

 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	V05	

طرح نگهداشت و افزایش تولید 27 مخزن

Thermal/Mechanical Calculation Book

نگهداشت و افزایش تولید میدان نفتی بینک

V05	Jan.2025	AFC	AAC	M.FAKHARIAN	S.FRAMARZPOUR	
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

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

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1	X	X	X	X	X	X
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3	X		X	X	X	
4	X		X	X	X	X
5	X	X	X		X	
6	X	X	X	X	X	
7	X	X	X	X	X	
8	X	X	X	X	X	
9			X	X	X	X
10			X	X	X	X
11			X	X	X	
12			X	X	X	
13			X	X	X	
14			X	X	X	
15			X	X	X	
16			X	X	X	
17			X	X	X	
18			X	X	X	
19			X	X	X	
20			X	X	X	
21			X	X	X	
22			X	X	X	
23			X	X	X	
24			X	X	X	
25			X	X	X	
26			X	X	X	
27			X	X	X	
28			X	X	X	
29			X	X	X	
30			X	X	X	
31			X	X	X	
32			X	X	X	
33			X	X	X	
34			X		X	
35			X		X	
36			X		X	
37			X		X	
38			X		X	
39			X		X	
40			X		X	
41			X		X	
42			X		X	
43			X		X	
44			X		X	
45			X		X	
46			X		X	
47			X		X	
48			X		X	
49			X		X	
50			X		X	
51			X		X	
52			X		X	
53			X		X	
54			X	X	X	
55			X	X	X	
56			X	X	X	
57			X	X	X	
58			X	X	X	
59			X	X	X	
60			X	X	X	
61			X	X	X	
62			X	X	X	
63			X	X	X	
64			X	X	X	
65			X	X	X	

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70			X	X	X	
71			X	X	X	
72			X	X	X	
73			X	X	X	
74			X	X	X	
75			X		X	
76			X		X	
77			X		X	
78			X		X	
79			X		X	
80			X		X	
81			X		X	
82			X		X	
83			X		X	
84			X		X	
85			X		X	
86			X		X	
87			X		X	
88			X		X	
89			X		X	
90			X		X	
91			X		X	
92			X		X	
93					X	
94				X	X	
95				X	X	
96				X	X	
97				X	X	
98				X	X	
99				X	X	
100				X	X	
101				X	X	
102				X	X	
103				X	X	
104				X	X	
105				X	X	
106				X	X	
107				X	X	
108				X	X	
109				X	X	
110				X	X	
111				X	X	
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114				X	X	
115				X	X	
116				X	X	
117				X	X	
118				X	X	
119				X	X	
120				X	X	
121				X	X	
122				X	X	
123				X	X	
124				X	X	
125				X	X	
126				X	X	
127				X	X	
128				X	X	
129				X	X	
130				X	X	

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)																									
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1.0 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.

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	BK	GCS	AA	120	PR	CN	0001	V05	

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 1/26/2025		V05	
Proposal No. _____		Contract No. _____			
Inquiry No. _____		Order No. _____			
Manufacturer _____ Model no. _____ Customer PEDCO/NISOC Plant location BINA K Oilfield Service 1st stage Gas Compression Cool 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, EFL (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 _____		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	/ 9530.4	
Dew/bubble point (Deg. C)	/	Water/Steam (kg/hr)	/	/	0
Latent heat (kJ/kg)		Noncondensables (kg/hr)	/	/	0
Inlet pressure (barG)	17.9	Molecular Wt. (Vap/Non-cond)	/	/	
Pressure drop (AII/Calc) (bar)	0.7 / 0.473	Density (Liq/Vap) (kg/m3)	/ 14.197	/ 17.141	
Velocity (AIIow/Calc) (m/s)	/ 17.09	Specific heat (Liq/Vap) (kJ/kg-C)	/ 2.2057	/ 1.9724	
Inside fouling resistance (m2-K/W)	0.0002	Thermal cond. (Liq/Vap) (W/m-K)	/ 0.0438	/ 0.0336	
Temperature (Deg. C)	In 129 Out 60	Viscosity (Liq/Vap) (mN-s/m2)	/ 0.0137	/ 0.0117	
Performance Data - Air Side					
Air inlet temperature (Deg. C)	50.26	Face velocity (m/s)	2.9		
Air flow rate/item (m3/s)	24.446	Minimum design ambient temp. (Deg. C)	5		
Mass velocity (kg/s-m2)		Altitude (m)	12.5		
Air outlet temperature (Deg. C)	65.15	Static pressure (Pa)	138.77		
Air flow rate/fan (m3/s)	12.223				
Design, Material, and Construction					
Design pressure (barG)	22	Heating Coil	NO		
Test pressure (barG)	28.6	No. of tubes			
Design temperature (Deg. C)	155	Tube outside diameter (mm)			
Min. design metal temp. (Deg. C)		Tube material			
Tube bundle		Fin material and type			
Size (WxL) (m)	1.922X 3.8	Fin thickness (mm)			
No./Bay	1	ASME Code, Sec. VIII, Div. 1			
Number of tube row s	4	Heating fluid			
Bundles in parallel	1	Heating fluid flow rate (kg/hr)			
Bundles in series		Temperature (In/Out) (Deg. C)	/		
Structure mounting		Inlet pressure (barG)			
Pipe rack beams		Pressure drop (AII/Calc) (kPa)	/		
Ladders, walkways, platforms		Design temperature (Deg. C)			
Structure surface prep.		Design pressure (barG)			
Header surface prep.		Inlet/Outlet nozzle	/		
Louver	YES	Header			
Material		Type	Plug		
Action control	Manual	Material	SA-240 TP316L		
Action type		Corrosion Allowance (mm)	0		
		No. of passes	4		

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		API 661 Air-Cooled Heat Exchanger - Specification Sheet				
		Job No.			Item No.	2101 (summer)
		Page			By	
		Date			Revision	V05
		Proposal No.			Contract No.	
		Inquiry No.			Order No.	
Design, Material, and Construction (continued)						
Header (continued)			No./Bundle			
Slope			1% ON LAST PASS			
Plug material			SA 182 F316L			
Gasket material			Solid metal			
Nozzle			Layout			
No.	Size, (In)	Rating/Facing	Triangular			
Inlet	1	6 300 RF	Fin			
Outlet	1	6 300 RF	Type			
Vent	1	2 300 RF	Material			
Drain	1	2 300 RF	Thickness			
Chemical Cleaning			Selection temp.			
Min. Wall Thk.			Outside diameter			
Tube			Fin density			
Material	SA-213 TP316L Tube (S) S31603		ASME Code, Sec. VIII, Div. 1			
Tube outside diameter	(mm)	25.4	Customer Specifications			
Wall thickness	(mm)	1.651				
Mechanical Equipment						
Fan			RPM			
Manufacturer			1500			
No./Bay	2		Service factor			
RPM	(Revs/min.)	626.4	Enclosure			
Diameter	(mm)	1372	Voltage			
No. of blades	4		Phase			
Angle	(degrees)		Cycle			
Pitch adjustment	50% Auto		Fan noise level			
Blade material	AL		(dB)			
Hub material	ALU/Steel		Speed Reducer			
@design temp	2.6		Type			
@min. ambient temp	3.5		Manufacturer			
Tip speed			No./Bay			
Driver			Service factor			
Type			Speed ratio			
Manufacturer			Support			
No./Bay	2		Vib. Switch			
Driver	(kW)	5.5	Enclosure			
Controls - Air Side						
Air recirculation			Lower			
Degree control of outlet process temp.			Positioner			
(Max. Cooling), +/-			Signal air pressure (barG)			
Action on control signal failure			From			
Fan pitch			From			
Louvers			Supply air pressure (barG)			
Actuator air supply			From			
Fan			From			
Shipping						
Plot area (WxL)			Total			
(m)			(kg)			
Bundle weight			Shipping			
(kg)			(kg)			
Bay						
Note: 1) Reported duty and flow rates include a user-specified multiplier of 1.10 2-Max allowable nozzle load = 3xAPI 3-Material will be meet requirements of NACE MR0175/ISO1516 and specification for material requirements in sour service (BK-GNRL-PEDCO-000-PI-SP-0008) 4-HTRI Weight is reported						

