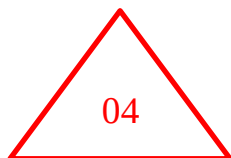


 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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طرح نگهداشت و افزایش تولید 27 مخزن



TOTALLY REVISED

Thermal/Mechanical Calculation Book

نگهداشت و افزایش تولید میدان نفتی بینک

V04	Nov.2024	AFC	AAC	M.FAKHARIAN	M.SADEGHIAN	
V03	Oct.2024	AFC	AAC	M.FAKHARIAN	M.SADEGHIAN	
V02	Jul.2024	IFA	AAC	M.FAKHARIAN	M.SADEGHIAN	
V01	Mar.2024	IFA	AAC	M.FAKHARIAN	S.FRAMARZPOUR	
V00	Nov.2023	IFA	AAC	M.FAKHARIAN	S.FRAMARZPOUR	
Rev.	Date	Purpose of Issue/Status	Prepared by:	Checked by:	Approved by:	CLIENT Approval

Status:

IFA: Issued For Approval

IFI: Issued For Information

AFC: Approved For Construction

	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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 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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	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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1.0 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:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
THIRD PARTY INSPECTOR (TPI):	Third Party Inspector
SHALL:	Is used where a provision is mandatory.
SHOULD:	Is used where a provision is advisory only.
WILL:	Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.
MAY:	Is used where a provision is completely discretionary.

 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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2.0 THERMAL/MECHANICAL CALCULATION BOOK

		API 661 Air-Cooled Heat Exchanger - Specification Sheet			
		Job No. _____		Item No. 2101 (summer)	
		Page Page 1		By _____	
		Date 11/20/2024		V03 V04	
		Proposal No. _____		Contract No. _____	
Inquiry No. _____		Order No. _____			
Manufacturer _____ Model no. _____ Customer PEDCO/NISOC Plant location BINAK Oilfield Service 1st stage Gas Compression Coo Type draft INDUCED Bay size (WxL) (m) 1.966 x 3.8 No. of bays/items 1		Heat exchanged (MegaWatts) 0.3818 Surface/Item-Finned tube (m2) 668.71 Bare tube (m2) 31.536 MTD, Eff. (Deg. C) 29.1 Transfer rate-Finned (W/m2-K) 20.125 Bare tube, service (W/m2-K) 426.74 Bare tube, clean (W/m2-K) 478.5			
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) 8664 x1.1 Dew /bubble point (Deg. C) / Latent heat (kJ/kg) Inlet pressure (barG) 17.9 Pressure drop (All/Calc) (bar) 0.7 / 0.473 Velocity (Allow /Calc) (m/s) / 17.09 Inside fouling resistance (m2-K/W) 0.0002 Temperature (Deg. C) In 129 Out 60		Total flow rate (Liq/Vap) (kg/hr) / 9530.4 / 9530.4 Water/Steam (kg/hr) / / 0 Noncondensables (kg/hr) / / 0 Molecular Wt. (Vap/Non-cond) / / Density (Liq/Vap) (kg/m3) / 14.197 / 17.141 Specific heat (Liq/Vap) (kJ/kg-C) / 2.2057 / 1.9724 Thermal cond. (Liq/Vap) (W/m-K) / 0.0438 / 0.0336 Viscosity (Liq/Vap) (mN-s/m2) / 0.0137 / 0.0117			
Performance Data - Air Side					
Air inlet temperature (Deg. C) 50.26 Air flow rate/item (m3/s) 24.446 Mass velocity (kg/s-m2) Air outlet temperature (Deg. C) 65.15 Air flow rate/fan (m3/s) 12.223		Face velocity (m/s) 2.9 Minimum design ambient temp. (Deg. C) 5 Altitude (m) 12.5 Static pressure (Pa) 138.77			
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) 1.922X 3.8 No./Bay 1 Number of tube row s 4 Bundles in parallel 1 Bundles in series Structure mounting Pipe rack beams Ladders, w alkw ays, platforms Structure surface prep. Header surface prep. Louver YES Material 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 Allow ance (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)								
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		API 661 Air-Cooled Heat Exchanger - Specification Sheet																
		Job No.	Item No. 2101 (summer)															
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		Proposal No.	Contract No.															
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Design, Material, and Construction (continued)																		
Header (continued) Slope 1% ON LAST PASS Plug material SA 182 F316L Gasket material Solid metal		No./Bundle 104 Length (m) 3.8 Pitch (mm) 63.5 Layout Triangular																
Nozzle <table border="1"> <thead> <tr> <th>No.</th> <th>Size, (In)</th> <th>Rating/Facing</th> </tr> </thead> <tbody> <tr> <td>Inlet 1</td> <td>6</td> <td>300 RF</td> </tr> <tr> <td>Outlet 1</td> <td>6</td> <td>300 RF</td> </tr> <tr> <td>Vent 1</td> <td>2</td> <td>300 RF</td> </tr> <tr> <td>Drain 1</td> <td>2</td> <td>300 RF</td> </tr> </tbody> </table>		No.	Size, (In)	Rating/Facing	Inlet 1	6	300 RF	Outlet 1	6	300 RF	Vent 1	2	300 RF	Drain 1	2	300 RF	Fin Type Extruded Material Aluminum Alloy 1060 - O Thickness (mm) 0.48 Selection temp. (C) Outside diameter (mm) 57.15 Fin density (fin/meter) 400 ASME Code, Sec. VIII, Div. 1 Customer Specifications	
No.	Size, (In)	Rating/Facing																
Inlet 1	6	300 RF																
Outlet 1	6	300 RF																
Vent 1	2	300 RF																
Drain 1	2	300 RF																
Tube Material SA-213 TP316L Tube (S) S31603 Tube outside diameter (mm) 25.4 Tube wall thickness (mm) 1.651																		
Mechanical Equipment																		
Fan Manufacturer No./Bay 2 RPM (Revs/min.) 626.4 Diameter (mm) 1372 No. of blades 4 Angle (degrees) Pitch adjustment 50% Auto Blade material AL Hub material ALU/Steel @design temp 2.6 @min. ambient temp 3.5 Tip speed Driver Type Manufacturer No./Bay 2 Driver (kW) 5.5		RPM 1500 Service factor 1 Enclosure EExd, IIB T3 (IP55) Voltage 400 Phase 3 Cycle 50 Fan noise level (dB) ≤85 Speed Reducer Type V-BELT Manufacturer No./Bay 2 Service factor 1.8 Speed ratio Support Vib. Switch Y ES, EExd, IIB T3 (IP65) Enclosure																
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) 1.966 x 3.8 Bundle weight (kg) 2252.7 Bay (kg)		Total (kg) 9140.4 Shipping (kg)																
Note: 1) Reported duty and flow rates include a user-specified multiplier of 1.10 2- Max allowable nozzle load = 3xAPI 3- Material will 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)								
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		API 661 Air-Cooled Heat Exchanger - Specification Sheet			
		Job No. _____ Page _____ Date _____ Proposal No. _____ Inquiry No. _____	Item No. 2101 (w inter) By _____ Revision V04 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) 1.966 x 3.8 No. of bays/items 1	Heat exchanged (MegaWatts) 0.276 Surface/Item-Finned tube (m2) 668.71 Bare tube (m2) 31.536 MTD, Eff. (Deg. C) 26.3 Transfer rate-Finned (W/m2-K) 19.37 Bare tube, service (W/m2-K) 410.75 Bare tube, clean (W/m2-K) 458.48				
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) 7585 x 1.1 Dew /bubble point (Deg. C) / Latent heat (kJ/kg) Inlet pressure (barG) 17.9 Pressure drop (All/Calc) (bar) 0.7 / 0.416 Velocity (Allow /Calc) (m/s) / 16.06 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) / 12.847 / 14.916 Specific heat (Liq/Vap) (kJ/kg-C) / 2.2197 / 2.0293 Thermal cond. (Liq/Vap) (W/m-K) / 0.0441 / 0.0356 Viscosity (Liq/Vap) (mN-s/m2) / 0.0137 / 0.0121			
Performance Data - Air Side					
Air inlet temperature (Deg. C) 50.26 Air flow rate/item (m3/s) 24.148 Mass velocity (kg/s-m2) Air outlet temperature (Deg. C) 61.02 Air flow rate/fan (m3/s) 12.074		Face velocity (m/s) 2.9 Minimum design ambient temp. (Deg. C) 5 Altitude (m) 12.5 Static pressure (Pa) 137.4			
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) 1.922X 3.80 No./Bay 1 Number of tube rows 4 Bundles in parallel 1 Bundles in series Structure mounting Pipe rack beams Ladders, w walk ways, platforms Structure surface prep. Header surface prep. Louver Material 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 Allow ance (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)								
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		API 661 Air-Cooled Heat Exchanger - Specification Sheet		
		Job No.	Item No. 2101 (w inter)	
		Page	By	
		Date 11/20/2024	Revision v04	
		Proposal No.	Contract No.	
		Inquiry No.		Order No.
Design, Material, and Construction (continued)				
Header (continued)		Fin		
Slope 1% ON LAST PASS Plug material SA 182 F316L Gasket material Solid Metal		No./Bundle 104 Length (m) 3.8 Pitch (mm) 63.5 Layout Triangular		
Nozzle	No. Size, (In) Rating/Facing	Type EXTRUDED Material Aluminum Alloy 1060 - O Thickness (mm) 0.48 Selection temp. (C) Outside diameter (mm) 57.15 Fin density (fin/meter) 400 ASME Code, Sec. VIII, Div. 1 Customer Specifications		
Inlet 1 6 300 RF Outlet 1 6 300RF Vent 1 2 300RF Drain 1 2 300RF Chemical Cleaning Min. Wall Thk.				
Tube				
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 No./Bay 2 RPM (Revs/min.) 626.4 Diameter (mm) 1372 No. of blades 4 Angle (degrees) Pitch adjustment 50% Auto Blade material AL Hub material Alu/Steel @design temp 2.6 @min. ambient temp 3.5 Tip speed Driver Type Manufacturer No./Bay 2 Driver (kW) 5.5		RPM 1500 Service factor 1 Enclosure EExd, IIB T3 (IP 55) Voltage 400 Phase 3 Cycle 50 Fan noise level (dB) <85 Type V-Belt Manufacturer No./Bay 2 Service factor 1.8 Speed ratio Support Vib. switch YES EExd, IIB T3 (IP 65) Enclosure		
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) 1.966 x 3.8 Bundle weight (Note 4) (kg) 2252.7 Bay (kg)		Total (Note 4) (kg) 9140.4 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-GNRAL-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)								
شماره پیمان: 053 - 073 - 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 10 از 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

		API 661 Air-Cooled Heat Exchanger - Specification Sheet	
		Job No.	Item No.
		Page	By
		Date	Revision
		Proposal No.	Contract No.
		Inquiry No.	Order No.
2101 (w inter) 11/20/2024 v04			
Design, Material, and Construction (continued)			
Header (continued)		Fin	
Slope	1% ON LAST PASS	No./Bundle	104
Plug material	SA 182 F316L	Length	(m) 3.8
Gasket material	Solid Metal	Pitch	(mm) 63.5
Nozzle	No. Size, (In) Rating/Facing	Layout	Triangular
Inlet	1 6 300 RF	Type	EXTRUDED
Outlet	1 6 300RF	Material	Aluminum Alloy 1060 - O
Vent	1 2 300RF	Thickness	(mm) 0.48
Drain	1 2 300RF	Selection temp.	(C)
Chemical Cleaning		Outside diameter	(mm) 57.15
Min. Wall Thk.		Fin density	(fin/meter) 400
Tube	SA-213 TP316L Tube (S) S31603	ASME Code, Sec. VIII, Div. 1	
Material		Customer Specifications	
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.)	626.4	Enclosure	EExd, IIB T3 (IP 55)
Diameter (mm)	1372	Voltage	400
No. of blades	4	Phase	3
Angle (degrees)		Cycle	50
Pitch adjustment	50% Auto	Fan noise level (dB)	<85
Blade material	AL	Type	V-Belt
Hub material	Alu/Steel	Manufacturer	
@design temp	2.6	No./Bay	2
@min. ambient temp	3.5	Service factor	1.8
Tip speed		Speed ratio	
Driver		Support	
Type		Vib. switch	YES EExd, IIB T3 (IP 65)
Manufacturer		Enclosure	
No./Bay	2		
Driver (kW)	5.5		
Controls - Air Side			
Controls		Shipping	
Air recirculation	NO	Plot area (WxL)	(m) 1.966 x 3.8
Degree control of outlet process temp.		Bundle w eight (Note 4)	(kg) 2252.7
(Max. Cooling), +/-	/	Bay	(kg)
Action on control signal failure		Total (Note 4)	(kg) 9140.4
Fan pitch		Shipping	(kg)
Louvers			
Actuator air supply			
Fan			
Note:1- Reported duty and flow rates include a user-specified multiplier of 1.10 2-Maximum allow able nozzle load = 3 x API. 3-Material w ill be meet requirements of NACE MR0175/ISO1516 and specification for material requirments in sour service (BK-GNRAL-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 : 11 از 150
شماره پیمان: 053 - 073 - 9184	پروژه BK	بسته کاری GCS	صادر کننده AA	تسهیلات 120	رشته PR	نوع مدرک CN	سریال 0001	نسخه V04

		API 661 Air-Cooled Heat Exchanger - Specification Sheet			
		Job No. _____	Item No. 2102 (Summer)		
Page _____		By _____		Date 11/20/2024	
Proposal No. _____		Revision v04		Contract No. _____	
Inquiry No. _____		Order No. _____		_____	
Manufacturer _____		Heat exchanged (MegaWatts) <u>0.582</u>		_____	
Model no. _____		Surface/Item-Finned tube (m2) <u>1027</u>		_____	
Customer PEDCO/NISOC		Bare tube (m2) <u>48.548</u>		_____	
Plant location BINAK oilfield		MTD, Eff. (Deg. C) <u>31.2</u>		_____	
Service 2st Stage Gas Compression Cooler		Transfer rate-Finned (W/m2-K) <u>17.389</u>		_____	
Type draft INDUCED		Bare tube, service (W/m2-K) <u>386.44</u>		_____	
Bay size (WxL) (m) <u>2.172 x 3.9</u>		Bare tube, clean (W/m2-K) <u>428.51</u>		_____	
No. of bays/items 1		_____			
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) 8664 X 1.1		Total flow rate (Liq/Vap) (kg/hr) _____ / 9530.4 <u>41.263</u> / <u>9489.2</u>			
Dew /bubble point (Deg. C) _____ / _____		Water/Steam (kg/hr) _____ / _____			
Latent heat (kJ/kg) _____		Noncondensables (kg/hr) _____			
Inlet pressure (barG) 54.8		Molecular Wt. (Vap/Non-cond) _____ / _____			
Pressure drop (All/Calc) (bar) 0.7 / <u>0.097</u>		Density (Liq/Vap) (kg/m3) _____ / <u>42.156</u> <u>981.96</u> / <u>60.185</u>			
Velocity (Allow/Calc) (m/s) _____ / <u>3.56</u>		Specific heat (Liq/Vap) (kJ/kg-C) _____ / <u>2.4264</u> <u>4.3096</u> / <u>2.4072</u>			
Inside fouling resistance (m2-K/W) 0.0002		Thermal cond. (Liq/Vap) (W/m-K) _____ / <u>0.0474</u> <u>0.6515</u> / <u>0.0371</u>			
Temperature (Deg. C) In 148 Out 60		Viscosity (Liq/Vap) (mN-s/m2) _____ / <u>0.0164</u> <u>0.4943</u> / <u>0.0142</u>			
Performance Data - Air Side					
Air inlet temperature (Deg. C) 50.26		Face velocity (m/s) <u>3.27</u>			
Air flow rate/item (m3/s) <u>31.43</u>		Minimum design ambient temp. (Deg. C) 5			
Mass velocity (kg/s-m2) _____		Altitude (m) 12.5			
Air outlet temperature (Deg. C) <u>68.06</u>		Static pressure (Pa) <u>168.85</u>			
Air flow rate/fan (m3/s) <u>15.714</u>		_____			
Design, Material, and Construction					
Design pressure (barG) 62		Heating Coil NO			
Test pressure (barG) 80.6		No. of tubes _____			
Design temperature (Deg. C) 175		Tube outside diameter (mm) _____			
Min. design metal temp. (Deg. C) 5		Tube material _____			
Tube bundle		Fin material and type _____			
Size (WxL) (m) <u>2.12</u> X 3.9		Fin thickness (mm) _____			
No./Bay 1		ASME Code, Sec. VIII, Div. 1 _____			
Number of tube rows 6		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, walkways, platforms _____		Design temperature (Deg. C) _____			
Structure surface prep. _____		Design pressure (barG) _____			
Header surface prep. _____		Inlet/Outlet nozzle _____ / _____			
Louver		Header			
Material YES		Type PLUG			
Action control Manual		Material SA-240 TP316L			
Action type _____		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 : 12 از 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

		API 661 Air-Cooled Heat Exchanger - Specification Sheet	
		Job No.	Item No.
		Page	By
		Date	Revision
		Proposal No.	Contract No.
		Inquiry No.	Order No.
		2102 (Summer) V04	
Design, Material, and Construction (continued)			
Header (continued)		Fin	
Slope 1% ON LAST PASS Plug material SA-182 F316 L Gasket material Solid METAL		No./Bundle 156 Length (m) 3.9 Pitch (mm) 70.5 Layout Triangular	
Nozzle	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.	Type Extruded Material Aluminum Alloy 1060 - O Thickness (mm) 0.48 Selection temp. (C) Outside diameter (mm) 57.15 Fin density (fin/meter) 400 ASME Code, Sec. VIII, Div. 1 Customer Specifications	
Tube	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 No./Bay RPM (Revs/min.) 645.4 Diameter (mm) 1450 No. of blades 4 Angle (degrees) Pitch adjustment 50% Auto Blade material Al Hub material steel/Alu @design temp 4.8 @min. ambient temp 6.6 Tip speed		RPM 1500 Service factor 1 Enclosure Eexd, IIB T3 (IP 55) Voltage 400 Phase 3 Cycle 50 Fan noise level (dB) <85 Type V-Belt Manufacturer No./Bay 2 Service factor 1.8 Speed ratio 2.28 Support Vib. switch YES, Eexd, IIB T3 (IP 65) Enclosure	
Driver			
Type Manufacturer No./Bay 2 Driver (kW) 7.5			
Controls - Air Side			
Air recirculation NO Degree control of outlet process temp. (Max. Cooling), +/- 2.12 X 3.900 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) 2.172 x 3.900 Bundle weight (Note 4) (kg) 3217.6 Bay (kg)		Total (kg) 10514 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)							  
	Thermal/Mechanical Calculation Book							شماره صفحه: 13 از 150
شماره پیمان: 053 - 073 - 9184	پروژه BK	بسته کاری GCS	صادر کننده AA	تسهیلات 120	رشته PR	نوع مدرک CN	سریال 0001	نسخه V04



API 661 Air-Cooled Heat Exchanger - Specification Sheet

Job No. _____		Item No. 2102 (winter)	
Page _____		By _____	
Date 11/20/2024		Revision V04	
Proposal No. _____		Contract No. _____	
Inquiry No. _____		Order No. _____	

Manufacturer _____	Heat exchanged (MegaWatts) 0.4955
Model no. _____	Surface/Item-Finned tube (m2) 1027
Customer PEDCO/NISOC	Bare tube (m2) 48.548
Plant location BINAK oilfield	MTD, Eff. (Deg. C) 34.1
Service 2st Stage Gas Compression Cooler	Transfer rate-Finned (W/m2-K) 16.86
Type draft INDUCED	Bare tube, service (W/m2-K) 356.65
Bay size (WxL) (m) 2.172 x 3.900	Bare tube, clean (W/m2-K) 392.2
No. of bays/items 1	

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) 7585 X1.1	Total flow rate (Liq/Vap) (kg/hr) / 8343.5	/ 8343.5	/ 8343.5
Dew/bubble point (Deg. C) /	Water/Steam (kg/hr) /	/	/
(Deg. C) /	Noncondensables (kg/hr) /	/	/
Latent heat (kJ/kg) /	Molecular Wt. (Vap/Non-cond) /	/	/
Inlet pressure (barG) 54.8	Density (Liq/Vap) (kg/m3) / 36.175	/ 50.059	
Pressure drop (All/Calc) (bar) 0.7 / 0.081	Specific heat (Liq/Vap) (kJ/kg-C) / 2.4633	/ 2.3853	
Velocity (Allow/Calc) (m/s) / 3.69	Thermal cond. (Liq/Vap) (W/m-K) / 0.05	/ 0.0387	
Inside fouling resistance (m2-K/W) 0.0002	Viscosity (Liq/Vap) (mN-s/m2) / 0.0163	/ 0.0139	
Temperature (Deg. C) In 149 Out 60			

Performance Data - Air Side			
Air inlet temperature (Deg. C) 50.26	Face velocity (m/s) 3.27		
Air flow rate/item (m3/s) 26.98	Minimum design ambient temp. (Deg. C) 5		
Mass velocity (kg/s-m2) /	Altitude (m) 12.5		
Air outlet temperature (Deg. C) 65.43	Static pressure (Pa) 167.92		
Air flow rate/fan (m3/s) 15.59			

Design, Material, and Construction			
Design pressure (barG) 62	Heating Coil NO		
Test pressure (barG) 80.6	No. of tubes _____		
Design temperature (Deg. C) 175	Tube outside diameter (mm) _____		
Min. design metal temp. (Deg. C) _____	Tube material _____		
Tube bundle	Fin material and type _____		
Size (WxL) (m) 2.116 x 3.9	Fin thickness (mm) _____		
No./Bay 1	ASME Code, Sec. VIII, Div. 1 _____		
Number of tube rows 6	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, walkways, platforms _____	Design temperature (Deg. C) _____		
Structure surface prep. _____	Design pressure (barG) _____		
Header surface prep. _____	Inlet/Outlet nozzle /		
Louver	Header		
Material YES	Type PLUG		
Action control Manual	Material SA-240 TP316L		
Action type _____	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 : 14 از 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

		API 661 Air-Cooled Heat Exchanger - Specification Sheet			
		Job No.		Item No.	2102 (w inter)
		Page		By	
		Date		Revision	V04
		Proposal No.		Contract No.	
		Inquiry No.		Order No.	
Design, Material, and Construction (continued)					
Header (continued)			Fin		
Slope 1% ON LAST PASS Plug material SA-182 F316 L Gasket material Solid METAL			No./Bundle 156 Length (m) 3.9 Pitch (mm) 70.5 Layout Triangular		
Nozzle			Tube		
No.	Size, (in)	Rating/Facing	Material SA-213 TP316L Tube (S) S31603 Tube outside diameter (mm) 25.4 w all thickness (mm) 1.651		
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.					
Mechanical Equipment					
Fan			Speed Reducer		
Manufacturer No./Bay RPM (Revs/min.) Diameter (mm) No. of blades Angle (degrees) Pitch adjustment Blade material Hub material @design temp @min. ambient temp Tip speed			RPM 1500 Service factor 1 Enclosure YES, EExd, IIB T3 (IP 55) Voltage 400 Phase 3 Cycle 50 Fan noise level (dB) <85 Type V-Belt Manufacturer No./Bay 2 Service factor 1.8 Speed ratio 2.28 Support Vib. switch YES, EExd, IIB T3 (IP 65) Enclosure		
Driver					
Type Manufacturer 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) 2.172 x 3.900 Bundle weight (Note 4) (kg) 3217.6 Bay (kg)			Total (kg) 10514 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 : 15 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

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./mm ²
Shell Allowable Stress at Ambient	SA	115.1465	N./mm ²
Shell Yield Stress at Design Temperature	Sy	129.8699	N./mm ²
SHORT-SIDE VESSEL DATA:			
Short-side Length Dimension	H	160.0000	mm.
Minimum Thickness of Short-side Plates	t1	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	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	63.5000	mm.
Uniform Hole Diameter	d0	25.6500	mm.
Depth of Holes	T0	20.0000	mm.
Long-side Plate # 2,			
Pitch Distance	p	63.5000	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 : 16 از 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

Rectangular Vessel Results, Item number 1, Desc: St.AE-2101
ASME Code, Section VIII, Division 1, 2021 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]:
= $Pitch - De / Pitch$
= $63.500 - 25.650 / 63.500$
= 0.596

Bending Ligament Efficiency [Eb]:
As diameter holes are uniform $E_b = E_m$
= 0.596

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

$$= -(t_1 - CA) / 2$$

$$= -(20.000 - 0.000) / 2$$

$$= -10.000 \text{ mm.}$$

Long-side 2 Calculations

Effective Diameter [De]:

$$= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA)$$

$$= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / (20.00 - 0.00)$$

$$= 29.618 \text{ mm.}$$

Membrane Ligament Efficiency [Em]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 63.500 - 29.618 / 63.500$$

$$= 0.534$$

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

Calculation of Xbar:

$$= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * (T_1/2 + T_2))) / (b_0 * T_0 + b_1 * T_1 + b_2 * T_2)$$

$$= ((1.07 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.38 * 17.30 * (17.30/2 + 0.00))) / (1.07 * 2.70 + 1.38 * 17.30 + 2.50 * 0.00)$$

$$= 9.734 \text{ mm.}$$

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

$Ci = Xbar$

$$= 9.734 \text{ mm.}$$

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

$$= -(t - CA - Xbar)$$

$$= -(20.000 - 0.000 - 9.734)$$

$$= -10.266 \text{ mm.}$$

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

$$= 0.085 \text{ cm}^4$$

Effective Diameter [De]:

$$= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co)))$$

$$= 63.50 - ((6 * 0.09) / ((20.00 - 0.00)^2 * (10.27)))$$

$$= 31.850 \text{ mm.}$$

Bending Ligament Efficiency [Eb]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 63.500 - 31.850 / 63.500$$

$$= 0.498$$

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	0.596	0.596	10.000	-10.000
2	0.534	0.498	9.734	-10.266

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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 = 1.3115
K = (I2/I1)*Alpha = 1.3115

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

= P * h / (2 * t1) * { 3 - [(6 + K *
(11 - alpha²) / (3 + 5 * K)] }
= 22.00 * 122.00 / (2 * 20.00) * { 3 - [(6 + 1.31 *
(11 - 1.31²) / (3 + 5 * 1.31)] }
= 7.37 N./mm²

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

= P * h / (2 * t1) * { 3 - [(6 + K *
(11 - alpha²) / (3 + 5 * K)] }
= 22.00 * 122.00 / (2 * 20.00) * { 3 - [(6 + 1.31 *
(11 - 1.31²) / (3 + 5 * 1.31)] }
= 7.37 N./mm²

Membrane Stresses at Long-side 1

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

= P * H / 2 * t2
= 22.00 * 160.00 / 2 * 20.00
= 8.80 N./mm²

If Em(0.596) < E(0.850) and Eb(0.596) < E(0.850) then

Sml = Sml / Em
= 8.80 / 0.60
= 14.76 N./mm²

Membrane Stresses at Long-side 2

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

= P * H / 2 * t2
= 22.00 * 160.00 / 2 * 20.00
= 8.80 N./mm²

If Em(0.534) < E(0.850) and Eb(0.498) < E(0.850) then

Sml = Sml / Em
= 8.80 / 0.53
= 16.49 N./mm²

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

= P * h / (2 * t3) * [(6 + K * (11 -
alpha²) / (3 + 5 * K)]
= 22.00 * 122.00 / (2 * 10.00) * [(6 + 1.31 * (11 -

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$$1.31^2) / (3 + 5 * 1.31)] \\ = 25.52 \text{ N./mm}^2$$

Membrane Stress at Stay Plate [t4]:

$$= P * h / (2 * t_4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \\ = 22.00 * 122.00 / (2 * 10.00) * [(6 + 1.31 * (11 - 1.31^2) / (3 + 5 * 1.31))] \\ = 25.52 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Actual	Allowable
Short-side 1	7.37	97.23
Short-side 2	7.37	97.23
Short-side Corner	7.37	97.23
Long-side 1 at A	14.76	114.39
Long-side 2 at A	16.49	114.39
Long-side Corner	8.80	97.23
Stay Plate (t3)	25.52	114.39
Stay Plate (t4)	25.52	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]:

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))] \\ = 22.00 * 10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))] \\ = -44.45 \text{ N./mm}^2$$

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

$$= P * c / (24 * I_1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))] \\ = 22.00 * -10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))] \\ = 44.45 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K)) \\ = 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31)) \\ = 61.15 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K)) \\ = 22.00 * 122.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31)) \\ = -61.15 \text{ N./mm}^2$$

Bending Stresses at Short-side 2

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

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

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$$((3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)))$$

$$= 22.00 * 10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))]$$

$$= -44.45 \text{ N./mm}^2$$

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

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

$$= 22.00 * -10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))]$$

$$= 44.45 \text{ N./mm}^2$$

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

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

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

$$= 61.15 \text{ N./mm}^2$$

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

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

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

$$= -61.15 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

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

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

$$= 36.89 \text{ N./mm}^2$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$SblMi = SblMi / E_b$$

$$= 36.89 / 0.60$$

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

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

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

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

$$= -36.89 \text{ N./mm}^2$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$SblMo = SblMo / E_b$$

$$= -36.89 / 0.60$$

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

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

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

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

$$= 61.15 \text{ N./mm}^2$$

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

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$$= P * h^2 * c / (12 * I_2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

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

$$= -61.15 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

$$= P * h^2 * c / (12 * I_2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * 9.73 / (12 * 0.07) * [(3 + 1.31 * (6 - 1.31^2)) / (3 + 5 * 1.31)]$$

$$= 35.91 \text{ N./mm}^2$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$SblMi = SblMi / E_b$$

$$= 35.91 / 0.50$$

$$= 72.04 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_2) * [(3 + K * (6 - Alpha^2)) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * -10.27 / (12 * 0.07) * [(3 + 1.31 * (6 - 1.31^2)) / (3 + 5 * 1.31)]$$

$$= -37.87 \text{ N./mm}^2$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$SblMo = SblMo / E_b$$

$$= -37.87 / 0.50$$

$$= -75.98 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * 9.73 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31)]$$

$$= 59.53 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I_2) * [(3 + 5 * Alpha^2 * K) / (3 + 5 * K)]$$

$$= 22.00 * 122.00^2 * -10.27 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31)]$$

$$= -62.78 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-44.45	44.45	145.85
at Q	61.15	-61.15	145.85
Short-side 2 at N	-44.45	44.45	145.85
at Q	61.15	-61.15	145.85
Long-side 1 at M	61.89	-61.89	171.58
at Q	61.15	-61.15	145.85
Long-side 2 at M	72.04	-75.98	171.58
at Q	59.53	-62.78	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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Total Stress Calculations per Section 13-9

Total Stresses at Short-side 1

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 7.37 + -44.45 \\
 &= -37.08 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 7.37 + 44.45 \\
 &= 51.83 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 7.37 + 61.15 \\
 &= 68.53 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 7.37 + -61.15 \\
 &= -53.78 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 7.37 + -44.45 \\
 &= -37.08 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 7.37 + 44.45 \\
 &= 51.83 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 7.37 + 61.15 \\
 &= 68.53 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 7.37 + -61.15 \\
 &= -53.78 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 1

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

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 14.76 + 61.89 \\
 &= 76.65 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blMo} \\
 &= 14.76 + -61.89 \\
 &= -47.12 \text{ N./mm}^2
 \end{aligned}$$

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

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$$\begin{aligned}
 &= S_{m1} + S_{b1Q_i} \\
 &= 8.80 + 61.15 \\
 &= 69.95 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1B} + S_{b1Q_o} \\
 &= 8.80 + -61.15 \\
 &= -52.35 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 2

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

$$\begin{aligned}
 &= S_{m1} + S_{b1M_i} \\
 &= 16.49 + 72.04 \\
 &= 88.53 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1M_o} \\
 &= 16.49 + -75.98 \\
 &= -59.49 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Q_i} \\
 &= 8.80 + 59.53 \\
 &= 68.33 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1B} + S_{b1Q_o} \\
 &= 8.80 + -62.78 \\
 &= -53.98 \text{ N./mm}^2
 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-37.08	51.83	145.85
at Q	68.53	-53.78	145.85
Short-side 2 at N	-37.08	51.83	145.85
at Q	68.53	-53.78	145.85
Long-side 1 at M	76.65	-47.12	171.58
at Q	69.95	-52.35	145.85
Long-side 2 at M	88.53	-59.49	171.58
at Q	68.33	-53.98	145.85

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	67.73	114.39

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

$$\begin{aligned}
 &= d * \sqrt{Z * C * P / (SE)} + c_a \\
 &= 160.000 * \sqrt{2.405 * 0.200 * 22.000 / (114.390)} + 0.000 \\
 &= 15.390 \text{ mm.}
 \end{aligned}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$\begin{aligned}
 &= ((T-c_a)/d)^2 * ((SE)/(C*Z)) \text{ per UG-34 (c) (3)} \\
 &= ((20.0000-0.0000)/160.0000)^2 * ((114)/(0.20*2.41)) \\
 &= 37.154 \text{ bars}
 \end{aligned}$$

 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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	BK	GCS	AA	120	PR	CN	0001	V04	

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)	25.52	N./mm ²
High Stress Percentage	22.31	%
M.A.W.P. for Membrane Stresses	98.63	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-75.98	N./mm ²
High Stress Percentage	44.28	%
M.A.W.P. for Bending Stresses	49.68	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	88.53	N./mm ²
High Stress Percentage	51.60	%
M.A.W.P. for Total Stresses	42.64	bars

Rectangular Vessel Results For Item 1 : A8

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	25.52	N./mm ²
High Stress Percentage	22.31	%
M.A.W.P. for Membrane Stresses	98.63	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-75.98	N./mm ²
High Stress Percentage	44.28	%
M.A.W.P. for Bending Stresses	49.68	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	88.53	N./mm ²
High Stress Percentage	51.60	%
M.A.W.P. for Total Stresses	42.64	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 : 25 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

3.2 STATIONARY HEADER CALCULATION @ TEST PRESSURE FOR AE-2101.

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

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./mm²
Shell Allowable Stress at Ambient SA 155.0000 N./mm²
Shell Yield Stress at Design Temperature Sy 172.3750 N./mm²

SHORT-SIDE VESSEL DATA:
Short-side Length Dimension H 160.0000 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 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 63.5000 mm.
Uniform Hole Diameter d0 25.6500 mm.
Depth of Holes T0 20.0000 mm.
Long-side Plate # 2,
Pitch Distance p 63.5000 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

Rectangular Vessel Results, Item number 1, Desc: St.AE-2101-Test **ASME Code, Section VIII, Division 1, 2021 App. 13**

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

Short-side 1 Calculations

 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 : 26 از 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Membrane Ligament Efficiency [Em]:
= 0.850

Bending Ligament Efficiency [Eb]:
= 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 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 vesssel [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]:
= $Pitch - De / Pitch$
= $63.500 - 25.650 / 63.500$
= 0.596

Bending Ligament Efficiency [Eb]:
As diameter holes are uniform $E_b = E_m$
= 0.596

Dist from Neutral axis of c/s to inside surface of the vesssel [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.

