation of Xbar:

$$\begin{aligned}
 &= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * \\
 &\quad (T_1/2 + T_2)) + (b_2 * T_2 * (T_2/2))) / \\
 &\quad (b_0 * T_0 + b_1 * T_1 + b_2 * T_2) \\
 &= ((1.29 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.59 * 17.30 * \\
 &\quad (17.30/2 + 0.00)) + (2.72 * 0.00 * (0.00/2))) / \\
 &\quad (1.29 * 2.70 + 1.59 * 17.30 + 2.72 * 0.00) \\
 &= 9.771 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 Ci &= Xbar \\
 &= 9.771 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= -(t - CA - Xbar) \\
 &= -(20.000 - 0.000 - 9.771) \\
 &= -10.229 \text{ mm.}
 \end{aligned}$$

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

$$= 0.100 \text{ cm}^4$$

Effective Diameter [De]:

$$\begin{aligned}
 &= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co))) \\
 &= 69.00 - ((6 * 0.10) / ((20.00 - 0.00)^2 * (10.23))) \\
 &= 31.848 \text{ mm.}
 \end{aligned}$$

Bending Ligament Efficiency [Eb]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 69.000 - 31.848 / 69.000 \\
 &= 0.538
 \end{aligned}$$

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 67 از 93	
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	BK	GCS	AA	120	PR	CN	0001		V02

Moment of Inertia of a Strip of the Vessel Wall:

$$\begin{aligned} \text{Thickness } t_1, I_1 &= 0.0667 \text{ cm}^4 \\ \text{Thickness } t_2, I_2 &= 0.0667 \text{ cm}^4 \end{aligned}$$

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 1.1579 \\ K &= (I_2/I_1) * \text{Alpha} = 1.1579 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \} \\ &= 80.60 * 95.00 / (2 * 20.00) * \{ 3 - [(6 + 1.16 * (11 - 1.16^2) / (3 + 5 * 1.16))] \} \\ &= 20.00 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \} \\ &= 80.60 * 95.00 / (2 * 20.00) * \{ 3 - [(6 + 1.16 * (11 - 1.16^2) / (3 + 5 * 1.16))] \} \\ &= 20.00 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 80.60 * 110.00 / 2 * 20.00 \\ &= 22.17 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 22.17 / 0.63 \\ &= 35.28 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 80.60 * 110.00 / 2 * 20.00 \\ &= 22.17 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 22.17 / 0.57 \\ &= 38.84 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$\begin{aligned} &= P * h / (2 * t_3) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \\ &= 80.60 * 95.00 / (2 * 10.00) * [(6 + 1.16 * (11 - \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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$$1.16^2) / (3 + 5 * 1.16)] \\ = 74.86 \text{ N./mm}^2$$

Membrane Stress at Stay Plate [t4]:

$$= P * h / (2 * t4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \\ = 80.60 * 95.00 / (2 * 10.00) * [(6 + 1.16 * (11 - 1.16^2) / (3 + 5 * 1.16))] \\ = 74.86 \text{ N./mm}^2$$

MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9, Equations (13-15). (N./mm²) :

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]:

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))] \\ = 80.60 * 10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 95.00^2 * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))] \\ = -71.53 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))] \\ = 80.60 * -10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 95.00^2 * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))] \\ = 71.53 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K)) \\ = 80.60 * 95.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)) \\ = 111.34 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K)) \\ = 80.60 * 95.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)) \\ = -111.34 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

Bending Stresses at Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 80.60 * 10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 95.00^2 * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))]$$

$$= -71.53 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 80.60 * -10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 95.00^2 * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))]$$

$$= 71.53 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 80.60 * 95.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))$$

$$= 111.34 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 80.60 * 95.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16))$$

$$= -111.34 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 80.60 * 95.00^2 * 10.00 / (12 * 0.07) * [(3 + 1.16 * (6 - 1.16^2)) / (3 + 5 * 1.16)]$$

$$= 86.85 \text{ N./mm}^2$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 86.85 / 0.63$$

$$= 138.24 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 80.60 * 95.00^2 * -10.00 / (12 * 0.07) * [(3 + 1.16 * (6 - 1.16^2)) / (3 + 5 * 1.16)]$$

$$= -86.85 \text{ N./mm}^2$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -86.85 / 0.63$$