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		API 661 Air-Cooled Heat Exchanger - Specification Sheet			
Job No. _____ Page _____ Date <u>1/26/2025</u> Proposal No. _____ Inquiry No. _____		Item No. <u>2101 (w/inter)</u> By _____ Revision <u>V05</u> Contract No. _____ Order No. _____			
Manufacturer _____ Model no. _____ Customer <u>PEDCO/NISOC</u> Plant location <u>Binak oilfield</u> Service <u>1st stage Gas Compression Cooler</u> Type draft <u>INDUCED</u> Bay size (WxL) (m) <u>1.966 x 3.8</u> No. of bays/items <u>1</u>		Heat exchanged (MegaWatts) <u>0.276</u> Surface/Item-Finned tube (m ²) <u>668.71</u> Bare tube (m ²) <u>31.536</u> MTD, Eff. (Deg. C) <u>26.3</u> Transfer rate-Finned (W/m ² -K) <u>19.37</u> Bare tube, service (W/m ² -K) <u>410.75</u> Bare tube, clean (W/m ² -K) <u>458.48</u>			
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 <u>HYDROCARBON</u> Total fluid entering (kg/hr) <u>7585 x 1.1</u> Dew /bubble point (Deg. C) <u>/</u> Latent heat (kJ/kg) _____ Inlet pressure (barG) <u>17.9</u> Pressure drop (All/Calc) (bar) <u>0.7 / 0.416</u> Velocity (Allow /Calc) (m/s) <u>/ 16.06</u> Inside fouling resistance (m ² -K/W) <u>0.0002</u> Temperature (Deg. C) <u>In 116 Out 60</u>		In _____ Out _____ Total flow rate (Liq/Vap) (kg/hr) <u>/ 8343.5</u> Water/Steam (kg/hr) <u>/</u> Noncondensables (kg/hr) _____ Molecular Wt. (Vap/Non-cond) _____ Density (Liq/Vap) (kg/m ³) <u>/ 12.847</u> Specific heat (Liq/Vap) (kJ/kg-C) <u>/ 2.2197</u> Thermal cond. (Liq/Vap) (W/m-K) <u>/ 0.0441</u> Viscosity (Liq/Vap) (mN-s/m ²) <u>/ 0.0137</u> Density (Liq/Vap) (kg/m ³) <u>/ 14.916</u> Specific heat (Liq/Vap) (kJ/kg-C) <u>/ 2.0293</u> Thermal cond. (Liq/Vap) (W/m-K) <u>/ 0.0356</u> Viscosity (Liq/Vap) (mN-s/m ²) <u>/ 0.0121</u>			
Performance Data - Air Side					
Air inlet temperature (Deg. C) <u>50.26</u> Air flow rate/item (m ³ /s) <u>24.148</u> Mass velocity (kg/s-m ²) _____ Air outlet temperature (Deg. C) <u>61.02</u> Air flow rate/fan (m ³ /s) <u>12.074</u>		Face velocity (m/s) <u>2.9</u> Minimum design ambient temp. (Deg. C) <u>5</u> Altitude (m) <u>12.5</u> Static pressure (Pa) <u>137.4</u>			
Design, Material, and Construction					
Design pressure (barG) <u>22</u> Test pressure (barG) <u>28.6</u> Design temperature (Deg. C) <u>155</u> Min. design metal temp. (Deg. C) _____ Tube bundle Size (WxL) (m) <u>1.922X 3.80</u> No./Bay <u>1</u> Number of tube row s <u>4</u> Bundles in parallel <u>1</u> Bundles in series _____ Structure mounting _____ Pipe rack beams _____ Ladders, w/alk ways, platforms _____ Structure surface prep. _____ Header surface prep. _____ Louver <u>YES</u> Material _____ Action control <u>Manual</u> Action type _____		Heating Coil <u>NO</u> 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) <u>/</u> Inlet pressure (barG) _____ Pressure drop (All/Calc) (kPa) <u>/</u> Design temperature (Deg. C) _____ Design pressure (barG) _____ Inlet/Outlet nozzle <u>/</u> Header Type _____ Material <u>SA-240 TP316L</u> Corrosion Allow ance (mm) <u>0</u> No. of passes <u>4</u>			

 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: 8 از 148
شماره پیمان: 053-073-9184	پروژه BK بسته کاری GCS صادر کننده AA تسهیلات 120 رشته PR نوع مدرک CN سریال 0001 نسخه V05		

		API 661 Air-Cooled Heat Exchanger - Specification Sheet																						
		Job No. _____ Page _____ Date 1/26/2025 Proposal No. _____ Inquiry No. _____	Item No. 2101 (w inter) By _____ Revision V05 Contract No. _____ Order No. _____																					
Design, Material, and Construction (continued)																								
Header (continued) Slope 1% ON LAST PASS Plug material SA 182 F316L Gasket material Solid Metal 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>300RF</td> </tr> <tr> <td>Vent 1</td> <td>2</td> <td>300RF</td> </tr> <tr> <td>Drain 1</td> <td>2</td> <td>300RF</td> </tr> <tr> <td>Chemical Cleaning</td> <td></td> <td></td> </tr> <tr> <td>Min. Wall Thk.</td> <td></td> <td></td> </tr> </tbody> </table> Tube Material SA-213 TP316L Tube (S) S31603 Tube outside diameter (mm) 25.4 wall thickness (mm) 1.651		No.	Size, (in)	Rating/Facing	Inlet 1	6	300 RF	Outlet 1	6	300RF	Vent 1	2	300RF	Drain 1	2	300RF	Chemical Cleaning			Min. Wall Thk.			No./Bundle 104 Length (m) 3.8 Pitch (mm) 63.5 Layout Triangular 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	300RF																						
Vent 1	2	300RF																						
Drain 1	2	300RF																						
Chemical Cleaning																								
Min. Wall Thk.																								
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 (IP 55) 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. sw itch 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-GNRAI-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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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

HTRI				API 661 Air-Cooled Heat Exchanger - Specification Sheet			
Job No.		Item No.		2102 (Summer)			
Page		By					
Date		Revision		v05			
Proposal No.		Contract No.					
Inquiry No.		Order No.					
Manufacturer		Heat exchanged (MegaWatts)		0.582			
Model no.		Surface/Item-Finned tube		1027			
Customer		Bare tube		(m2)		48.548	
Plant location		MTD, Eff.		(Deg. C)		31.2	
Service		Transfer rate-Finned		(W/m2-K)		5 18.267	
Type draft		Bare tube, service		(W/m2-K)		386.44	
Bay size (WxL)		Bare tube, clean		(W/m2-K)		428.51	
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/V ap) (kg/hr)		9530.4 / 41.263 / 9489.2	
Dew/bubble point (Deg. C)		/		Water/Steam (kg/hr)		/	
Noncondensables (kg/hr)		/		Noncondensables (kg/hr)		/	
Latent heat (kJ/kg)		/		Molecular Wt. (Vap/Non-cond)		/	
Inlet pressure (barG)		54.8		Density (Liq/Vap) (kg/m3)		42.156 / 981.96 / 60.185	
Pressure drop (All/Calc) (bar)		0.7 / 0.097		Specific heat (Liq/Vap) (kJ/kg-C)		2.4264 / 4.3096 / 2.4072	
Velocity (Allow /Calc) (m/s)		/ 3.56		Thermal cond. (Liq/Vap) (W/m-K)		0.0474 / 0.6515 / 0.0371	
Inside fouling resistance (m2-K/W)		0.0002		Viscosity (Liq/Vap) (mN-s/m2)		0.0164 / 0.4943 / 0.0142	
In		Out					
Temperature (Deg. C)		148 / 60					
Performance Data - Air Side							
Air inlet temperature (Deg. C)		50.26		Face velocity (m/s)		3.27	
Air flow rate/item (m3/s)		31.43		Minimum design ambient temp. (Deg. C)		5	
Mass velocity (kg/s-m2)		/		Altitude (m)		12.5	
Air outlet temperature (Deg. C)		68.06		Static pressure (Pa)		168.85	
Air flow rate/fan (m3/s)		15.714					
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)		2.12 X 3.9		Fin thickness (mm)			
No./Bay		1		ASME Code, Sec. V III, 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		/	
Cover				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 : 10 از 148	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

		API 661 Air-Cooled Heat Exchanger - Specification Sheet																
		Job No. _____	Item No. <u>2102 (Summer)</u>															
		Page _____	By _____															
		Date <u>1/26/2025</u>	Revision <u>V05</u>															
Proposal No. _____ Inquiry No. _____		Contract No. _____ Order No. _____																
Design, Material, and Construction (continued)																		
Header (continued) Slope <u>1% ON LAST PASS</u> Plug material <u>SA-182 F316 L</u> Gasket material <u>Solid METAL</u>		No./Bundle <u>156</u> Length (m) <u>3.9</u> Pitch (mm) <u>70.5</u> Layout <u>Triangular</u>																
Nozzle <table border="1"> <tr> <th>No.</th> <th>Size, (in)</th> <th>Rating/Facing</th> </tr> <tr> <td>Inlet <u>1</u></td> <td><u>4</u></td> <td><u>600 RF</u></td> </tr> <tr> <td>Outlet <u>1</u></td> <td><u>4</u></td> <td><u>600 RF</u></td> </tr> <tr> <td>Vent <u>1</u></td> <td><u>2</u></td> <td><u>600 RF</u></td> </tr> <tr> <td>Drain <u>1</u></td> <td><u>2</u></td> <td><u>600 RF</u></td> </tr> </table>		No.	Size, (in)	Rating/Facing	Inlet <u>1</u>	<u>4</u>	<u>600 RF</u>	Outlet <u>1</u>	<u>4</u>	<u>600 RF</u>	Vent <u>1</u>	<u>2</u>	<u>600 RF</u>	Drain <u>1</u>	<u>2</u>	<u>600 RF</u>	Fin Type <u>Extruded</u> Material <u>Aluminum Alloy 1060 - O</u> Thickness (mm) <u>0.48</u> Selection temp. (C) _____ Outside diameter (mm) <u>57.15</u> Fin density (fin/meter) <u>400</u> ASME Code, Sec. VIII, Div. 1 _____ Customer Specifications _____	
No.	Size, (in)	Rating/Facing																
Inlet <u>1</u>	<u>4</u>	<u>600 RF</u>																
Outlet <u>1</u>	<u>4</u>	<u>600 RF</u>																
Vent <u>1</u>	<u>2</u>	<u>600 RF</u>																
Drain <u>1</u>	<u>2</u>	<u>600 RF</u>																
Tube Material <u>SA-213 TP316L Tube (S) S31603</u> Tube outside diameter (mm) <u>25.4</u> wall thickness (mm) <u>1.651</u>																		
Mechanical Equipment																		
Fan Manufacturer _____ No./Bay <u>2</u> RPM (Revs/min.) <u>645.4</u> Diameter (mm) <u>1450</u> No. of blades <u>4</u> Angle (degrees) _____ Pitch adjustment <u>50% Auto</u> Blade material <u>Al</u> Hub material <u>steel/Alu</u> @design temp <u>4.8</u> @min. ambient temp <u>6.6</u> Tip speed _____ Driver Type _____ Manufacturer _____ No./Bay <u>2</u> Driver (kW) <u>7.5</u>		RPM <u>1500</u> Service factor <u>1</u> Enclosure <u>Exd, IIB T3 (IP55)</u> Voltage <u>400</u> Phase <u>3</u> Cycle <u>50</u> Fan noise level (dB) <u><85</u> Speed Reducer Type <u>V-Belt</u> Manufacturer _____ No./Bay <u>2</u> Service factor <u>1.8</u> Speed ratio <u>2.28</u> Support _____ Vib. switch <u>YES, Exd, IIB T3 (IP65)</u> Enclosure _____																
Controls - Air Side																		
Air recirculation <u>NO</u> Degree control of outlet process temp. _____ (Max. Cooling), +/- <u>2.12 X 3.900</u> 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 (VxL) (m) <u>2.172 x 3.900</u> Bundle weight (Note 4) (kg) <u>3217.6</u> Bay (kg) _____		Total (kg) <u>10514</u> Shipping (kg) _____																
Note: 1-Reported duty and flow rates include a user-specified multiplier of 1.10 2-Maximum allowable nozzle load = 3 x API 3-Material will be meet requirements of NACE MR0175/ISO1516 and specification for material requirments in sour service (BK-GNRL-PEDOO-000-FI-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)		  
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شماره پیمان: 053-073-9184	پروژه BK بسته کاری GCS صادرکننده AA تسهیلات 120 رشته PR نوع مدرک CN سریال 0001 نسخه V05		