 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 : 27 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

Long-side 2 Calculations

Effective Diameter [De]:

$$= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA)$$

$$= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / (20.00 - 0.00)$$

$$= 29.618 \text{ mm.}$$

Membrane Ligament Efficiency [Em]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 63.500 - 29.618 / 63.500$$

$$= 0.534$$

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

Calculation of Xbar:

$$= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * (T_1/2 + T_2))) / (b_0 * T_0 + b_1 * T_1 + b_2 * T_2)$$

$$= ((1.07 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.38 * 17.30 * (17.30/2 + 0.00))) / (1.07 * 2.70 + 1.38 * 17.30 + 2.50 * 0.00)$$

$$= 9.734 \text{ mm.}$$

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

$$Ci = Xbar$$

$$= 9.734 \text{ mm.}$$

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

$$= -(t - CA - Xbar)$$

$$= -(20.000 - 0.000 - 9.734)$$

$$= -10.266 \text{ mm.}$$

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

$$= 0.085 \text{ cm}^4$$

Effective Diameter [De]:

$$= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co)))$$

$$= 63.50 - ((6 * 0.09) / ((20.00 - 0.00)^2 * (10.27)))$$

$$= 31.850 \text{ mm.}$$

Bending Ligament Efficiency [Eb]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 63.500 - 31.850 / 63.500$$

$$= 0.498$$

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	0.596	0.596	10.000	-10.000
2	0.534	0.498	9.734	-10.266

Moment of Inertia of a Strip of the Vessel Wall:

$$\text{Thickness } t_1, I_1 = 0.0667 \text{ cm}^4$$

$$\text{Thickness } t_2, I_2 = 0.0667 \text{ cm}^4$$

 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 : 28 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 1.3115 \\ K &= (I2/I1) * \text{Alpha} = 1.3115 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * \\ &\quad (11 - \text{alpha}^2) / (3 + 5 * K)] \} \\ &= 28.60 * 122.00 / (2 * 20.00) * \{ 3 - [(6 + 1.31 * \\ &\quad (11 - 1.31^2) / (3 + 5 * 1.31)] \} \\ &= 9.59 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * \\ &\quad (11 - \text{alpha}^2) / (3 + 5 * K)] \} \\ &= 28.60 * 122.00 / (2 * 20.00) * \{ 3 - [(6 + 1.31 * \\ &\quad (11 - 1.31^2) / (3 + 5 * 1.31)] \} \\ &= 9.59 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 28.60 * 160.00 / 2 * 20.00 \\ &= 11.44 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 11.44 / 0.60 \\ &= 19.19 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 28.60 * 160.00 / 2 * 20.00 \\ &= 11.44 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 11.44 / 0.53 \\ &= 21.44 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$\begin{aligned} &= P * h / (2 * t3) * [(6 + K * (11 - \\ &\quad \text{alpha}^2) / (3 + 5 * K)] \\ &= 28.60 * 122.00 / (2 * 10.00) * [(6 + 1.31 * (11 - \\ &\quad 1.31^2) / (3 + 5 * 1.31)] \\ &= 33.17 \text{ N./mm}^2 \end{aligned}$$

 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	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Membrane Stress at Stay Plate [t4]:

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

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

$$= 33.17 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Actual	Allowable
Short-side 1	9.59	131.75
Short-side 2	9.59	131.75
Short-side Corner	9.59	131.75
Long-side 1 at A	19.19	155.00
Long-side 2 at A	21.44	155.00
Long-side Corner	11.44	131.75
Stay Plate (t3)	33.17	114.39
Stay Plate (t4)	33.17	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]:

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

$$= 28.60 * 10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))]$$

$$= -57.79 \text{ N./mm}^2$$

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

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

$$= 28.60 * -10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))]$$

$$= 57.79 \text{ N./mm}^2$$

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

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

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

$$= 79.50 \text{ N./mm}^2$$

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

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

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

$$= -79.50 \text{ N./mm}^2$$

Bending Stresses at Short-side 2

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

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

$$= 28.60 * 10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))]$$

$$= -57.79 \text{ N./mm}^2$$

 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	V04	

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

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

$$= 28.60 * -10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))]$$

$$= 57.79 \text{ N./mm}^2$$

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

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

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

$$= 79.50 \text{ N./mm}^2$$

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

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

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

$$= -79.50 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

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

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

$$= 47.96 \text{ N./mm}^2$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 47.96 / 0.60$$

$$= 80.45 \text{ N./mm}^2$$

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

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

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

$$= -47.96 \text{ N./mm}^2$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -47.96 / 0.60$$

$$= -80.45 \text{ N./mm}^2$$

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

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

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

$$= 79.50 \text{ N./mm}^2$$

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

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

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

$$= -79.50 \text{ N./mm}^2$$

 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	V04	

Bending Stresses at Long-side 2

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

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

$$= 28.60 * 122.00^2 * 9.73 / (12 * 0.07) * [(3 + 1.31 * (6 - 1.31^2)) / (3 + 5 * 1.31)]$$

$$= 46.68 \text{ N./mm}^2$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 46.68 / 0.50$$

$$= 93.65 \text{ N./mm}^2$$

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

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

$$= 28.60 * 122.00^2 * -10.27 / (12 * 0.07) * [(3 + 1.31 * (6 - 1.31^2)) / (3 + 5 * 1.31)]$$

$$= -49.23 \text{ N./mm}^2$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -49.23 / 0.50$$

$$= -98.78 \text{ N./mm}^2$$

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

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

$$= 28.60 * 122.00^2 * 9.73 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31)]$$

$$= 77.38 \text{ N./mm}^2$$

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

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

$$= 28.60 * 122.00^2 * -10.27 / (12 * 0.07) * [(3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31)]$$

$$= -81.62 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-57.79	57.79	197.62
at Q	79.50	-79.50	197.62
Short-side 2 at N	-57.79	57.79	197.62
at Q	79.50	-79.50	197.62
Long-side 1 at M	80.45	-80.45	232.50
at Q	79.50	-79.50	197.62
Long-side 2 at M	93.65	-98.78	232.50
at Q	77.38	-81.62	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]:

 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 : 32 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
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$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 9.59 + -57.79 \\
 &= -48.20 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 9.59 + 57.79 \\
 &= 67.37 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 9.59 + 79.50 \\
 &= 89.08 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 9.59 + -79.50 \\
 &= -69.91 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 9.59 + -57.79 \\
 &= -48.20 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 9.59 + 57.79 \\
 &= 67.37 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 9.59 + 79.50 \\
 &= 89.08 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 9.59 + -79.50 \\
 &= -69.91 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 1

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

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 19.19 + 80.45 \\
 &= 99.65 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blMo} \\
 &= 19.19 + -80.45 \\
 &= -61.26 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blQi} \\
 &= 11.44 + 79.50 \\
 &= 90.94 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{mlB} + S_{blQo} \\
 &= 11.44 + -79.50 \\
 &= -68.06 \text{ N./mm}^2
 \end{aligned}$$

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Total Stresses at Long-side 2

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 21.44 + 93.65 \\
 &= 115.09 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 21.44 + -98.78 \\
 &= -77.33 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 11.44 + 77.38 \\
 &= 88.82 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 11.44 + -81.62 \\
 &= -70.18 \text{ N./mm}^2
 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-48.20	67.37	197.62
at Q	89.08	-69.91	197.62
Short-side 2 at N	-48.20	67.37	197.62
at Q	89.08	-69.91	197.62
Long-side 1 at M	99.65	-61.26	232.50
at Q	90.94	-68.06	197.62
Long-side 2 at M	115.09	-77.33	232.50
at Q	88.82	-70.18	197.62

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	88.05	155.00

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

$$\begin{aligned}
 &= d * \sqrt{Z * C * P / (SE)} + c_a \\
 &= 160.000 * \sqrt{2.405 * 0.200 * 28.600 / (155.000)} + 0.000 \\
 &= 15.074 \text{ mm.}
 \end{aligned}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$\begin{aligned}
 &= ((T-c_a)/d)^2 * ((SE)/(C*Z)) \text{ per UG-34 (c) (3)} \\
 &= ((20.0000-0.0000)/160.0000)^2 * ((155)/(.20*2.41)) \\
 &= 50.344 \text{ bars}
 \end{aligned}$$

where Z is:

$$\begin{aligned}
 &= \min(3.4 - 2.4(d/D), 2.5) \\
 &= \min(3.4 - 2.4(160.000 / 386.000), 2.5) \\
 &= 2.405
 \end{aligned}$$

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SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	33.17	N./mm ²
High Stress Percentage	29.00	%
M.A.W.P. for Membrane Stresses	98.63	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-98.78	N./mm ²
High Stress Percentage	42.48	%
M.A.W.P. for Bending Stresses	67.32	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	115.09	N./mm ²
High Stress Percentage	49.50	%
M.A.W.P. for Total Stresses	57.77	bars

Rectangular Vessel Results For Item 1 : A8

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	33.17	N./mm ²
High Stress Percentage	29.00	%
M.A.W.P. for Membrane Stresses	98.63	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-98.78	N./mm ²
High Stress Percentage	42.48	%
M.A.W.P. for Bending Stresses	67.32	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	115.09	N./mm ²
High Stress Percentage	49.50	%
M.A.W.P. for Total Stresses	57.77	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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3.3 FLOATING HEADER CALCULATION @ DESIGN PRESSURE FOR AE-2101.

Input Echo, COMPONENT 1, Description: FI.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./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 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 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 63.5000 mm.
Uniform Hole Diameter d0 25.6500 mm.
Depth of Holes T0 20.0000 mm.
Long-side Plate # 2,
Pitch Distance p 63.5000 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.
The Stay(s) Are Not Welded to the End Plate

Rectangular Vessel Results, Item number 1, Desc: FI.AE-2101 ASME Code, Section VIII, Division 1, 2021 App. 13

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

Short-side 1 Calculations

 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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Membrane Ligament Efficiency [Em]:
= 0.850

Bending Ligament Efficiency [Eb]:
= 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 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 vesssel [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]:
= $Pitch - De / Pitch$
= $63.500 - 25.650 / 63.500$
= 0.596

Bending Ligament Efficiency [Eb]:
As diameter holes are uniform $Eb = Em$
= 0.596

Dist from Neutral axis of c/s to inside surface of the vesssel [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.

 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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Long-side 2 Calculations

Effective Diameter [De]:

$$= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA)$$

$$= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / (20.00 - 0.00)$$

$$= 29.618 \text{ mm.}$$

Membrane Ligament Efficiency [Em]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 63.500 - 29.618 / 63.500$$

$$= 0.534$$

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

Calculation of Xbar:

$$= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * (T_1/2 + T_2))) / (b_0 * T_0 + b_1 * T_1 + b_2 * T_2)$$

$$= ((1.07 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.38 * 17.30 * (17.30/2 + 0.00))) / (1.07 * 2.70 + 1.38 * 17.30 + 2.50 * 0.00)$$

$$= 9.734 \text{ mm.}$$

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

$$Ci = Xbar$$

$$= 9.734 \text{ mm.}$$

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

$$= -(t - CA - Xbar)$$

$$= -(20.000 - 0.000 - 9.734)$$

$$= -10.266 \text{ mm.}$$

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

$$= 0.085 \text{ cm}^4$$

Effective Diameter [De]:

$$= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co)))$$

$$= 63.50 - ((6 * 0.09) / ((20.00 - 0.00)^2 * (10.27)))$$

$$= 31.850 \text{ mm.}$$

Bending Ligament Efficiency [Eb]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 63.500 - 31.850 / 63.500$$

$$= 0.498$$

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	0.596	0.596	10.000	-10.000
2	0.534	0.498	9.734	-10.266

Moment of Inertia of a Strip of the Vessel Wall:

$$\text{Thickness } t_1, I_1 = 0.0667 \text{ cm}^4$$

$$\text{Thickness } t_2, I_2 = 0.0667 \text{ cm}^4$$

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Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 0.8197 \\ K &= (I2/I1) * \text{Alpha} = 0.8197 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= p * h / (4 * t1) * \{ 4 - [(2 + K * (5 - \text{alpha}^2)) / (1 + 2 * K)] \} \\ &= 22.00 * 122.00 / (4 * 20.00) * \{ 4 - [(2 + 0.82 * (5 - 0.82^2)) / (1 + 2 * 0.82)] \} \\ &= 6.37 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= p * h / (4 * t1) * \{ 4 - [(2 + K * (5 - \text{alpha}^2)) / (1 + 2 * K)] \} \\ &= 22.00 * 122.00 / (4 * 20.00) * \{ 4 - [(2 + 0.82 * (5 - 0.82^2)) / (1 + 2 * 0.82)] \} \\ &= 6.37 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 22.00 * 100.00 / 2 * 20.00 \\ &= 5.50 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 5.50 / 0.60 \\ &= 9.23 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 22.00 * 100.00 / 2 * 20.00 \\ &= 5.50 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 5.50 / 0.53 \\ &= 10.31 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [Smsp]:

$$\begin{aligned} &= P * h / (2 * t3) * [(2 + K * (5 - \text{alpha}^2)) / (1 + 2 * K)] \\ &= 22.00 * 122.00 / (2 * 10.00) * [(2 + 0.82 * (5 - 0.82^2)) / (1 + 2 * 0.82)] \\ &= 28.21 \text{ N./mm}^2 \end{aligned}$$

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

STRESS LOCATIONS	Actual	Allowable
Short-side 1	6.37	97.23
Short-side 2	6.37	97.23
Short-side Corner	6.37	97.23
Long-side 1 at A	9.23	114.39
Long-side 2 at A	10.31	114.39
Long-side Corner	5.50	97.23
Stay Plate (t3)	28.21	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]:

$$\begin{aligned}
 &= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * \\
 &\quad ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\
 &= 22.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * \\
 &\quad ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))] \\
 &= -8.66 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * \\
 &\quad ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\
 &= 22.00 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * \\
 &\quad ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))] \\
 &= 8.66 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I1) * ((1 + 2 * \\
 &\quad Alpha^2 * K) / (1 + 2 * K)) \\
 &= 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * ((1 + 2 * \\
 &\quad 0.82^2 * 0.82) / (1 + 2 * 0.82)) \\
 &= 32.59 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I1) * ((1 + 2 * \\
 &\quad Alpha^2 * K) / (1 + 2 * K)) \\
 &= 22.00 * 122.00^2 * -10.00 / (12 * 0.07) * ((1 + 2 * \\
 &\quad 0.82^2 * 0.82) / (1 + 2 * 0.82)) \\
 &= -32.59 \text{ N./mm}^2
 \end{aligned}$$

Bending Stresses at Short-side 2

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

$$\begin{aligned}
 &= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * \\
 &\quad ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\
 &= 22.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * \\
 &\quad ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))] \\
 &= -8.66 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * \\
 &\quad ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\
 &= 22.00 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * \\
 &\quad ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))] \\
 &= 8.66 \text{ N./mm}^2
 \end{aligned}$$

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

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

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

$$= 32.59 \text{ N./mm}^2$$

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

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

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

$$= -32.59 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

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

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

$$= 45.10 \text{ N./mm}^2$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$SblMi = SblMi / E_b$$

$$= 45.10 / 0.60$$

$$= 75.67 \text{ N./mm}^2$$

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

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

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

$$= -45.10 \text{ N./mm}^2$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$SblMo = SblMo / E_b$$

$$= -45.10 / 0.60$$

$$= -75.67 \text{ N./mm}^2$$

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

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

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

$$= 32.59 \text{ N./mm}^2$$

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

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

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

$$= -32.59 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

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

$$= 22.00 * 122.00^2 * 9.73 / (12 * 0.07) * [(1 + 0.82 * (3 - 0.82^2)) / (1 + 2 * 0.82)]$$

 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 : 41 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

$$\frac{(3 - 0.82^2)}{(1 + 2 * 0.82)} = 43.90 \text{ N./mm}^2$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$\begin{aligned} S_{blMi} &= S_{blMi} / E_b \\ &= 43.90 / 0.50 \\ &= 88.08 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} &= P * h^2 * c / (12 * I_2) * [(1 + K * (3 - \alpha^2)) / (1 + 2 * K)] \\ &= 22.00 * 122.00^2 * -10.27 / (12 * 0.07) * [(1 + 0.82 * (3 - 0.82^2)) / (1 + 2 * 0.82)] \\ &= -46.31 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$\begin{aligned} S_{blMo} &= S_{blMo} / E_b \\ &= -46.31 / 0.50 \\ &= -92.90 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} &= P * h^2 * c / (12 * I_2) * [(1 + 2 * \alpha^2 * K) / (1 + 2 * K)] \\ &= 22.00 * 122.00^2 * 9.73 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82)] \\ &= 31.72 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} &= P * h^2 * c / (12 * I_2) * [(1 + 2 * \alpha^2 * K) / (1 + 2 * K)] \\ &= 22.00 * 122.00^2 * -10.27 / (12 * 0.07) * [(1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82)] \\ &= -33.46 \text{ N./mm}^2 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-8.66	8.66	145.85
at Q	32.59	-32.59	145.85
Short-side 2 at N	-8.66	8.66	145.85
at Q	32.59	-32.59	145.85
Long-side 1 at M	75.67	-75.67	171.58
at Q	32.59	-32.59	145.85
Long-side 2 at M	88.08	-92.90	171.58
at Q	31.72	-33.46	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]:

$$\begin{aligned} &= S_{ms} + S_{bsNi} \\ &= 6.37 + -8.66 \\ &= -2.29 \text{ N./mm}^2 \end{aligned}$$

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

$$= S_{ms} + S_{bsNo}$$

 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 : 42 از 150
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	AA	120	PR	CN	0001	V04

$$= 6.37 + 8.66$$

$$= 15.03 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsQi}$$

$$= 6.37 + 32.59$$

$$= 38.96 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsQo}$$

$$= 6.37 + -32.59$$

$$= -26.22 \text{ N./mm}^2$$

Total Stresses at Short-side 2

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

$$= S_{ms} + S_{bsNi}$$

$$= 6.37 + -8.66$$

$$= -2.29 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsNo}$$

$$= 6.37 + 8.66$$

$$= 15.03 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsQi}$$

$$= 6.37 + 32.59$$

$$= 38.96 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsQo}$$

$$= 6.37 + -32.59$$

$$= -26.22 \text{ N./mm}^2$$

Total Stresses at Long-side 1

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

$$= S_{ml} + S_{blMi}$$

$$= 9.23 + 75.67$$

$$= 84.90 \text{ N./mm}^2$$

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

$$= S_{ml} + S_{blMo}$$

$$= 9.23 + -75.67$$

$$= -66.44 \text{ N./mm}^2$$

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

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

$$= 5.50 + 32.59$$

$$= 38.09 \text{ N./mm}^2$$

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

$$= S_{ml} + S_{blQo}$$

$$= 5.50 + -32.59$$

$$= -27.09 \text{ N./mm}^2$$

Total Stresses at Long-side 2

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

 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 : 43 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 10.31 + 88.08 \\
 &= 98.39 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blMo} \\
 &= 10.31 + -92.90 \\
 &= -82.59 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blQi} \\
 &= 5.50 + 31.72 \\
 &= 37.22 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blQo} \\
 &= 5.50 + -33.46 \\
 &= -27.96 \text{ N./mm}^2
 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-2.29	15.03	145.85
at Q	38.96	-26.22	145.85
Short-side 2 at N	-2.29	15.03	145.85
at Q	38.96	-26.22	145.85
Long-side 1 at M	84.90	-66.44	171.58
at Q	38.09	-27.09	145.85
Long-side 2 at M	98.39	-82.59	171.58
at Q	37.22	-27.96	145.85

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	30.85	114.39

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

$$\begin{aligned}
 &= d * \sqrt{Z * C * P / (SE)} + c_a \\
 &= 110.000 * \sqrt{2.318 * 0.200 * 22.000 / (114.390)} + 0.000 \\
 &= 10.387 \text{ mm.}
 \end{aligned}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$\begin{aligned}
 &= ((T-c_a)/d)^2 * ((SE)/(C*Z)) \text{ per UG-34 (c) (3)} \\
 &= ((20.0000-0.0000)/110.0000)^2 * ((114)/(0.20*2.32)) \\
 &= 81.562 \text{ bars}
 \end{aligned}$$

where Z is:

$$\begin{aligned}
 &= \min(3.4 - 2.4(d/D), 2.5) \\
 &= \min(3.4 - 2.4(110.000 / 244.000), 2.5) \\
 &= 2.318
 \end{aligned}$$

 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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 44 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	28.21	N./mm ²
High Stress Percentage	24.66	%
M.A.W.P. for Membrane Stresses	89.21	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-92.90	N./mm ²
High Stress Percentage	54.14	%
M.A.W.P. for Bending Stresses	40.63	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	98.39	N./mm ²
High Stress Percentage	57.34	%
M.A.W.P. for Total Stresses	38.37	bars

Rectangular Vessel Results For Item 1 : A7

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	28.21	N./mm ²
High Stress Percentage	24.66	%
M.A.W.P. for Membrane Stresses	89.21	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-92.90	N./mm ²
High Stress Percentage	54.14	%
M.A.W.P. for Bending Stresses	40.63	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	98.39	N./mm ²
High Stress Percentage	57.34	%
M.A.W.P. for Total Stresses	38.37	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 : 45 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

3.4 FLOATING HEADER CALCULATION @ TEST PRESSURE FOR AE-2101.

Input Echo, COMPONENT 1, Description: FI.AE-2101-Test

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./mm²
Shell Allowable Stress at Ambient SA 155.0000 N./mm²
Shell Yield Stress at Design Temperature Sy 172.3750 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 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 63.5000 mm.
Uniform Hole Diameter d0 25.6500 mm.
Depth of Holes T0 20.0000 mm.
Long-side Plate # 2,
Pitch Distance p 63.5000 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.
The Stay(s) Are Not Welded to the End Plate

Rectangular Vessel Results, Item number 1, Desc: FI.AE-2101-Test ASME Code, Section VIII, Division 1, 2021 App. 13

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

Short-side 1 Calculations

 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 : 46 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

Membrane Ligament Efficiency [Em]:
= 0.850

Bending Ligament Efficiency [Eb]:
= 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 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 vesssel [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]:
= $Pitch - De / Pitch$
= $63.500 - 25.650 / 63.500$
= 0.596

Bending Ligament Efficiency [Eb]:
As diameter holes are uniform $Eb = Em$
= 0.596

Dist from Neutral axis of c/s to inside surface of the vesssel [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.

 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 : 47 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Long-side 2 Calculations

Effective Diameter [De]:

$$= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA)$$

$$= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / (20.00 - 0.00)$$

$$= 29.618 \text{ mm.}$$

Membrane Ligament Efficiency [Em]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 63.500 - 29.618 / 63.500$$

$$= 0.534$$

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

Calculation of Xbar:

$$= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * (T_1/2 + T_2))) / (b_0 * T_0 + b_1 * T_1 + b_2 * T_2)$$

$$= ((1.07 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.38 * 17.30 * (17.30/2 + 0.00))) / (1.07 * 2.70 + 1.38 * 17.30 + 2.50 * 0.00)$$

$$= 9.734 \text{ mm.}$$

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

$$Ci = Xbar$$

$$= 9.734 \text{ mm.}$$

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

$$= -(t - CA - Xbar)$$

$$= -(20.000 - 0.000 - 9.734)$$

$$= -10.266 \text{ mm.}$$

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

$$= 0.085 \text{ cm}^4$$

Effective Diameter [De]:

$$= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co)))$$

$$= 63.50 - ((6 * 0.09) / ((20.00 - 0.00)^2 * (10.27)))$$

$$= 31.850 \text{ mm.}$$

Bending Ligament Efficiency [Eb]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 63.500 - 31.850 / 63.500$$

$$= 0.498$$

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	0.596	0.596	10.000	-10.000
2	0.534	0.498	9.734	-10.266

Moment of Inertia of a Strip of the Vessel Wall:

$$\text{Thickness } t_1, I_1 = 0.0667 \text{ cm}^4$$

$$\text{Thickness } t_2, I_2 = 0.0667 \text{ cm}^4$$

 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 : 48 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 0.8197 \\ K &= (I2/I1) * \text{Alpha} = 0.8197 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= p * h / (4 * t1) * \{ 4 - [(2 + K * (5 - \text{alpha}^2)) / (1 + 2 * K)] \} \\ &= 28.60 * 122.00 / (4 * 20.00) * \{ 4 - [(2 + 0.82 * (5 - 0.82^2)) / (1 + 2 * 0.82)] \} \\ &= 8.28 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= p * h / (4 * t1) * \{ 4 - [(2 + K * (5 - \text{alpha}^2)) / (1 + 2 * K)] \} \\ &= 28.60 * 122.00 / (4 * 20.00) * \{ 4 - [(2 + 0.82 * (5 - 0.82^2)) / (1 + 2 * 0.82)] \} \\ &= 8.28 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 28.60 * 100.00 / 2 * 20.00 \\ &= 7.15 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 7.15 / 0.60 \\ &= 12.00 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 28.60 * 100.00 / 2 * 20.00 \\ &= 7.15 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 7.15 / 0.53 \\ &= 13.40 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [Smsp]:

$$\begin{aligned} &= P * h / (2 * t3) * [(2 + K * (5 - \text{alpha}^2)) / (1 + 2 * K)] \\ &= 28.60 * 122.00 / (2 * 10.00) * [(2 + 0.82 * (5 - 0.82^2)) / (1 + 2 * 0.82)] \\ &= 36.67 \text{ N./mm}^2 \end{aligned}$$

 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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 49 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

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

STRESS LOCATIONS	Actual	Allowable
Short-side 1	8.28	131.75
Short-side 2	8.28	131.75
Short-side Corner	8.28	131.75
Long-side 1 at A	12.00	155.00
Long-side 2 at A	13.40	155.00
Long-side Corner	7.15	131.75
Stay Plate (t3)	36.67	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]:

$$\begin{aligned}
 &= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * \\
 &\quad ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\
 &= 28.60 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * \\
 &\quad ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))] \\
 &= -11.26 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * \\
 &\quad ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\
 &= 28.60 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * \\
 &\quad ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))] \\
 &= 11.26 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I1) * ((1 + 2 * \\
 &\quad Alpha^2 * K) / (1 + 2 * K)) \\
 &= 28.60 * 122.00^2 * 10.00 / (12 * 0.07) * ((1 + 2 * \\
 &\quad 0.82^2 * 0.82) / (1 + 2 * 0.82)) \\
 &= 42.37 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I1) * ((1 + 2 * \\
 &\quad Alpha^2 * K) / (1 + 2 * K)) \\
 &= 28.60 * 122.00^2 * -10.00 / (12 * 0.07) * ((1 + 2 * \\
 &\quad 0.82^2 * 0.82) / (1 + 2 * 0.82)) \\
 &= -42.37 \text{ N./mm}^2
 \end{aligned}$$

Bending Stresses at Short-side 2

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

$$\begin{aligned}
 &= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * \\
 &\quad ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\
 &= 28.60 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * \\
 &\quad ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))] \\
 &= -11.26 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * \\
 &\quad ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))] \\
 &= 28.60 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * \\
 &\quad ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))] \\
 &= 11.26 \text{ N./mm}^2
 \end{aligned}$$

 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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 50 از 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

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

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

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

$$= 42.37 \text{ N./mm}^2$$

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

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

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

$$= -42.37 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

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

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

$$= 58.64 \text{ N./mm}^2$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$SblMi = SblMi / E_b$$

$$= 58.64 / 0.60$$

$$= 98.37 \text{ N./mm}^2$$

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

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

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

$$= -58.64 \text{ N./mm}^2$$

If $E_m(0.596) < E(0.850)$ and $E_b(0.596) < E(0.850)$ then

$$SblMo = SblMo / E_b$$

$$= -58.64 / 0.60$$

$$= -98.37 \text{ N./mm}^2$$

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

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

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

$$= 42.37 \text{ N./mm}^2$$

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

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

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

$$= -42.37 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

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

$$= 28.60 * 122.00^2 * 9.73 / (12 * 0.07) * [(1 + 0.82 * (3 - 0.82^2)) / (1 + 2 * 0.82)]$$