$$= -138.24 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 80.60 * 95.00^2 * 10.00 / (12 * 0.07) * [(3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)]$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

$$= 1.16^2 * 1.16 / (3 + 5 * 1.16)]$$

$$= 111.34 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 80.60 * 95.00^2 * -10.00 / (12 * 0.07) * [(3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)]$$

$$= -111.34 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 80.60 * 95.00^2 * 9.77 / (12 * 0.07) * [(3 + 1.16 * (6 - 1.16^2)) / (3 + 5 * 1.16)]$$

$$= 84.86 \text{ N./mm}^2$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 84.86 / 0.54$$

$$= 157.61 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 80.60 * 95.00^2 * -10.23 / (12 * 0.07) * [(3 + 1.16 * (6 - 1.16^2)) / (3 + 5 * 1.16)]$$

$$= -88.84 \text{ N./mm}^2$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -88.84 / 0.54$$

$$= -165.00 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 80.60 * 95.00^2 * 9.77 / (12 * 0.07) * [(3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)]$$

$$= 108.79 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 80.60 * 95.00^2 * -10.23 / (12 * 0.07) * [(3 + 5 * 1.16^2 * 1.16) / (3 + 5 * 1.16)]$$

$$= -113.89 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 - 073 - 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 71 از 93	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

BENDING STRESSES: Bending Stress Calculations per Section 13-9, Equations (16-19). (N./mm²) :

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]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 20.00 + -71.53 \\
 &= -51.53 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 20.00 + 71.53 \\
 &= 91.53 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 20.00 + 111.34 \\
 &= 131.34 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 20.00 + -111.34 \\
 &= -91.34 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 20.00 + -71.53 \\
 &= -51.53 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 20.00 + 71.53 \\
 &= 91.53 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 20.00 + 111.34 \\
 &= 131.34 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 20.00 + -111.34 \\
 &= -91.34 \text{ N./mm}^2
 \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 35.28 + 138.24 \\
 &= 173.52 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 35.28 + -138.24 \\
 &= -102.96 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 22.17 + 111.34 \\
 &= 133.51 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 22.17 + -111.34 \\
 &= -89.17 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 38.84 + 157.61 \\
 &= 196.44 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 38.84 + -165.00 \\
 &= -126.16 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 22.17 + 108.79 \\
 &= 130.96 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 22.17 + -113.89 \\
 &= -91.72 \text{ N./mm}^2
 \end{aligned}$$

TOTAL STRESSES: Total Stress Calculations per Section 13-9, Equations (20-24). (N./mm²) :

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 73 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	121.91	155.00

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

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

$$= 110.000 * \sqrt{2.500 * 0.200 * 80.600 / (155.000)} + 0.000$$

$$= 17.737 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/110.0000)^2 * ((155)/(0.20*2.50))$$

$$= 102.473 \text{ bars}$$

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 74 از 93	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

3.7 FLOATING HEADER CALCULATION @ DESIGN PRESSURE FOR AE-2102.

Input Echo, COMPONENT 1, Description: FI.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./mm²
Shell Allowable Stress at Ambient SA 115.1465 N./mm²
Shell Yield Stress at Design Temperature Sy 126.1469 N./mm²

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./mm²
Stay Allowable Stress at Ambient SA 115.1465 N./mm²
Stay Yield Stress at Design Temp Sy 129.8699 N./mm²

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 75 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

Rectangular Vessel Results, Item number 1, Desc: FI.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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(20.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(20.000 - 0.000) / 2$
= -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 $E_b = E_m$
= 0.628

Dist from Neutral axis of c/s to inside surface of the vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 76 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

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

$$\begin{aligned}
 &= -(t_1 - CA) / 2 \\
 &= -(20.000 - 0.000) / 2 \\
 &= -10.000 \text{ mm.}
 \end{aligned}$$

Long-side 2 Calculations

Effective Diameter [De]:

$$\begin{aligned}
 &= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA) \\
 &= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / \\
 &\quad (20.00 - 0.00) \\
 &= 29.618 \text{ mm.}
 \end{aligned}$$

Membrane Ligament Efficiency [Em]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 69.000 - 29.618 / 69.000 \\
 &= 0.571
 \end{aligned}$$