		API 661 Air-Cooled Heat Exchanger - Specification Sheet	
Job No. _____ Page _____ Date 1/26/2025 Proposal No. _____ Inquiry No. _____		Item No. 2102 (winter) By _____ Revision V05 Contract No. _____ Order No. _____	
Manufacturer _____ Model no. _____ Customer PEDCO/NISOC Plant location BINA oil field Service 2st Stage Gas Compression Cooler Type draft INDUCED Bay size (WxL) (m) 2.172 x 3.900 No. of bays/items 1	Heat exchanged (MegaWatts) 0.4955 Surface/Item-Finned tube (m2) 1027 Bare tube (m2) 48.548 MTD, Eff. (Deg. C) 34.1 Transfer rate-Finned (W/m2-K) 16.86 Bare tube, service (W/m2-K) 356.65 Bare tube, clean (W/m2-K) 392.2		
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 X1.1 Dew /bubble point (Deg. C) / Latent heat (kJ/kg) _____ Inlet pressure (barG) 54.8 Pressure drop (All/Calc) (bar) 0.7 / 0.081 Velocity (Allow /Calc) (m/s) / 3.69 Inside fouling resistance (m2-K/W) 0.0002 Temperature (Deg. C) In 149 Out 60		Total flow rate (Liq/Vap) (kg/hr) / 8343.5 / 8343.5 Water/Steam (kg/hr) / / Noncondensables (kg/hr) / / Molecular Wt. (Vap/Non-cond) / / Density (Liq/Vap) (kg/m3) / 36.175 / 50.059 Specific heat (Liq/Vap) (kJ/kg-C) / 2.4633 / 2.3853 Thermal cond. (Liq/Vap) (W/m-K) / 0.05 / 0.0387 Viscosity (Liq/Vap) (mN-s/m2) / 0.0163 / 0.0139	
Performance Data - Air Side			
Air inlet temperature (Deg. C) 50.26 Air flow rate/item (m3/s) 5 31.18 Mass velocity (kg/s-m2) / Air outlet temperature (Deg. C) 65.43 Air flow rate/fan (m3/s) 15.59		Face velocity (m/s) 3.27 Minimum design ambient temp. (Deg. C) 5 Altitude (m) 12.5 Static pressure (Pa) 167.92	
Design, Material, and Construction			
Design pressure (barG) 62 Test pressure (barG) 80.6 Design temperature (Deg. C) 175 Min. design metal temp. (Deg. C) _____ Tube bundle Size (WxL) (m) 2.116 X 3.9 No./Bay 1 Number of tube rows 6 Bundles in parallel 1 Bundles in series _____ Structure mounting _____ Pipe rack beams _____ Ladders, walkways, platforms _____ Structure surface prep. _____ Header surface prep. _____ Louver Material YES Action control Manual Action type _____		Heating Coil NO No. of tubes _____ Tube outside diameter (mm) _____ Tube material _____ Fin material and type _____ Fin thickness (mm) _____ ASME Code, Sec. VIII, Div. 1 _____ Heating fluid _____ Heating fluid flow rate (kg/hr) _____ Temperature (In/Out) (Deg. C) / / Inlet pressure (barG) _____ Pressure drop (All/Calc) (kPa) / / Design temperature (Deg. C) _____ Design pressure (barG) _____ Inlet/Outlet nozzle / / Header Type _____ Material SA-240 TP316L Corrosion Allowance (mm) 0 No. of passes 4	

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							 	
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	BK	GCS	AA	120	PR	CN	0001	V05	

		API 661 Air-Cooled Heat Exchanger - Specification Sheet	
		Job No. _____ Page _____ Date _____ Proposal No. _____ Inquiry No. _____	Item No. 2102 (winter) By _____ Revision V05 Contract No. _____ Order No. _____
Design, Material, and Construction (continued)			
Header (continued) 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 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. _____	No. Size, (in) Rating/Facing 1 4 600 RF 1 4 600 RF 1 2 600 RF 1 2 600 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 _____	
Tube Material SA-213 TP316L Tube (S) S31603 Tube outside diameter (mm) 25.4 wall thickness (mm) 1.651			
Mechanical Equipment			
Fan Manufacturer _____ No./Bay 2 RPM (Revs/min.) 645.4 Diameter (mm) 1450 No. of blades 4 Angle (degrees) _____ Pitch adjustment 50% Auto Blade material AI Hub material steel/Alu @design temp 4.8 @min. ambient temp 6.6 Tip speed _____		RFM 1500 Service factor 1 Enclosure YES, Exd, IIB T3 (P 55) 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 2.28 Support _____ Vib. switch YES, Exd, IIB T3 (P 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 _____		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 requirments in sour service (BK-GNRL-PEOCO-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)							
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	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	
	V05	0001	CN	PR	120	AA	GCS	BK

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)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

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:

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

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

Rectangular Vessel Parameters:

$$\text{Alpha} = H / h = 1.3115$$

$$K = (I_2/I_1) * \text{Alpha} = 1.3115$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

$$\begin{aligned} \text{Membrane Stress at Short-side 1 [Sms]:} \\ &= P * h / (2 * t_1) * \{ 3 - [(6 + K * \\ &\quad (11 - \alpha^2) / (3 + 5 * K))] \} \\ &= 22.00 * 122.00 / (2 * 20.00) * \{ 3 - [(6 + 1.31 * \\ &\quad (11 - 1.31^2) / (3 + 5 * 1.31))] \} \\ &= 7.37 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

$$\begin{aligned} \text{Membrane Stress at Short-side 2 [Sms]:} \\ &= P * h / (2 * t_1) * \{ 3 - [(6 + K * \\ &\quad (11 - \alpha^2) / (3 + 5 * K))] \} \\ &= 22.00 * 122.00 / (2 * 20.00) * \{ 3 - [(6 + 1.31 * \\ &\quad (11 - 1.31^2) / (3 + 5 * 1.31))] \} \\ &= 7.37 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

$$\begin{aligned} \text{Membrane Stress at Long-side 1 at A [Sml]:} \\ &= P * H / 2 * t_2 \\ &= 22.00 * 160.00 / 2 * 20.00 \\ &= 8.80 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 8.80 / 0.60 \\ &= 14.76 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 2

$$\begin{aligned} \text{Membrane Stress at Long-side 2 at A [Sml]:} \\ &= P * H / 2 * t_2 \\ &= 22.00 * 160.00 / 2 * 20.00 \\ &= 8.80 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} S_{ml} &= S_{ml} / E_m \\ &= 8.80 / 0.53 \\ &= 16.49 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Stay Plate

$$\begin{aligned} \text{Membrane Stress at Stay Plate [t3]:} \\ &= P * h / (2 * t_3) * [(6 + K * (11 - \\ &\quad \alpha^2) / (3 + 5 * K))] \\ &= 22.00 * 122.00 / (2 * 10.00) * [(6 + 1.31 * (11 - \end{aligned}$$

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

Membrane Stress at Stay Plate [t4]:

$$= P * h / (2 * t4) * [(6 + K * (11 - \alpha^2) / (3 + 5 * K))] \\ = 22.00 * 122.00 / (2 * 10.00) * [(6 + 1.31 * (11 - 1.31^2) / (3 + 5 * 1.31))] \\ = 25.52 \text{ N./mm}^2$$

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]:

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))] \\ = 22.00 * 10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))] \\ = -44.45 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K))] \\ = 22.00 * -10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))] \\ = 44.45 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K)) \\ = 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31)) \\ = 61.15 \text{ N./mm}^2$$

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

$$= P * h^2 * c / (12 * I1) * ((3 + 5 * \alpha^2 * K) / (3 + 5 * K)) \\ = 22.00 * 122.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31)) \\ = -61.15 \text{ N./mm}^2$$

Bending Stresses at Short-side 2

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

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

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$$\begin{aligned}
 & ((3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K)) \\
 &= 22.00 * 10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * \\
 &((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))] \\
 &= -44.45 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * \\
 &((3 + 5 * \text{Alpha}^2 * K) / (3 + 5 * K))] \\
 &= 22.00 * -10.00 / (24 * 0.07) * [-3 * 160.00^2 + 2 * 122.00^2 * \\
 &((3 + 5 * 1.31^2 * 1.31) / (3 + 5 * 1.31))] \\
 &= 44.45 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I1) * ((3 + 5 * \\
 &\text{Alpha}^2 * K) / (3 + 5 * K)) \\
 &= 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * \\
 &1.31^2 * 1.31) / (3 + 5 * 1.31)) \\
 &= 61.15 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I1) * ((3 + 5 * \\
 &\text{Alpha}^2 * K) / (3 + 5 * K)) \\
 &= 22.00 * 122.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * \\
 &1.31^2 * 1.31) / (3 + 5 * 1.31)) \\
 &= -61.15 \text{ N./mm}^2
 \end{aligned}$$