 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 : 51 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

$$\frac{(3 - 0.82^2)}{(1 + 2 * 0.82)} = 57.08 \text{ N./mm}^2$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$\begin{aligned} S_{blMi} &= S_{blMi} / E_b \\ &= 57.08 / 0.50 \\ &= 114.51 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} &= P * h^2 * c / (12 * I_2) * [(1 + K * \\ &\quad (3 - \alpha^2)) / (1 + 2 * K)] \\ &= 28.60 * 122.00^2 * -10.27 / (12 * 0.07) * [(1 + 0.82 * \\ &\quad (3 - 0.82^2)) / (1 + 2 * 0.82)] \\ &= -60.20 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.534) < E(0.850)$ and $E_b(0.498) < E(0.850)$ then

$$\begin{aligned} S_{blMo} &= S_{blMo} / E_b \\ &= -60.20 / 0.50 \\ &= -120.77 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} &= P * h^2 * c / (12 * I_2) * [(1 + 2 * \\ &\quad \alpha^2 * K) / (1 + 2 * K)] \\ &= 28.60 * 122.00^2 * 9.73 / (12 * 0.07) * [(1 + 2 * \\ &\quad 0.82^2 * 0.82) / (1 + 2 * 0.82)] \\ &= 41.24 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} &= P * h^2 * c / (12 * I_2) * [(1 + 2 * \\ &\quad \alpha^2 * K) / (1 + 2 * K)] \\ &= 28.60 * 122.00^2 * -10.27 / (12 * 0.07) * [(1 + 2 * \\ &\quad 0.82^2 * 0.82) / (1 + 2 * 0.82)] \\ &= -43.50 \text{ N./mm}^2 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-11.26	11.26	197.62
at Q	42.37	-42.37	197.62
Short-side 2 at N	-11.26	11.26	197.62
at Q	42.37	-42.37	197.62
Long-side 1 at M	98.37	-98.37	232.50
at Q	42.37	-42.37	197.62
Long-side 2 at M	114.51	-120.77	232.50
at Q	41.24	-43.50	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]:

$$\begin{aligned} &= S_{ms} + S_{bsNi} \\ &= 8.28 + -11.26 \\ &= -2.98 \text{ N./mm}^2 \end{aligned}$$

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

$$= S_{ms} + S_{bsNo}$$

 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 : 52 از 150
	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	
	V04	0001	CN	PR	120	AA	GCS	BK

$$= 8.28 + 11.26$$

$$= 19.54 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsQi}$$

$$= 8.28 + 42.37$$

$$= 50.65 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsQo}$$

$$= 8.28 + -42.37$$

$$= -34.09 \text{ N./mm}^2$$

Total Stresses at Short-side 2

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

$$= S_{ms} + S_{bsNi}$$

$$= 8.28 + -11.26$$

$$= -2.98 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsNo}$$

$$= 8.28 + 11.26$$

$$= 19.54 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsQi}$$

$$= 8.28 + 42.37$$

$$= 50.65 \text{ N./mm}^2$$

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

$$= S_{ms} + S_{bsQo}$$

$$= 8.28 + -42.37$$

$$= -34.09 \text{ N./mm}^2$$

Total Stresses at Long-side 1

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

$$= S_{ml} + S_{blMi}$$

$$= 12.00 + 98.37$$

$$= 110.37 \text{ N./mm}^2$$

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

$$= S_{ml} + S_{blMo}$$

$$= 12.00 + -98.37$$

$$= -86.38 \text{ N./mm}^2$$

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

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

$$= 7.15 + 42.37$$

$$= 49.52 \text{ N./mm}^2$$

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

$$= S_{ml} + S_{blQo}$$

$$= 7.15 + -42.37$$

$$= -35.22 \text{ N./mm}^2$$

Total Stresses at Long-side 2

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

$$= S_{ml} + S_{blMi}$$

$$= 13.40 + 114.51$$

$$= 127.91 \text{ N./mm}^2$$

 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 : 53 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 13.40 + -120.77 \\
 &= -107.37 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 7.15 + 41.24 \\
 &= 48.39 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Qo} \\
 &= 7.15 + -43.50 \\
 &= -36.35 \text{ N./mm}^2
 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-2.98	19.54	197.62
at Q	50.65	-34.09	197.62
Short-side 2 at N	-2.98	19.54	197.62
at Q	50.65	-34.09	197.62
Long-side 1 at M	110.37	-86.38	232.50
at Q	49.52	-35.22	197.62
Long-side 2 at M	127.91	-107.37	232.50
at Q	48.39	-36.35	197.62

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	40.11	155.00

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

$$\begin{aligned}
 &= d * \sqrt{Z * C * P / (SE)} + c_a \\
 &= 110.000 * \sqrt{2.318 * 0.200 * 28.600 / (155.000)} + 0.000 \\
 &= 10.174 \text{ mm.}
 \end{aligned}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$\begin{aligned}
 &= ((T-c_a)/d)^2 * ((SE)/(C*Z)) \text{ per UG-34 (c) (3)} \\
 &= ((20.0000-0.0000)/110.0000)^2 * ((155)/(0.20*2.32)) \\
 &= 110.518 \text{ bars}
 \end{aligned}$$

where Z is:

$$\begin{aligned}
 &= \min(3.4 - 2.4(d/D), 2.5) \\
 &= \min(3.4 - 2.4(110.000 / 244.000), 2.5) \\
 &= 2.318
 \end{aligned}$$

 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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 54 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	36.67	N./mm ²
High Stress Percentage	32.06	%
M.A.W.P. for Membrane Stresses	89.21	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-120.77	N./mm ²
High Stress Percentage	51.95	%
M.A.W.P. for Bending Stresses	55.06	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	127.91	N./mm ²
High Stress Percentage	55.02	%
M.A.W.P. for Total Stresses	51.99	bars

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	36.67	N./mm ²
High Stress Percentage	32.06	%
M.A.W.P. for Membrane Stresses	89.21	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-120.77	N./mm ²
High Stress Percentage	51.95	%
M.A.W.P. for Bending Stresses	55.06	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	127.91	N./mm ²
High Stress Percentage	55.02	%
M.A.W.P. for Total Stresses	51.99	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 : 55 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

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 130.0000 mm.
Minimum Thickness of Long-side Plates t2 28.0000 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 70.5000 mm.
Uniform Hole Diameter d0 25.6500 mm.
Depth of Holes T0 28.0000 mm.
Long-side Plate # 2,
Pitch Distance p 70.5000 mm.
1: Hole Diameter d0 36.3000 mm.
Hole Depth T0 2.7000 mm.
2: Hole Diameter d1 28.5750 mm.
Hole Depth T1 25.3000 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

Rectangular Vessel Results, Item number 1, Desc: St.AE-2102
ASME Code, Section VIII, Division 1, 2021 App. 13

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

 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 : 56 از 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Short-side 1 Calculations

Membrane Ligament Efficiency [Em]:
= 0.850

Bending Ligament Efficiency [Eb]:
= 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 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 vesssel [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]:
= $Pitch - De / Pitch$
= $70.500 - 25.650 / 70.500$
= 0.636

Bending Ligament Efficiency [Eb]:
As diameter holes are uniform $E_b = E_m$
= 0.636

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= $t_1 - CA / 2$
= $28.000 - 0.000 / 2$
= 14.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(28.000 - 0.000) / 2$
= -14.000 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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Long-side 2 Calculations

Effective Diameter [De]:

$$= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA)$$

$$= (36.30 * 2.70 + 28.57 * 25.30 + 0.00 * 0.00) / (28.00 - 0.00)$$

$$= 29.320 \text{ mm.}$$

Membrane Ligament Efficiency [Em]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 70.500 - 29.320 / 70.500$$

$$= 0.584$$

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

Calculation of Xbar:

$$= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * (T_1/2 + T_2))) / (b_0 * T_0 + b_1 * T_1 + b_2 * T_2)$$

$$= ((1.35 * 2.70 * (2.70/2 + 25.30 + 0.00)) + (1.65 * 25.30 * (25.30/2 + 0.00))) / (1.35 * 2.70 + 1.65 * 25.30 + 2.78 * 0.00)$$

$$= 13.771 \text{ mm.}$$

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

$$Ci = Xbar$$

$$= 13.771 \text{ mm.}$$

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

$$= -(t - CA - Xbar)$$

$$= -(28.000 - 0.000 - 13.771)$$

$$= -14.229 \text{ mm.}$$

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

$$= 0.289 \text{ cm}^4$$

Effective Diameter [De]:

$$= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co)))$$

$$= 70.50 - ((6 * 0.29) / ((28.00 - 0.00)^2 * (14.23)))$$

$$= 31.084 \text{ mm.}$$

Bending Ligament Efficiency [Eb]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 70.500 - 31.084 / 70.500$$

$$= 0.559$$

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	0.636	0.636	14.000	-14.000
2	0.584	0.559	13.771	-14.229

Moment of Inertia of a Strip of the Vessel Wall:

$$\text{Thickness } t_1, I_1 = 0.0667 \text{ cm}^4$$

$$\text{Thickness } t_2, I_2 = 0.1829 \text{ cm}^4$$

 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)								
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Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 0.8462 \\ K &= (I2/I1) * \text{Alpha} = 2.3218 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \} \\ &= 62.00 * 130.00 / (2 * 20.00) * \{ 3 - [(6 + 2.32 * (11 - 0.85^2) / (3 + 5 * 2.32))] \} \\ &= 19.24 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \} \\ &= 62.00 * 130.00 / (2 * 20.00) * \{ 3 - [(6 + 2.32 * (11 - 0.85^2) / (3 + 5 * 2.32))] \} \\ &= 19.24 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 62.00 * 110.00 / 2 * 28.00 \\ &= 12.18 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 12.18 / 0.64 \\ &= 19.14 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 62.00 * 110.00 / 2 * 28.00 \\ &= 12.18 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.584) < E(0.850)$ and $E_b(0.559) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 12.18 / 0.58 \\ &= 20.85 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$\begin{aligned} &= P * h / (2 * t3) * [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \\ &= 62.00 * 130.00 / (2 * 10.00) * [(6 + 2.32 * (11 - 0.85^2) / (3 + 5 * 2.32))] \\ &= 82.42 \text{ N./mm}^2 \end{aligned}$$

Membrane Stress at Stay Plate [t4]:

$$\begin{aligned} &= P * h / (2 * t4) * [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \\ &= 62.00 * 130.00 / (2 * 10.00) * [(6 + 2.32 * (11 - 0.85^2) / (3 + 5 * 2.32))] \\ &= 82.42 \text{ N./mm}^2 \end{aligned}$$

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

STRESS LOCATIONS	Actual	Allowable
Short-side 1	19.24	95.12
Short-side 2	19.24	95.12
Short-side Corner	19.24	95.12
Long-side 1 at A	19.14	111.91
Long-side 2 at A	20.85	111.91
Long-side Corner	12.18	95.12
Stay Plate (t3)	82.42	114.39
Stay Plate (t4)	82.42	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]:

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

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 130.00^2 * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))]$$

$$= -39.25 \text{ N./mm}^2$$

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

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

$$= 62.00 * -10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 130.00^2 * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))]$$

$$= 39.25 \text{ N./mm}^2$$

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

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

$$= 62.00 * 130.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))$$

$$= 101.42 \text{ N./mm}^2$$

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

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

$$= 62.00 * 130.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))$$

$$= -101.42 \text{ N./mm}^2$$

Bending Stresses at Short-side 2

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

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

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 130.00^2 * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))]$$

$$= -39.25 \text{ N./mm}^2$$

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

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

$$= 62.00 * -10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 130.00^2 * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))]$$

 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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$$= 39.25 \text{ N./mm}^2$$

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

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

$$= 62.00 * 130.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))$$

$$= 101.42 \text{ N./mm}^2$$

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

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

$$= 62.00 * 130.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))$$

$$= -101.42 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

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

$$= 62.00 * 130.00^2 * 14.00 / (12 * 0.18) * [(3 + 2.32 * (6 - 0.85^2)) / (3 + 5 * 2.32)]$$

$$= 69.84 \text{ N./mm}^2$$

If $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 69.84 / 0.64$$

$$= 109.79 \text{ N./mm}^2$$

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

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

$$= 62.00 * 130.00^2 * -14.00 / (12 * 0.18) * [(3 + 2.32 * (6 - 0.85^2)) / (3 + 5 * 2.32)]$$

$$= -69.84 \text{ N./mm}^2$$

If $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -69.84 / 0.64$$

$$= -109.79 \text{ N./mm}^2$$

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

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

$$= 62.00 * 130.00^2 * 14.00 / (12 * 0.18) * [(3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32)]$$

$$= 51.74 \text{ N./mm}^2$$

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

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

$$= 62.00 * 130.00^2 * -14.00 / (12 * 0.18) * [(3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32)]$$

$$= -51.74 \text{ N./mm}^2$$

Bending Stresses at Long-side 2

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

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

 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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$$= \frac{(6 - \alpha^2)}{(3 + 5 * K)} \cdot \left[\frac{62.00 * 130.00^2 * 13.77}{(12 * 0.18)} * \left[\frac{(6 - 0.85^2)}{(3 + 5 * 2.32)} \right] \right]$$

$$= 68.70 \text{ N./mm}^2$$

If $E_m(0.584) < E(0.850)$ and $E_b(0.559) < E(0.850)$ then

$$S_{blMi} = S_{blMi} / E_b$$

$$= 68.70 / 0.56$$

$$= 122.88 \text{ N./mm}^2$$

Bending Stress at Long-side 2 at M Outer [S_{blMo}]:

$$= P * h^2 * c / (12 * I_2) * \left[\frac{(6 - \alpha^2)}{(3 + 5 * K)} \right]$$

$$= 62.00 * 130.00^2 * -14.23 / (12 * 0.18) * \left[\frac{(6 - 0.85^2)}{(3 + 5 * 2.32)} \right]$$

$$= -70.99 \text{ N./mm}^2$$

If $E_m(0.584) < E(0.850)$ and $E_b(0.559) < E(0.850)$ then

$$S_{blMo} = S_{blMo} / E_b$$

$$= -70.99 / 0.56$$

$$= -126.97 \text{ N./mm}^2$$

Bending Stress at Long-side 2 at Q Inner [S_{blQi}]:

$$= P * h^2 * c / (12 * I_2) * \left[\frac{\alpha^2 * K}{(3 + 5 * K)} \right]$$

$$= 62.00 * 130.00^2 * 13.77 / (12 * 0.18) * \left[\frac{0.85^2 * 2.32}{(3 + 5 * 2.32)} \right]$$

$$= 50.90 \text{ N./mm}^2$$

Bending Stress at Long-side 2 at Q Outer [S_{blQo}]:

$$= P * h^2 * c / (12 * I_2) * \left[\frac{\alpha^2 * K}{(3 + 5 * K)} \right]$$

$$= 62.00 * 130.00^2 * -14.23 / (12 * 0.18) * \left[\frac{0.85^2 * 2.32}{(3 + 5 * 2.32)} \right]$$

$$= -52.59 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-39.25	39.25	142.68
at Q	101.42	-101.42	142.68
Short-side 2 at N	-39.25	39.25	142.68
at Q	101.42	-101.42	142.68
Long-side 1 at M	109.79	-109.79	167.86
at Q	51.74	-51.74	142.68
Long-side 2 at M	122.88	-126.97	167.86
at Q	50.90	-52.59	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}]:

$$= S_{ms} + S_{bsNi}$$

$$= 19.24 + -39.25$$

$$= -20.01 \text{ N./mm}^2$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 19.24 + 39.25 \\
 &= 58.49 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 19.24 + 101.42 \\
 &= 120.66 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 19.24 + -101.42 \\
 &= -82.18 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 19.24 + -39.25 \\
 &= -20.01 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 19.24 + 39.25 \\
 &= 58.49 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 19.24 + 101.42 \\
 &= 120.66 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 19.24 + -101.42 \\
 &= -82.18 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 1

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

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 19.14 + 109.79 \\
 &= 128.93 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blMo} \\
 &= 19.14 + -109.79 \\
 &= -90.64 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blQi} \\
 &= 12.18 + 51.74 \\
 &= 63.92 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blQo} \\
 &= 12.18 + -51.74 \\
 &= -39.57 \text{ N./mm}^2
 \end{aligned}$$

 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 2

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 20.85 + 122.88 \\
 &= 143.73 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 20.85 + -126.97 \\
 &= -106.11 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 12.18 + 50.90 \\
 &= 63.08 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 12.18 + -52.59 \\
 &= -40.41 \text{ N./mm}^2
 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-20.01	58.49	142.68
at Q	120.66	-82.18	142.68
Short-side 2 at N	-20.01	58.49	142.68
at Q	120.66	-82.18	142.68
Long-side 1 at M	128.93	-90.64	167.86
at Q	63.92	-39.57	142.68
Long-side 2 at M	143.73	-106.11	167.86
at Q	63.08	-40.41	142.68

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	93.78	111.91

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

$$\begin{aligned}
 &= d * \sqrt{Z * C * P / (SE)} + c_a \\
 &= 110.000 * \sqrt{2.500 * 0.200 * 62.000 / (111.908)} + 0.000 \\
 &= 18.309 \text{ mm.}
 \end{aligned}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$\begin{aligned}
 &= ((T-c_a)/d)^2 * ((SE)/(C*Z)) \text{ per UG-34 (c) (3)} \\
 &= ((20.0000-0.0000)/110.0000)^2 * ((111)/(.20*2.50)) \\
 &= 73.984 \text{ bars}
 \end{aligned}$$

where Z is:

$$\begin{aligned}
 &= \min(3.4 - 2.4(d/D), 2.5) \\
 &= \min(3.4 - 2.4(110.000 / 410.000), 2.5) \\
 &= 2.500
 \end{aligned}$$

 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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 64 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	82.42	N./mm ²
High Stress Percentage	72.06	%
M.A.W.P. for Membrane Stresses	86.04	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-126.97	N./mm ²
High Stress Percentage	75.64	%
M.A.W.P. for Bending Stresses	81.97	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	143.73	N./mm ²
High Stress Percentage	85.63	%
M.A.W.P. for Total Stresses	72.41	bars

Rectangular Vessel Results For Item 1 : A8

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	82.42	N./mm ²
High Stress Percentage	72.06	%
M.A.W.P. for Membrane Stresses	86.04	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-126.97	N./mm ²
High Stress Percentage	75.64	%
M.A.W.P. for Bending Stresses	81.97	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	143.73	N./mm ²
High Stress Percentage	85.63	%
M.A.W.P. for Total Stresses	72.41	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 : 65 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

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 155.1000 N./mm²
Shell Allowable Stress at Ambient SA 155.1000 N./mm²
Shell Yield Stress at Design Temperature Sy 172.3750 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 130.0000 mm.
Minimum Thickness of Long-side Plates t2 28.0000 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 70.5000 mm.
Uniform Hole Diameter d0 25.6500 mm.
Depth of Holes T0 28.0000 mm.
Long-side Plate # 2,
Pitch Distance p 70.5000 mm.
1: Hole Diameter d0 36.3000 mm.
Hole Depth T0 2.7000 mm.
2: Hole Diameter d1 28.5750 mm.
Hole Depth T1 25.3000 mm.

STAY PLATE MATERIAL DATA:
Stay Material Specification SA-240 316L
Stay Allowable Stress at Design Temp Sr 116.9000 N./mm²
Stay Allowable Stress at Ambient SA 116.9000 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

Rectangular Vessel Results, Item number 1, Desc: St.AE-2102-Test **ASME Code, Section VIII, Division 1, 2021 App. 13**

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

Short-side 1 Calculations

 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 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Membrane Ligament Efficiency [Em]:
= 0.850

Bending Ligament Efficiency [Eb]:
= 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 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 vesssel [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]:
= $Pitch - De / Pitch$
= $70.500 - 25.650 / 70.500$
= 0.636

Bending Ligament Efficiency [Eb]:
As diameter holes are uniform $E_b = E_m$
= 0.636

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= $t_1 - CA / 2$
= $28.000 - 0.000 / 2$
= 14.000 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
= $-(t_1 - CA) / 2$
= $-(28.000 - 0.000) / 2$
= -14.000 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 : 67 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Long-side 2 Calculations

Effective Diameter [De]:

$$= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA)$$

$$= (36.30 * 2.70 + 28.57 * 25.30 + 0.00 * 0.00) / (28.00 - 0.00)$$

$$= 29.320 \text{ mm.}$$

Membrane Ligament Efficiency [Em]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 70.500 - 29.320 / 70.500$$

$$= 0.584$$

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

Calculation of Xbar:

$$= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * (T_1/2 + T_2))) / (b_0 * T_0 + b_1 * T_1 + b_2 * T_2)$$

$$= ((1.35 * 2.70 * (2.70/2 + 25.30 + 0.00)) + (1.65 * 25.30 * (25.30/2 + 0.00))) / (1.35 * 2.70 + 1.65 * 25.30 + 2.78 * 0.00)$$

$$= 13.771 \text{ mm.}$$

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

$$Ci = Xbar$$

$$= 13.771 \text{ mm.}$$

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

$$= -(t - CA - Xbar)$$

$$= -(28.000 - 0.000 - 13.771)$$

$$= -14.229 \text{ mm.}$$

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

$$= 0.289 \text{ cm}^4$$

Effective Diameter [De]:

$$= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co)))$$

$$= 70.50 - ((6 * 0.29) / ((28.00 - 0.00)^2 * (14.23)))$$

$$= 31.084 \text{ mm.}$$

Bending Ligament Efficiency [Eb]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 70.500 - 31.084 / 70.500$$

$$= 0.559$$

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	0.636	0.636	14.000	-14.000
2	0.584	0.559	13.771	-14.229

Moment of Inertia of a Strip of the Vessel Wall:

$$\text{Thickness } t_1, I_1 = 0.0667 \text{ cm}^4$$

$$\text{Thickness } t_2, I_2 = 0.1829 \text{ cm}^4$$

 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 : 68 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 0.8462 \\ K &= (I2/I1) * \text{Alpha} = 2.3218 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \} \\ &= 80.60 * 130.00 / (2 * 20.00) * \{ 3 - [(6 + 2.32 * (11 - 0.85^2) / (3 + 5 * 2.32))] \} \\ &= 25.01 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \} \\ &= 80.60 * 130.00 / (2 * 20.00) * \{ 3 - [(6 + 2.32 * (11 - 0.85^2) / (3 + 5 * 2.32))] \} \\ &= 25.01 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 80.60 * 110.00 / 2 * 28.00 \\ &= 15.83 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 15.83 / 0.64 \\ &= 24.89 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 80.60 * 110.00 / 2 * 28.00 \\ &= 15.83 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.584) < E(0.850)$ and $E_b(0.559) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 15.83 / 0.58 \\ &= 27.11 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$\begin{aligned} &= P * h / (2 * t3) * [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \\ &= 80.60 * 130.00 / (2 * 10.00) * [(6 + 2.32 * (11 - 0.85^2) / (3 + 5 * 2.32))] \\ &= 107.15 \text{ N./mm}^2 \end{aligned}$$

 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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 69 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Membrane Stress at Stay Plate [t4]:

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

$$= 80.60 * 130.00 / (2 * 10.00) * [(6 + 2.32 * (11 - 0.85^2) / (3 + 5 * 2.32))]$$

$$= 107.15 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Actual	Allowable
Short-side 1	25.01	131.84
Short-side 2	25.01	131.84
Short-side Corner	25.01	131.84
Long-side 1 at A	24.89	155.10
Long-side 2 at A	27.11	155.10
Long-side Corner	15.83	131.84
Stay Plate (t3)	107.15	116.90
Stay Plate (t4)	107.15	116.90

Bending Stress Calculations per Section 13-9

Bending Stresses at Short-side 1

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

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

$$= 80.60 * 10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 130.00^2 * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))]$$

$$= -51.03 \text{ N./mm}^2$$

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

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

$$= 80.60 * -10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 130.00^2 * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))]$$

$$= 51.03 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))$$

$$= 131.85 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))$$

$$= -131.85 \text{ N./mm}^2$$

Bending Stresses at Short-side 2

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

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

$$= 80.60 * 10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 130.00^2 * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))]$$

$$= -51.03 \text{ N./mm}^2$$

 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 : 70 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

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

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

$$= 80.60 * -10.00 / (24 * 0.07) * [-3 * 110.00^2 + 2 * 130.00^2 * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))]$$

$$= 51.03 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))$$

$$= 131.85 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32))$$

$$= -131.85 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

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

$$= 80.60 * 130.00^2 * 14.00 / (12 * 0.18) * [(3 + 2.32 * (6 - 0.85^2)) / (3 + 5 * 2.32)]$$

$$= 90.80 \text{ N./mm}^2$$

If $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 90.80 / 0.64$$

$$= 142.73 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * -14.00 / (12 * 0.18) * [(3 + 2.32 * (6 - 0.85^2)) / (3 + 5 * 2.32)]$$

$$= -90.80 \text{ N./mm}^2$$

If $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -90.80 / 0.64$$

$$= -142.73 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * 14.00 / (12 * 0.18) * [(3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32)]$$

$$= 67.27 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * -14.00 / (12 * 0.18) * [(3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32)]$$

$$= -67.27 \text{ N./mm}^2$$

 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 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Bending Stresses at Long-side 2

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I_2) * [(3 + K * \\
 &\quad (6 - \text{Alpha}^2)) / (3 + 5 * K)] \\
 &= 80.60 * 130.00^2 * 13.77 / (12 * 0.18) * [(3 + 2.32 * \\
 &\quad (6 - 0.85^2)) / (3 + 5 * 2.32)] \\
 &= 89.31 \text{ N./mm}^2
 \end{aligned}$$

If $E_m(0.584) < E(0.850)$ and $E_b(0.559) < E(0.850)$ then

$$\begin{aligned}
 SblMi &= SblMi / E_b \\
 &= 89.31 / 0.56 \\
 &= 159.75 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I_2) * [(3 + K * \\
 &\quad (6 - \text{Alpha}^2)) / (3 + 5 * K)] \\
 &= 80.60 * 130.00^2 * -14.23 / (12 * 0.18) * [(3 + 2.32 * \\
 &\quad (6 - 0.85^2)) / (3 + 5 * 2.32)] \\
 &= -92.28 \text{ N./mm}^2
 \end{aligned}$$

If $E_m(0.584) < E(0.850)$ and $E_b(0.559) < E(0.850)$ then

$$\begin{aligned}
 SblMo &= SblMo / E_b \\
 &= -92.28 / 0.56 \\
 &= -165.06 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I_2) * [(3 + 5 * \\
 &\quad \text{Alpha}^2 * K) / (3 + 5 * K)] \\
 &= 80.60 * 130.00^2 * 13.77 / (12 * 0.18) * [(3 + 5 * \\
 &\quad 0.85^2 * 2.32) / (3 + 5 * 2.32)] \\
 &= 66.17 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I_2) * [(3 + 5 * \\
 &\quad \text{Alpha}^2 * K) / (3 + 5 * K)] \\
 &= 80.60 * 130.00^2 * -14.23 / (12 * 0.18) * [(3 + 5 * \\
 &\quad 0.85^2 * 2.32) / (3 + 5 * 2.32)] \\
 &= -68.37 \text{ N./mm}^2
 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-51.03	51.03	197.75
at Q	131.85	-131.85	197.75
Short-side 2 at N	-51.03	51.03	197.75
at Q	131.85	-131.85	197.75
Long-side 1 at M	142.73	-142.73	232.65
at Q	67.27	-67.27	197.75
Long-side 2 at M	159.75	-165.06	232.65
at Q	66.17	-68.37	197.75

 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 : 72 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Total Stress Calculations per Section 13-9 Total Stresses at Short-side 1

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 25.01 + -51.03 \\
 &= -26.01 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 25.01 + 51.03 \\
 &= 76.04 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 25.01 + 131.85 \\
 &= 156.86 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 25.01 + -131.85 \\
 &= -106.83 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Short-side 2

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNi} \\
 &= 25.01 + -51.03 \\
 &= -26.01 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsNo} \\
 &= 25.01 + 51.03 \\
 &= 76.04 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQi} \\
 &= 25.01 + 131.85 \\
 &= 156.86 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 25.01 + -131.85 \\
 &= -106.83 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 1

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

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 24.89 + 142.73 \\
 &= 167.61 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blMo} \\
 &= 24.89 + -142.73 \\
 &= -117.84 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blQi} \\
 &= 15.83 + 67.27 \\
 &= 83.10 \text{ N./mm}^2
 \end{aligned}$$

 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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 73 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

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

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 15.83 + -67.27 \\
 &= -51.44 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 2

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Mi} \\
 &= 27.11 + 159.75 \\
 &= 186.85 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 27.11 + -165.06 \\
 &= -137.95 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 15.83 + 66.17 \\
 &= 82.00 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 15.83 + -68.37 \\
 &= -52.53 \text{ N./mm}^2
 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-26.01	76.04	197.75
at Q	156.86	-106.83	197.75
Short-side 2 at N	-26.01	76.04	197.75
at Q	156.86	-106.83	197.75
Long-side 1 at M	167.61	-117.84	232.65
at Q	83.10	-51.44	197.75
Long-side 2 at M	186.85	-137.95	232.65
at Q	82.00	-52.53	197.75

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	121.91	155.10

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

$$\begin{aligned}
 &= d * \sqrt{Z * C * P / (SE)} + c_a \\
 &= 110.000 * \sqrt{2.500 * 0.200 * 80.600 / (155.100)} + 0.000 \\
 &= 17.732 \text{ mm.}
 \end{aligned}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$\begin{aligned}
 &= ((T-c_a)/d)^2 * ((SE)/(C*Z)) \text{ per UG-34 (c) (3)} \\
 &= ((20.0000-0.0000)/110.0000)^2 * ((155)/(0.20*2.50)) \\
 &= 102.540 \text{ bars}
 \end{aligned}$$

where Z is:

$$\begin{aligned}
 &= \min(3.4 - 2.4(d/D), 2.5) \\
 &= \min(3.4 - 2.4(110.000 / 410.000), 2.5) \\
 &= 2.500
 \end{aligned}$$

 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)							
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 74 از 150
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	AA	120	PR	CN	0001	V04

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	107.15	N./mm ²
High Stress Percentage	91.66	%
M.A.W.P. for Membrane Stresses	87.93	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-165.06	N./mm ²
High Stress Percentage	70.95	%
M.A.W.P. for Bending Stresses	113.61	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	186.85	N./mm ²
High Stress Percentage	80.31	%
M.A.W.P. for Total Stresses	100.35	bars

Rectangular Vessel Results For Item 1 : A8

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	107.15	N./mm ²
High Stress Percentage	91.66	%
M.A.W.P. for Membrane Stresses	87.93	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-165.06	N./mm ²
High Stress Percentage	70.95	%
M.A.W.P. for Bending Stresses	113.61	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	186.85	N./mm ²
High Stress Percentage	80.31	%
M.A.W.P. for Total Stresses	100.35	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 : 75 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

3.7 FLOATING HEADER CALCULATION @ DESIGN PRESSURE FOR AE-2102.

Input Echo, COMPONENT 1, Description: FI.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 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 70.5000 mm.
Uniform Hole Diameter d0 25.6500 mm.
Depth of Holes T0 20.0000 mm.
Long-side Plate # 2,
Pitch Distance p 70.5000 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

Rectangular Vessel Results, Item number 1, Desc: FI.AE-2102
ASME Code, Section VIII, Division 1, 2021 App. 13

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

 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 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Short-side 1 Calculations

Membrane Ligament Efficiency [Em]:
= 0.850

Bending Ligament Efficiency [Eb]:
= 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 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 vesssel [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]:
= $Pitch - De / Pitch$
= $70.500 - 25.650 / 70.500$
= 0.636

Bending Ligament Efficiency [Eb]:
As diameter holes are uniform $E_b = E_m$
= 0.636

Dist from Neutral axis of c/s to inside surface of the vesssel [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.