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

Calculation of Xbar:

$$\begin{aligned}
 &= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * \\
 &\quad (T_1/2 + T_2)) + (b_2 * T_2 * (T_2/2))) / \\
 &\quad (b_0 * T_0 + b_1 * T_1 + b_2 * T_2) \\
 &= ((1.29 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.59 * 17.30 * \\
 &\quad (17.30/2 + 0.00)) + (2.72 * 0.00 * (0.00/2))) / \\
 &\quad (1.29 * 2.70 + 1.59 * 17.30 + 2.72 * 0.00) \\
 &= 9.771 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 Ci &= Xbar \\
 &= 9.771 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= -(t - CA - Xbar) \\
 &= -(20.000 - 0.000 - 9.771) \\
 &= -10.229 \text{ mm.}
 \end{aligned}$$

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

$$= 0.100 \text{ cm}^4$$

Effective Diameter [De]:

$$\begin{aligned}
 &= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co))) \\
 &= 69.00 - ((6 * 0.10) / ((20.00 - 0.00)^2 * (10.23))) \\
 &= 31.848 \text{ mm.}
 \end{aligned}$$

Bending Ligament Efficiency [Eb]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 69.000 - 31.848 / 69.000 \\
 &= 0.538
 \end{aligned}$$

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 77 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

Moment of Inertia of a Strip of the Vessel Wall:

$$\begin{aligned} \text{Thickness } t_1, I_1 &= 0.0667 \text{ cm}^4 \\ \text{Thickness } t_2, I_2 &= 0.0667 \text{ cm}^4 \end{aligned}$$

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 1.6667 \\ K &= (I_2/I_1) * \text{Alpha} = 1.6667 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \} \\ &= 62.00 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2)) / (3 + 5 * 1.67)] \} \\ &= 11.73 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \} \\ &= 62.00 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2)) / (3 + 5 * 1.67)] \} \\ &= 11.73 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 62.00 * 100.00 / 2 * 20.00 \\ &= 15.50 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 15.50 / 0.63 \\ &= 24.67 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 62.00 * 100.00 / 2 * 20.00 \\ &= 15.50 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 15.50 / 0.57 \\ &= 27.16 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$\begin{aligned} &= P * h / (2 * t_3) * [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \\ &= 62.00 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

$$= 1.67^2) / (3 + 5 * 1.67)]$$

$$= 32.34 \text{ N./mm}^2$$

Membrane Stress at Stay Plate [t4]:

$$= P * h / (2 * t_4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))]$$

$$= 62.00 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))]$$

$$= 32.34 \text{ N./mm}^2$$

MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9, Equations (13-15). (N./mm²) :

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]:

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= -51.88 \text{ N./mm}^2$$

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

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 62.00 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= 51.88 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 62.00 * 60.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= 64.37 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 62.00 * 60.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= -64.37 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	AA	120	PR	CN	0001	V02

Bending Stresses at Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= -51.88 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 62.00 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= 51.88 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 62.00 * 60.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= 64.37 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 62.00 * 60.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= -64.37 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 62.00 * 60.00^2 * 10.00 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= 20.61 \text{ N./mm}^2$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 20.61 / 0.63$$

$$= 32.80 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 62.00 * 60.00^2 * -10.00 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= -20.61 \text{ N./mm}^2$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -20.61 / 0.63$$

$$= -32.80 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 62.00 * 60.00^2 * 10.00 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

$$= 64.37 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 62.00 * 60.00^2 * -10.00 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= -64.37 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 62.00 * 60.00^2 * 9.77 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= 20.14 \text{ N./mm}^2$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 20.14 / 0.54$$

$$= 37.40 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 62.00 * 60.00^2 * -10.23 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= -21.08 \text{ N./mm}^2$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -21.08 / 0.54$$

$$= -39.15 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 62.00 * 60.00^2 * 9.77 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= 62.90 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 62.00 * 60.00^2 * -10.23 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= -65.85 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