Bending Stresses at Long-side 1

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I2) * [(3 + K * \\
 &(6 - \text{Alpha}^2)) / (3 + 5 * K)] \\
 &= 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * [(3 + 1.31 * \\
 &(6 - 1.31^2)) / (3 + 5 * 1.31)] \\
 &= 36.89 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 \text{SblMi} &= \text{SblMi} / E_b \\
 &= 36.89 / 0.60 \\
 &= 61.89 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I2) * [(3 + K * \\
 &(6 - \text{Alpha}^2)) / (3 + 5 * K)] \\
 &= 22.00 * 122.00^2 * -10.00 / (12 * 0.07) * [(3 + 1.31 * \\
 &(6 - 1.31^2)) / (3 + 5 * 1.31)] \\
 &= -36.89 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 \text{SblMo} &= \text{SblMo} / E_b \\
 &= -36.89 / 0.60 \\
 &= -61.89 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= P * h^2 * c / (12 * I2) * [(3 + 5 * \\
 &\text{Alpha}^2 * K) / (3 + 5 * K)] \\
 &= 22.00 * 122.00^2 * 10.00 / (12 * 0.07) * [(3 + 5 * \\
 &1.31^2 * 1.31) / (3 + 5 * 1.31)] \\
 &= 61.15 \text{ N./mm}^2
 \end{aligned}$$

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

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

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

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

Bending Stresses at Long-side 2

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

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

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

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

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]:

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

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

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

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]:

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

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

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

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

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

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

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

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]:

 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	V05	

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

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

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

Total Stresses at Long-side 2

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

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

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

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

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

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

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

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

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]:

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

End Plate MAWP at given Thickness [MAWPEP]:

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

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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)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

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./mm ²
Shell Allowable Stress at Ambient	SA	155.0000	N./mm ²
Shell Yield Stress at Design Temperature	Sy	172.3750	N./mm ²
SHORT-SIDE VESSEL DATA:			
Short-side Length Dimension	H	160.0000	mm.
Minimum Thickness of Short-side Plates	t1	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			

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

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شماره پیمان: 053 - 073 - 9184	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 24 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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.

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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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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	V05	0001	CN	PR	120	AA	GCS	BK

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 1.3115 \\ K &= (I_2/I_1) * \text{Alpha} = 1.3115 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * \\ &\quad (11 - \alpha^2) / (3 + 5 * K))] \} \\ &= 28.60 * 122.00 / (2 * 20.00) * \{ 3 - [(6 + 1.31 * \\ &\quad (11 - 1.31^2) / (3 + 5 * 1.31)] \} \\ &= 9.59 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * \\ &\quad (11 - \alpha^2) / (3 + 5 * K))] \} \\ &= 28.60 * 122.00 / (2 * 20.00) * \{ 3 - [(6 + 1.31 * \\ &\quad (11 - 1.31^2) / (3 + 5 * 1.31)] \} \\ &= 9.59 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 28.60 * 160.00 / 2 * 20.00 \\ &= 11.44 \text{ N./mm}^2 \end{aligned}$$

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]:

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 28.60 * 160.00 / 2 * 20.00 \\ &= 11.44 \text{ N./mm}^2 \end{aligned}$$

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]:

$$\begin{aligned} &= P * h / (2 * t_3) * [(6 + K * (11 - \\ &\quad \alpha^2) / (3 + 5 * K))] \\ &= 28.60 * 122.00 / (2 * 10.00) * [(6 + 1.31 * (11 - \\ &\quad 1.31^2) / (3 + 5 * 1.31))] \\ &= 33.17 \text{ N./mm}^2 \end{aligned}$$

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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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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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Bending Stresses at Long-side 2

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

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

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

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

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

$$SblMi = SblMi / E_b$$

$$= 46.68 / 0.50$$

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

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

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

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

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

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

$$SblMo = SblMo / E_b$$

$$= -49.23 / 0.50$$

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

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

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

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

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

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

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

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

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

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)																									
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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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

$$= 9.59 + -57.79$$

$$= -48.20 \text{ N./mm}^2$$

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

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

$$= 9.59 + 57.79$$

$$= 67.37 \text{ N./mm}^2$$

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

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

$$= 9.59 + 79.50$$

$$= 89.08 \text{ N./mm}^2$$

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

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

$$= 9.59 + -79.50$$

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

Total Stresses at Short-side 2

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

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

$$= 9.59 + -57.79$$

$$= -48.20 \text{ N./mm}^2$$

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

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

$$= 9.59 + 57.79$$

$$= 67.37 \text{ N./mm}^2$$

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

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

$$= 9.59 + 79.50$$

$$= 89.08 \text{ N./mm}^2$$

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

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

$$= 9.59 + -79.50$$

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

Total Stresses at Long-side 1

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

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

$$= 19.19 + 80.45$$

$$= 99.65 \text{ N./mm}^2$$

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

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

$$= 19.19 + -80.45$$

$$= -61.26 \text{ N./mm}^2$$

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

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

$$= 11.44 + 79.50$$

$$= 90.94 \text{ N./mm}^2$$

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

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

$$= 11.44 + -79.50$$

$$= -68.06 \text{ N./mm}^2$$

 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 Stresses at Long-side 2

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

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

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

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

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

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

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

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

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:

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

 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	V05	

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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	BK	GCS	AA	120	PR	CN	0001	V05

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./mm ²
Shell Allowable Stress at Ambient	SA	115.1465	N./mm ²
Shell Yield Stress at Design Temperature	Sy	129.8699	N./mm ²
SHORT-SIDE VESSEL DATA:			
Short-side Length Dimension	H	100.0000	mm.
Minimum Thickness of Short-side Plates	t1	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.
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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Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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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	BK	GCS	AA	120	PR	CN	0001	V05	

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:

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

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

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

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)							
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	V05	0001	CN	PR	120	AA	GCS	BK

Rectangular Vessel Parameters:

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

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= p * h / (4 * t_1) * \{ 4 - [(2 + K * \\ &\quad (5 - \text{alpha}^2)) / (1 + 2 * K)] \} \\ &= 22.00 * 122.00 / (4 * 20.00) * \{ 4 - [(2 + 0.82 * \\ &\quad (5 - 0.82^2)) / (1 + 2 * 0.82)] \} \\ &= 6.37 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= p * h / (4 * t_1) * \{ 4 - [(2 + K * \\ &\quad (5 - \text{alpha}^2)) / (1 + 2 * K)] \} \\ &= 22.00 * 122.00 / (4 * 20.00) * \{ 4 - [(2 + 0.82 * \\ &\quad (5 - 0.82^2)) / (1 + 2 * 0.82)] \} \\ &= 6.37 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

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

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]:

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

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]:

$$\begin{aligned} &= P * h / (2 * t_3) * [(2 + K * (5 - \\ &\quad \text{alpha}^2)) / (1 + 2 * K)] \\ &= 22.00 * 122.00 / (2 * 10.00) * [(2 + 0.82 * (5 - \\ &\quad 0.82^2)) / (1 + 2 * 0.82)] \\ &= 28.21 \text{ N./mm}^2 \end{aligned}$$

 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	V05	

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]:

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))]$$

$$= 22.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))]$$

$$= -8.66 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))]$$

$$= 22.00 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))]$$

$$= 8.66 \text{ N./mm}^2$$

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

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

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

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

Bending Stress at Short-side 1 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 Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))]$$

$$= 22.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))]$$

$$= -8.66 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))]$$

$$= 22.00 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))]$$

$$= 8.66 \text{ N./mm}^2$$

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

$$SblMi = SblMi / Eb$$

$$= 45.10 / 0.60$$

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

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

$$SblMo = SblMo / Eb$$

$$= -45.10 / 0.60$$

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

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

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]:

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

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]:

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

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

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

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)								
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$$= 6.37 + 8.66$$

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

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

$$= 10.31 + 88.08$$

$$= 98.39 \text{ N./mm}^2$$

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

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

$$= 10.31 + -92.90$$

$$= -82.59 \text{ N./mm}^2$$

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

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

$$= 5.50 + 31.72$$

$$= 37.22 \text{ N./mm}^2$$

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

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

$$= 5.50 + -33.46$$

$$= -27.96 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-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]:

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

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

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

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/110.0000)^2 * ((114)/(0.20*2.32))$$

$$= 81.562 \text{ bars}$$

where Z is:

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

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

$$= 2.318$$

 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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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)							
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	V05	0001	CN	PR	120	AA	GCS	BK

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./mm ²
Shell Allowable Stress at Ambient	SA	155.0000	N./mm ²
Shell Yield Stress at Design Temperature	Sy	172.3750	N./mm ²
SHORT-SIDE VESSEL DATA:			
Short-side Length Dimension	H	100.0000	mm.
Minimum Thickness of Short-side Plates	t1	20.0000	mm.
Mid-side Joint Efficiency on Short-side	E	0.8500	
Corner Joint Efficiency on Short-side	EC	0.8500	
LONG-SIDE VESSEL DATA:			
Long-side Length Dimension	h	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.
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)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

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.