 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 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Long-side 2 Calculations

Effective Diameter [De]:

$$= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA)$$

$$= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / (20.00 - 0.00)$$

$$= 29.618 \text{ mm.}$$

Membrane Ligament Efficiency [Em]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 70.500 - 29.618 / 70.500$$

$$= 0.580$$

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

Calculation of Xbar:

$$= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * (T_1/2 + T_2))) / (b_0 * T_0 + b_1 * T_1 + b_2 * T_2)$$

$$= ((1.35 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.65 * 17.30 * (17.30/2 + 0.00))) / (1.35 * 2.70 + 1.65 * 17.30 + 2.78 * 0.00)$$

$$= 9.779 \text{ mm.}$$

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

$$Ci = Xbar$$

$$= 9.779 \text{ mm.}$$

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

$$= -(t - CA - Xbar)$$

$$= -(20.000 - 0.000 - 9.779)$$

$$= -10.221 \text{ mm.}$$

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

$$= 0.104 \text{ cm}^4$$

Effective Diameter [De]:

$$= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co)))$$

$$= 70.50 - ((6 * 0.10) / ((20.00 - 0.00)^2 * (10.22)))$$

$$= 31.848 \text{ mm.}$$

Bending Ligament Efficiency [Eb]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 70.500 - 31.848 / 70.500$$

$$= 0.548$$

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	0.636	0.636	10.000	-10.000
2	0.580	0.548	9.779	-10.221

Moment of Inertia of a Strip of the Vessel Wall:

$$\text{Thickness } t_1, I_1 = 0.0667 \text{ cm}^4$$

$$\text{Thickness } t_2, I_2 = 0.0667 \text{ cm}^4$$

 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)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 1.6667 \\ K &= (I2/I1) * \text{Alpha} = 1.6667 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \} \\ &= 62.00 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))] \} \\ &= 11.73 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \} \\ &= 62.00 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))] \} \\ &= 11.73 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 62.00 * 100.00 / 2 * 20.00 \\ &= 15.50 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 15.50 / 0.64 \\ &= 24.37 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 62.00 * 100.00 / 2 * 20.00 \\ &= 15.50 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.548) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 15.50 / 0.58 \\ &= 26.73 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$\begin{aligned} &= P * h / (2 * t3) * [(6 + K * (11 - \text{alpha}^2) / (3 + 5 * K))] \\ &= 62.00 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))] \\ &= 32.34 \text{ N./mm}^2 \end{aligned}$$

 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)								
شماره پیمان: 053-073-9184	Thermal/Mechanical Calculation Book							شماره صفحه : 79 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Membrane Stress at Stay Plate [t4]:

$$= P * h / (2 * t4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))]$$

$$= 62.00 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))]$$

$$= 32.34 \text{ N./mm}^2$$

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	24.37	111.91
Long-side 2 at A	26.73	111.91
Long-side Corner	15.50	95.12
Stay Plate (t3)	32.34	114.39
Stay Plate (t4)	32.34	114.39

Bending Stress Calculations per Section 13-9

Bending Stresses at Short-side 1

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

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

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= -51.88 \text{ N./mm}^2$$

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

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

$$= 62.00 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= 51.88 \text{ N./mm}^2$$

Bending Stress at Short-side 1 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 1 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 Short-side 2

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

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

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= -51.88 \text{ N./mm}^2$$

 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 : 80 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

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 $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 20.61 / 0.64$$

$$= 32.39 \text{ N./mm}^2$$

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 $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -20.61 / 0.64$$

$$= -32.39 \text{ N./mm}^2$$

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

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

$$= 62.00 * 60.00^2 * 10.00 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= 64.37 \text{ N./mm}^2$$

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

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

$$= 62.00 * 60.00^2 * -10.00 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= -64.37 \text{ N./mm}^2$$

 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		V04

Bending Stresses at Long-side 2

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I_2) * [(3 + K * \\
 &\quad (6 - \text{Alpha}^2)) / (3 + 5 * K)] \\
 &= 62.00 * 60.00^2 * 9.78 / (12 * 0.07) * [(3 + 1.67 * \\
 &\quad (6 - 1.67^2)) / (3 + 5 * 1.67)] \\
 &= 20.15 \text{ N./mm}^2
 \end{aligned}$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.548) < E(0.850)$ then

$$\begin{aligned}
 S_{blMi} &= S_{blMi} / E_b \\
 &= 20.15 / 0.55 \\
 &= 36.76 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I_2) * [(3 + K * \\
 &\quad (6 - \text{Alpha}^2)) / (3 + 5 * K)] \\
 &= 62.00 * 60.00^2 * -10.22 / (12 * 0.07) * [(3 + 1.67 * \\
 &\quad (6 - 1.67^2)) / (3 + 5 * 1.67)] \\
 &= -21.06 \text{ N./mm}^2
 \end{aligned}$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.548) < E(0.850)$ then

$$\begin{aligned}
 S_{blMo} &= S_{blMo} / E_b \\
 &= -21.06 / 0.55 \\
 &= -38.42 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I_2) * [(3 + 5 * \\
 &\quad \text{Alpha}^2 * K) / (3 + 5 * K)] \\
 &= 62.00 * 60.00^2 * 9.78 / (12 * 0.07) * [(3 + 5 * \\
 &\quad 1.67^2 * 1.67) / (3 + 5 * 1.67)] \\
 &= 62.95 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I_2) * [(3 + 5 * \\
 &\quad \text{Alpha}^2 * K) / (3 + 5 * K)] \\
 &= 62.00 * 60.00^2 * -10.22 / (12 * 0.07) * [(3 + 5 * \\
 &\quad 1.67^2 * 1.67) / (3 + 5 * 1.67)] \\
 &= -65.79 \text{ N./mm}^2
 \end{aligned}$$

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	32.39	-32.39	167.86
at Q	64.37	-64.37	142.68
Long-side 2 at M	36.76	-38.42	167.86
at Q	62.95	-65.79	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 : 82 از 150
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	AA	120	PR	CN	0001	V04

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]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 11.73 + -64.37 \\
 &= -52.64 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 1

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

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 24.37 + 32.39 \\
 &= 56.76 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blMo} \\
 &= 24.37 + -32.39 \\
 &= -8.03 \text{ N./mm}^2
 \end{aligned}$$

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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 83 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

$$= 15.50 + 64.37$$

$$= 79.88 \text{ N./mm}^2$$

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

$$= S_{mlB} + S_{blQo}$$

$$= 15.50 + -64.37$$

$$= -48.87 \text{ N./mm}^2$$

Total Stresses at Long-side 2

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

$$= S_{ml} + S_{blMi}$$

$$= 26.73 + 36.76$$

$$= 63.49 \text{ N./mm}^2$$

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

$$= S_{ml} + S_{blMo}$$

$$= 26.73 + -38.42$$

$$= -11.68 \text{ N./mm}^2$$

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

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

$$= 15.50 + 62.95$$

$$= 78.45 \text{ N./mm}^2$$

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

$$= S_{mlB} + S_{blQo}$$

$$= 15.50 + -65.79$$

$$= -50.29 \text{ N./mm}^2$$

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	56.76	-8.03	167.86
at Q	79.88	-48.87	142.68
Long-side 2 at M	63.49	-11.68	167.86
at Q	78.45	-50.29	142.68

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	68.20	111.91

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

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

$$= 100.000 * \sqrt{2.200 * 0.200 * 62.000 / (111.908)} + 0.000$$

$$= 15.614 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/100.0000)^2 * ((111)/(.20*2.20))$$

$$= 101.728 \text{ bars}$$

 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)								
شماره پیمان: 053-073-9184	Thermal/Mechanical Calculation Book								شماره صفحه : 84 از 150
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	
	BK	GCS	AA	120	PR	CN	0001	V04	

where Z is:

$$\begin{aligned}
 &= \min(3.4 - 2.4(d/D), 2.5) \\
 &= \min(3.4 - 2.4(100.000 / 200.000), 2.5) \\
 &= 2.200
 \end{aligned}$$

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)	-65.79	N./mm ²
High Stress Percentage	46.11	%
M.A.W.P. for Bending Stresses	134.45	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	79.88	N./mm ²
High Stress Percentage	55.98	%
M.A.W.P. for Total Stresses	110.75	bars

Rectangular Vessel Results For Item 1 : A8

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	32.34	N./mm ²
High Stress Percentage	28.27	%
M.A.W.P. for Membrane Stresses	219.31	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-65.79	N./mm ²
High Stress Percentage	46.11	%
M.A.W.P. for Bending Stresses	134.45	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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 85 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

3.8 FLOATING HEADER CALCULATION @ TEST PRESSURE FOR AE-2102.

Input Echo, COMPONENT 1, Description: Fl.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./mm²
Shell Allowable Stress at Ambient SA 155.0000 N./mm²
Shell Yield Stress at Design Temperature Sy 172.3750 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 70.5000 mm.
Uniform Hole Diameter d0 25.6500 mm.
Depth of Holes T0 20.0000 mm.
Long-side Plate # 2,
Pitch Distance p 70.5000 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

Rectangular Vessel Results, Item number 1, Desc: Fl.AE-2102-Test **ASME Code, Section VIII, Division 1, 2021 App. 13**

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

Short-side 1 Calculations

 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 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Membrane Ligament Efficiency [Em]:
= 0.850

Bending Ligament Efficiency [Eb]:
= 0.850

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= $t_1 - CA / 2$
= $20.000 - 0.000 / 2$
= 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 vesssel [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]:
= $Pitch - De / Pitch$
= $70.500 - 25.650 / 70.500$
= 0.636

Bending Ligament Efficiency [Eb]:
As diameter holes are uniform $E_b = E_m$
= 0.636

Dist from Neutral axis of c/s to inside surface of the vesssel [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.

 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 : 87 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Long-side 2 Calculations

Effective Diameter [De]:

$$= (d_0 * T_0 + d_1 * T_1 + d_2 * T_2) / (t_1 - CA)$$

$$= (36.30 * 2.70 + 28.57 * 17.30 + 0.00 * 0.00) / (20.00 - 0.00)$$

$$= 29.618 \text{ mm.}$$

Membrane Ligament Efficiency [Em]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 70.500 - 29.618 / 70.500$$

$$= 0.580$$

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

Calculation of Xbar:

$$= ((b_0 * T_0 * (T_0/2 + T_1 + T_2)) + (b_1 * T_1 * (T_1/2 + T_2))) / (b_0 * T_0 + b_1 * T_1 + b_2 * T_2)$$

$$= ((1.35 * 2.70 * (2.70/2 + 17.30 + 0.00)) + (1.65 * 17.30 * (17.30/2 + 0.00))) / (1.35 * 2.70 + 1.65 * 17.30 + 2.78 * 0.00)$$

$$= 9.779 \text{ mm.}$$

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

$$Ci = Xbar$$

$$= 9.779 \text{ mm.}$$

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

$$= -(t - CA - Xbar)$$

$$= -(20.000 - 0.000 - 9.779)$$

$$= -10.221 \text{ mm.}$$

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

$$= 0.104 \text{ cm}^4$$

Effective Diameter [De]:

$$= \text{Pitch} - ((6 * I) / ((t - CA)^2 * (-Co)))$$

$$= 70.50 - ((6 * 0.10) / ((20.00 - 0.00)^2 * (10.22)))$$

$$= 31.848 \text{ mm.}$$

Bending Ligament Efficiency [Eb]:

$$= \text{Pitch} - De / \text{Pitch}$$

$$= 70.500 - 31.848 / 70.500$$

$$= 0.548$$

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	0.636	0.636	10.000	-10.000
2	0.580	0.548	9.779	-10.221

Moment of Inertia of a Strip of the Vessel Wall:

$$\text{Thickness } t_1, I_1 = 0.0667 \text{ cm}^4$$

$$\text{Thickness } t_2, I_2 = 0.0667 \text{ cm}^4$$

 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 : 88 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 1.6667 \\ K &= (I2/I1) * \text{Alpha} = 1.6667 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \} \\ &= 80.60 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))] \} \\ &= 15.25 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \} \\ &= 80.60 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))] \} \\ &= 15.25 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 80.60 * 100.00 / 2 * 20.00 \\ &= 20.15 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.636) < E(0.850)$ and $E_b(0.636) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 20.15 / 0.64 \\ &= 31.68 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

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

$$\begin{aligned} &= P * H / 2 * t2 \\ &= 80.60 * 100.00 / 2 * 20.00 \\ &= 20.15 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.548) < E(0.850)$ then

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 20.15 / 0.58 \\ &= 34.75 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

Membrane Stress at Stay Plate [t3]:

$$\begin{aligned} &= P * h / (2 * t3) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \\ &= 80.60 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))] \\ &= 42.04 \text{ N./mm}^2 \end{aligned}$$

Membrane Stress at Stay Plate [t4]:

$$\begin{aligned} &= P * h / (2 * t4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \\ &= 80.60 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))] \\ &= 42.04 \text{ N./mm}^2 \end{aligned}$$

 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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	BK	GCS	AA	120	PR	CN	0001		V04

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	31.68	155.00
Long-side 2 at A	34.75	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]:

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

$$= 80.60 * 60.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= -83.69 \text{ N./mm}^2$$

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]:

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

$$= 80.60 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= 67.45 \text{ N./mm}^2$$

 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 : 90 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

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 $Em(0.636) < E(0.850)$ and $Eb(0.636) < E(0.850)$ then

$$SblMi = SblMi / Eb$$

$$= 26.79 / 0.64$$

$$= 42.11 \text{ N./mm}^2$$

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 $Em(0.636) < E(0.850)$ and $Eb(0.636) < E(0.850)$ then

$$SblMo = SblMo / Eb$$

$$= -26.79 / 0.64$$

$$= -42.11 \text{ N./mm}^2$$

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

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

$$= 80.60 * 60.00^2 * 10.00 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= 83.69 \text{ N./mm}^2$$

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]:

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

$$= 80.60 * 60.00^2 * 9.78 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= 26.20 \text{ N./mm}^2$$

 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
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If $E_m(0.580) < E(0.850)$ and $E_b(0.548) < E(0.850)$ then
 $S_{blMi} = S_{blMi} / E_b$
 $= 26.20 / 0.55$
 $= 47.78 \text{ N./mm}^2$

Bending Stress at Long-side 2 at M Outer [S_{blMo}]:
 $= P * h^2 * c / (12 * I_2) * [(3 + K * (6 - \alpha^2)) / (3 + 5 * K)]$
 $= 80.60 * 60.00^2 * -10.22 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$
 $= -27.38 \text{ N./mm}^2$

If $E_m(0.580) < E(0.850)$ and $E_b(0.548) < E(0.850)$ then
 $S_{blMo} = S_{blMo} / E_b$
 $= -27.38 / 0.55$
 $= -49.94 \text{ N./mm}^2$

Bending Stress at Long-side 2 at Q Inner [S_{blQi}]:
 $= P * h^2 * c / (12 * I_2) * [(3 + 5 * \alpha^2 * K) / (3 + 5 * K)]$
 $= 80.60 * 60.00^2 * 9.78 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$
 $= 81.84 \text{ N./mm}^2$

Bending Stress at Long-side 2 at Q Outer [S_{blQo}]:
 $= P * h^2 * c / (12 * I_2) * [(3 + 5 * \alpha^2 * K) / (3 + 5 * K)]$
 $= 80.60 * 60.00^2 * -10.22 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$
 $= -85.53 \text{ N./mm}^2$

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	42.11	-42.11	232.50
at Q	83.69	-83.69	197.62
Long-side 2 at M	47.78	-49.94	232.50
at Q	81.84	-85.53	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}]:
 $= S_{ms} + S_{bsNi}$
 $= 15.25 + -67.45$
 $= -52.20 \text{ N./mm}^2$

Total Stress at short side 1 at N outer [STS_{No}]:
 $= S_{ms} + S_{bsNo}$
 $= 15.25 + 67.45$
 $= 82.70 \text{ N./mm}^2$

 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 : 92 از 150
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	BK	GCS	AA	120	PR	CN	0001	V04

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]:

$$\begin{aligned}
 &= S_{ms} + S_{bsQo} \\
 &= 15.25 + -83.69 \\
 &= -68.43 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 1

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

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 31.68 + 42.11 \\
 &= 73.79 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blMo} \\
 &= 31.68 + -42.11 \\
 &= -10.43 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{ml} + S_{blQi} \\
 &= 20.15 + 83.69 \\
 &= 103.84 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{mlB} + S_{blQo} \\
 &= 20.15 + -83.69 \\
 &= -63.54 \text{ N./mm}^2
 \end{aligned}$$

Total Stresses at Long-side 2

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

$$\begin{aligned}
 &= S_{ml} + S_{blMi} \\
 &= 34.75 + 47.78 \\
 &= 82.53 \text{ N./mm}^2
 \end{aligned}$$

 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	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Mo} \\
 &= 34.75 + -49.94 \\
 &= -15.19 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1} + S_{b1Qi} \\
 &= 20.15 + 81.84 \\
 &= 101.99 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{m1B} + S_{b1Qo} \\
 &= 20.15 + -85.53 \\
 &= -65.38 \text{ N./mm}^2
 \end{aligned}$$

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	73.79	-10.43	232.50
at Q	103.84	-63.54	197.62
Long-side 2 at M	82.53	-15.19	232.50
at Q	101.99	-65.38	197.62

End Plate Stresses (N./mm²):

	Actual	Allowable
End Plate	88.67	155.00

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

$$\begin{aligned}
 &= d * \sqrt{Z * C * P / (SE)} + c_a \\
 &= 100.000 * \sqrt{2.200 * 0.200 * 80.600 / (155.000)} + 0.000 \\
 &= 15.127 \text{ mm.}
 \end{aligned}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$\begin{aligned}
 &= ((T-c_a)/d)^2 * ((SE)/(C*Z)) \text{ per UG-34 (c) (3)} \\
 &= ((20.0000-0.0000)/100.0000)^2 * ((155)/(0.20*2.20)) \\
 &= 140.901 \text{ bars}
 \end{aligned}$$

where Z is:

$$\begin{aligned}
 &= \min(3.4 - 2.4(d/D), 2.5) \\
 &= \min(3.4 - 2.4(100.000 / 200.000), 2.5) \\
 &= 2.200
 \end{aligned}$$

 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	V04	

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)	-85.53	N./mm ²
High Stress Percentage	43.28	%
M.A.W.P. for Bending Stresses	186.23	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)	-85.53	N./mm ²
High Stress Percentage	43.28	%
M.A.W.P. for Bending Stresses	186.23	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

 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 : 95 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

3.9 FINITE ELEMENT FOR AE-2101

Tabular Results

Results were generated with the finite element program FE/Pipe®. Stress results are post-processed in accordance with the rules specified in ASME Section III and ASME Section VIII, Division 2.

Analysis Time Stamp: Mon Nov 25 13:33:28 2024.

- [Model Notes, Tube Results and API Check](#)
- [Load Case Report](#)
- [Solution Data](#)
- [ASME Code Stress Output Plots](#)
- [Stress Results - Notes](#)
- [ASME Overstressed Areas](#)
- [Highest Primary Stress Ratios](#)
- [Highest Secondary Stress Ratios](#)
- [Highest Fatigue Stress Ratios](#)
- [Highest Stress Ratios Per Region](#)
- [Compressive Stress Summary](#)
- [Graphical Results](#)

Model Notes, Tube Results and API Check
Model Notes, Tube Results and API Check

661PRO 3.0 - API 661 - Air-Cooled Heat Exchanger Nozzle Model

Input Echo:

Notes:

- The centerline of the header box is along the -Z axis.
- Only 1 Nozzle will be modeled at a time. The Nozzle Number Modeled can be seen below.
- User Defined Loads API 661 Check is shown below.
- Sum of ALL Nozzle Loads must not exceed 3*API Allowable Loads shown in paragraph 7.1.10.2 according to API 661 2013 paragraph 7.1.10.3.
- Results are given as: Actual Load, Allowable Load, percentage of allowable for API Check in lbs. and ft-lbs. for English Units and N. and N-m for SI Units.

Nozzle Number Modelled : 1
Top or Bottom Nozzle : Top

Analysis Type : User Defined Loads

Nozzle Type : Straight
Flange Type : Weldneck

Header Box Dimensions:
Centerline on :Centerline on LEFT Side
Height : 333.000 mm.
Width : 200.000 mm.
Length : 1939.000 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 : 96 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Outboard Thickness : 20.000 mm.
Tubesheet Side Thickness : 20.000 mm.
Top Plate Thickness : 20.000 mm.
Free End Plate Thickness : 20.000 mm.

Header Box Pressure : 2.200 MPa

Symmetric Boundary Condition at Centerline

Partition Plates:

Number of Partition Plates : 2

Partition Plate #1

Plate Elevation from Bottom : 91.000 mm.

Plate Thickness : 10.000 mm.

Partition Plate #2

Plate Elevation from Bottom : 223.000 mm.

Plate Thickness : 10.000 mm.

Nozzle Dimensions:

Distance to CenterLine : 969.500 mm.

Nozzle Outside Diameter : 168.300 mm.

Nozzle Thickness : 9.600 mm.

Projection to Face of Flange : 315.000 mm.

Flange Thickness Used : 31.800 mm.

Flange ID : 202.480 mm.

Flange Hub Length Used : 47.700 mm.

Weld Size and SCF : 0.000, 1.350

Engineering Details:

Operating Cycles : 7000

Occasional Cycles : 0

Ambient Temperature : 21.100 deg.

Computation Type : Gauss Average

Material Properties

Nozzle:

Cold Allowable Stress : 115.100 MPa
Hot Allowable Stress : 86.600 MPa
Elastic Modulus : 0.186E+06 MPa
Poissons Ratio : 0.300
Material ID : 4-Austenitic Steels
Density : 0.000E+00 N /cu. mm.
Cold Yield Stress : 172.400 MPa
Hot Yield Stress : 129.900 MPa
Cold Tensile Stress : 482.600 MPa
Density : 0.000E+00 N /cu. mm.

Header Box:

Cold Allowable Stress : 115.100 MPa
Hot Allowable Stress : 86.600 MPa
Elastic Modulus : 0.186E+06 MPa
Poissons Ratio : 0.300
Material ID : 4-Austenitic Steels
Density : 0.000E+00 N /cu. mm.
Cold Yield Stress : 172.400 MPa
Hot Yield Stress : 129.900 MPa
Cold Tensile Stress : 482.600 MPa
Density : 0.000E+00 N /cu. mm.

Tubesheet was not modeled

 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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User Defined Loads:

Forces [N]	Moments [mm.- N]					
FX	FY	FZ	MX	MY	MZ	
Weight	12000	15090	15090	6420000	9150000	4890000
Operating	12000	15090	15090	6420000	9150000	4890000
Occasional	0	0	0	0	0	0

No Tube Results

API Check for User Defined Loads and API Evaluation
API 661 2013 paragraph 7.1.10.2 and 7.1.10.3.

Results below are shown as:
Actual Load, Allowable Load, % of Allowable
Allowable Load: 3x API Allowable from para. 7.1.10.2

Total Nozzle Loads per DOF in [N and N.m]

Global FX	:	12000, 15015,	79 %
Global FY	:	15090, 30030,	50 %
Global FZ	:	15090, 25020,	60 %
Global MX	:	6420, 9150,	70 %
Global MY	:	9150, 12195,	75 %
Global MZ	:	4890, 6105,	80 %

API 661 para. 7.1.10.3 check PASSED. The summation of all nozzle loads did NOT exceed the 1.5x API value from para. 7.1.10.2.

Symmetric boundary condition applied at the center of the headerbox, the API multiplier from paragraph 7.1.10.3 will be 1.5 since total loads will be 2x larger due to symmetry.

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Load Case Report
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\$P

Load Case Report \$X

Inner and outer element temperatures are the same throughout the model. No thermal ratcheting calculations will be performed.

THE 4 LOAD CASES ANALYZED ARE:

1 WEIGHT ONLY (Wgt Only)

Weight ONLY case run to get the stress range between the installed and the operating states.

/----- Loads in Case 1
Loads due to Weight

2 SUSTAINED (Wgt+Pr)

Sustained case run to satisfy local primary membrane and bending stress limits.

/----- Loads in Case 2
Loads due to Weight

 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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Pressure Case 1

3 OPERATING

Case run to compute the operating stresses used in secondary, peak and range calculations as needed.

/----- Loads in Case 3
Pressure Case 1
Loads from (Operating)

4 RANGE (Fatigue Calc Performed)

Case run to get the RANGE of stresses.
as described in NB-3222.2, 5.5.3.2, 5.5.5.2 or 5.5.6.1.

/----- Combinations in Range Case 4
Plus Stress Results from CASE 3
Minus Stress Results from CASE 1

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Solution Data
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Solution Data

Maximum Solution Row Size = 1758
Number of Nodes = 8895
Number of Elements = 3027
Number of Solution Cases = 3

Summation of Loads per Case

Case #	FX	FY	FZ
1	12000.	53502.	15090.
2	12000.	-44684.	-108858.
3	12000.	-44684.	-108858.

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ASME Code Stress Output Plots
FEPipe Version 15.0 Jobname: setup2 \$P
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ASME Code Stress Output Plots \$X

- 1) P1 < SPL (SUS,Membrane) Case 2
- 2) Qb < SPS (SUS,Bending) Case 2
- 3) P1+Pb+Q < SPS (SUS,Inside) Case 2
- 4) P1+Pb+Q < SPS (SUS,Outside) Case 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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- 5) $S1+S2+S3 < 4S$ (SUS,S1+S2+S3) Case 2
- 6) $P1+Pb+Q < SPS$ (OPE,Inside) Case 3
- 7) $P1+Pb+Q < SPS$ (OPE,Outside) Case 3
- 8) Membrane $< User$ (OPE,Membrane) Case 3
- 9) Bending $< User$ (OPE,Bending) Case 3
- 10) $P1+Pb+Q < SPS$ (EXP,Inside) Case 4
- 11) $P1+Pb+Q < SPS$ (EXP,Outside) Case 4
- 12) $P1+Pb+Q+F < 2Sa$ (EXP,Inside) Case 4
- 13) $P1+Pb+Q+F < 2Sa$ (EXP,Outside) Case 4

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Stress Results - Notes
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Stress Results - Notes

- Results in this analysis were generated using the finite element solution method.
- Using 2019 ASME Section VIII Division 2
- Use Polished Bar fatigue curve.
- Ratio between Operating and Design Pressure = 1.000000
 Range cases use operating pressure. Primary cases use design pressure.
- Assume free end displacements of attached pipe (e.g. thermal loads) are secondary loads.
- Primary bending stresses at discontinuities are treated like secondary stresses. ($Pb=0$)
- Use Equivalent Stress (Von Mises).
- TRIAXIAL Stress Guidelines:
 S1+S2+S3 evaluation omitted from operating stress.
 Include S1+S2+S3 evaluation in primary case evaluation.
 Bending stress NOT included for all S1+S2+S3 calculations.
- Use local tensor values for averaged and not averaged stresses.

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ASME Overstressed Areas
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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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ASME Overstressed Areas

\$X

*** NO OVERSTRESSED NODES IN THIS MODEL ***

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Highest Primary Stress Ratios

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Highest Primary Stress Ratios

\$X

Circ Plate for Plate # 1

P1	SPL	Primary Membrane Load Case 2
43	130	Min Prin. Stress = -66. (49% Neg, 6% NegHi)
MPa	MPa	Plot Reference:
		1) P1 < SPL (SUS,Membrane) Case 2

33%

Long Plate for Plate # 1

P1	SPL	Primary Membrane Load Case 2
108	130	Min Prin. Stress = -114. (97% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
		1) P1 < SPL (SUS,Membrane) Case 2

83%

Circ Plate for Plate # 2

P1	SPL	Primary Membrane Load Case 2
53	130	Min Prin. Stress = -30. (56% Neg, 8% NegHi)
MPa	MPa	Plot Reference:
		1) P1 < SPL (SUS,Membrane) Case 2

40%

Circ Plate for Plate # 3

P1	SPL	Primary Membrane Load Case 2
121	130	Min Prin. Stress = -169. (87% Neg, 46% NegHi)
MPa	MPa	Plot Reference:
		1) P1 < SPL (SUS,Membrane) Case 2

93%

Circ Plate for Plate # 4

P1	SPL	Primary Membrane Load Case 2
92	130	Min Prin. Stress = -114. (76% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
		1) P1 < SPL (SUS,Membrane) Case 2

70%

Long Plate for Plate # 4

P1	SPL	Primary Membrane Load Case 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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23 MPa	130 MPa	Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
17%		

Circ Plate for Plate # 5

Pl 35 MPa	SPL 130 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
26%		

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Highest Secondary Stress Ratios
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Highest Secondary Stress Ratios \$X

In combination case 4 the max range stress divided by the max component stress is 1.99. The case tensor components are in some directions additive and so the combination case will have HIGHER stresses than the largest of any of the individual cases by more than 50%.