**BENDING STRESSES: Bending Stress Calculations per Section 13-9,
Equations (16-19). (N./mm²) :**

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]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 11.73 + -51.88 \\
 &= -40.15 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 11.73 + 51.88 \\
 &= 63.61 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 11.73 + 64.37 \\
 &= 76.11 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 11.73 + -64.37 \\
 &= -52.64 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 11.73 + -51.88 \\
 &= -40.15 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 11.73 + 51.88 \\
 &= 63.61 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 11.73 + 64.37 \\
 &= 76.11 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 11.73 + -64.37 \\
 &= -52.64 \text{ N./mm}^2
 \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 24.67 + 32.80 \\
 &= 57.47 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 24.67 + -32.80 \\
 &= -8.13 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 15.50 + 64.37 \\
 &= 79.88 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 15.50 + -64.37 \\
 &= -48.87 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 27.16 + 37.40 \\
 &= 64.55 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 27.16 + -39.15 \\
 &= -11.99 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 15.50 + 62.90 \\
 &= 78.40 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 15.50 + -65.85 \\
 &= -50.35 \text{ N./mm}^2
 \end{aligned}$$

TOTAL STRESSES: Total Stress Calculations per Section 13-9, Equations (20-24). (N./mm²) :

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 83 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
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End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	68.20	111.91

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

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

$$= 100.000 * \sqrt{2.200 * 0.200 * 62.000 / (111.908)} + 0.000$$

$$= 15.614 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/100.0000)^2 * ((111)/(0.20*2.20))$$

$$= 101.728 \text{ bars}$$

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

Rectanqular 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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

3.8 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			

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 85 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V02

Rectangular Vessel Results, Item number 1, Desc: FI.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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(20.000 - 0.000) / 2$
= -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 vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(20.000 - 0.000) / 2$
= -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 $E_b = E_m$
= 0.628

Dist from Neutral axis of c/s to inside surface of the vessel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 10.000 mm.

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 86 از 93	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V02	

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

$$\begin{aligned}
 &= -(t_1 - CA) / 2 \\
 &= -(20.000 - 0.000) / 2 \\
 &= -10.000 \text{ mm.}
 \end{aligned}$$

Long-side 2 Calculations

Effective Diameter [De]:

$$\begin{aligned}
 &= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA) \\
 &= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / \\
 &\quad (20.00 - 0.00) \\
 &= 29.618 \text{ mm.}
 \end{aligned}$$

Membrane Ligament Efficiency [Em]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 69.000 - 29.618 / 69.000 \\
 &= 0.571
 \end{aligned}$$

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

Calculation of Xbar:

$$\begin{aligned}
 &= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * \\
 &\quad (T_1/2 + T_2)) + (b_2 * T_2 * (T_2/2))) / \\
 &\quad (b_0 * T_0 + b_1 * T_1 + b_2 * T_2) \\
 &= ((1.29 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.59 * 17.30 * \\
 &\quad (17.30/2 + 0.00)) + (2.72 * 0.00 * (0.00/2))) / \\
 &\quad (1.29 * 2.70 + 1.59 * 17.30 + 2.72 * 0.00) \\
 &= 9.771 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 Ci &= Xbar \\
 &= 9.771 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= -(t - CA - Xbar) \\
 &= -(20.000 - 0.000 - 9.771) \\
 &= -10.229 \text{ mm.}
 \end{aligned}$$

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

$$= 0.100 \text{ cm}^4$$

Effective Diameter [De]:

$$\begin{aligned}
 &= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co))) \\
 &= 69.00 - ((6 * 0.10) / ((20.00 - 0.00)^2 * (10.23))) \\
 &= 31.848 \text{ mm.}
 \end{aligned}$$

Bending Ligament Efficiency [Eb]:

$$\begin{aligned}
 &= \text{Pitch} - De / \text{Pitch} \\
 &= 69.000 - 31.848 / 69.000 \\
 &= 0.538
 \end{aligned}$$

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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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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]:

$$= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \}$$

$$= 80.60 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))] \}$$

$$= 15.25 \text{ N./mm}^2$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \}$$

$$= 80.60 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))] \}$$

$$= 15.25 \text{ N./mm}^2$$

Membrane Stresses at Long-side 1

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

$$= P * H / 2 * t2$$

$$= 80.60 * 100.00 / 2 * 20.00$$

$$= 20.15 \text{ N./mm}^2$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$S_{ml} = S_{ml} / E_m$$

$$= 20.15 / 0.63$$

$$= 32.07 \text{ N./mm}^2$$

Membrane Stresses at Long-side 2

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

$$= P * H / 2 * t2$$

$$= 80.60 * 100.00 / 2 * 20.00$$

$$= 20.15 \text{ N./mm}^2$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$S_{ml} = S_{ml} / E_m$$