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	BK	GCS	AA	120	PR	CN	0001	V05	

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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شماره پیمان: 053-073-9184	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 46 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

Rectangular Vessel Parameters:

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

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= p * h / (4 * t_1) * \{ 4 - [(2 + K * (5 - \text{alpha}^2)) / (1 + 2 * K)] \} \\ &= 28.60 * 122.00 / (4 * 20.00) * \{ 4 - [(2 + 0.82 * (5 - 0.82^2)) / (1 + 2 * 0.82)] \} \\ &= 8.28 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= p * h / (4 * t_1) * \{ 4 - [(2 + K * (5 - \text{alpha}^2)) / (1 + 2 * K)] \} \\ &= 28.60 * 122.00 / (4 * 20.00) * \{ 4 - [(2 + 0.82 * (5 - 0.82^2)) / (1 + 2 * 0.82)] \} \\ &= 8.28 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

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

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]:

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

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]:

$$\begin{aligned} &= P * h / (2 * t_3) * [(2 + K * (5 - \text{alpha}^2)) / (1 + 2 * K)] \\ &= 28.60 * 122.00 / (2 * 10.00) * [(2 + 0.82 * (5 - 0.82^2)) / (1 + 2 * 0.82)] \\ &= 36.67 \text{ N./mm}^2 \end{aligned}$$

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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	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]:

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))]$$

$$= 28.60 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))]$$

$$= -11.26 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))]$$

$$= 28.60 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))]$$

$$= 11.26 \text{ N./mm}^2$$

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

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

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

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

Bending Stress at Short-side 1 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 Short-side 2

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))]$$

$$= 28.60 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))]$$

$$= -11.26 \text{ N./mm}^2$$

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

$$= P * c / (24 * I1) * [-3 * H^2 + 2 * h^2 * ((1 + 2 * Alpha^2 * K) / (1 + 2 * K))]$$

$$= 28.60 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 122.00^2 * ((1 + 2 * 0.82^2 * 0.82) / (1 + 2 * 0.82))]$$

$$= 11.26 \text{ N./mm}^2$$

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

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

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

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

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

$$SblMi = SblMi / Eb$$

$$= 58.64 / 0.60$$

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

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

$$SblMo = SblMo / Eb$$

$$= -58.64 / 0.60$$

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

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]:

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

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

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

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]:

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

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$$= 8.28 + 11.26$$

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

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]:

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

$$= 13.40 + 114.51$$

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

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Total Stress at long side 2 at M outer [STL_Mo]:
 $= S_{ml} + S_{blMo}$
 $= 13.40 + -120.77$
 $= -107.37 \text{ N./mm}^2$

Total Stress at long side 2 at Q inner [STL_Qi]:
 $= S_{ml} + S_{blQi}$
 $= 7.15 + 41.24$
 $= 48.39 \text{ N./mm}^2$

Total Stress at long side 2 at Q outer [STL_Qo]:
 $= S_{ml} + S_{blQo}$
 $= 7.15 + -43.50$
 $= -36.35 \text{ N./mm}^2$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-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]:

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

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

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

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/110.0000)^2 * ((155)/(2.318))$$

$$= 110.518 \text{ bars}$$

where Z is:

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

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

$$= 2.318$$

 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	V05

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)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

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./mm ²
Shell Allowable Stress at Ambient	SA	115.1465	N./mm ²
Shell Yield Stress at Design Temperature	Sy	126.1469	N./mm ²
SHORT-SIDE VESSEL DATA:			
Short-side Length Dimension	H	110.0000	mm.
Minimum Thickness of Short-side Plates	t1	20.0000	mm.
Mid-side Joint Efficiency on Short-side	E	0.8500	
Corner Joint Efficiency on Short-side	EC	0.8500	
LONG-SIDE VESSEL DATA:			
Long-side Length Dimension	h	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./mm ²
Stay Allowable Stress at Ambient	SA	115.1465	N./mm ²
Stay Yield Stress at Design Temp	Sy	129.8699	N./mm ²
STAY PLATE DATA:			
Minimum Thickness of Stay	t3	10.0000	mm.
Minimum Thickness of Stay	t4	10.0000	mm.
The Stay(s) Are Not Welded to the End Plate			

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

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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:

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

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

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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

$$\begin{aligned} \text{Membrane Stress at Short-side 1 [Sms]:} \\ &= P * h / (2 * t1) * \{ 3 - [(6 + K * \\ &\quad (11 - \text{alpha}^2) / (3 + 5 * K)] \} \\ &= 62.00 * 130.00 / (2 * 20.00) * \{ 3 - [(6 + 2.32 * \\ &\quad (11 - 0.85^2) / (3 + 5 * 2.32)] \} \\ &= 19.24 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

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

Membrane Stresses at Long-side 1

$$\begin{aligned} \text{Membrane Stress at Long-side 1 at A [Sml]:} \\ &= P * H / 2 * t2 \\ &= 62.00 * 110.00 / 2 * 28.00 \\ &= 12.18 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Membrane Stress at Long-side 2 at A [Sml]:} \\ &= P * H / 2 * t2 \\ &= 62.00 * 110.00 / 2 * 28.00 \\ &= 12.18 \text{ N./mm}^2 \end{aligned}$$

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

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

Membrane Stress at Stay Plate [t4]:

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

 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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	V05	0001	CN	PR	120	AA	GCS	BK

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]:

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

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

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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 $Em(0.636) < E(0.850)$ and $Eb(0.636) < E(0.850)$ 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 $Em(0.636) < E(0.850)$ and $Eb(0.636) < E(0.850)$ 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]:

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

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$$\begin{aligned}
 & (6 - \alpha^2) / (3 + 5 * K) \\
 & = 62.00 * 130.00^2 * 13.77 / (12 * 0.18) * [(3 + 2.32 * \\
 & (6 - 0.85^2) / (3 + 5 * 2.32)] \\
 & = 68.70 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 S_{blMi} &= S_{blMi} / E_b \\
 &= 68.70 / 0.56 \\
 &= 122.88 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 & = P * h^2 * c / (12 * I_2) * [(3 + K * \\
 & (6 - \alpha^2) / (3 + 5 * K)] \\
 & = 62.00 * 130.00^2 * -14.23 / (12 * 0.18) * [(3 + 2.32 * \\
 & (6 - 0.85^2) / (3 + 5 * 2.32)] \\
 & = -70.99 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 S_{blMo} &= S_{blMo} / E_b \\
 &= -70.99 / 0.56 \\
 &= -126.97 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 & = P * h^2 * c / (12 * I_2) * [(3 + 5 * \\
 & \alpha^2 * K) / (3 + 5 * K)] \\
 & = 62.00 * 130.00^2 * 13.77 / (12 * 0.18) * [(3 + 5 * \\
 & 0.85^2 * 2.32) / (3 + 5 * 2.32)] \\
 & = 50.90 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 & = P * h^2 * c / (12 * I_2) * [(3 + 5 * \\
 & \alpha^2 * K) / (3 + 5 * K)] \\
 & = 62.00 * 130.00^2 * -14.23 / (12 * 0.18) * [(3 + 5 * \\
 & 0.85^2 * 2.32) / (3 + 5 * 2.32)] \\
 & = -52.59 \text{ N./mm}^2
 \end{aligned}$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-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]:

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

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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

Total Stress at short side 1 at N outer [STS_No]:
= S_{ms} + S_{bsNo}
= 19.24 + 39.25
= 58.49 N./mm²

Total Stress at short side 1 at Q inner [STS_Qi]:
= S_{ms} + S_{bsQi}
= 19.24 + 101.42
= 120.66 N./mm²

Total Stress at short side 1 at Q outer [STS_Qo]:
= S_{ms} + S_{bsQo}
= 19.24 + -101.42
= -82.18 N./mm²

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:
= S_{ms} + S_{bsNi}
= 19.24 + -39.25
= -20.01 N./mm²

Total Stress at short side 2 at N outer [STS_No]:
= S_{ms} + S_{bsNo}
= 19.24 + 39.25
= 58.49 N./mm²

Total Stress at short side 2 at Q inner [STS_Qi]:
= S_{ms} + S_{bsQi}
= 19.24 + 101.42
= 120.66 N./mm²

Total Stress at short side 2 at Q outer [STS_Qo]:
= S_{ms} + S_{bsQo}
= 19.24 + -101.42
= -82.18 N./mm²

Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:
= S_{ml} + S_{blMi}
= 19.14 + 109.79
= 128.93 N./mm²

Total Stress at long side 1 at M outer [STL_Mo]:
= S_{ml} + S_{blMo}
= 19.14 + -109.79
= -90.64 N./mm²

Total Stress at long side 1 at Q inner [STL_Qi]:
= S_{ml} + S_{blQi}
= 12.18 + 51.74
= 63.92 N./mm²

Total Stress at long side 1 at Q outer [STL_Qo]:
= S_{ml} + S_{blQo}
= 12.18 + -51.74
= -39.57 N./mm²

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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

Total Stresses at Long-side 2

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

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

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

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

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

$$\begin{aligned}
 &= S_{ml} + S_{blQi} \\
 &= 12.18 + 50.90 \\
 &= 63.08 \text{ N./mm}^2
 \end{aligned}$$

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

$$\begin{aligned}
 &= S_{mlB} + S_{blQo} \\
 &= 12.18 + -52.59 \\
 &= -40.41 \text{ N./mm}^2
 \end{aligned}$$

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]:

$$\begin{aligned}
 &= d * \sqrt{Z * C * P / (SE)} + ca \\
 &= 110.000 * \sqrt{2.500 * 0.200 * 62.000 / (111.908)} + 0.000 \\
 &= 18.309 \text{ mm.}
 \end{aligned}$$

End Plate MAWP at given Thickness [MAWPEP]:

$$\begin{aligned}
 &= ((T-ca)/d)^2 * ((SE)/(C*Z)) \text{ per UG-34 (c)(3)} \\
 &= ((20.0000-0.0000)/110.0000)^2 * ((111)/(.20*2.50)) \\
 &= 73.984 \text{ bars}
 \end{aligned}$$

where Z is:

$$\begin{aligned}
 &= \min(3.4 - 2.4(d/D), 2.5) \\
 &= \min(3.4 - 2.4(110.000 / 410.000), 2.5) \\
 &= 2.500
 \end{aligned}$$

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	BK	GCS	AA	120	PR	CN	0001	V05

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)							
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	V05	0001	CN	PR	120	AA	GCS	BK

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./mm ²
Shell Allowable Stress at Ambient	SA	155.1000	N./mm ²
Shell Yield Stress at Design Temperature	Sy	172.3750	N./mm ²
SHORT-SIDE VESSEL DATA:			
Short-side Length Dimension	H	110.0000	mm.
Minimum Thickness of Short-side Plates	t1	20.0000	mm.
Mid-side Joint Efficiency on Short-side	E	0.8500	
Corner Joint Efficiency on Short-side	EC	0.8500	
LONG-SIDE VESSEL DATA:			
Long-side Length Dimension	h	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./mm ²
Stay Allowable Stress at Ambient	SA	116.9000	N./mm ²
Stay Yield Stress at Design Temp	Sy	129.8699	N./mm ²
STAY PLATE DATA:			
Minimum Thickness of Stay	t3	10.0000	mm.
Minimum Thickness of Stay	t4	10.0000	mm.
The Stay(s) Are Not Welded to the End Plate			

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

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

Short-side 1 Calculations

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Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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.