Load Case	Combined/Max (Inside)	Combined/Max (Outside)
-----	-----	-----
4	1.989	1.976

Circ Plate for Plate # 1

Pl+Pb+Q 90 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
29%		

Pl+Pb+Q 90 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
29%		

Long Plate for Plate # 1

Pl+Pb+Q 201 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -114. (97% Neg, 19% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
66%		

Pl+Pb+Q 201 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -114. (97% Neg, 19% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
66%		

Circ Plate for Plate # 2

	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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Pl+Pb+Q 75 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -30. (56% Neg, 8% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
24%		
Pl+Pb+Q 75 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -30. (56% Neg, 8% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
24%		
Circ Plate for Plate # 3		
Pl+Pb+Q 227 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -169. (87% Neg, 46% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
75%		
Pl+Pb+Q 227 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -169. (87% Neg, 46% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
75%		
Circ Plate for Plate # 4		
Pl+Pb+Q 154 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -114. (76% Neg, 19% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
50%		
Pl+Pb+Q 154 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -114. (76% Neg, 19% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
50%		
Long Plate for Plate # 4		
Pl+Pb+Q 38 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
12%		
Pl+Pb+Q 38 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
12%		
Circ Plate for Plate # 5		
Pl+Pb+Q 57 MPa	SPS 302 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
18%		
Pl+Pb+Q 57 MPa	SPS 302 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
18%		

 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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Highest Fatigue Stress Ratios

FEPipe Version 15.0

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Highest Fatigue Stress Ratios

\$X

Circ Plate for Plate # 1

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
40	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.051 Stress	Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 1.0000E11
Allowable		"B31" Fatigue Stress Allowable = 504.2
777.2		Markl Fatigue Stress Allowable = 659.5
MPa		WRC 474 Mean Cycles to Failure = 56,350,536.
		WRC 474 99% Probability Cycles = 13,090,740.
5%		WRC 474 95% Probability Cycles = 18,174,846.
		BS5500 Allowed Cycles(Curve F) = 18,787,840.
		Membrane-to-Bending Ratio = 0.293
		Bending-to-PL+PB+Q Ratio = 0.774
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

Long Plate for Plate # 1

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4
67	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.087 Stress	Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 1.0000E11
Allowable		"B31" Fatigue Stress Allowable = 504.2
777.2		Markl Fatigue Stress Allowable = 659.5
MPa		WRC 474 Mean Cycles to Failure = 12,010,429.
		WRC 474 99% Probability Cycles = 2,790,129.
8%		WRC 474 95% Probability Cycles = 3,873,743.
		BS5500 Allowed Cycles(Curve F) = 2,958,582.
		Membrane-to-Bending Ratio = 0.250
		Bending-to-PL+PB+Q Ratio = 0.800
		Plot Reference:
		13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4

Circ Plate for Plate # 2

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
40	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.051 Stress	Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 1.0000E11
Allowable		"B31" Fatigue Stress Allowable = 504.2
777.2		Markl Fatigue Stress Allowable = 659.5
MPa		WRC 474 Mean Cycles to Failure = 56,350,524.
		WRC 474 99% Probability Cycles = 13,090,738.
5%		WRC 474 95% Probability Cycles = 18,174,842.
		BS5500 Allowed Cycles(Curve F) = 18,787,830.
		Membrane-to-Bending Ratio = 0.293
		Bending-to-PL+PB+Q Ratio = 0.774
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

Circ Plate for Plate # 3

 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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Pl+Pb+Q+F Damage Ratio Primary+Secondary+Peak (Inner) Load Case 4
55 0.000 Life Stress Concentration Factor = 1.000
MPa 0.071 Stress Strain Concentration Factor = 1.000
Cycles Allowed for this Stress = 1.0000E11
Allowable "B31" Fatigue Stress Allowable = 504.2
777.2 Markl Fatigue Stress Allowable = 659.5
MPa WRC 474 Mean Cycles to Failure = 32,177,282.
7% WRC 474 99% Probability Cycles = 7,475,067.
WRC 474 95% Probability Cycles = 10,378,200.
BS5500 Allowed Cycles(Curve F) = 5,431,522.
Membrane-to-Bending Ratio = 0.699
Bending-to-PL+PB+Q Ratio = 0.589
Plot Reference:
12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

Circ Plate for Plate # 4

Pl+Pb+Q+F Damage Ratio Primary+Secondary+Peak (Inner) Load Case 4
28 0.000 Life Stress Concentration Factor = 1.000
MPa 0.036 Stress Strain Concentration Factor = 1.000
Cycles Allowed for this Stress = 1.0000E11
Allowable "B31" Fatigue Stress Allowable = 504.2
777.2 Markl Fatigue Stress Allowable = 659.5
MPa WRC 474 Mean Cycles to Failure = 2.4830E8
3% WRC 474 99% Probability Cycles = 57,681,924.
WRC 474 95% Probability Cycles = 80,084,096.
BS5500 Allowed Cycles(Curve F) = 1.0043E8
Membrane-to-Bending Ratio = 0.992
Bending-to-PL+PB+Q Ratio = 0.502
Plot Reference:
12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

Long Plate for Plate # 4

Pl+Pb+Q+F Damage Ratio Primary+Secondary+Peak (Inner) Load Case 4
10 0.000 Life Stress Concentration Factor = 1.000
MPa 0.013 Stress Strain Concentration Factor = 1.000
Cycles Allowed for this Stress = 1.0000E11
Allowable "B31" Fatigue Stress Allowable = 504.2
777.2 Markl Fatigue Stress Allowable = 659.5
MPa WRC 474 Mean Cycles to Failure = 2.1819E9
1% WRC 474 99% Probability Cycles = 5.0689E8
WRC 474 95% Probability Cycles = 7.0375E8
BS5500 Allowed Cycles(Curve F) = 7.0539E9
Membrane-to-Bending Ratio = 0.884
Bending-to-PL+PB+Q Ratio = 0.531
Plot Reference:
12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

Circ Plate for Plate # 5

Pl+Pb+Q+F Damage Ratio Primary+Secondary+Peak (Inner) Load Case 4
29 0.000 Life Stress Concentration Factor = 1.000
MPa 0.055 Stress Strain Concentration Factor = 1.000
Cycles Allowed for this Stress = 1.0000E11
Allowable "B31" Fatigue Stress Allowable = 0.0
530.5 Markl Fatigue Stress Allowable = 575.0
MPa WRC 474 Mean Cycles to Failure = 2.0803E8
5% WRC 474 99% Probability Cycles = 48,327,864.
WRC 474 95% Probability Cycles = 67,097,160.
BS5500 Allowed Cycles(Curve F) = 86,841,704.
Membrane-to-Bending Ratio = 11.897
Bending-to-PL+PB+Q Ratio = 0.078
Plot Reference:
12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

	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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Highest Stress Ratios Per Region
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Highest Stress Ratios Per Region \$X

Circ Plate for Plate # 1

P1 43 MPa	SPL 130 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 1) P1 < SPL (SUS,Membrane) Case 2
33%		
Qb 63 MPa	SPS 303 MPa	Primary Bending Load Case 2 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
20%		
P1+Pb+Q 90 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 3) P1+Pb+Q < SPS (SUS,Inside) Case 2
29%		
P1+Pb+Q 71 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 4) P1+Pb+Q < SPS (SUS,Outside) Case 2
23%		
S1+S2+S3 48 MPa	4S 346 MPa	Part 5 (5.3.2) Load Case 2 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
13%		
P1+Pb+Q 90 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 6) P1+Pb+Q < SPS (OPE,Inside) Case 3
29%		
P1+Pb+Q 71 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 7) P1+Pb+Q < SPS (OPE,Outside) Case 3
23%		
Membrane 43 MPa	User 303 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
14%		
Bending 63 MPa	User 303 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 9) Bending < User (OPE,Bending) Case 3
20%		
P1+Pb+Q 40	SPS 303	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -16. (48% Neg, 6% NegHi)

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MPa	MPa	Plot Reference:
13%		10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 4
34	303	Min Prin. Stress = -16. (48% Neg, 6% NegHi)
MPa	MPa	Plot Reference:
11%		11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
40	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.051 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
777.2		"B31" Fatigue Stress Allowable = 504.2
MPa		Markl Fatigue Stress Allowable = 659.5
5%		WRC 474 Mean Cycles to Failure = 56,350,536.
		WRC 474 99% Probability Cycles = 13,090,740.
		WRC 474 95% Probability Cycles = 18,174,846.
		BS5500 Allowed Cycles(Curve F) = 18,787,840.
		Membrane-to-Bending Ratio = 0.293
		Bending-to-PL+PB+Q Ratio = 0.774
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4
34	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.043 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
777.2		"B31" Fatigue Stress Allowable = 504.2
MPa		Markl Fatigue Stress Allowable = 659.5
4%		WRC 474 Mean Cycles to Failure = 94,135,936.
		WRC 474 99% Probability Cycles = 21,868,632.
		WRC 474 95% Probability Cycles = 30,361,844.
		BS5500 Allowed Cycles(Curve F) = 41,888,972.
		Membrane-to-Bending Ratio = 0.452
		Bending-to-PL+PB+Q Ratio = 0.689
		Plot Reference:
		13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
Long Plate for Plate # 1		
Pl	SPL	Primary Membrane Load Case 2
108	130	Min Prin. Stress = -114. (97% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
83%		1) Pl < SPL (SUS,Membrane) Case 2
Qb	SPS	Primary Bending Load Case 2
147	303	Min Prin. Stress = -114. (97% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
48%		2) Qb < SPS (SUS,Bending) Case 2
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 2
149	303	Min Prin. Stress = -114. (97% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
49%		3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
201	303	Min Prin. Stress = -114. (97% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
66%		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
S1+S2+S3	4S	Part 5 (5.3.2) Load Case 2
128	346	Min Prin. Stress = -114. (97% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
36%		5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2

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Pl+Pb+Q 149 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -114. (97% Neg, 19% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
49%		
Pl+Pb+Q 201 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -114. (97% Neg, 19% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
66%		
Membrane 108 MPa	User 303 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -114. (97% Neg, 19% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
35%		
Bending 147 MPa	User 303 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -114. (97% Neg, 19% NegHi) Plot Reference: 9) Bending < User (OPE,Bending) Case 3
48%		
Pl+Pb+Q 67 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -32. (91% Neg, 15% NegHi) Plot Reference: 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
22%		
Pl+Pb+Q 67 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -32. (91% Neg, 15% NegHi) Plot Reference: 11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
22%		
Pl+Pb+Q+F 67 MPa	Damage Ratio 0.000 Life 0.086 Stress	Primary+Secondary+Peak (Inner) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 504.2 Markl Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 12,292,206. WRC 474 99% Probability Cycles = 2,855,588. WRC 474 95% Probability Cycles = 3,964,625. BS5500 Allowed Cycles(Curve F) = 3,012,915. Membrane-to-Bending Ratio = 0.248 Bending-to-PL+PB+Q Ratio = 0.802 Plot Reference: 12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Allowable 777.2 MPa		
8%		
Pl+Pb+Q+F 67 MPa	Damage Ratio 0.000 Life 0.087 Stress	Primary+Secondary+Peak (Outer) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 504.2 Markl Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 12,010,429. WRC 474 99% Probability Cycles = 2,790,129. WRC 474 95% Probability Cycles = 3,873,743. BS5500 Allowed Cycles(Curve F) = 2,958,582. Membrane-to-Bending Ratio = 0.250 Bending-to-PL+PB+Q Ratio = 0.800 Plot Reference: 13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
Allowable 777.2 MPa		
8%		
Circ Plate for Plate # 2		
Pl 53	SPL 130	Primary Membrane Load Case 2 Min Prin. Stress = -30. (56% Neg, 8% NegHi)

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MPa	MPa	Plot Reference:
40%		1) Pl < SPL (SUS,Membrane) Case 2
Qb	SPS	Primary Bending Load Case 2
51	303	Min Prin. Stress = -30. (56% Neg, 8% NegHi)
MPa	MPa	Plot Reference:
16%		2) Qb < SPS (SUS,Bending) Case 2
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 2
57	303	Min Prin. Stress = -30. (56% Neg, 8% NegHi)
MPa	MPa	Plot Reference:
18%		3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
75	303	Min Prin. Stress = -30. (56% Neg, 8% NegHi)
MPa	MPa	Plot Reference:
24%		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
S1+S2+S3	4S	Part 5 (5.3.2) Load Case 2
28	346	Min Prin. Stress = -30. (56% Neg, 8% NegHi)
MPa	MPa	Plot Reference:
8%		5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 3
57	303	Min Prin. Stress = -30. (56% Neg, 8% NegHi)
MPa	MPa	Plot Reference:
18%		6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 3
75	303	Min Prin. Stress = -30. (56% Neg, 8% NegHi)
MPa	MPa	Plot Reference:
24%		7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
Membrane	User	Component Evaluation Load Case 3
53	303	Min Prin. Stress = -30. (56% Neg, 8% NegHi)
MPa	MPa	Plot Reference:
17%		8) Membrane < User (OPE,Membrane) Case 3
Bending	User	Component Evaluation Load Case 3
51	303	Min Prin. Stress = -30. (56% Neg, 8% NegHi)
MPa	MPa	Plot Reference:
16%		9) Bending < User (OPE,Bending) Case 3
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 4
40	303	Min Prin. Stress = -16. (51% Neg, 7% NegHi)
MPa	MPa	Plot Reference:
13%		10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 4
34	303	Min Prin. Stress = -16. (51% Neg, 7% NegHi)
MPa	MPa	Plot Reference:
11%		11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
40	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.051 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
777.2		"B31" Fatigue Stress Allowable = 504.2
MPa		MarkI Fatigue Stress Allowable = 659.5
		WRC 474 Mean Cycles to Failure = 56,350,524.
		WRC 474 99% Probability Cycles = 13,090,738.

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5%		WRC 474 95% Probability Cycles = 18,174,842. BS5500 Allowed Cycles(Curve F) = 18,787,830. Membrane-to-Bending Ratio = 0.293 Bending-to-PL+PB+Q Ratio = 0.774 Plot Reference: 12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4
34	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.043 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
777.2		"B31" Fatigue Stress Allowable = 504.2
MPa		MarkI Fatigue Stress Allowable = 659.5
4%		WRC 474 Mean Cycles to Failure = 1.0976E8
		WRC 474 99% Probability Cycles = 25,499,066.
		WRC 474 95% Probability Cycles = 35,402,244.
		BS5500 Allowed Cycles(Curve F) = 42,899,516.
		Membrane-to-Bending Ratio = 0.254
		Bending-to-PL+PB+Q Ratio = 0.797
		Plot Reference: 13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
Circ Plate for Plate # 3		
Pl	SPL	Primary Membrane Load Case 2
121	130	Min Prin. Stress = -169. (87% Neg, 46% NegHi)
MPa	MPa	Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
93%		
Qb	SPS	Primary Bending Load Case 2
184	303	Min Prin. Stress = -169. (87% Neg, 46% NegHi)
MPa	MPa	Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
60%		
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 2
227	303	Min Prin. Stress = -169. (87% Neg, 46% NegHi)
MPa	MPa	Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
75%		
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
170	303	Min Prin. Stress = -169. (87% Neg, 46% NegHi)
MPa	MPa	Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
56%		
S1+S2+S3	4S	Part 5 (5.3.2) Load Case 2
171	346	Min Prin. Stress = -169. (87% Neg, 46% NegHi)
MPa	MPa	Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
49%		
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 3
227	303	Min Prin. Stress = -169. (87% Neg, 46% NegHi)
MPa	MPa	Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
75%		
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 3
170	303	Min Prin. Stress = -169. (87% Neg, 46% NegHi)
MPa	MPa	Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
56%		
Membrane	User	Component Evaluation Load Case 3
121	303	Min Prin. Stress = -169. (87% Neg, 46% NegHi)
MPa	MPa	Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
39%		

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Bending 184 MPa	User 303 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -169. (87% Neg, 46% NegHi) Plot Reference: 9) Bending < User (OPE,Bending) Case 3
60%		
Pl+Pb+Q 55 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -36. (99% Neg, 29% NegHi) Plot Reference: 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
18%		
Pl+Pb+Q 34 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -36. (99% Neg, 29% NegHi) Plot Reference: 11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
11%		
Pl+Pb+Q+F 55 MPa	Damage Ratio 0.000 Life 0.071 Stress	Primary+Secondary+Peak (Inner) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 504.2 Markl Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 32,177,282. WRC 474 99% Probability Cycles = 7,475,067. WRC 474 95% Probability Cycles = 10,378,200. BS5500 Allowed Cycles(Curve F) = 5,431,522. Membrane-to-Bending Ratio = 0.699 Bending-to-PL+PB+Q Ratio = 0.589 Plot Reference: 12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Allowable 777.2 MPa		
7%		
Pl+Pb+Q+F 34 MPa	Damage Ratio 0.000 Life 0.044 Stress	Primary+Secondary+Peak (Outer) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 504.2 Markl Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 1.3386E8 WRC 474 99% Probability Cycles = 31,096,466. WRC 474 95% Probability Cycles = 43,173,532. BS5500 Allowed Cycles(Curve F) = 40,585,156. Membrane-to-Bending Ratio = 4.699 Bending-to-PL+PB+Q Ratio = 0.175 Plot Reference: 13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
Allowable 777.2 MPa		
4%		
Circ Plate for Plate # 4		
Pl 92 MPa	SPL 130 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -114. (76% Neg, 19% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
70%		
Qb 97 MPa	SPS 303 MPa	Primary Bending Load Case 2 Min Prin. Stress = -114. (76% Neg, 19% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
32%		
Pl+Pb+Q 154 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -114. (76% Neg, 19% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
50%		
Pl+Pb+Q 107	SPS 303	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -114. (76% Neg, 19% NegHi)

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MPa	MPa	Plot Reference:
35%		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
S1+S2+S3	4S	Part 5 (5.3.2) Load Case 2
143	346	Min Prin. Stress = -114. (76% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
41%		5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 3
154	303	Min Prin. Stress = -114. (76% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
50%		6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 3
107	303	Min Prin. Stress = -114. (76% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
35%		7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
Membrane	User	Component Evaluation Load Case 3
92	303	Min Prin. Stress = -114. (76% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
30%		8) Membrane < User (OPE,Membrane) Case 3
Bending	User	Component Evaluation Load Case 3
97	303	Min Prin. Stress = -114. (76% Neg, 19% NegHi)
MPa	MPa	Plot Reference:
32%		9) Bending < User (OPE,Bending) Case 3
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 4
28	303	Min Prin. Stress = -19. (60% Neg, 11% NegHi)
MPa	MPa	Plot Reference:
9%		10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 4
28	303	Min Prin. Stress = -19. (60% Neg, 11% NegHi)
MPa	MPa	Plot Reference:
9%		11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
28	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.036 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
777.2		"B31" Fatigue Stress Allowable = 504.2
MPa		MarkI Fatigue Stress Allowable = 659.5
3%		WRC 474 Mean Cycles to Failure = 2.4830E8
		WRC 474 99% Probability Cycles = 57,681,924.
		WRC 474 95% Probability Cycles = 80,084,096.
		BS5500 Allowed Cycles(Curve F) = 1.0043E8
		Membrane-to-Bending Ratio = 0.992
		Bending-to-PL+PB+Q Ratio = 0.502
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4
28	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.036 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
777.2		"B31" Fatigue Stress Allowable = 504.2
MPa		MarkI Fatigue Stress Allowable = 659.5
3%		WRC 474 Mean Cycles to Failure = 2.5702E8
		WRC 474 99% Probability Cycles = 59,708,216.
		WRC 474 95% Probability Cycles = 82,897,344.
		BS5500 Allowed Cycles(Curve F) = 1.0771E8
		Membrane-to-Bending Ratio = 1.230

 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 : 112 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Bending-to-PL+PB+Q Ratio = 0.448
Plot Reference:
13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4

Long Plate for Plate # 4

Pl 23 MPa	SPS 130 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
17%		
Qb 26 MPa	SPS 303 MPa	Primary Bending Load Case 2 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
8%		
Pl+Pb+Q 24 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
7%		
Pl+Pb+Q 38 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
12%		
S1+S2+S3 17 MPa	4S 346 MPa	Part 5 (5.3.2) Load Case 2 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
4%		
Pl+Pb+Q 24 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
7%		
Pl+Pb+Q 38 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
12%		
Membrane 23 MPa	User 303 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
7%		
Bending 26 MPa	User 303 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -16. (77% Neg, 10% NegHi) Plot Reference: 9) Bending < User (OPE,Bending) Case 3
8%		
Pl+Pb+Q 10 MPa	SPS 303 MPa	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -4. (46% Neg, 8% NegHi) Plot Reference: 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
3%		
Pl+Pb+Q 7 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -4. (46% Neg, 8% NegHi) Plot Reference: 11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
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 : 113 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Pl+Pb+Q+F 10 MPa	Damage Ratio 0.000 Life 0.013 Stress	Primary+Secondary+Peak (Inner) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 504.2 Markl Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 2.1819E9 WRC 474 99% Probability Cycles = 5.0689E8 WRC 474 95% Probability Cycles = 7.0375E8 BS5500 Allowed Cycles(Curve F) = 7.0539E9 Membrane-to-Bending Ratio = 0.884 Bending-to-PL+PB+Q Ratio = 0.531 Plot Reference: 12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Allowable 777.2 MPa 1%		
Pl+Pb+Q+F 7 MPa	Damage Ratio 0.000 Life 0.008 Stress	Primary+Secondary+Peak (Outer) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 504.2 Markl Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 9.6172E9 WRC 474 99% Probability Cycles = 2.2342E9 WRC 474 95% Probability Cycles = 3.1018E9 BS5500 Allowed Cycles(Curve F) = 5.8682E10 Membrane-to-Bending Ratio = 0.877 Bending-to-PL+PB+Q Ratio = 0.533 Plot Reference: 13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
Allowable 777.2 MPa 0%		
Circ Plate for Plate # 5		
Pl 35 MPa	SPL 130 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
26%		
Qb 23 MPa	SPS 302 MPa	Primary Bending Load Case 2 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
7%		
Pl+Pb+Q 46 MPa	SPS 302 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
15%		
Pl+Pb+Q 57 MPa	SPS 302 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
18%		
Pl+Pb+Q 46 MPa	SPS 302 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
15%		
Pl+Pb+Q 57 MPa	SPS 302 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
18%		
Membrane 35	User 302	Component Evaluation Load Case 3 Min Prin. Stress = -9. (37% Neg, 9% NegHi)

 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 : 114 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

MPa	MPa	Plot Reference:
11%		8) Membrane < User (OPE,Membrane) Case 3
Bending	User	Component Evaluation Load Case 3
23	302	Min Prin. Stress = -9. (37% Neg, 9% NegHi)
MPa	MPa	Plot Reference:
7%		9) Bending < User (OPE,Bending) Case 3
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 4
29	302	Min Prin. Stress = -3. (13% Neg, 4% NegHi)
MPa	MPa	Plot Reference:
9%		10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 4
28	302	Min Prin. Stress = -3. (13% Neg, 4% NegHi)
MPa	MPa	Plot Reference:
9%		11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
29	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.055 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
530.5		"B31" Fatigue Stress Allowable = 0.0
MPa		MarkI Fatigue Stress Allowable = 575.0
5%		WRC 474 Mean Cycles to Failure = 2.0803E8
		WRC 474 99% Probability Cycles = 48,327,864.
		WRC 474 95% Probability Cycles = 67,097,160.
		BS5500 Allowed Cycles(Curve F) = 86,841,704.
		Membrane-to-Bending Ratio = 11.897
		Bending-to-PL+PB+Q Ratio = 0.078
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4
28	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.054 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
530.5		"B31" Fatigue Stress Allowable = 0.0
MPa		MarkI Fatigue Stress Allowable = 575.0
5%		WRC 474 Mean Cycles to Failure = 2.2691E8
		WRC 474 99% Probability Cycles = 52,713,152.
		WRC 474 95% Probability Cycles = 73,185,576.
		BS5500 Allowed Cycles(Curve F) = 99,494,024.
		Membrane-to-Bending Ratio = 7.877
		Bending-to-PL+PB+Q Ratio = 0.113
		Plot Reference:
		13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4

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Compressive Stress Summary
FEPipe Version 15.0
Released Jan. 2021

Jobname: setup2
1:33pm NOV 25,2024

\$P

Compressive Stress Summary (MPa) \$X

Nomenclature:

Min Stress - Compressive Membrane and Bending Stress
Pts in Region - No. of nodes in the model region
>5% Compression - 5% or more of Compressive Stress Limit

 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 : 115 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

>50% Compression - 50% or more of Compressive Stress Limit

Compressive Stress Limit = $-0.55 \text{ Min}(\text{Sy}, k\text{Et}/R)$, Section slenderness ratio (elastic buckling) not considered.

#	Load Type	Case	Min Stress	Pts in Region	>5% >50% Compression and Bending		Region
1	SUSTAINED	2	-66.	1920	49%	6%	Circ Plate for Plate # 1
2	OPERATING	3	-66.	1920	49%	6%	Circ Plate for Plate # 1
3	EXPANSION	4	-16.	1920	48%	6%	Circ Plate for Plate # 1
4	SUSTAINED	2	-114.	8424	97%	19%	Long Plate for Plate # 1
5	OPERATING	3	-114.	8424	97%	19%	Long Plate for Plate # 1
6	EXPANSION	4	-32.	8424	91%	15%	Long Plate for Plate # 1
7	SUSTAINED	2	-30.	1568	56%	8%	Circ Plate for Plate # 2
8	OPERATING	3	-30.	1568	56%	8%	Circ Plate for Plate # 2
9	EXPANSION	4	-16.	1568	51%	7%	Circ Plate for Plate # 2
10	SUSTAINED	2	-169.	1600	87%	46%	Circ Plate for Plate # 3
11	OPERATING	3	-169.	1600	87%	46%	Circ Plate for Plate # 3
12	EXPANSION	4	-36.	1600	99%	29%	Circ Plate for Plate # 3
13	SUSTAINED	2	-114.	1440	76%	19%	Circ Plate for Plate # 4
14	OPERATING	3	-114.	1440	76%	19%	Circ Plate for Plate # 4
15	EXPANSION	4	-19.	1440	60%	11%	Circ Plate for Plate # 4
16	SUSTAINED	2	-16.	640	77%	10%	Long Plate for Plate # 4
17	OPERATING	3	-16.	640	77%	10%	Long Plate for Plate # 4
18	EXPANSION	4	-4.	640	46%	8%	Long Plate for Plate # 4
19	SUSTAINED	2	-9.	8624	37%	9%	Circ Plate for Plate # 5
20	OPERATING	3	-9.	8624	37%	9%	Circ Plate for Plate # 5
21	EXPANSION	4	-3.	8624	13%	4%	Circ Plate for Plate # 5

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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:

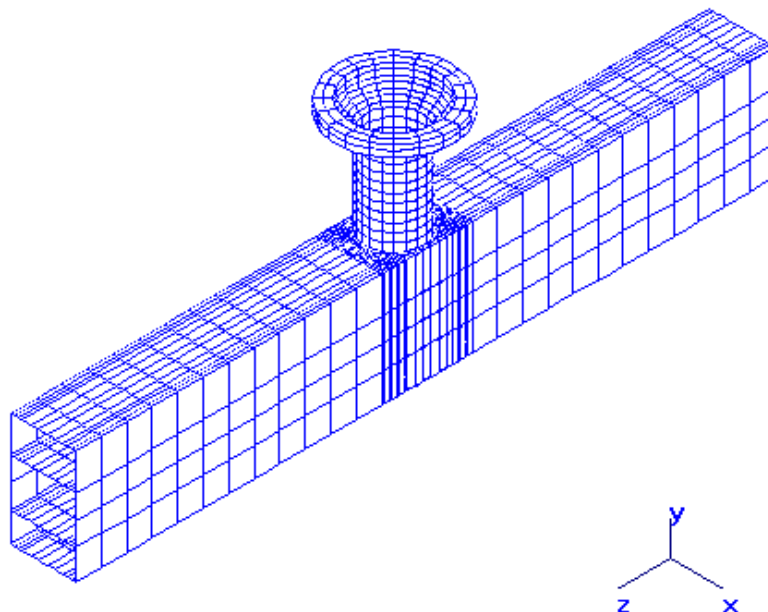
053 - 073 - 9184

Thermal/Mechanical Calculation Book

پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
BK	GCS	AA	120	PR	CN	0001	V04

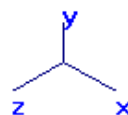
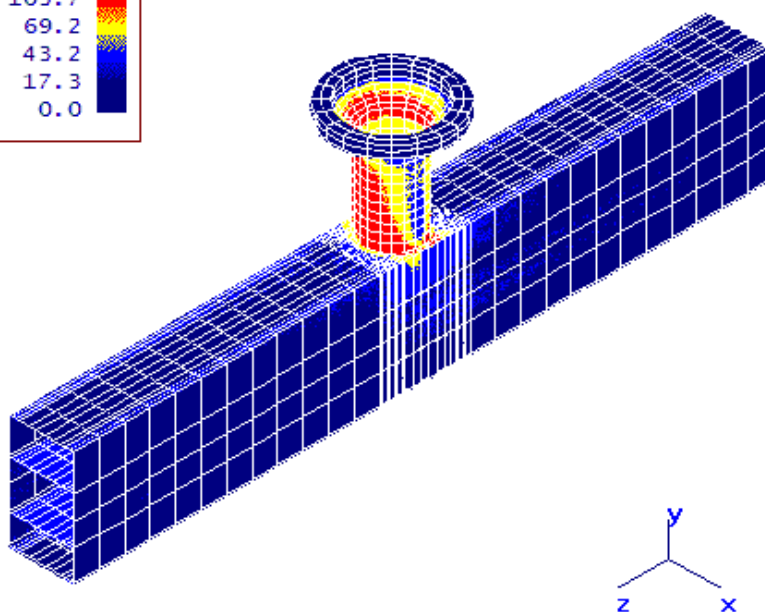
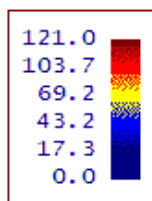
شماره صفحه : 116 از 150

Finite Element Model



3d

1) P1 < SPL (SUS Membrane) Case 2

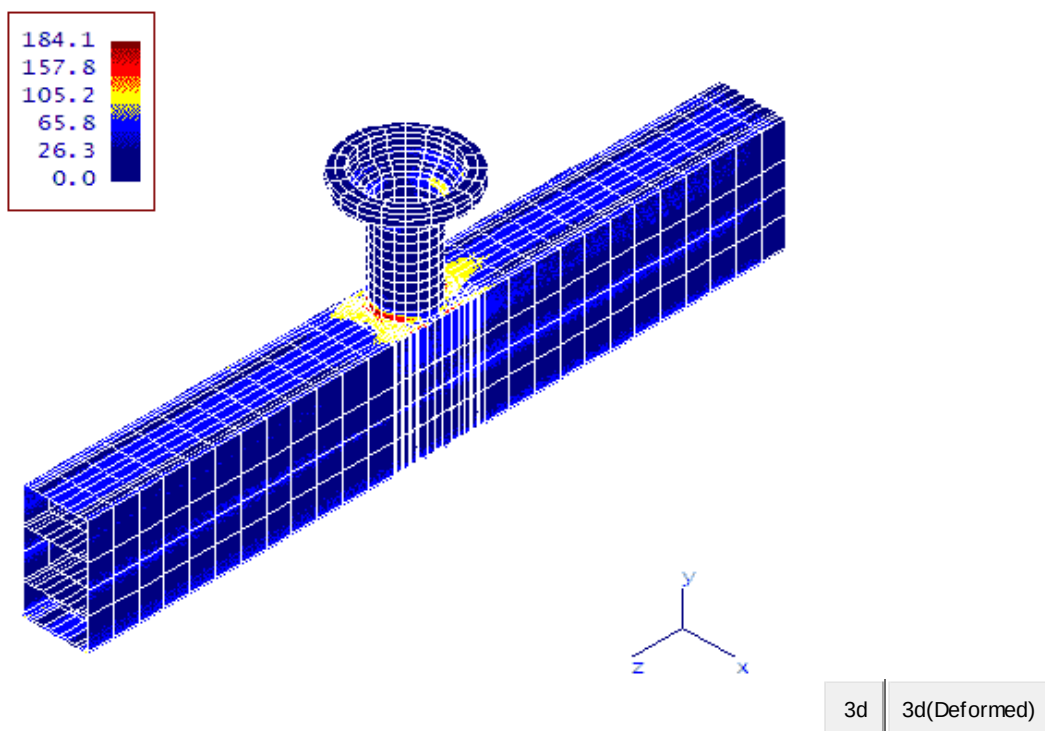


3d

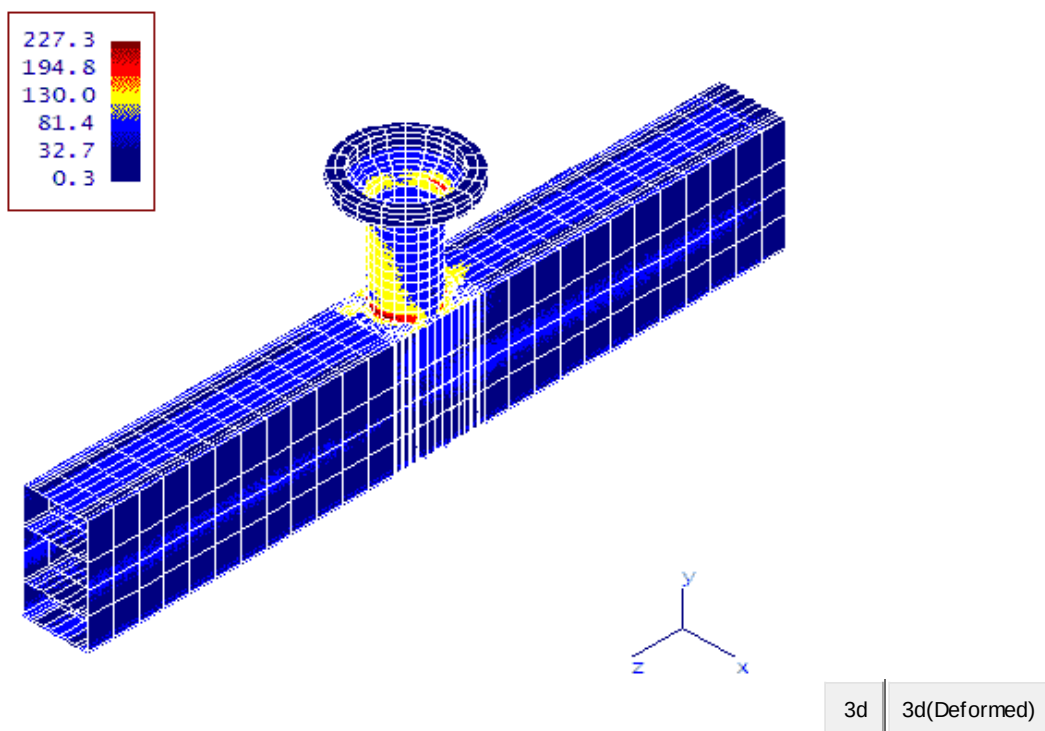
3d(Deformed)