$$= 20.15 / 0.57$$

$$= 35.31 \text{ N./mm}^2$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$= P * h / (2 * t3) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))]$$

$$= 80.60 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 -$$

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$$1.67^2) / (3 + 5 * 1.67)]$$

$$= 42.04 \text{ N./mm}^2$$

Membrane Stress at Stay Plate [t4]:

$$= P * h / (2 * t4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))]$$

$$= 80.60 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))]$$

$$= 42.04 \text{ N./mm}^2$$

MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-9, Equations (13-15). (N./mm²) :

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]:

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 80.60 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= -67.45 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))]$$

$$= 80.60 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= 67.45 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 80.60 * 60.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= 83.69 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))$$

$$= 80.60 * 60.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= -83.69 \text{ N./mm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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Bending Stresses at Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 80.60 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= -67.45 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))]$$

$$= 80.60 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= 67.45 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 80.60 * 60.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= 83.69 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * Alpha^2 * K) / (3 + 5 * K))$$

$$= 80.60 * 60.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= -83.69 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 80.60 * 60.00^2 * 10.00 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= 26.79 \text{ N./mm}^2$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 26.79 / 0.63$$

$$= 42.64 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 80.60 * 60.00^2 * -10.00 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= -26.79 \text{ N./mm}^2$$

If $E_m(0.628) < E(0.850)$ and $E_b(0.628) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -26.79 / 0.63$$

$$= -42.64 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 80.60 * 60.00^2 * 10.00 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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$$= 1.67^2 * 1.67 / (3 + 5 * 1.67)]$$

$$= 83.69 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 80.60 * 60.00^2 * -10.00 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= -83.69 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 80.60 * 60.00^2 * 9.77 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= 26.18 \text{ N./mm}^2$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 26.18 / 0.54$$

$$= 48.61 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 80.60 * 60.00^2 * -10.23 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= -27.40 \text{ N./mm}^2$$

If $E_m(0.571) < E(0.850)$ and $E_b(0.538) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -27.40 / 0.54$$

$$= -50.89 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 80.60 * 60.00^2 * 9.77 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= 81.77 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 80.60 * 60.00^2 * -10.23 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= -85.60 \text{ N./mm}^2$$

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**BENDING STRESSES: Bending Stress Calculations per Section 13-9,
Equations (16-19). (N./mm²) :**

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]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 15.25 + -67.45 \\
 &= -52.20 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 15.25 + 67.45 \\
 &= 82.70 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 15.25 + 83.69 \\
 &= 98.94 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 1 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 15.25 + -83.69 \\
 &= -68.43 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 15.25 + -67.45 \\
 &= -52.20 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at N outer [STS_No]:

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 15.25 + 67.45 \\
 &= 82.70 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q inner [STS_Qi]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 15.25 + 83.69 \\
 &= 98.94 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at short side 2 at Q outer [STS_Qo]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 15.25 + -83.69 \\
 &= -68.43 \text{ N./mm}^2
 \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 32.07 + 42.64 \\
 &= 74.71 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 32.07 + -42.64 \\
 &= -10.57 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 20.15 + 83.69 \\
 &= 103.84 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 1 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 20.15 + -83.69 \\
 &= -63.54 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 35.31 + 48.61 \\
 &= 83.92 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at M outer [STL_Mo]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 35.31 + -50.89 \\
 &= -15.59 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q inner [STL_Qi]:

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 20.15 + 81.77 \\
 &= 101.92 \text{ N./mm}^2
 \end{aligned}$$

Total Stress at long side 2 at Q outer [STL_Qo]:

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 20.15 + -85.60 \\
 &= -65.45 \text{ N./mm}^2
 \end{aligned}$$

TOTAL STRESSES: Total Stress Calculations per Section 13-9, Equations (20-24). (N./mm²) :

STRESS LOCATIONS	Inner	Outer	Allowable
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

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	88.67	155.00

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

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

$$= 100.000 * \sqrt{2.200 * 0.200 * 80.600 / (155.000)} + 0.000$$

$$= 15.127 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/100.0000)^2 * ((155)/(2.20*2.20))$$

$$= 140.901 \text{ bars}$$

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