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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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:

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

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

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Thermal/Mechanical Calculation Book																										
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V05	0001	CN	PR	120	AA	GCS	BK																			

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]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * \\ &\quad (11 - \text{alpha}^2) / (3 + 5 * K)] \} \\ &= 80.60 * 130.00 / (2 * 20.00) * \{ 3 - [(6 + 2.32 * \\ &\quad (11 - 0.85^2) / (3 + 5 * 2.32)] \} \\ &= 25.01 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t1) * \{ 3 - [(6 + K * \\ &\quad (11 - \text{alpha}^2) / (3 + 5 * K)] \} \\ &= 80.60 * 130.00 / (2 * 20.00) * \{ 3 - [(6 + 2.32 * \\ &\quad (11 - 0.85^2) / (3 + 5 * 2.32)] \} \\ &= 25.01 \text{ N./mm}^2 \end{aligned}$$

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]:

$$\begin{aligned} &= P * h / (2 * t3) * [(6 + K * (11 - \\ &\quad \text{alpha}^2) / (3 + 5 * K)] \\ &= 80.60 * 130.00 / (2 * 10.00) * [(6 + 2.32 * (11 - \\ &\quad 0.85^2) / (3 + 5 * 2.32)] \\ &= 107.15 \text{ N./mm}^2 \end{aligned}$$

 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)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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 : 68 از 148
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	AA	120	PR	CN	0001	V05

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 $Em(0.636) < E(0.850)$ and $Eb(0.636) < E(0.850)$ 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 $Em(0.636) < E(0.850)$ and $Eb(0.636) < E(0.850)$ 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)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

Bending Stresses at Long-side 2

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

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

$$= 80.60 * 130.00^2 * 13.77 / (12 * 0.18) * [(3 + 2.32 * (6 - 0.85^2)) / (3 + 5 * 2.32)]$$

$$= 89.31 \text{ N./mm}^2$$

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

$$SblMi = SblMi / E_b$$

$$= 89.31 / 0.56$$

$$= 159.75 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * -14.23 / (12 * 0.18) * [(3 + 2.32 * (6 - 0.85^2)) / (3 + 5 * 2.32)]$$

$$= -92.28 \text{ N./mm}^2$$

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

$$SblMo = SblMo / E_b$$

$$= -92.28 / 0.56$$

$$= -165.06 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * 13.77 / (12 * 0.18) * [(3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32)]$$

$$= 66.17 \text{ N./mm}^2$$

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

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

$$= 80.60 * 130.00^2 * -14.23 / (12 * 0.18) * [(3 + 5 * 0.85^2 * 2.32) / (3 + 5 * 2.32)]$$

$$= -68.37 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-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	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 70 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

Total Stress at long side 1 at Q outer [STL_Qo]:
 $= S_{mlB} + S_{blQo}$
 $= 15.83 + -67.27$
 $= -51.44 \text{ N./mm}^2$

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:
 $= S_{ml} + S_{blMi}$
 $= 27.11 + 159.75$
 $= 186.85 \text{ N./mm}^2$

Total Stress at long side 2 at M outer [STL_Mo]:
 $= S_{ml} + S_{blMo}$
 $= 27.11 + -165.06$
 $= -137.95 \text{ N./mm}^2$

Total Stress at long side 2 at Q inner [STL_Qi]:
 $= S_{ml} + S_{blQi}$
 $= 15.83 + 66.17$
 $= 82.00 \text{ N./mm}^2$

Total Stress at long side 2 at Q outer [STL_Qo]:
 $= S_{mlB} + S_{blQo}$
 $= 15.83 + -68.37$
 $= -52.53 \text{ N./mm}^2$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-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]:

$= d * \sqrt{Z * C * P / (SE)} + c_a$
 $= 110.000 * \sqrt{2.500 * 0.200 * 80.600 / (155.100)} + 0.000$
 $= 17.732 \text{ mm.}$

End Plate MAWP at given Thickness [MAWPEP]:

$= ((T-c_a)/d)^2 * ((SE)/(C*Z)) \text{ per UG-34 (c)(3)}$
 $= ((20.0000-0.0000)/110.0000)^2 * ((155)/(.20*2.50))$
 $= 102.540 \text{ bars}$

where Z is:

$= \min(3.4 - 2.4(d/D), 2.5)$
 $= \min(3.4 - 2.4(110.000 / 410.000), 2.5)$
 $= 2.500$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)							
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	AA	120	PR	CN	0001	V05

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 : 73 از 148
	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	
	V05	0001	CN	PR	120	AA	GCS	BK

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)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	
	BK	GCS	AA	120	PR	CN	0001	V05	

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)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

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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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

Rectangular Vessel Parameters:

$$\begin{aligned} \text{Alpha} &= H / h = 1.6667 \\ K &= (I_2/I_1) * \text{Alpha} = 1.6667 \end{aligned}$$

Membrane Stress Calculations per Section 13-9

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * \\ &\quad (11 - \text{alpha}^2) / (3 + 5 * K)] \} \\ &= 62.00 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * \\ &\quad (11 - 1.67^2) / (3 + 5 * 1.67)] \} \\ &= 11.73 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:

$$\begin{aligned} &= P * h / (2 * t_1) * \{ 3 - [(6 + K * \\ &\quad (11 - \text{alpha}^2) / (3 + 5 * K)] \} \\ &= 62.00 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * \\ &\quad (11 - 1.67^2) / (3 + 5 * 1.67)] \} \\ &= 11.73 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

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

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 62.00 * 100.00 / 2 * 20.00 \\ &= 15.50 \text{ N./mm}^2 \end{aligned}$$

If $E_m(0.636) < E(0.850)$ 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]:

$$\begin{aligned} &= P * H / 2 * t_2 \\ &= 62.00 * 100.00 / 2 * 20.00 \\ &= 15.50 \text{ N./mm}^2 \end{aligned}$$

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]:

$$\begin{aligned} &= P * h / (2 * t_3) * [(6 + K * (11 - \\ &\quad \text{alpha}^2) / (3 + 5 * K)] \\ &= 62.00 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - \\ &\quad 1.67^2) / (3 + 5 * 1.67)] \\ &= 32.34 \text{ N./mm}^2 \end{aligned}$$

 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)							
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Membrane Stress at Stay Plate [t4]:

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

$$= 62.00 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - 1.67^2) / (3 + 5 * 1.67))]$$

$$= 32.34 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Actual	Allowable
Short-side 1	11.73	95.12
Short-side 2	11.73	95.12
Short-side Corner	11.73	95.12
Long-side 1 at A	24.37	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]:

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

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= -51.88 \text{ N./mm}^2$$

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

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

$$= 62.00 * -10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= 51.88 \text{ N./mm}^2$$

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

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

$$= 62.00 * 60.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= 64.37 \text{ N./mm}^2$$

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

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

$$= 62.00 * 60.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= -64.37 \text{ N./mm}^2$$

Bending Stresses at Short-side 2

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

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

$$= 62.00 * 10.00 / (24 * 0.07) * [-3 * 100.00^2 + 2 * 60.00^2 * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))]$$

$$= -51.88 \text{ N./mm}^2$$

 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)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

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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V05	0001	CN	PR	120	AA	GCS	BK																			

Bending Stresses at Long-side 2

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

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

$$= 62.00 * 60.00^2 * 9.78 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= 20.15 \text{ N./mm}^2$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.548) < E(0.850)$ then

$$SblMi = SblMi / E_b$$

$$= 20.15 / 0.55$$

$$= 36.76 \text{ N./mm}^2$$

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

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

$$= 62.00 * 60.00^2 * -10.22 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= -21.06 \text{ N./mm}^2$$

If $E_m(0.580) < E(0.850)$ and $E_b(0.548) < E(0.850)$ then

$$SblMo = SblMo / E_b$$

$$= -21.06 / 0.55$$

$$= -38.42 \text{ N./mm}^2$$

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

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

$$= 62.00 * 60.00^2 * 9.78 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= 62.95 \text{ N./mm}^2$$

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

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

$$= 62.00 * 60.00^2 * -10.22 / (12 * 0.07) * [(3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67)]$$

$$= -65.79 \text{ N./mm}^2$$

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

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	-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

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V05	0001	CN	PR	120	AA	GCS	BK																			

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)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

$$= 15.50 + 64.37$$

$$= 79.88 \text{ N./mm}^2$$

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

$$= SmlB + SblQo$$

$$= 15.50 + -64.37$$

$$= -48.87 \text{ N./mm}^2$$

Total Stresses at Long-side 2

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

$$= Sml + SblMi$$

$$= 26.73 + 36.76$$

$$= 63.49 \text{ N./mm}^2$$

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

$$= Sml + SblMo$$

$$= 26.73 + -38.42$$

$$= -11.68 \text{ N./mm}^2$$

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

$$= Sml + SblQi$$

$$= 15.50 + 62.95$$

$$= 78.45 \text{ N./mm}^2$$

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

$$= SmlB + SblQo$$

$$= 15.50 + -65.79$$

$$= -50.29 \text{ N./mm}^2$$

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]:

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

$$= 100.000 * \sqrt{2.200 * 0.200 * 62.000 / (111.908)} + 0.000$$

$$= 15.614 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/100.0000)^2 * ((111)/(0.20*2.20))$$

$$= 101.728 \text{ bars}$$

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

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

$$= \min(3.4 - 2.4(100.000 / 200.000), 2.5)$$

$$= 2.200$$

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,		
High Stress (Highest % of Allowable)	32.34	N./mm ²
High Stress Percentage	28.27	%
M.A.W.P. for Membrane Stresses	219.31	bars
BENDING STRESS SUMMARY,		
High Stress (Highest % of Allowable)	-65.79	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)								
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	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	
	V05	0001	CN	PR	120	AA	GCS	BK	

3.8 FLOATING HEADER CALCULATION @ TEST PRESSURE FOR AE-2102.

Input Echo, COMPONENT 1, Description: FI.AE-2102-Test

Figure Number Analyzed	A8		
Design Internal Pressure	P	80.6000	bars
Design Temperature	Temp	25.0000	C
VESSEL MATERIAL DATA:			
Material Specification		SA-240 316L	
Shell Allowable Stress at Design Temp	S	155.0000	N./mm ²
Shell Allowable Stress at Ambient	SA	155.0000	N./mm ²
Shell Yield Stress at Design Temperature	Sy	172.3750	N./mm ²
SHORT-SIDE VESSEL DATA:			
Short-side Length Dimension	H	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./mm ²
Stay Allowable Stress at Ambient	SA	115.1465	N./mm ²
Stay Yield Stress at Design Temp	Sy	129.8699	N./mm ²
STAY PLATE DATA:			
Minimum Thickness of Stay	t3	10.0000	mm.
Minimum Thickness of Stay	t4	10.0000	mm.
The Stay(s) Are Not Welded to the End Plate			

Rectangular Vessel Results, Item number 1, Desc: FI.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

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	V05	0001	CN	PR	120	AA	GCS	BK

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.

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	BK	GCS	AA	120	PR	CN	0001	V05	

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:

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

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

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شماره پیمان: 053-073-9184	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 86 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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

$$\begin{aligned} \text{Membrane Stress at Short-side 1 [Sms]:} \\ &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \} \\ &= 80.60 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2)) / (3 + 5 * 1.67)] \} \\ &= 15.25 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Short-side 2

$$\begin{aligned} \text{Membrane Stress at Short-side 2 [Sms]:} \\ &= P * h / (2 * t1) * \{ 3 - [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \} \\ &= 80.60 * 60.00 / (2 * 20.00) * \{ 3 - [(6 + 1.67 * (11 - 1.67^2)) / (3 + 5 * 1.67)] \} \\ &= 15.25 \text{ N./mm}^2 \end{aligned}$$

Membrane Stresses at Long-side 1

$$\begin{aligned} \text{Membrane Stress at Long-side 1 at A [Sml]:} \\ &= P * H / 2 * t2 \\ &= 80.60 * 100.00 / 2 * 20.00 \\ &= 20.15 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Membrane Stress at Long-side 2 at A [Sml]:} \\ &= P * H / 2 * t2 \\ &= 80.60 * 100.00 / 2 * 20.00 \\ &= 20.15 \text{ N./mm}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Membrane Stress at Stay Plate [t3]:} \\ &= P * h / (2 * t3) * [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \\ &= 80.60 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - 1.67^2)) / (3 + 5 * 1.67)] \\ &= 42.04 \text{ N./mm}^2 \end{aligned}$$

Membrane Stress at Stay Plate [t4]:

$$\begin{aligned} &= P * h / (2 * t4) * [(6 + K * (11 - \alpha^2)) / (3 + 5 * K)] \\ &= 80.60 * 60.00 / (2 * 10.00) * [(6 + 1.67 * (11 - 1.67^2)) / (3 + 5 * 1.67)] \\ &= 42.04 \text{ N./mm}^2 \end{aligned}$$

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	V05	0001	CN	PR	120	AA	GCS	BK

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)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

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

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

$$= 80.60 * 60.00^2 * 10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= 83.69 \text{ N./mm}^2$$

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

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

$$= 80.60 * 60.00^2 * -10.00 / (12 * 0.07) * ((3 + 5 * 1.67^2 * 1.67) / (3 + 5 * 1.67))$$

$$= -83.69 \text{ N./mm}^2$$

Bending Stresses at Long-side 1

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

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

$$= 80.60 * 60.00^2 * 10.00 / (12 * 0.07) * [(3 + 1.67 * (6 - 1.67^2)) / (3 + 5 * 1.67)]$$

$$= 26.79 \text{ N./mm}^2$$

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

$$SblMi = SblMi / E_b$$

$$= 26.79 / 0.64$$

$$= 42.11 \text{ N./mm}^2$$

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

$$SblMo = SblMo / E_b$$

$$= -26.79 / 0.64$$

$$= -42.11 \text{ N./mm}^2$$

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
	BK	GCS	AA	120	PR	CN	0001	V05	

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	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 90 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

Total Stress at short side 1 at Q inner [STS_Qi]:
= Sms + SbsQi
= 15.25 + 83.69
= 98.94 N./mm²

Total Stress at short side 1 at Q outer [STS_Qo]:
= Sms + SbsQo
= 15.25 + -83.69
= -68.43 N./mm²

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:
= Sms + SbsNi
= 15.25 + -67.45
= -52.20 N./mm²

Total Stress at short side 2 at N outer [STS_No]:
= Sms + SbsNo
= 15.25 + 67.45
= 82.70 N./mm²

Total Stress at short side 2 at Q inner [STS_Qi]:
= Sms + SbsQi
= 15.25 + 83.69
= 98.94 N./mm²

Total Stress at short side 2 at Q outer [STS_Qo]:
= Sms + SbsQo
= 15.25 + -83.69
= -68.43 N./mm²

Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:
= Sml + SblMi
= 31.68 + 42.11
= 73.79 N./mm²

Total Stress at long side 1 at M outer [STL_Mo]:
= Sml + SblMo
= 31.68 + -42.11
= -10.43 N./mm²

Total Stress at long side 1 at Q inner [STL_Qi]:
= Sml + SblQi
= 20.15 + 83.69
= 103.84 N./mm²

Total Stress at long side 1 at Q outer [STL_Qo]:
= SmlB + SblQo
= 20.15 + -83.69
= -63.54 N./mm²

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:
= Sml + SblMi
= 34.75 + 47.78
= 82.53 N./mm²

 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	V05	

Total Stress at long side 2 at M outer [STL_Mo]:
= Sml + SblMo
= 34.75 + -49.94
= -15.19 N./mm²

Total Stress at long side 2 at Q inner [STL_Qi]:
= Sml + SblQi
= 20.15 + 81.84
= 101.99 N./mm²

Total Stress at long side 2 at Q outer [STL_Qo]:
= SmlB + SblQo
= 20.15 + -85.53
= -65.38 N./mm²

**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]:

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

$$= 100.000 * \sqrt{2.200 * 0.200 * 80.600 / (155.000)} + 0.000$$

$$= 15.127 \text{ mm.}$$

End Plate MAWP at given Thickness [MAWPEP]:

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

$$= ((20.0000-0.0000)/100.0000)^2 * ((155)/(2.20*2.20))$$

$$= 140.901 \text{ bars}$$

where Z is:

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

$$= \min(3.4 - 2.4(100.000 / 200.000), 2.5)$$

$$= 2.200$$

 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	V05	

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)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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)																									
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Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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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V05	0001	CN	PR	120	AA	GCS	BK																			

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
FEPipe Version 15.0
Released Jan. 2021

Jobname: setup2
12:34am NOV 25,2024

\$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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Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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
FEPipe Version 15.0 Jobname: setup2 \$P
Released Jan. 2021 1:32pm NOV 25,2024

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
Released Jan. 2021 1:33pm NOV 25,2024

ASME Code Stress Output Plots \$X

- 1) Pl < SPL (SUS,Membrane) Case 2
- 2) Qb < SPS (SUS,Bending) Case 2
- 3) Pl+Pb+Q < SPS (SUS,Inside) Case 2
- 4) Pl+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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Thermal/Mechanical Calculation Book																										
پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه																			
BK	GCS	AA	120	PR	CN	0001	V05																			

- 5) $S1+S2+S3 < 4S$ (SUS,S1+S2+S3) Case 2
- 6) $Pl+Pb+Q < SPS$ (OPE,Inside) Case 3
- 7) $Pl+Pb+Q < SPS$ (OPE,Outside) Case 3
- 8) Membrane < User (OPE,Membrane) Case 3
- 9) Bending < User (OPE,Bending) Case 3
- 10) $Pl+Pb+Q < SPS$ (EXP,Inside) Case 4
- 11) $Pl+Pb+Q < SPS$ (EXP,Outside) Case 4
- 12) $Pl+Pb+Q+F < 2Sa$ (EXP,Inside) Case 4
- 13) $Pl+Pb+Q+F < 2Sa$ (EXP,Outside) Case 4

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Stress Results - Notes
 FEPipe Version 15.0
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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
 FEPipe Version 15.0
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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	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 98 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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
43
MPa

SPL
130
MPa

Primary Membrane Load Case 2
Min Prin. Stress = -66. (49% Neg, 6% NegHi)
Plot Reference:
1) PL < SPL (SUS,Membrane) Case 2

33%

Long Plate for Plate # 1

PL
108
MPa

SPL
130
MPa

Primary Membrane Load Case 2
Min Prin. Stress = -114. (97% Neg, 19% NegHi)
Plot Reference:
1) PL < SPL (SUS,Membrane) Case 2

83%

Circ Plate for Plate # 2

PL
53
MPa

SPL
130
MPa

Primary Membrane Load Case 2
Min Prin. Stress = -30. (56% Neg, 8% NegHi)
Plot Reference:
1) PL < SPL (SUS,Membrane) Case 2

40%

Circ Plate for Plate # 3

PL
121
MPa

SPL
130
MPa

Primary Membrane Load Case 2
Min Prin. Stress = -169. (87% Neg, 46% NegHi)
Plot Reference:
1) PL < SPL (SUS,Membrane) Case 2