 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 : 117 از 150	
	پروژه	بسته کاری	صادر کننده	تسهيلات	رشته	نوع مدرک	سريال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

2) $Q_b < SPS$ (SUS Bending) Case 2

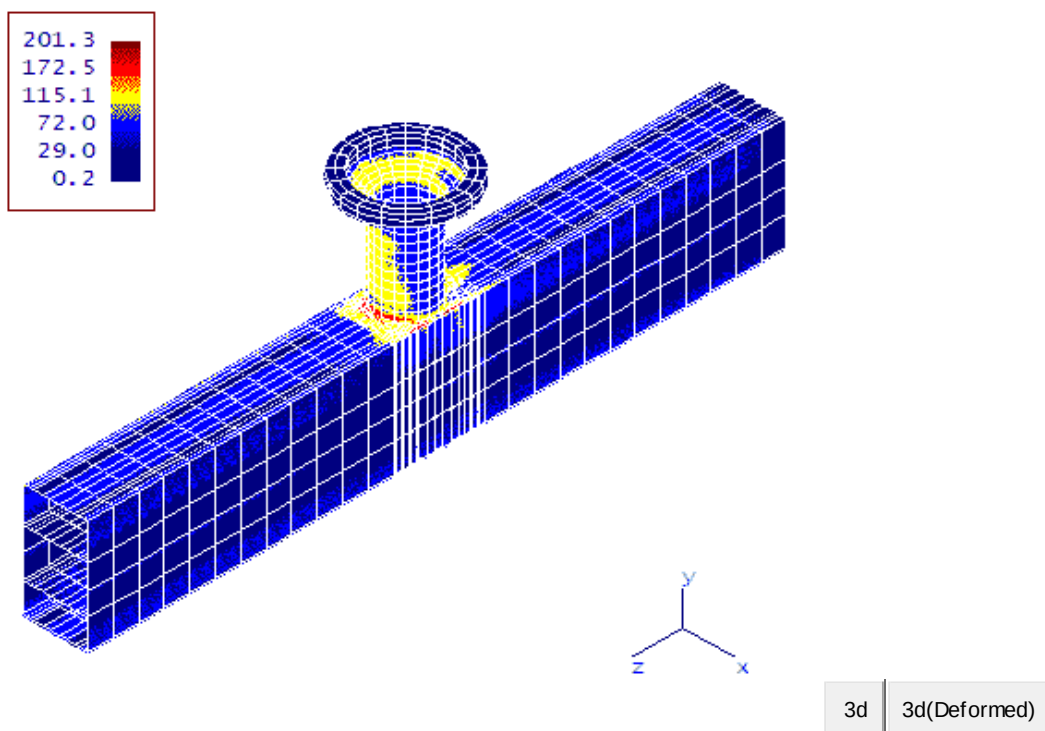


3) $P1+Pb+Q < SPS$ (SUS Inside) Case 2

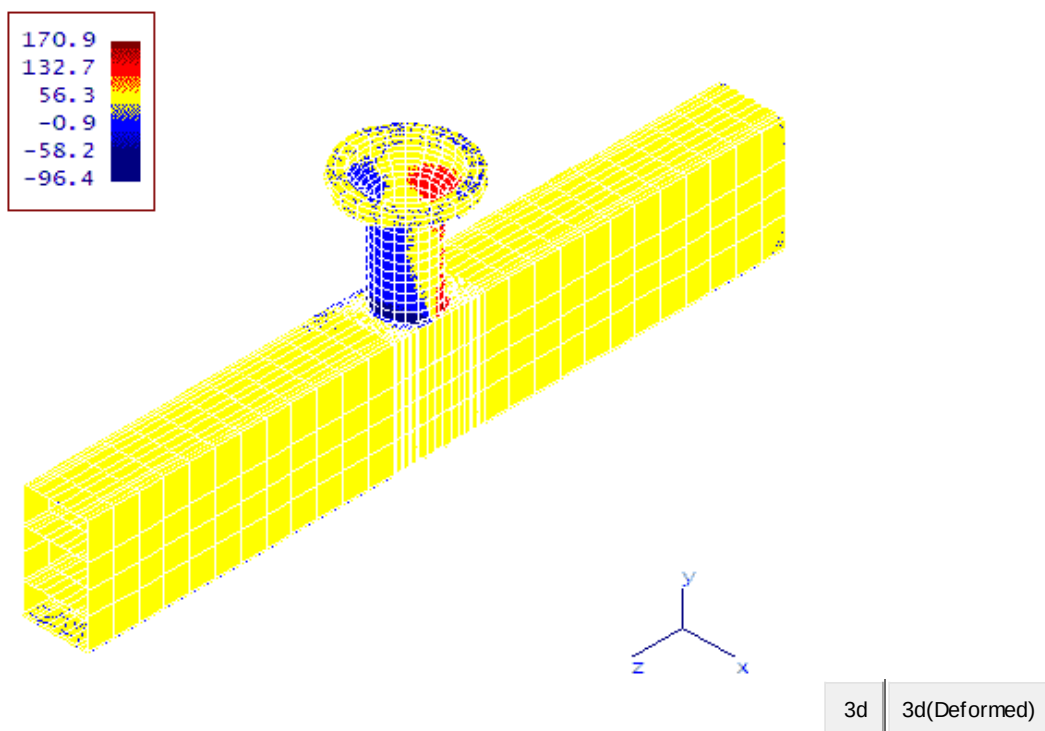


 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							 	
شماره پیمان: 053 - 073 - 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 118 از 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

4) P1+Pb+Q < SPS (SUS Outside) Case 2

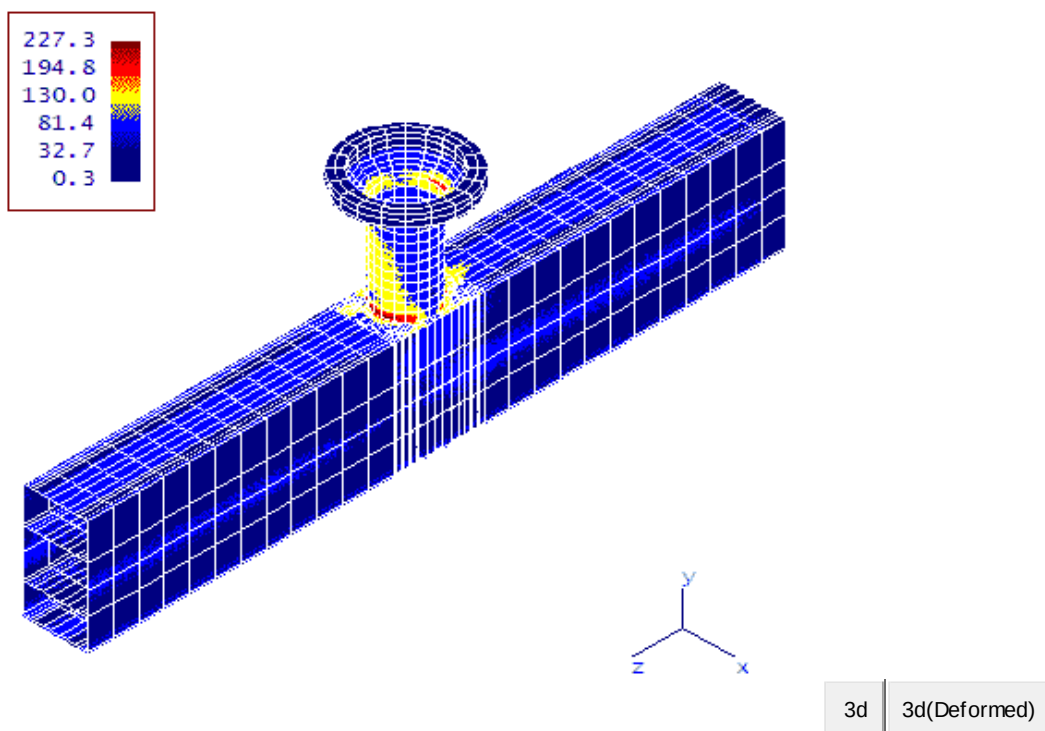


5) S1+S2+S3 < 4S (SUS S1+S2+S3) Case 2

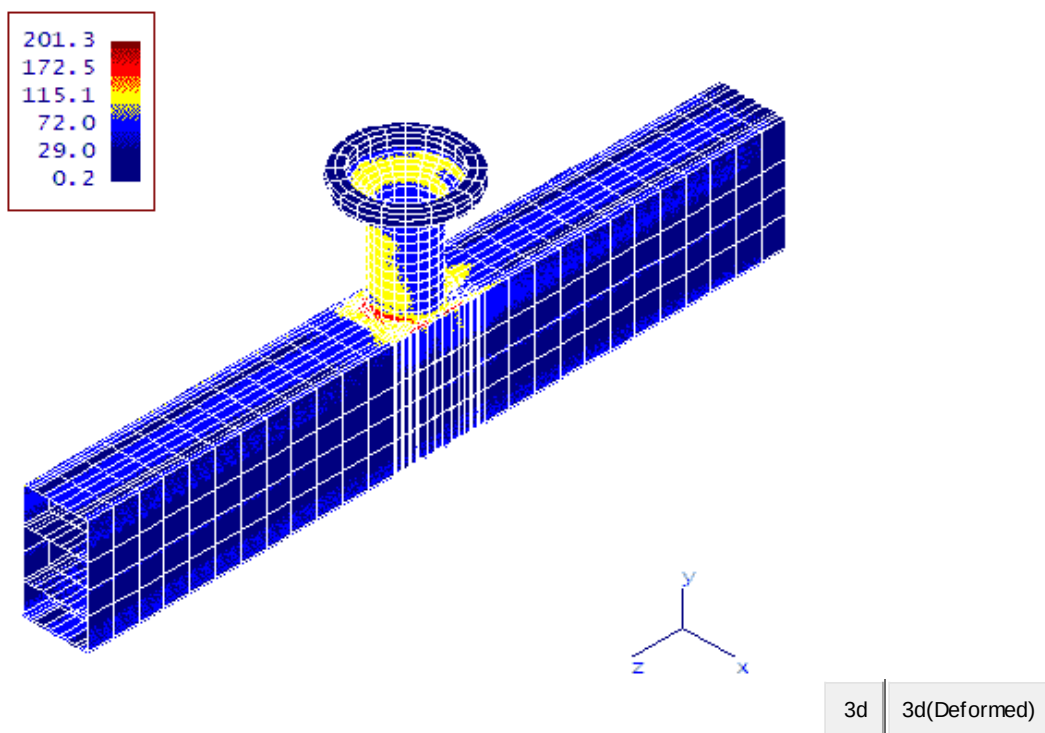


 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							 	
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 119 از 150	
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	BK	GCS	AA	120	PR	CN	0001	V04	

6) P1+Pb+Q < SPS (OPE Inside) Case 3

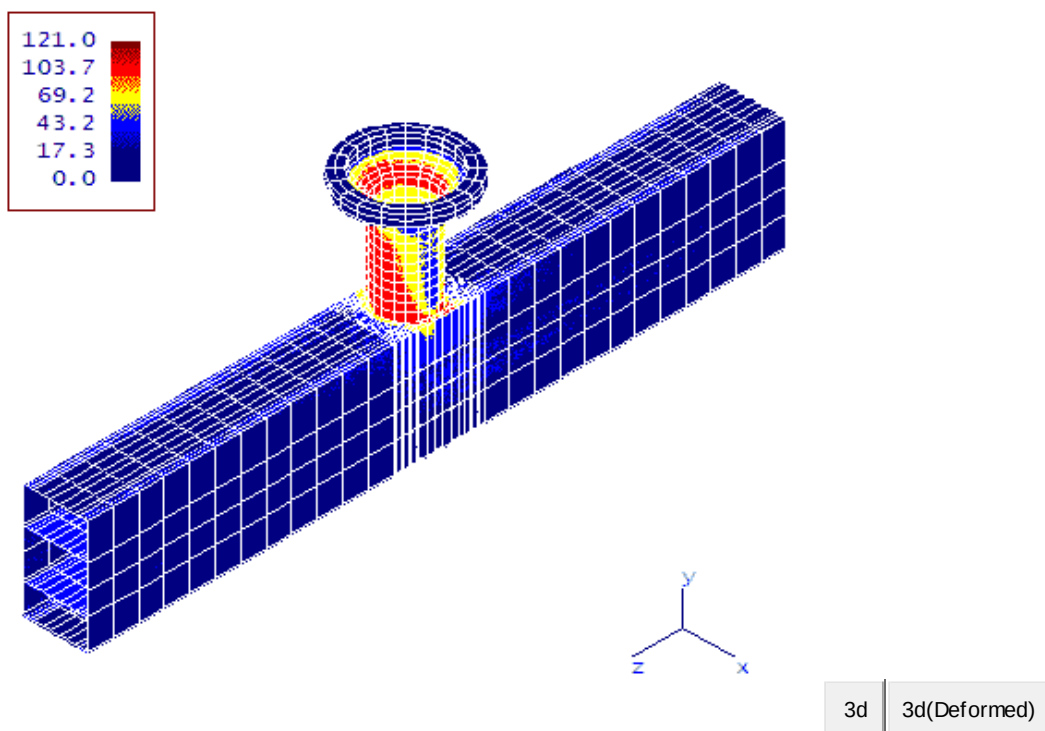


7) P1+Pb+Q < SPS (OPE Outside) Case 3

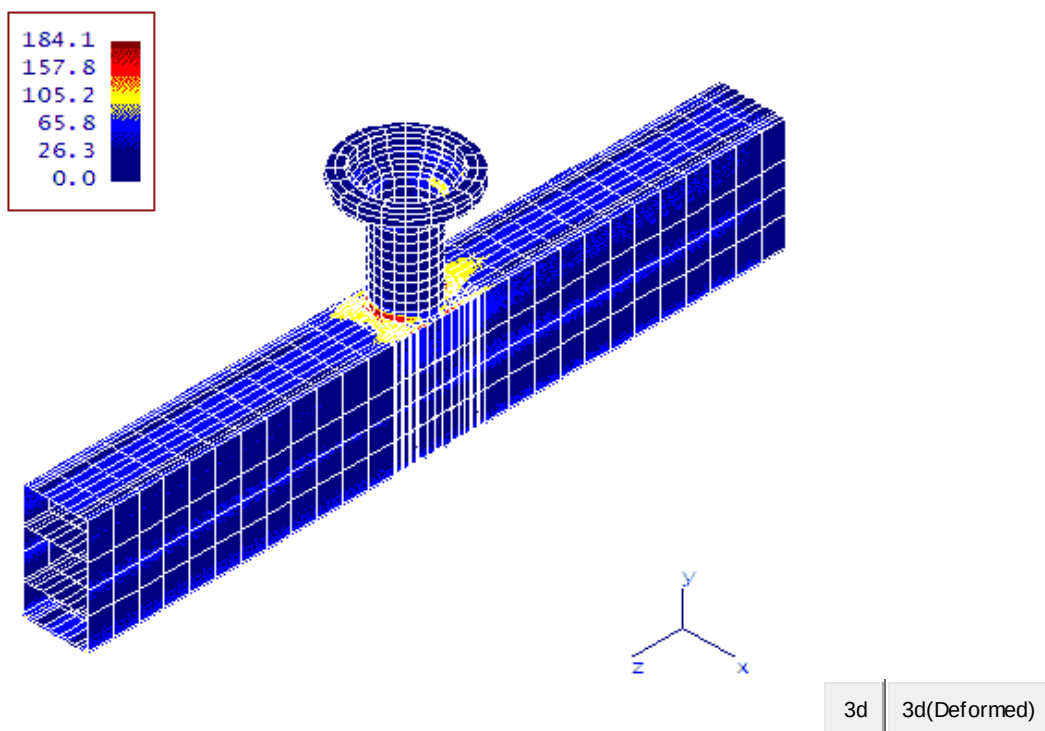


 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 120 از 150	
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	BK	GCS	AA	120	PR	CN	0001	V04	

8) Membrane < User (OPE Membrane) Case 3



9) Bending < User (OPE Bending) Case 3





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:

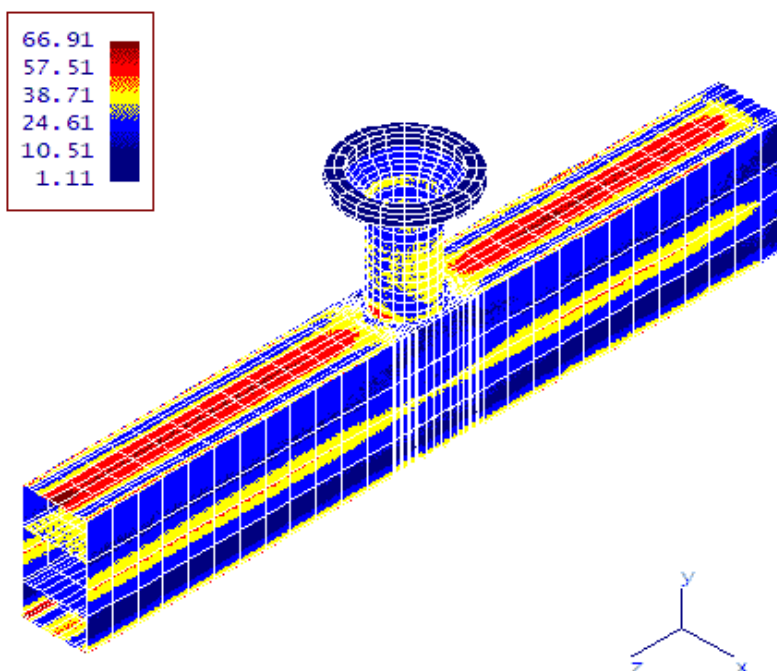
053 - 073 - 9184

Thermal/Mechanical Calculation Book

پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
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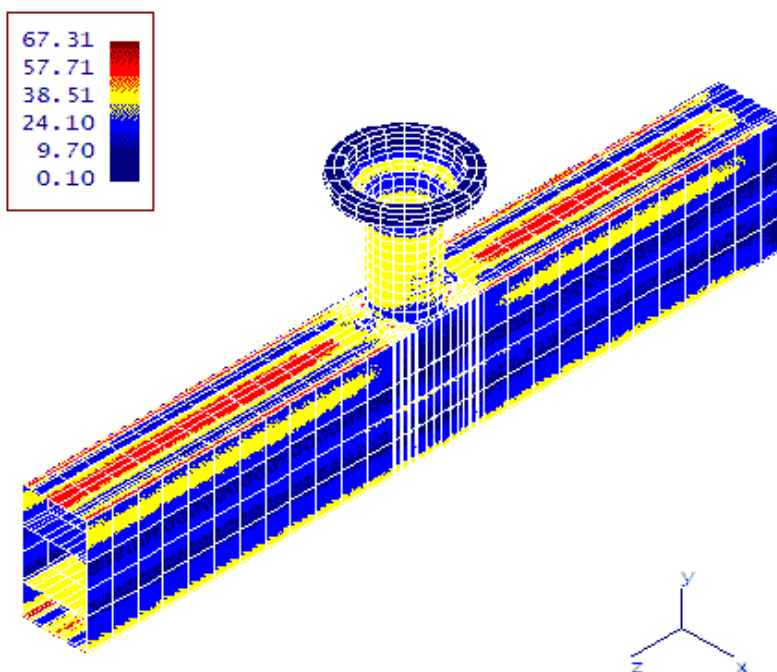
شماره صفحه : 121 از 150

10) P1+Pb+Q < SPS (EXP Inside) Case 4



3d

11) P1+Pb+Q < SPS (EXP Outside) Case 4



3d



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:

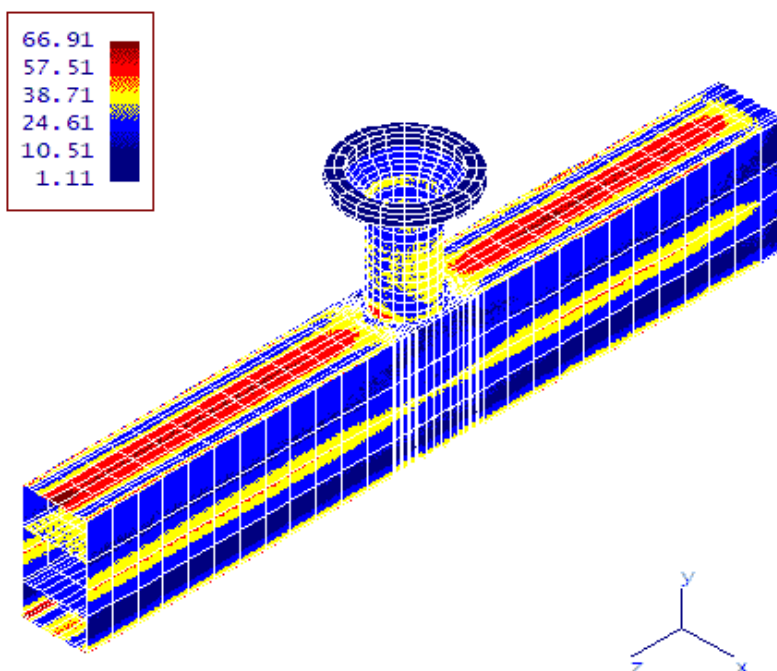
053 - 073 - 9184

Thermal/Mechanical Calculation Book

پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
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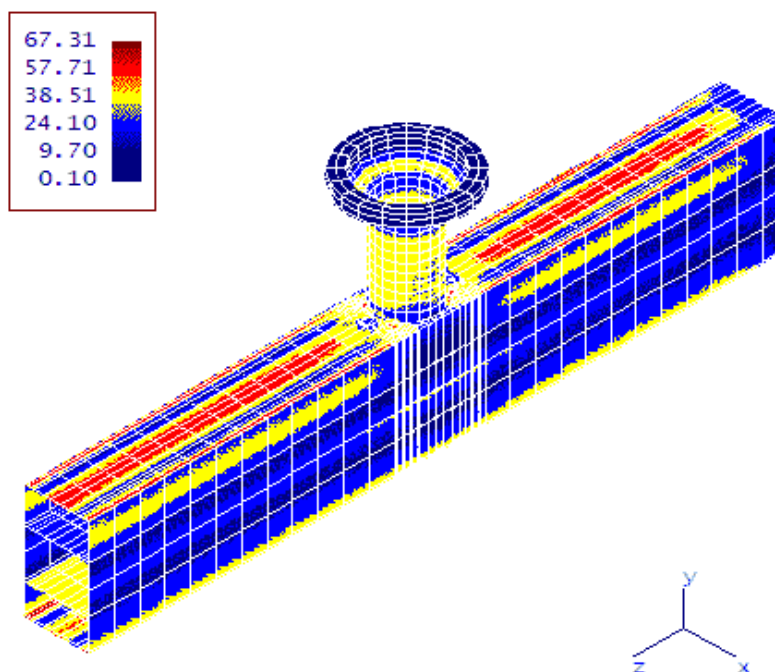
شماره صفحه : 122 از 150

12) $P1+Pb+Q+F < 25a$ (EXP Inside) Case 4



3d

13) $P1+Pb+Q+F < 25a$ (EXP Outside) Case 4



3d

 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 : 123 از 150	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

3.10 FINITE ELEMENT FOR AE-2102

Tabular Results

Results were generated with the finite element program FE/Pipe®. Stress results are post-processed in accordance with the rules specified in ASME Section III and ASME Section VIII, Division 2.

Analysis Time Stamp: Mon Nov 25 14:42:44 2024.

- [Model Notes, Tube Results and API Check](#)
- [Load Case Report](#)
- [Solution Data](#)
- [ASME Code Stress Output Plots](#)
- [Stress Results - Notes](#)
- [ASME Overstressed Areas](#)
- [Highest Primary Stress Ratios](#)
- [Highest Secondary Stress Ratios](#)
- [Highest Fatigue Stress Ratios](#)
- [Highest Stress Ratios Per Region](#)
- [Compressive Stress Summary](#)
- [Graphical Results](#)

Model Notes, Tube Results and API Check
Model Notes, Tube Results and API Check

661PRO 3.0 - API 661 - Air-Cooled Heat Exchanger Nozzle Model

Input Echo:

Notes:

- The centerline of the header box is along the -Z axis.
- Only 1 Nozzle will be modeled at a time. The Nozzle Number Modeled can be seen below.
- User Defined Loads API 661 Check is shown below.
- Sum of ALL Nozzle Loads must not exceed 3*API Allowable Loads shown in paragraph 7.1.10.2 according to API 661 2013 paragraph 7.1.10.3.
- Results are given as: Actual Load, Allowable Load, percentage of allowable for API Check in lbs. and ft-lbs. for English Units and N. and N-m for SI Units.

Nozzle Number Modelled : 1
Top or Bottom Nozzle : Top

Analysis Type : User Defined Loads

Nozzle Type : Straight
Flange Type : Weldneck

Header Box Dimensions:
Centerline on :Centerline on LEFT Side
Height : 485.000 mm.
Width : 166.000 mm.
Length : 2135.000 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 : 124 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V04	

Outboard Thickness : 28.000 mm.
 Tubesheet Side Thickness : 28.000 mm.
 Top Plate Thickness : 20.000 mm.
 Free End Plate Thickness : 20.000 mm.

Header Box Pressure : 6.200 MPa

Symmetric Boundary Condition at Centerline

Partition Plates:

Number of Partition Plates : 2

Partition Plate #1

Plate Elevation from Bottom : 130.000 mm.
 Plate Thickness : 10.000 mm.

Partition Plate #2

Plate Elevation from Bottom : 305.000 mm.
 Plate Thickness : 10.000 mm.

Nozzle Dimensions:

Distance to CenterLine : 1067.500 mm.
 Nozzle Outside Diameter : 114.300 mm.
 Nozzle Thickness : 7.500 mm.
 Projection to Face of Flange : 320.000 mm.
 Flange Thickness Used : 27.300 mm.
 Flange ID : 154.059 mm.
 Flange Hub Length Used : 40.950 mm.

Weld Size and SCF : 0.000, 1.350

Engineering Details:

Operating Cycles : 7000
 Occasional Cycles : 0
 Ambient Temperature : 21.100 deg.
 Computation Type : Gauss Average

Material Properties

Nozzle:

Cold Allowable Stress : 115.100 MPa
 Hot Allowable Stress : 111.900 MPa
 Elastic Modulus : 0.184E+06 MPa
 Poissons Ratio : 0.300
 Material ID : 4-Austenitic Steels
 Density : 0.000E+00 N /cu. mm.
 Cold Yield Stress : 172.400 MPa
 Hot Yield Stress : 126.100 MPa
 Cold Tensile Stress : 482.700 MPa
 Density : 0.000E+00 N /cu. mm.

Header Box:

Cold Allowable Stress : 115.100 MPa
 Hot Allowable Stress : 111.900 MPa
 Elastic Modulus : 0.184E+06 MPa
 Poissons Ratio : 0.300
 Material ID : 4-Austenitic Steels
 Density : 0.000E+00 N /cu. mm.
 Cold Yield Stress : 172.400 MPa
 Hot Yield Stress : 126.100 MPa
 Cold Tensile Stress : 482.700 MPa
 Density : 0.000E+00 N /cu. mm.

Tubesheet was not modeled

 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		V04

User Defined Loads:

	Forces [N] Moments [mm.- N]					
	FX	FY	FZ	MX	MY	MZ
Weight	10020	8010	10020	2430000	3660000	2430000
Operating	10020	8010	10020	2430000	3660000	2430000
Occasional	0	0	0	0	0	0

No Tube Results

API Check for User Defined Loads and API Evaluation
API 661 2013 paragraph 7.1.10.2 and 7.1.10.3.

Results below are shown as:
Actual Load, Allowable Load, % of Allowable
Allowable Load: 3x API Allowable from para. 7.1.10.2

Total Nozzle Loads per DOF in [N and N.m]			
Global FX	: 10020,	15015,	66 %
Global FY	: 8010,	30030,	26 %
Global FZ	: 10020,	25020,	40 %
Global MX	: 2430,	9150,	26 %
Global MY	: 3660,	12195,	30 %
Global MZ	: 2430,	6105,	39 %

API 661 para. 7.1.10.3 check PASSED. The summation of all nozzle loads did NOT exceed the 1.5x API value from para. 7.1.10.2.

Symmetric boundary condition applied at the center of the headerbox, the API multiplier from paragraph 7.1.10.3 will be 1.5 since total loads will be 2x larger due to symmetry.

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Load Case Report
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Released Jan. 2021

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\$P

Load Case Report \$X

Inner and outer element temperatures are the same throughout the model. No thermal ratcheting calculations will be performed.

THE 4 LOAD CASES ANALYZED ARE:

1 WEIGHT ONLY (Wgt Only)

Weight ONLY case run to get the stress range between the installed and the operating states.

/----- Loads in Case 1
Loads due to Weight

2 SUSTAINED (Wgt+Pr)

Sustained case run to satisfy local primary membrane and bending stress limits.

/----- Loads in Case 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	V04	

Loads due to Weight
Pressure Case 1

3 OPERATING

Case run to compute the operating stresses used in secondary, peak and range calculations as needed.

/----- Loads in Case 3
Pressure Case 1
Loads from (Operating)

4 RANGE (Fatigue Calc Performed)

Case run to get the RANGE of stresses.
as described in NB-3222.2, 5.5.3.2, 5.5.5.2 or 5.5.6.1.

/----- Combinations in Range Case 4
Plus Stress Results from CASE 3
Minus Stress Results from CASE 1

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Solution Data
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Solution Data

Maximum Solution Row Size = 2370
Number of Nodes = 13048
Number of Elements = 4400
Number of Solution Cases = 3

Summation of Loads per Case

Case #	FX	FY	FZ
1	10020.	56025.	10020.
2	10020.	-119625.	-387834.
3	10020.	-119625.	-387834.

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ASME Code Stress Output Plots
FEPipe Version 15.0 Jobname: setup2 \$P
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ASME Code Stress Output Plots \$X

- 1) P1 < SPL (SUS,Membrane) Case 2
- 2) Qb < SPS (SUS,Bending) Case 2
- 3) P1+Pb+Q < SPS (SUS,Inside) Case 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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- 4) $P_l+P_b+Q < SPS$ (SUS,Outside) Case 2
- 5) $S_1+S_2+S_3 < 4S$ (SUS, $S_1+S_2+S_3$) Case 2
- 6) $P_l+P_b+Q < SPS$ (OPE,Inside) Case 3
- 7) $P_l+P_b+Q < SPS$ (OPE,Outside) Case 3
- 8) Membrane < User (OPE,Membrane) Case 3
- 9) Bending < User (OPE,Bending) Case 3
- 10) $P_l+P_b+Q < SPS$ (EXP,Inside) Case 4
- 11) $P_l+P_b+Q < SPS$ (EXP,Outside) Case 4
- 12) $P_l+P_b+Q+F < 2Sa$ (EXP,Inside) Case 4
- 13) $P_l+P_b+Q+F < 2Sa$ (EXP,Outside) Case 4

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Stress Results - Notes

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Stress Results - Notes

- Results in this analysis were generated using the finite element solution method.
- Using 2019 ASME Section VIII Division 2
- Use Polished Bar fatigue curve.
- Ratio between Operating and Design Pressure = 1.000000
Range cases use operating pressure. Primary cases use design pressure.
- Assume free end displacements of attached pipe (e.g. thermal loads) are secondary loads.
- Primary bending stresses at discontinuities are treated like secondary stresses. ($P_b=0$)
- Use Equivalent Stress (Von Mises).
- TRIAXIAL Stress Guidelines:
S1+S2+S3 evaluation omitted from operating stress.
Include S1+S2+S3 evaluation in primary case evaluation.
Bending stress NOT included for all S1+S2+S3 calculations.
- Use local tensor values for averaged and not averaged stresses.

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ASME Overstressed Areas

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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)							 	
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 128 از 150	
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	BK	GCS	AA	120	PR	CN	0001		V04

ASME Overstressed Areas

\$X

*** NO OVERSTRESSED NODES IN THIS MODEL ***

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Highest Primary Stress Ratios

FEPipe Version 15.0
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Highest Primary Stress Ratios

\$X

Circ Plate for Plate # 1

Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
126	340	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
36%		

Long Plate for Plate # 1

Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
241	340	Min Prin. Stress = -125. (92% Neg, 27% NegHi)
MPa	MPa	Plot Reference:
		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
70%		

Circ Plate for Plate # 2

Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
104	340	Min Prin. Stress = -31. (58% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
30%		

Circ Plate for Plate # 3

Pl	SPL	Primary Membrane Load Case 2
146	168	Min Prin. Stress = -189. (76% Neg, 47% NegHi)
MPa	MPa	Plot Reference:
		1) Pl < SPL (SUS,Membrane) Case 2
86%		

Circ Plate for Plate # 4

Pl	SPL	Primary Membrane Load Case 2
122	168	Min Prin. Stress = -172. (69% Neg, 22% NegHi)
MPa	MPa	Plot Reference:
		1) Pl < SPL (SUS,Membrane) Case 2
72%		

Long Plate for Plate # 4

	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	V04	

Pl SPL Primary Membrane Load Case 2
27 168 Min Prin. Stress = -18. (75% Neg, 4% NegHi)
MPa MPa Plot Reference:
1) Pl < SPL (SUS,Membrane) Case 2

15%

Circ Plate for Plate # 5

Pl SPL Primary Membrane Load Case 2
118 126 Min Prin. Stress = -7. (10% Neg, 2% NegHi)
MPa MPa Plot Reference:
1) Pl < SPL (SUS,Membrane) Case 2

93%

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Highest Secondary Stress Ratios
FEPIPE Version 15.0 Jobname: setup2 \$P
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Highest Secondary Stress Ratios \$X

In combination case 4 the max range stress divided by the max component stress is 1.85. The case tensor components are in some directions additive and so the combination case will have HIGHER stresses than the largest of any of the individual cases by more than 50%.

Load Case	Combined/Max (Inside)	Combined/Max (Outside)
4	1.849	1.663

Circ Plate for Plate # 1

Pl+Pb+Q SPS Primary+Secondary (Outer) Load Case 2
126 340 Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa MPa Plot Reference:
4) Pl+Pb+Q < SPS (SUS,Outside) Case 2

36%

Pl+Pb+Q SPS Primary+Secondary (Outer) Load Case 3
126 340 Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa MPa Plot Reference:
7) Pl+Pb+Q < SPS (OPE,Outside) Case 3

36%

Long Plate for Plate # 1

Pl+Pb+Q SPS Primary+Secondary (Outer) Load Case 2
241 340 Min Prin. Stress = -125. (92% Neg, 27% NegHi)
MPa MPa Plot Reference:
4) Pl+Pb+Q < SPS (SUS,Outside) Case 2

70%

Pl+Pb+Q SPS Primary+Secondary (Outer) Load Case 3
241 340 Min Prin. Stress = -125. (92% Neg, 27% NegHi)
MPa MPa Plot Reference:
7) Pl+Pb+Q < SPS (OPE,Outside) Case 3

70%

 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	V04	

Circ Plate for Plate # 2

Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
104	340	Min Prin. Stress = -31. (58% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
30%		

Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 3
104	340	Min Prin. Stress = -31. (58% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
30%		

Circ Plate for Plate # 3

Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 2
256	340	Min Prin. Stress = -189. (76% Neg, 47% NegHi)
MPa	MPa	Plot Reference:
		3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
75%		

Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 3
256	340	Min Prin. Stress = -189. (76% Neg, 47% NegHi)
MPa	MPa	Plot Reference:
		6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
75%		

Circ Plate for Plate # 4

Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 2
211	340	Min Prin. Stress = -172. (69% Neg, 22% NegHi)
MPa	MPa	Plot Reference:
		3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
61%		

Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 3
211	340	Min Prin. Stress = -172. (69% Neg, 22% NegHi)
MPa	MPa	Plot Reference:
		6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
61%		

Long Plate for Plate # 4

Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
46	340	Min Prin. Stress = -18. (75% Neg, 4% NegHi)
MPa	MPa	Plot Reference:
		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
13%		

Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 3
46	340	Min Prin. Stress = -18. (75% Neg, 4% NegHi)
MPa	MPa	Plot Reference:
		7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
13%		

Circ Plate for Plate # 5

Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 2
126	298	Min Prin. Stress = -7. (10% Neg, 2% NegHi)
MPa	MPa	Plot Reference:
		3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
42%		

Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 3
126	298	Min Prin. Stress = -7. (10% Neg, 2% NegHi)
MPa	MPa	Plot Reference:
		6) Pl+Pb+Q < SPS (OPE,Inside) Case 3

 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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42%

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Highest Fatigue Stress Ratios

FEPipe Version 15.0

Released Jan. 2021

Jobname: setup2

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Highest Fatigue Stress Ratios

\$X

Circ Plate for Plate # 1

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4
126	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.163 Stress	Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 1.0000E11
Allowable		"B31" Fatigue Stress Allowable = 567.5
771.0		Markl Fatigue Stress Allowable = 659.5
MPa		WRC 474 Mean Cycles to Failure = 1,528,132.
		WRC 474 99% Probability Cycles = 354,999.
16%		WRC 474 95% Probability Cycles = 492,872.
		BS5500 Allowed Cycles(Curve F) = 464,450.
		Membrane-to-Bending Ratio = 0.370
		Bending-to-PL+PB+Q Ratio = 0.730
		Plot Reference:
		13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4

Long Plate for Plate # 1

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4
164	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.213 Stress	Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 1.0000E11
Allowable		"B31" Fatigue Stress Allowable = 567.5
771.0		Markl Fatigue Stress Allowable = 659.5
MPa		WRC 474 Mean Cycles to Failure = 667,819.
		WRC 474 99% Probability Cycles = 155,140.
21%		WRC 474 95% Probability Cycles = 215,393.
		BS5500 Allowed Cycles(Curve F) = 208,596.
		Membrane-to-Bending Ratio = 0.308
		Bending-to-PL+PB+Q Ratio = 0.764
		Plot Reference:
		13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4

Circ Plate for Plate # 2

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
74	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.096 Stress	Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 1.0000E11
Allowable		"B31" Fatigue Stress Allowable = 567.5
770.9		Markl Fatigue Stress Allowable = 659.5
MPa		WRC 474 Mean Cycles to Failure = 6,294,933.
		WRC 474 99% Probability Cycles = 1,462,370.
9%		WRC 474 95% Probability Cycles = 2,030,317.
		BS5500 Allowed Cycles(Curve F) = 1,906,701.
		Membrane-to-Bending Ratio = 0.239
		Bending-to-PL+PB+Q Ratio = 0.807
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 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)								
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Circ Plate for Plate # 3

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
132	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.172 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
770.9		"B31" Fatigue Stress Allowable = 567.5
MPa		Mark1 Fatigue Stress Allowable = 659.5
17%		WRC 474 Mean Cycles to Failure = 2,294,650.
		WRC 474 99% Probability Cycles = 533,068.
		WRC 474 95% Probability Cycles = 740,098.
		BS5500 Allowed Cycles(Curve F) = 399,227.
		Membrane-to-Bending Ratio = 1.204
		Bending-to-PL+PB+Q Ratio = 0.454
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

Circ Plate for Plate # 4

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
108	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.140 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
770.9		"B31" Fatigue Stress Allowable = 567.5
MPa		Mark1 Fatigue Stress Allowable = 659.5
13%		WRC 474 Mean Cycles to Failure = 4,468,199.
		WRC 474 99% Probability Cycles = 1,038,003.
		WRC 474 95% Probability Cycles = 1,441,137.
		BS5500 Allowed Cycles(Curve F) = 736,712.
		Membrane-to-Bending Ratio = 0.786
		Bending-to-PL+PB+Q Ratio = 0.560
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

Long Plate for Plate # 4

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
32	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.042 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
770.9		"B31" Fatigue Stress Allowable = 567.5
MPa		Mark1 Fatigue Stress Allowable = 659.5
4%		WRC 474 Mean Cycles to Failure = 63,477,656.
		WRC 474 99% Probability Cycles = 14,746,436.
		WRC 474 95% Probability Cycles = 20,473,570.
		BS5500 Allowed Cycles(Curve F) = 27,561,694.
		Membrane-to-Bending Ratio = 0.845
		Bending-to-PL+PB+Q Ratio = 0.542
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

Circ Plate for Plate # 5

Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
120	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.227 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.3893E8
526.2		"B31" Fatigue Stress Allowable = 0.0
MPa		Mark1 Fatigue Stress Allowable = 575.0
22%		WRC 474 Mean Cycles to Failure = 2,470,444.
		WRC 474 99% Probability Cycles = 573,907.
		WRC 474 95% Probability Cycles = 796,797.
		BS5500 Allowed Cycles(Curve F) = 541,237.
		Membrane-to-Bending Ratio = 66.351
		Bending-to-PL+PB+Q Ratio = 0.015
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 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)							
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	BK	GCS	AA	120	PR	CN	0001	V04

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Highest Stress Ratios Per Region
 FEPipe Version 15.0 Jobname: setup2 \$P
 Released Jan. 2021 2:42pm NOV 25, 2024

Highest Stress Ratios Per Region \$X

Circ Plate for Plate # 1

Pl	SPS	Primary Membrane Load Case 2
41	168	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		1) Pl < SPL (SUS,Membrane) Case 2
24%		
Qb	SPS	Primary Bending Load Case 2
104	340	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		2) Qb < SPS (SUS,Bending) Case 2
30%		
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 2
97	340	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
28%		
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
126	340	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
36%		
S1+S2+S3	4S	Part 5 (5.3.2) Load Case 2
71	448	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
15%		
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 3
97	340	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
28%		
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 3
126	340	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
36%		
Membrane	User	Component Evaluation Load Case 3
41	340	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		8) Membrane < User (OPE,Membrane) Case 3
11%		
Bending	User	Component Evaluation Load Case 3
104	340	Min Prin. Stress = -51. (57% Neg, 0% NegHi)
MPa	MPa	Plot Reference:
		9) Bending < User (OPE,Bending) Case 3
30%		
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 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)								
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94 MPa	340 MPa	Min Prin. Stress = -35. (57% Neg, 0% NegHi) Plot Reference: 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
27%		
Pl+Pb+Q 126 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -35. (57% Neg, 0% NegHi) Plot Reference: 11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
36%		
Pl+Pb+Q+F 94 MPa	Damage Ratio 0.000 Life 0.123 Stress	Primary+Secondary+Peak (Inner) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 567.5 Mark1 Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 4,582,710. WRC 474 99% Probability Cycles = 1,064,605. WRC 474 95% Probability Cycles = 1,478,070. BS5500 Allowed Cycles(Curve F) = 1,096,921. Membrane-to-Bending Ratio = 0.370 Bending-to-PL+PB+Q Ratio = 0.730 Plot Reference: 12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Allowable 771.0 MPa		
12%		
Pl+Pb+Q+F 126 MPa	Damage Ratio 0.000 Life 0.163 Stress	Primary+Secondary+Peak (Outer) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 567.5 Mark1 Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 1,528,132. WRC 474 99% Probability Cycles = 354,999. WRC 474 95% Probability Cycles = 492,872. BS5500 Allowed Cycles(Curve F) = 464,450. Membrane-to-Bending Ratio = 0.370 Bending-to-PL+PB+Q Ratio = 0.730 Plot Reference: 13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
Allowable 771.0 MPa		
16%		
Long Plate for Plate # 1		
Pl 109 MPa	SPL 168 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -125. (92% Neg, 27% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
64%		
Qb 194 MPa	SPS 340 MPa	Primary Bending Load Case 2 Min Prin. Stress = -125. (92% Neg, 27% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
57%		
Pl+Pb+Q 175 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -125. (92% Neg, 27% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
51%		
Pl+Pb+Q 241 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -125. (92% Neg, 27% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
70%		
S1+S2+S3 123 MPa	4S 448 MPa	Part 5 (5.3.2) Load Case 2 Min Prin. Stress = -125. (92% Neg, 27% NegHi) Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 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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27%

Pl+Pb+Q SPS Primary+Secondary (Inner) Load Case 3
175 340 Min Prin. Stress = -125. (92% Neg, 27% NegHi)
MPa MPa Plot Reference:
6) Pl+Pb+Q < SPS (OPE,Inside) Case 3

51%

Pl+Pb+Q SPS Primary+Secondary (Outer) Load Case 3
241 340 Min Prin. Stress = -125. (92% Neg, 27% NegHi)
MPa MPa Plot Reference:
7) Pl+Pb+Q < SPS (OPE,Outside) Case 3

70%

Membrane User Component Evaluation Load Case 3
109 340 Min Prin. Stress = -125. (92% Neg, 27% NegHi)
MPa MPa Plot Reference:
8) Membrane < User (OPE,Membrane) Case 3

32%

Bending User Component Evaluation Load Case 3
194 340 Min Prin. Stress = -125. (92% Neg, 27% NegHi)
MPa MPa Plot Reference:
9) Bending < User (OPE,Bending) Case 3

57%

Pl+Pb+Q SPS Primary+Secondary (Inner) Load Case 4
124 340 Min Prin. Stress = -64. (90% Neg, 22% NegHi)
MPa MPa Plot Reference:
10) Pl+Pb+Q < SPS (EXP,Inside) Case 4

36%

Pl+Pb+Q SPS Primary+Secondary (Outer) Load Case 4
164 340 Min Prin. Stress = -64. (90% Neg, 22% NegHi)
MPa MPa Plot Reference:
11) Pl+Pb+Q < SPS (EXP,Outside) Case 4

48%

Pl+Pb+Q+F Damage Ratio Primary+Secondary+Peak (Inner) Load Case 4
124 0.000 Life Stress Concentration Factor = 1.000
MPa 0.161 Stress Strain Concentration Factor = 1.000
Cycles Allowed for this Stress = 1.0000E11
Allowable "B31" Fatigue Stress Allowable = 567.5
771.0 Markl Fatigue Stress Allowable = 659.5
MPa WRC 474 Mean Cycles to Failure = 1,723,323.
WRC 474 99% Probability Cycles = 400,344.
WRC 474 95% Probability Cycles = 555,827.
BS5500 Allowed Cycles(Curve F) = 484,575.
Membrane-to-Bending Ratio = 0.302
Bending-to-PL+PB+Q Ratio = 0.768
Plot Reference:
12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4

Pl+Pb+Q+F Damage Ratio Primary+Secondary+Peak (Outer) Load Case 4
164 0.000 Life Stress Concentration Factor = 1.000
MPa 0.213 Stress Strain Concentration Factor = 1.000
Cycles Allowed for this Stress = 1.0000E11
Allowable "B31" Fatigue Stress Allowable = 567.5
771.0 Markl Fatigue Stress Allowable = 659.5
MPa WRC 474 Mean Cycles to Failure = 667,819.
WRC 474 99% Probability Cycles = 155,140.
WRC 474 95% Probability Cycles = 215,393.
BS5500 Allowed Cycles(Curve F) = 208,596.
Membrane-to-Bending Ratio = 0.308
Bending-to-PL+PB+Q Ratio = 0.764
Plot Reference:
13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4

Circ Plate for Plate # 2

Pl SPL Primary Membrane Load Case 2

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42 MPa	168 MPa	Min Prin. Stress = -31. (58% Neg, 0% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
24%		
Qb 88 MPa	SPS 340 MPa	Primary Bending Load Case 2 Min Prin. Stress = -31. (58% Neg, 0% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
25%		
Pl+Pb+Q 79 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -31. (58% Neg, 0% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
23%		
Pl+Pb+Q 104 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -31. (58% Neg, 0% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
30%		
S1+S2+S3 70 MPa	4S 448 MPa	Part 5 (5.3.2) Load Case 2 Min Prin. Stress = -31. (58% Neg, 0% NegHi) Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
15%		
Pl+Pb+Q 79 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -31. (58% Neg, 0% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
23%		
Pl+Pb+Q 104 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -31. (58% Neg, 0% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
30%		
Membrane 42 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -31. (58% Neg, 0% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
12%		
Bending 88 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -31. (58% Neg, 0% NegHi) Plot Reference: 9) Bending < User (OPE,Bending) Case 3
25%		
Pl+Pb+Q 74 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -29. (55% Neg, 0% NegHi) Plot Reference: 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
21%		
Pl+Pb+Q 73 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -29. (55% Neg, 0% NegHi) Plot Reference: 11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
21%		
Pl+Pb+Q+F 74 MPa	Damage Ratio 0.000 Life 0.096 Stress	Primary+Secondary+Peak (Inner) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 567.5 Mark1 Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 6,294,933.
Allowable 770.9 MPa		

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9%		WRC 474 99% Probability Cycles = 1,462,370. WRC 474 95% Probability Cycles = 2,030,317. BS5500 Allowed Cycles(Curve F) = 1,906,701. Membrane-to-Bending Ratio = 0.239 Bending-to-PL+PB+Q Ratio = 0.807 Plot Reference: 12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Pl+Pb+Q+F 73 MPa	Damage Ratio 0.000 Life 0.094 Stress	Primary+Secondary+Peak (Outer) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 567.5 Markl Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 6,843,380. WRC 474 99% Probability Cycles = 1,589,780. WRC 474 95% Probability Cycles = 2,207,209. BS5500 Allowed Cycles(Curve F) = 2,014,515. Membrane-to-Bending Ratio = 0.379 Bending-to-PL+PB+Q Ratio = 0.725 Plot Reference: 13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
Allowable 770.9 MPa		
9%		
Circ Plate for Plate # 3		
Pl 146 MPa	SPL 168 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -189. (76% Neg, 47% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
86%		
Qb 162 MPa	SPS 340 MPa	Primary Bending Load Case 2 Min Prin. Stress = -189. (76% Neg, 47% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
47%		
Pl+Pb+Q 256 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -189. (76% Neg, 47% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
75%		
Pl+Pb+Q 154 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -189. (76% Neg, 47% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
45%		
S1+S2+S3 147 MPa	4S 448 MPa	Part 5 (5.3.2) Load Case 2 Min Prin. Stress = -189. (76% Neg, 47% NegHi) Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
32%		
Pl+Pb+Q 256 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -189. (76% Neg, 47% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
75%		
Pl+Pb+Q 154 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -189. (76% Neg, 47% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
45%		
Membrane 146 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -189. (76% Neg, 47% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3

 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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42%			
Bending	User	Component Evaluation Load Case 3	
162	340	Min Prin. Stress = -189. (76% Neg, 47% NegHi)	
MPa	MPa	Plot Reference:	
		9) Bending < User (OPE,Bending) Case 3	
47%			
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 4	
132	340	Min Prin. Stress = -105. (99% Neg, 54% NegHi)	
MPa	MPa	Plot Reference:	
		10) Pl+Pb+Q < SPS (EXP,Inside) Case 4	
38%			
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 4	
100	340	Min Prin. Stress = -105. (99% Neg, 54% NegHi)	
MPa	MPa	Plot Reference:	
		11) Pl+Pb+Q < SPS (EXP,Outside) Case 4	
29%			
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4	
132	0.000 Life	Stress Concentration Factor = 1.000	
MPa	0.172 Stress	Strain Concentration Factor = 1.000	
		Cycles Allowed for this Stress = 1.0000E11	
Allowable		"B31" Fatigue Stress Allowable = 567.5	
770.9		MarkI Fatigue Stress Allowable = 659.5	
MPa		WRC 474 Mean Cycles to Failure = 2,294,650.	
		WRC 474 99% Probability Cycles = 533,068.	
17%		WRC 474 95% Probability Cycles = 740,098.	
		BS5500 Allowed Cycles(Curve F) = 399,227.	
		Membrane-to-Bending Ratio = 1.204	
		Bending-to-PL+PB+Q Ratio = 0.454	
		Plot Reference:	
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4	
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4	
100	0.000 Life	Stress Concentration Factor = 1.000	
MPa	0.130 Stress	Strain Concentration Factor = 1.000	
		Cycles Allowed for this Stress = 1.0000E11	
Allowable		"B31" Fatigue Stress Allowable = 567.5	
770.9		MarkI Fatigue Stress Allowable = 659.5	
MPa		WRC 474 Mean Cycles to Failure = 5,276,676.	
		WRC 474 99% Probability Cycles = 1,225,820.	
12%		WRC 474 95% Probability Cycles = 1,701,896.	
		BS5500 Allowed Cycles(Curve F) = 925,016.	
		Membrane-to-Bending Ratio = 26.654	
		Bending-to-PL+PB+Q Ratio = 0.036	
		Plot Reference:	
		13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4	
Circ Plate for Plate # 4			
Pl	SPL	Primary Membrane Load Case 2	
122	168	Min Prin. Stress = -172. (69% Neg, 22% NegHi)	
MPa	MPa	Plot Reference:	
		1) Pl < SPL (SUS,Membrane) Case 2	
72%			
Qb	SPS	Primary Bending Load Case 2	
129	340	Min Prin. Stress = -172. (69% Neg, 22% NegHi)	
MPa	MPa	Plot Reference:	
		2) Qb < SPS (SUS,Bending) Case 2	
37%			
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 2	
211	340	Min Prin. Stress = -172. (69% Neg, 22% NegHi)	
MPa	MPa	Plot Reference:	
		3) Pl+Pb+Q < SPS (SUS,Inside) Case 2	
61%			
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2	

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149 MPa	340 MPa	Min Prin. Stress = -172. (69% Neg, 22% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
43%		
S1+S2+S3 151 MPa	4S 448 MPa	Part 5 (5.3.2) Load Case 2 Min Prin. Stress = -172. (69% Neg, 22% NegHi) Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
33%		
Pl+Pb+Q 211 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -172. (69% Neg, 22% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
61%		
Pl+Pb+Q 149 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -172. (69% Neg, 22% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
43%		
Membrane 122 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -172. (69% Neg, 22% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
35%		
Bending 129 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -172. (69% Neg, 22% NegHi) Plot Reference: 9) Bending < User (OPE,Bending) Case 3
37%		
Pl+Pb+Q 108 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -73. (77% Neg, 22% NegHi) Plot Reference: 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
31%		
Pl+Pb+Q 106 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -73. (77% Neg, 22% NegHi) Plot Reference: 11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
31%		
Pl+Pb+Q+F 108 MPa	Damage Ratio 0.000 Life 0.140 Stress	Primary+Secondary+Peak (Inner) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 567.5 Mark1 Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 4,468,199. WRC 474 99% Probability Cycles = 1,038,003. WRC 474 95% Probability Cycles = 1,441,137. BS5500 Allowed Cycles(Curve F) = 736,712. Membrane-to-Bending Ratio = 0.786 Bending-to-PL+PB+Q Ratio = 0.560 Plot Reference: 12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Allowable 770.9 MPa		
13%		
Pl+Pb+Q+F 106 MPa	Damage Ratio 0.000 Life 0.137 Stress	Primary+Secondary+Peak (Outer) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.0000E11 "B31" Fatigue Stress Allowable = 567.5 Mark1 Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 4,657,004. WRC 474 99% Probability Cycles = 1,081,864. WRC 474 95% Probability Cycles = 1,502,033. BS5500 Allowed Cycles(Curve F) = 777,781.
Allowable 770.9 MPa		
13%		

	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 : 140 از 150	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V04

Membrane-to-Bending Ratio = 1.095
 Bending-to-PL+PB+Q Ratio = 0.477
 Plot Reference:
 13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4

Long Plate for Plate # 4

Pl 27 MPa	SPL 168 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -18. (75% Neg, 4% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
15%		
Qb 37 MPa	SPS 340 MPa	Primary Bending Load Case 2 Min Prin. Stress = -18. (75% Neg, 4% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
10%		
Pl+Pb+Q 38 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -18. (75% Neg, 4% NegHi) Plot Reference: 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
11%		
Pl+Pb+Q 46 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -18. (75% Neg, 4% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
13%		
S1+S2+S3 21 MPa	4S 448 MPa	Part 5 (5.3.2) Load Case 2 Min Prin. Stress = -18. (75% Neg, 4% NegHi) Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
4%		
Pl+Pb+Q 38 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -18. (75% Neg, 4% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
11%		
Pl+Pb+Q 46 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -18. (75% Neg, 4% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
13%		
Membrane 27 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -18. (75% Neg, 4% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
7%		
Bending 37 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -18. (75% Neg, 4% NegHi) Plot Reference: 9) Bending < User (OPE,Bending) Case 3
10%		
Pl+Pb+Q 32 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -14. (87% Neg, 5% NegHi) Plot Reference: 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
9%		
Pl+Pb+Q 20 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -14. (87% Neg, 5% NegHi) Plot Reference: 11) Pl+Pb+Q < SPS (EXP,Outside) Case 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 : 141 از 150
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	AA	120	PR	CN	0001	V04

5%		
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Inner) Load Case 4
32	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.042 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
770.9		"B31" Fatigue Stress Allowable = 567.5
MPa		Markl Fatigue Stress Allowable = 659.5
		WRC 474 Mean Cycles to Failure = 63,477,656.
		WRC 474 99% Probability Cycles = 14,746,436.
4%		WRC 474 95% Probability Cycles = 20,473,570.
		BS5500 Allowed Cycles(Curve F) = 27,561,694.
		Membrane-to-Bending Ratio = 0.845
		Bending-to-PL+PB+Q Ratio = 0.542
		Plot Reference:
		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Pl+Pb+Q+F	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4
20	0.000 Life	Stress Concentration Factor = 1.000
MPa	0.026 Stress	Strain Concentration Factor = 1.000
Allowable		Cycles Allowed for this Stress = 1.0000E11
770.9		"B31" Fatigue Stress Allowable = 567.5
MPa		Markl Fatigue Stress Allowable = 659.5
		WRC 474 Mean Cycles to Failure = 3.3666E8
		WRC 474 99% Probability Cycles = 78,208,688.
2%		WRC 474 95% Probability Cycles = 1.0858E8
		BS5500 Allowed Cycles(Curve F) = 2.8954E8
		Membrane-to-Bending Ratio = 0.834
		Bending-to-PL+PB+Q Ratio = 0.545
		Plot Reference:
		13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
Circ Plate for Plate # 5		
Pl	SPL	Primary Membrane Load Case 2
118	126	Min Prin. Stress = -7. (10% Neg, 2% NegHi)
MPa	MPa	Plot Reference:
		1) Pl < SPL (SUS,Membrane) Case 2
93%		
Qb	SPS	Primary Bending Load Case 2
41	298	Min Prin. Stress = -7. (10% Neg, 2% NegHi)
MPa	MPa	Plot Reference:
		2) Qb < SPS (SUS,Bending) Case 2
13%		
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 2
126	298	Min Prin. Stress = -7. (10% Neg, 2% NegHi)
MPa	MPa	Plot Reference:
		3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
42%		
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 2
123	298	Min Prin. Stress = -7. (10% Neg, 2% NegHi)
MPa	MPa	Plot Reference:
		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
41%		
Pl+Pb+Q	SPS	Primary+Secondary (Inner) Load Case 3
126	298	Min Prin. Stress = -7. (10% Neg, 2% NegHi)
MPa	MPa	Plot Reference:
		6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
42%		
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 3
123	298	Min Prin. Stress = -7. (10% Neg, 2% NegHi)
MPa	MPa	Plot Reference:
		7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
41%		
Membrane	User	Component Evaluation Load Case 3

 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	V04	

118 MPa	298 MPa	Min Prin. Stress = -7. (10% Neg, 2% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
39%		
Bending 41 MPa	User 298 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -7. (10% Neg, 2% NegHi) Plot Reference: 9) Bending < User (OPE,Bending) Case 3
13%		
Pl+Pb+Q 120 MPa	SPS 298 MPa	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -5. (7% Neg, 2% NegHi) Plot Reference: 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
40%		
Pl+Pb+Q 116 MPa	SPS 298 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -5. (7% Neg, 2% NegHi) Plot Reference: 11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
38%		
Pl+Pb+Q+F 120 MPa	Damage Ratio 0.000 Life 0.227 Stress	Primary+Secondary+Peak (Inner) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 1.3893E8 "B31" Fatigue Stress Allowable = 0.0 Mark1 Fatigue Stress Allowable = 575.0 WRC 474 Mean Cycles to Failure = 2,470,444. WRC 474 99% Probability Cycles = 573,907. WRC 474 95% Probability Cycles = 796,797. BS5500 Allowed Cycles(Curve F) = 541,237. Membrane-to-Bending Ratio = 66.351 Bending-to-PL+PB+Q Ratio = 0.015 Plot Reference: 12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
Allowable 526.2 MPa		
22%		
Pl+Pb+Q+F 116 MPa	Damage Ratio 0.000 Life 0.221 Stress	Primary+Secondary+Peak (Outer) Load Case 4 Stress Concentration Factor = 1.000 Strain Concentration Factor = 1.000 Cycles Allowed for this Stress = 2.4288E8 "B31" Fatigue Stress Allowable = 0.0 Mark1 Fatigue Stress Allowable = 575.0 WRC 474 Mean Cycles to Failure = 2,701,216. WRC 474 99% Probability Cycles = 627,517. WRC 474 95% Probability Cycles = 871,228. BS5500 Allowed Cycles(Curve F) = 589,676. Membrane-to-Bending Ratio = 66.363 Bending-to-PL+PB+Q Ratio = 0.015 Plot Reference: 13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
Allowable 526.2 MPa		
22%		

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Compressive Stress Summary
FEPipe Version 15.0
Released Jan. 2021

Jobname: setup2
2:42pm NOV 25, 2024

\$P

Compressive Stress Summary (MPa) \$X

Nomenclature:

Min Stress - Compressive Membrane and Bending Stress
Pts in Region - No. of nodes in the model region

 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	V04	

>5% Compression - 5% or more of Compressive Stress Limit
>50% Compression - 50% or more of Compressive Stress Limit

Compressive Stress Limit = $-0.55 \text{ Min}(S_y, kE_t/R)$, Section slenderness ratio (elastic buckling) not considered.

#	Load Type	Case	Min Stress	Pts in Region	>5% Compression and Bending	>50% Compression and Bending	Region
1	SUSTAINED	2	-51.	2560	57%	0%	Circ Plate for Plate # 1
2	OPERATING	3	-51.	2560	57%	0%	Circ Plate for Plate # 1
3	EXPANSION	4	-35.	2560	57%	0%	Circ Plate for Plate # 1
4	SUSTAINED	2	-125.	13480	92%	27%	Long Plate for Plate # 1
5	OPERATING	3	-125.	13480	92%	27%	Long Plate for Plate # 1
6	EXPANSION	4	-64.	13480	90%	22%	Long Plate for Plate # 1
7	SUSTAINED	2	-31.	1800	58%	0%	Circ Plate for Plate # 2
8	OPERATING	3	-31.	1800	58%	0%	Circ Plate for Plate # 2
9	EXPANSION	4	-29.	1800	55%	0%	Circ Plate for Plate # 2
10	SUSTAINED	2	-189.	1600	76%	47%	Circ Plate for Plate # 3
11	OPERATING	3	-189.	1600	76%	47%	Circ Plate for Plate # 3
12	EXPANSION	4	-105.	1600	99%	54%	Circ Plate for Plate # 3
13	SUSTAINED	2	-172.	1440	69%	22%	Circ Plate for Plate # 4
14	OPERATING	3	-172.	1440	69%	22%	Circ Plate for Plate # 4
15	EXPANSION	4	-73.	1440	77%	22%	Circ Plate for Plate # 4
16	SUSTAINED	2	-18.	640	75%	4%	Long Plate for Plate # 4
17	OPERATING	3	-18.	640	75%	4%	Long Plate for Plate # 4
18	EXPANSION	4	-14.	640	87%	5%	Long Plate for Plate # 4
19	SUSTAINED	2	-7.	13680	10%	2%	Circ Plate for Plate # 5
20	OPERATING	3	-7.	13680	10%	2%	Circ Plate for Plate # 5
21	EXPANSION	4	-5.	13680	7%	2%	Circ Plate for Plate # 5

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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:

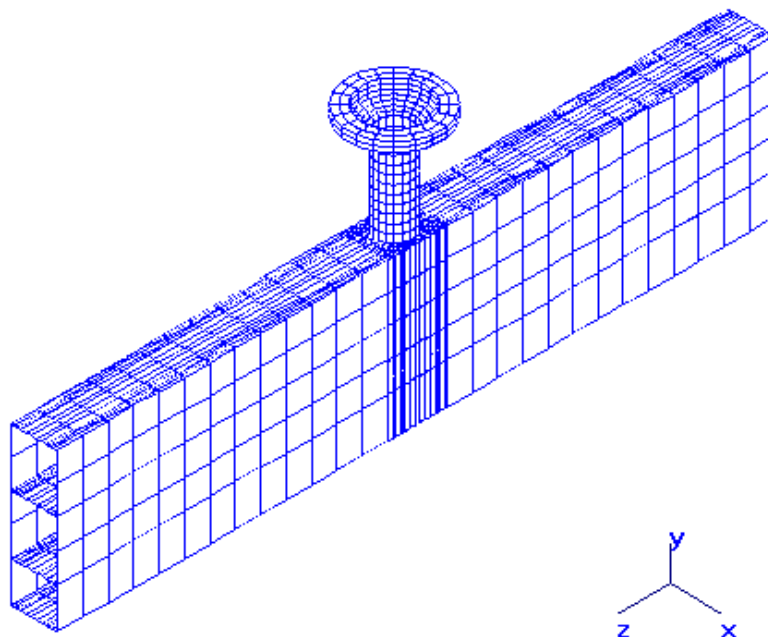
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Thermal/Mechanical Calculation Book

پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
BK	GCS	AA	120	PR	CN	0001	V04

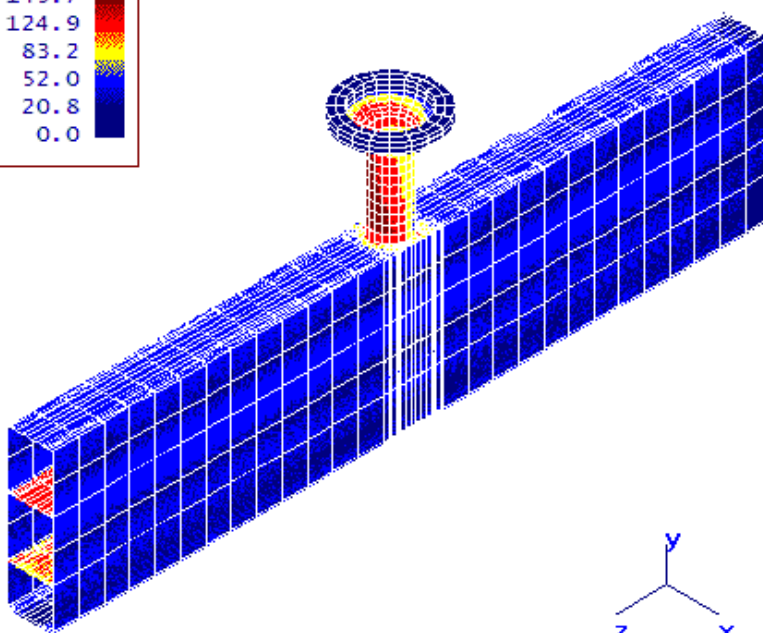
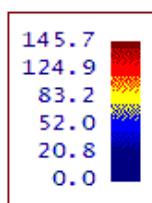
شماره صفحه : 144 از 150

Finite Element Model



3d

1) P1 < SPL (SUS Membrane) Case 2

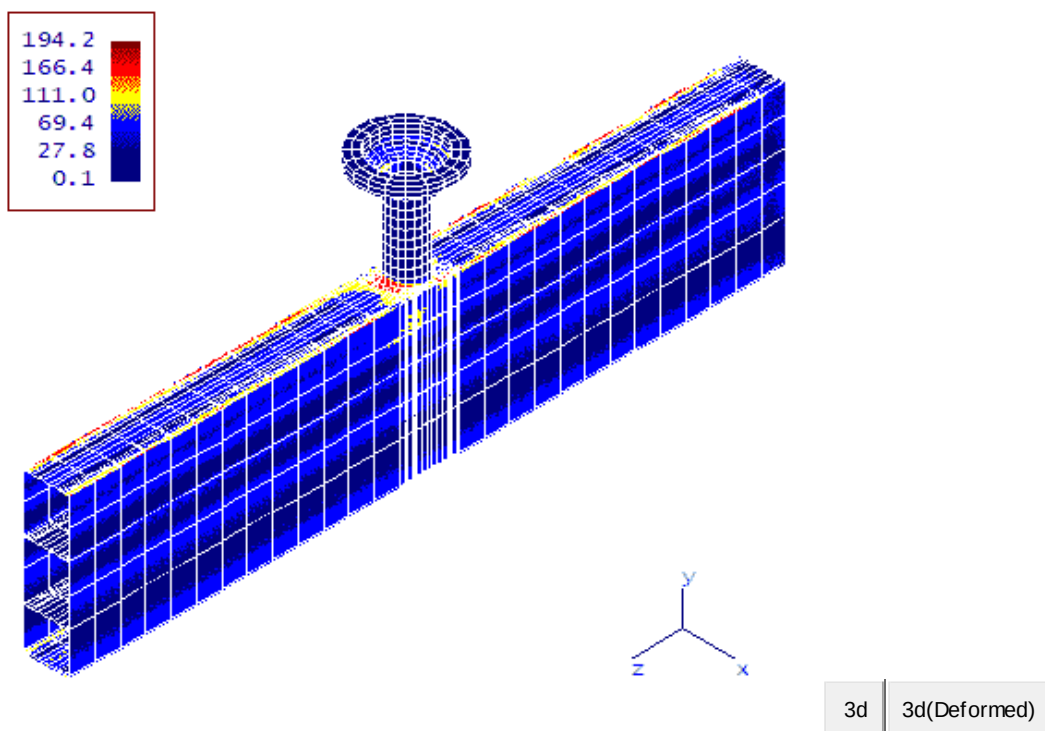


3d

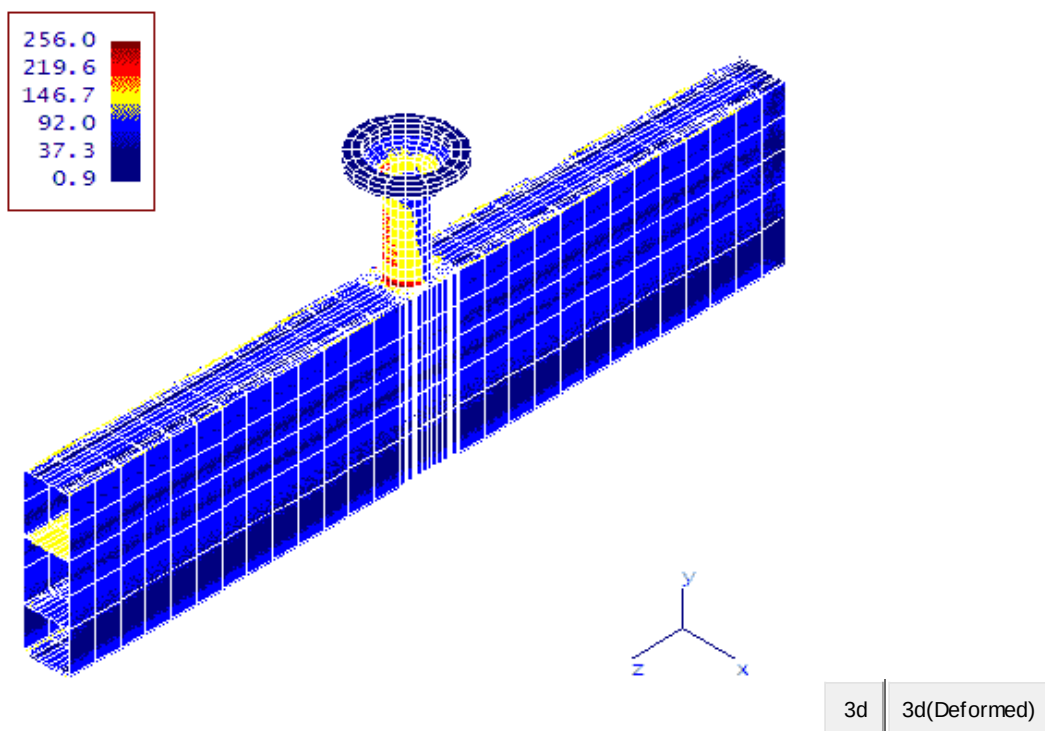
3d(Deformed)

 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	V04	

2) Qb < SPS (SUS Bending) Case 2



3) P1+Pb+Q < SPS (SUS Inside) Case 2





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:

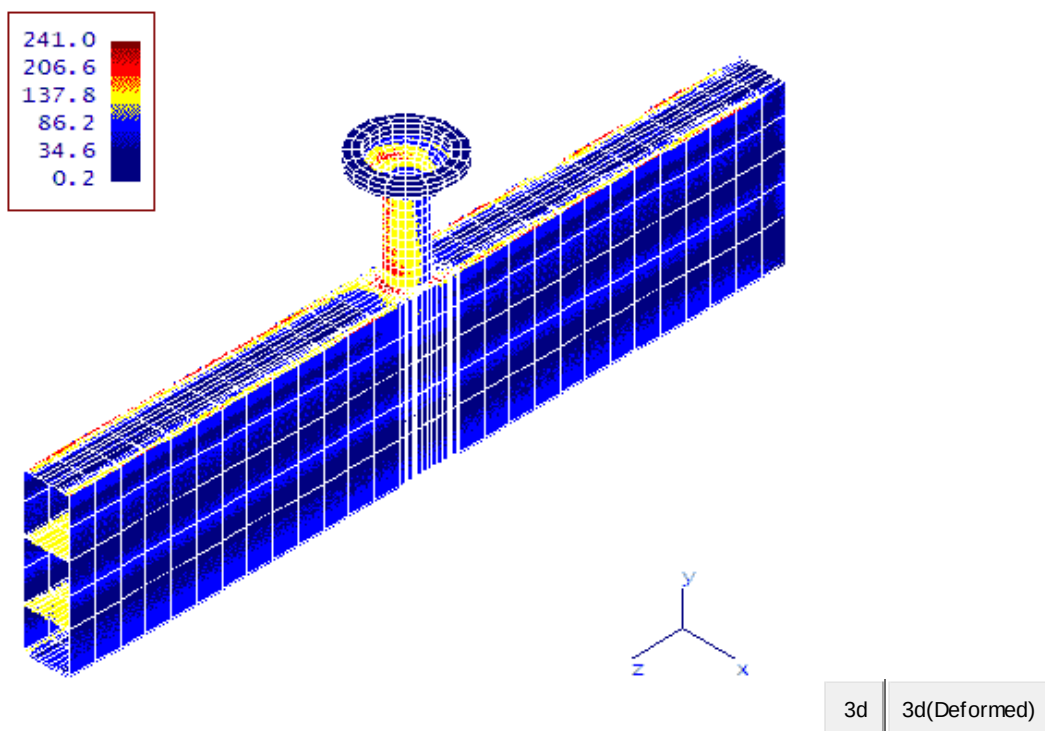
053 - 073 - 9184

Thermal/Mechanical Calculation Book

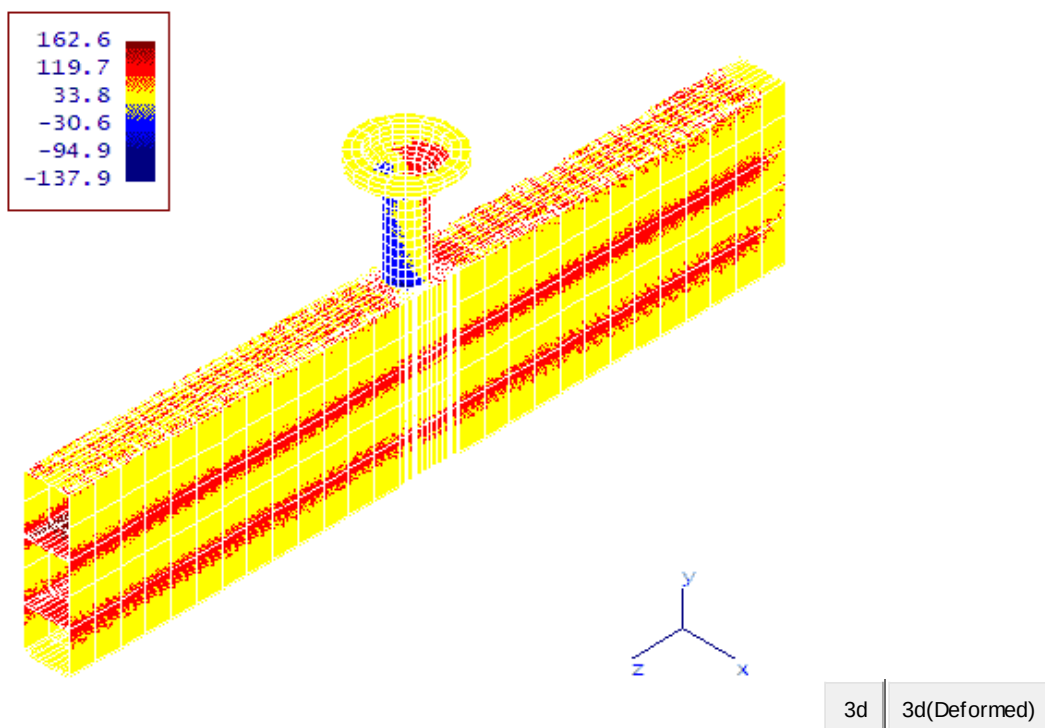
پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
BK	GCS	AA	120	PR	CN	0001	V04

شماره صفحه : 146 از 150

4) P1+Pb+Q < SPS (SUS Outside) Case 2



5) S1+S2+S3 < 4S (SUS S1+S2+S3) Case 2





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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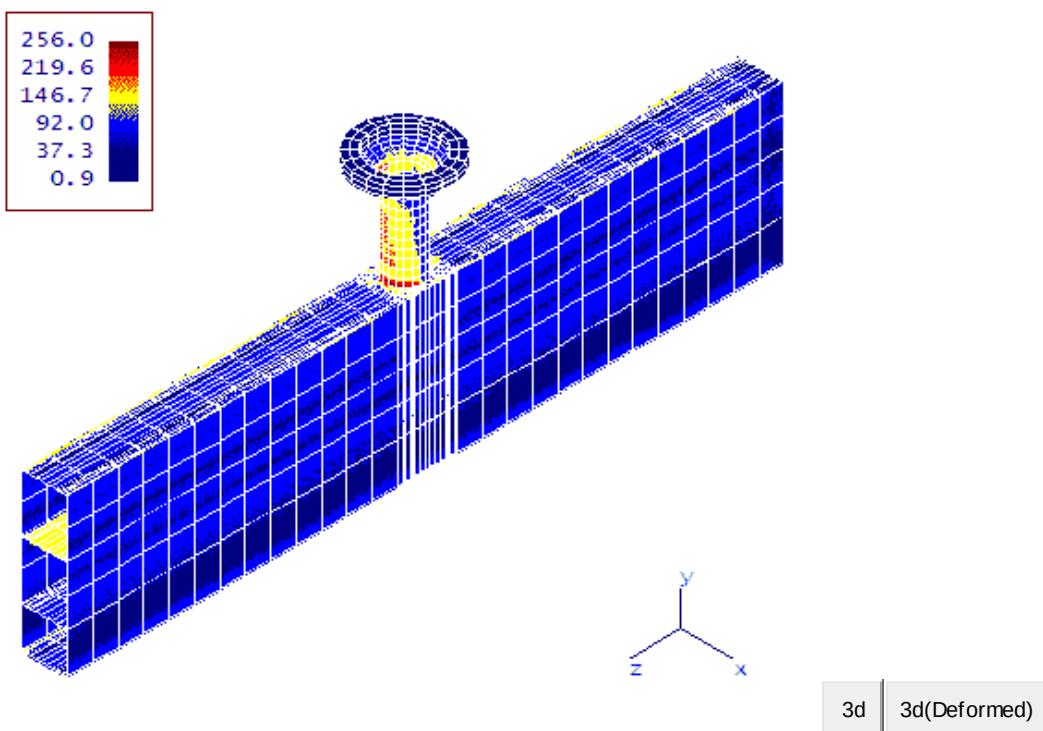
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Thermal/Mechanical Calculation Book

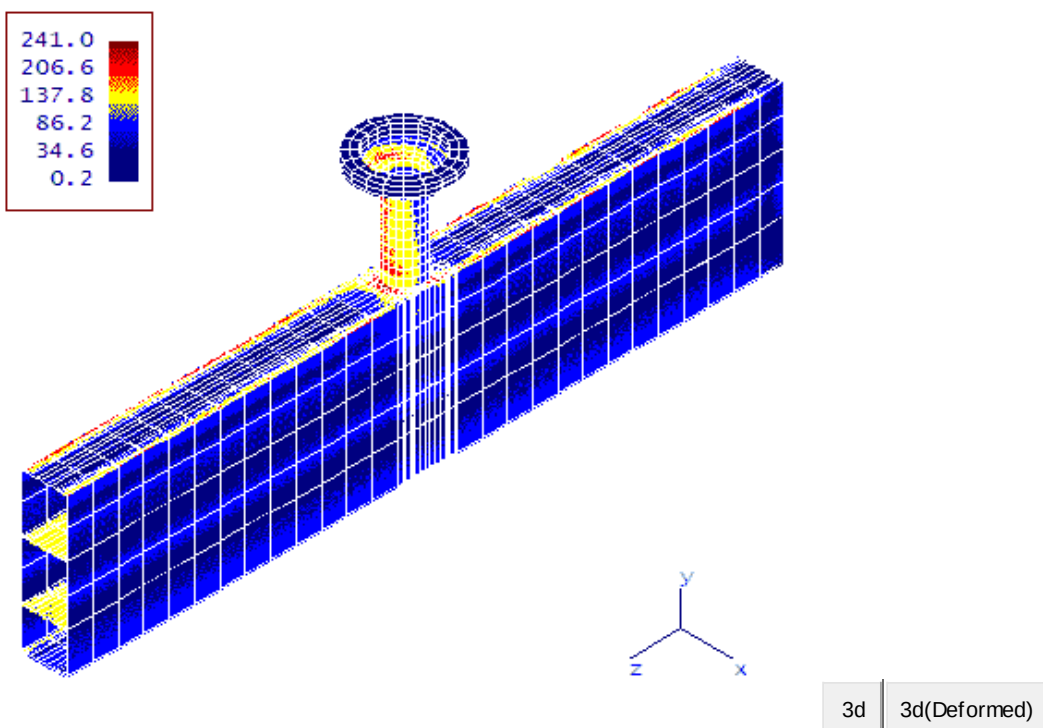
پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
BK	GCS	AA	120	PR	CN	0001	V04

شماره صفحه : 147 از 150

6) P1+Pb+Q < SPS (OPE Inside) Case 3

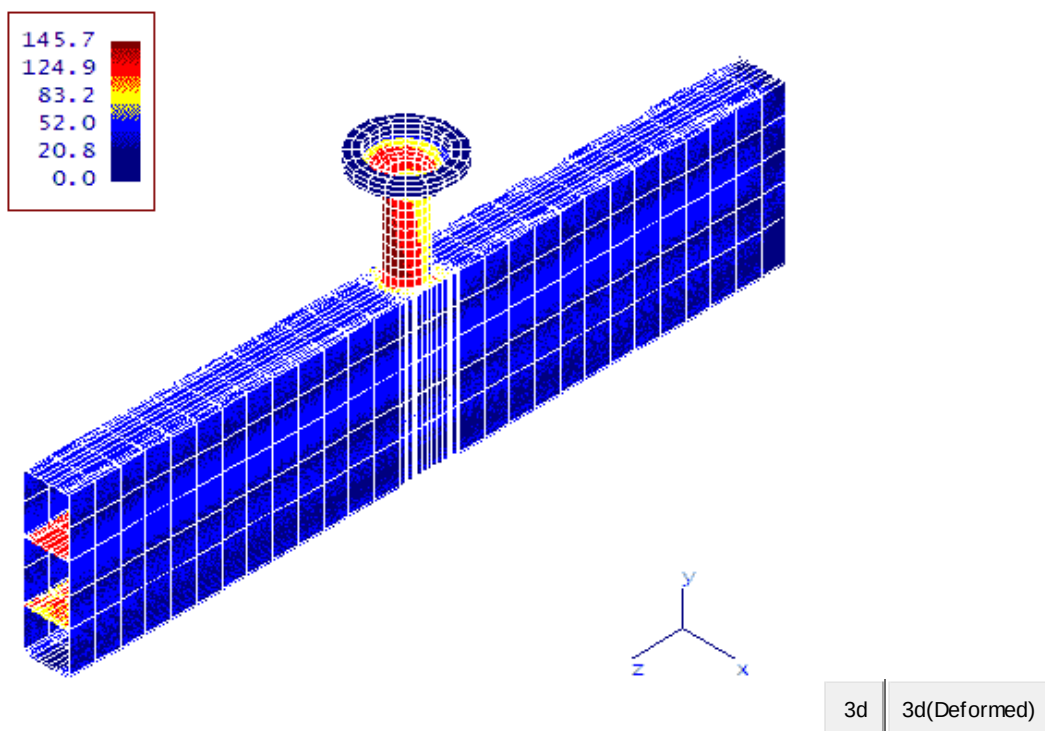


7) P1+Pb+Q < SPS (OPE Outside) Case 3

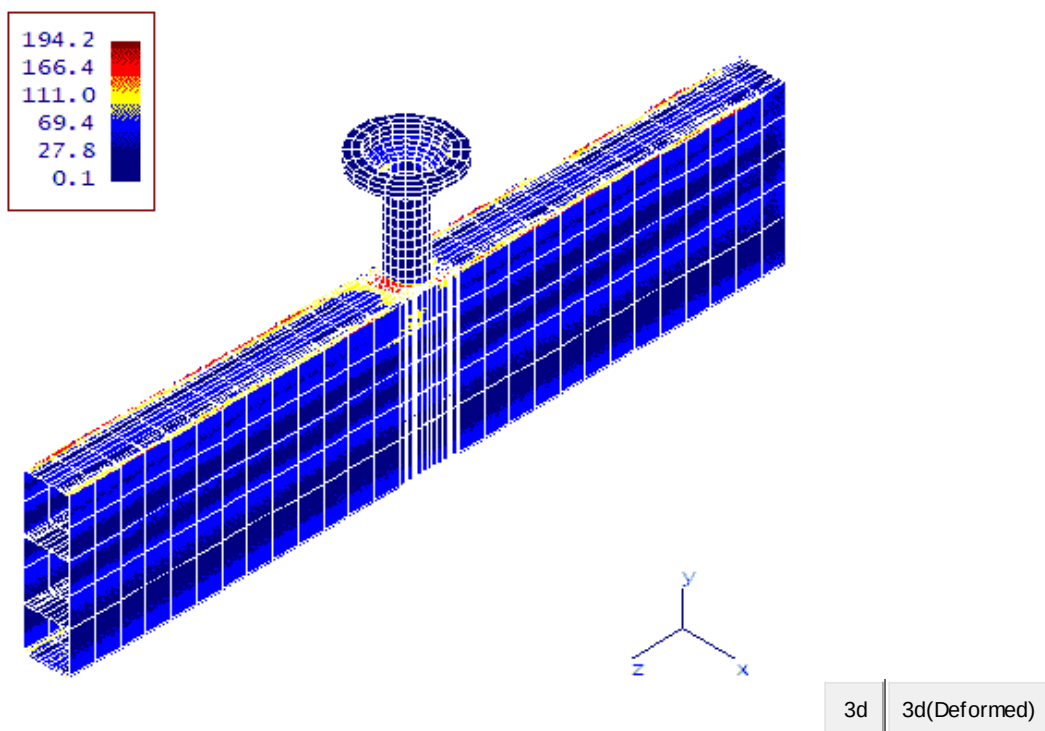


 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	BK	GCS	AA	120	PR	CN	0001	V04	

8) Membrane < User (OPE Membrane) Case 3



9) Bending < User (OPE Bending) Case 3





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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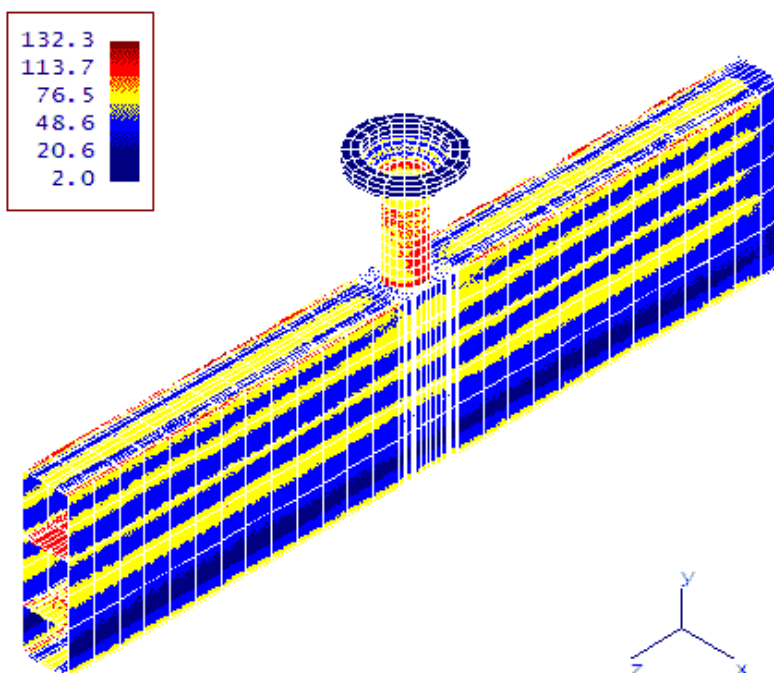
053-073-9184

Thermal/Mechanical Calculation Book

پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
BK	GCS	AA	120	PR	CN	0001	V04

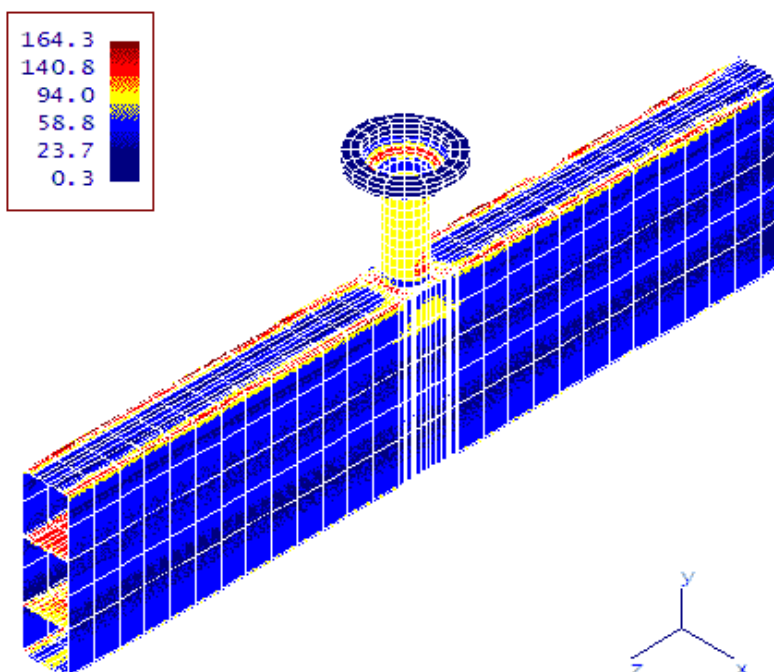
شماره صفحه : 149 از 150

10) P1+Pb+Q < SPS (EXP Inside) Case 4



3d

11) P1+Pb+Q < SPS (EXP Outside) Case 4



3d



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:

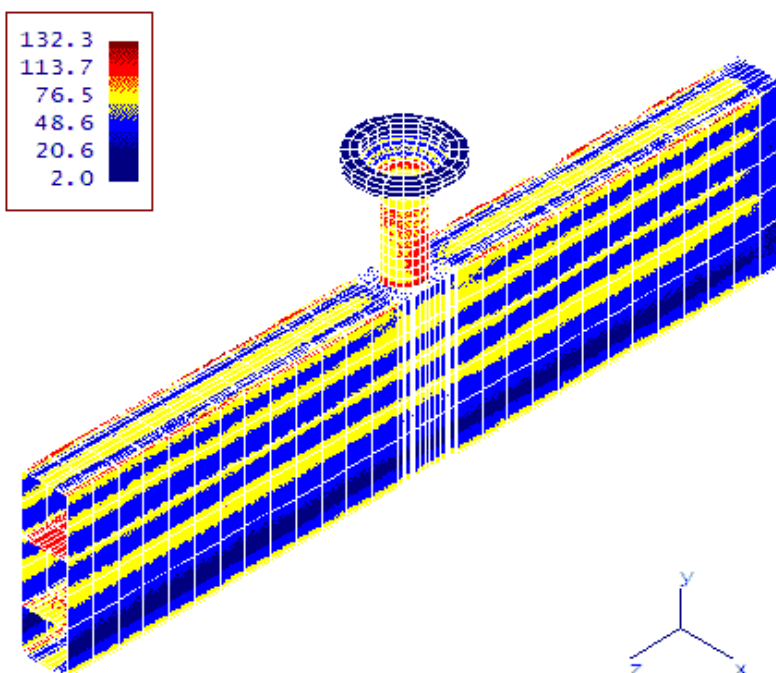
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Thermal/Mechanical Calculation Book

پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
BK	GCS	AA	120	PR	CN	0001	V04

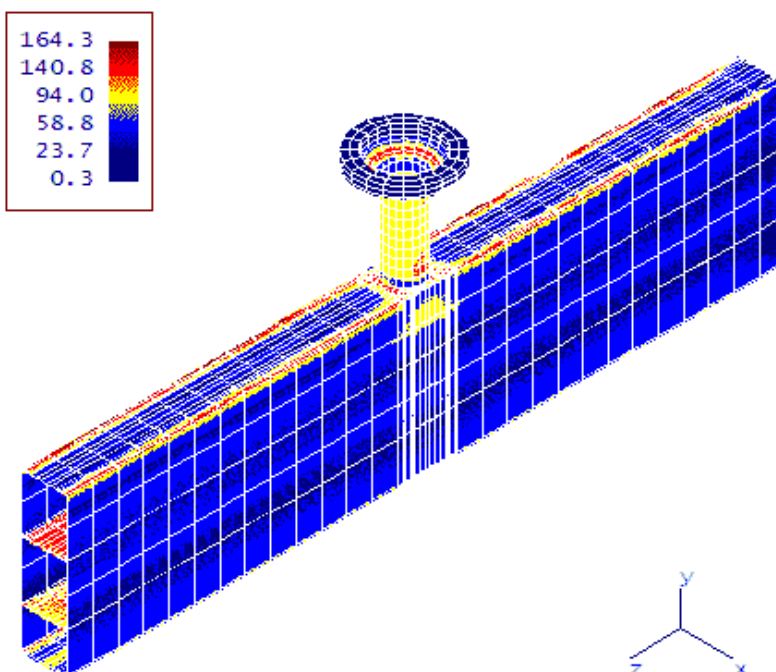
شماره صفحه : 150 از 150

12) P1+Pb+Q+F < 25a (EXP Inside) Case 4



3d

13) P1+Pb+Q+F < 25a (EXP Outside) Case 4



3d