93%

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%

Long Plate for Plate # 4

PL

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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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	AA	120	PR	CN	0001	V05

23 MPa 130 MPa Min Prin. Stress = -16. (77% Neg, 10% NegHi)
 17% Plot Reference:
 1) Pl < SPL (SUS,Membrane) Case 2

Circ Plate for Plate # 5

PL SPL Primary Membrane Load Case 2
 35 130 Min Prin. Stress = -9. (37% Neg, 9% NegHi)
 MPa MPa Plot Reference:
 26% 1) Pl < SPL (SUS,Membrane) Case 2

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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 SPS Primary+Secondary (Inner) Load Case 2
 90 303 Min Prin. Stress = -66. (49% Neg, 6% NegHi)
 MPa MPa Plot Reference:
 29% 3) PL+Pb+Q < SPS (SUS,Inside) Case 2

PL+Pb+Q SPS Primary+Secondary (Inner) Load Case 3
 90 303 Min Prin. Stress = -66. (49% Neg, 6% NegHi)
 MPa MPa Plot Reference:
 29% 6) PL+Pb+Q < SPS (OPE,Inside) Case 3

Long Plate for Plate # 1

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

PL+Pb+Q SPS Primary+Secondary (Outer) Load Case 3
 201 303 Min Prin. Stress = -114. (97% Neg, 19% NegHi)
 MPa MPa Plot Reference:
 66% 7) PL+Pb+Q < SPS (OPE,Outside) Case 3

Circ Plate for Plate # 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 : 100 از 148	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001		V05

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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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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Highest Fatigue Stress Ratios
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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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	V05	0001	CN	PR	120	AA	GCS	BK

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

 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	V05	

Highest Stress Ratios Per Region
 FEPipe Version 15.0 Jobname: setup2 \$P
 Released Jan. 2021 1:33pm NOV 25,2024

Highest Stress Ratios Per Region \$X

Circ Plate for Plate # 1

Pl 43 MPa	SPL 130 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 1) Pl < 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%		
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 71 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 4) Pl+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%		
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%		
Pl+Pb+Q 71 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -66. (49% Neg, 6% NegHi) Plot Reference: 7) Pl+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%		
Pl+Pb+Q 40	SPS 303	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -16. (48% Neg, 6% 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)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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

 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	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 105 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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)

 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	V05	

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		Markl Fatigue Stress Allowable = 659.5
		WRC 474 Mean Cycles to Failure = 56,350,524.
		WRC 474 99% Probability Cycles = 13,090,738.

 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	V05	

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 34 MPa	Damage Ratio 0.000 Life 0.043 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 = 1.0976E8 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
Allowable 777.2 MPa		
4%		
Circ Plate for Plate # 3		
Pl 121 MPa	SPL 130 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -169. (87% Neg, 46% NegHi) Plot Reference: 1) Pl < SPL (SUS,Membrane) Case 2
93%		
Qb 184 MPa	SPS 303 MPa	Primary Bending Load Case 2 Min Prin. Stress = -169. (87% Neg, 46% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
60%		
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 170 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -169. (87% Neg, 46% NegHi) Plot Reference: 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
56%		
S1+S2+S3 171 MPa	4S 346 MPa	Part 5 (5.3.2) Load Case 2 Min Prin. Stress = -169. (87% Neg, 46% NegHi) Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
49%		
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%		
Pl+Pb+Q 170 MPa	SPS 303 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -169. (87% Neg, 46% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
56%		
Membrane 121 MPa	User 303 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -169. (87% Neg, 46% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
39%		

 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	V05	

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)

 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	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 109 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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		Markl 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		Markl 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

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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	SPL 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)							
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	BK	GCS	AA	120	PR	CN	0001	V05

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

Pl+Pb+Q+F Damage Ratio Primary+Secondary+Peak (Outer) Load Case 4
7 0.000 Life Stress Concentration Factor = 1.000
MPa 0.008 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 = 9.6172E9
0% 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

Circ Plate for Plate # 5

Pl SPL Primary Membrane Load Case 2
35 130 Min Prin. Stress = -9. (37% Neg, 9% NegHi)
MPa MPa Plot Reference:
1) Pl < SPL (SUS,Membrane) Case 2

26%

Qb SPS Primary Bending Load Case 2
23 302 Min Prin. Stress = -9. (37% Neg, 9% NegHi)
MPa MPa Plot Reference:
2) Qb < SPS (SUS,Bending) Case 2

7%

Pl+Pb+Q SPS Primary+Secondary (Inner) Load Case 2
46 302 Min Prin. Stress = -9. (37% Neg, 9% NegHi)
MPa MPa Plot Reference:
3) Pl+Pb+Q < SPS (SUS,Inside) Case 2

15%

Pl+Pb+Q SPS Primary+Secondary (Outer) Load Case 2
57 302 Min Prin. Stress = -9. (37% Neg, 9% NegHi)
MPa MPa Plot Reference:
4) Pl+Pb+Q < SPS (SUS,Outside) Case 2

18%

Pl+Pb+Q SPS Primary+Secondary (Inner) Load Case 3
46 302 Min Prin. Stress = -9. (37% Neg, 9% NegHi)
MPa MPa Plot Reference:
6) Pl+Pb+Q < SPS (OPE,Inside) Case 3

15%

Pl+Pb+Q SPS Primary+Secondary (Outer) Load Case 3
57 302 Min Prin. Stress = -9. (37% Neg, 9% NegHi)
MPa MPa Plot Reference:
7) Pl+Pb+Q < SPS (OPE,Outside) Case 3

18%

Membrane User Component Evaluation Load Case 3
35 302 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 : 112 از 148	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

MPa	MPa	Plot Reference:
11%		8) Membrane < User (OPE,Membrane) Case 3
Bending 23 MPa	User 302 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -9. (37% Neg, 9% NegHi) Plot Reference:
7%		9) Bending < User (OPE,Bending) Case 3
Pl+Pb+Q 29 MPa	SPS 302 MPa	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -3. (13% Neg, 4% NegHi) Plot Reference:
9%		10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
Pl+Pb+Q 28 MPa	SPS 302 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -3. (13% Neg, 4% NegHi) Plot Reference:
9%		11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
Pl+Pb+Q+F 29 MPa	Damage Ratio 0.000 Life 0.055 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 = 0.0 Markl Fatigue Stress Allowable = 575.0 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:
Allowable 530.5 MPa		12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
5%		
Pl+Pb+Q+F 28 MPa	Damage Ratio 0.000 Life 0.054 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 = 0.0 Markl Fatigue Stress Allowable = 575.0 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:
Allowable 530.5 MPa		13) Pl+Pb+Q+F < 2Sa (EXP,Outside) Case 4
5%		

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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)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

>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	>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:

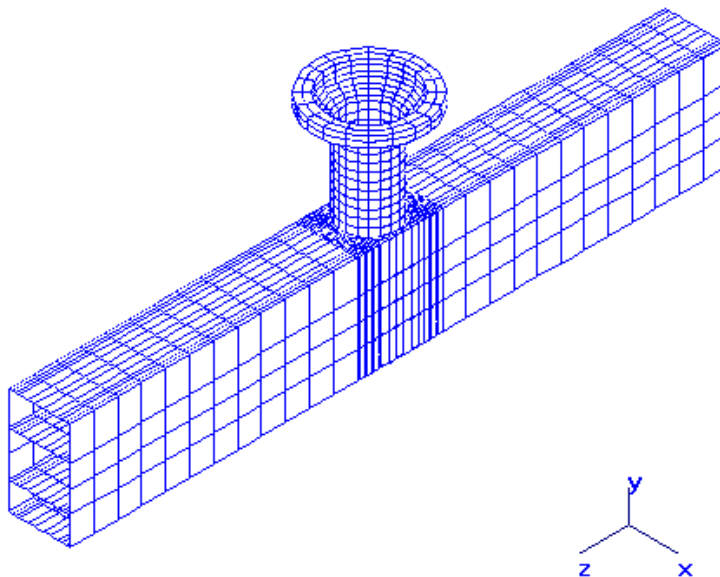
053-073-9184

Thermal/Mechanical Calculation Book

نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه
V05	0001	CN	PR	120	AA	GCS	BK

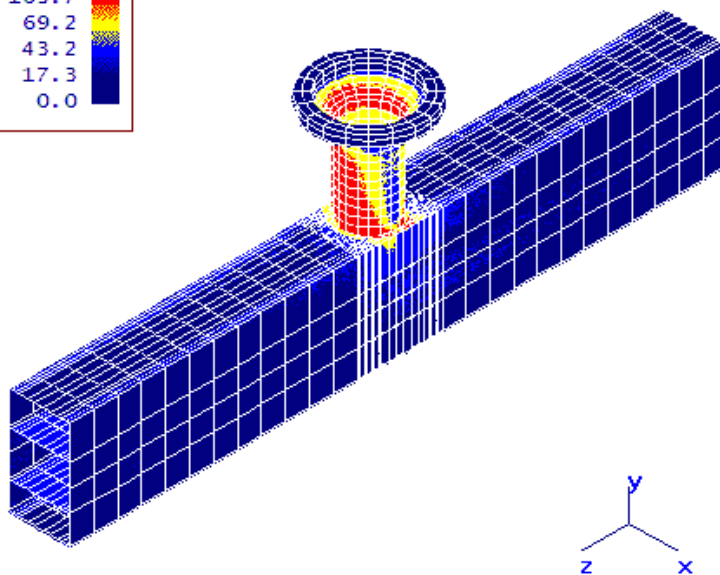
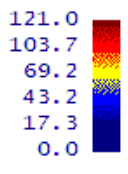
شماره صفحه : 114 از 148

Finite Element Model



3d

1) P1 < SPL (SUS Membrane) Case 2



3d

3d(Deformed)



نگهداشت و افزایش تولید میدان نفتی بینک
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شماره پیمان:

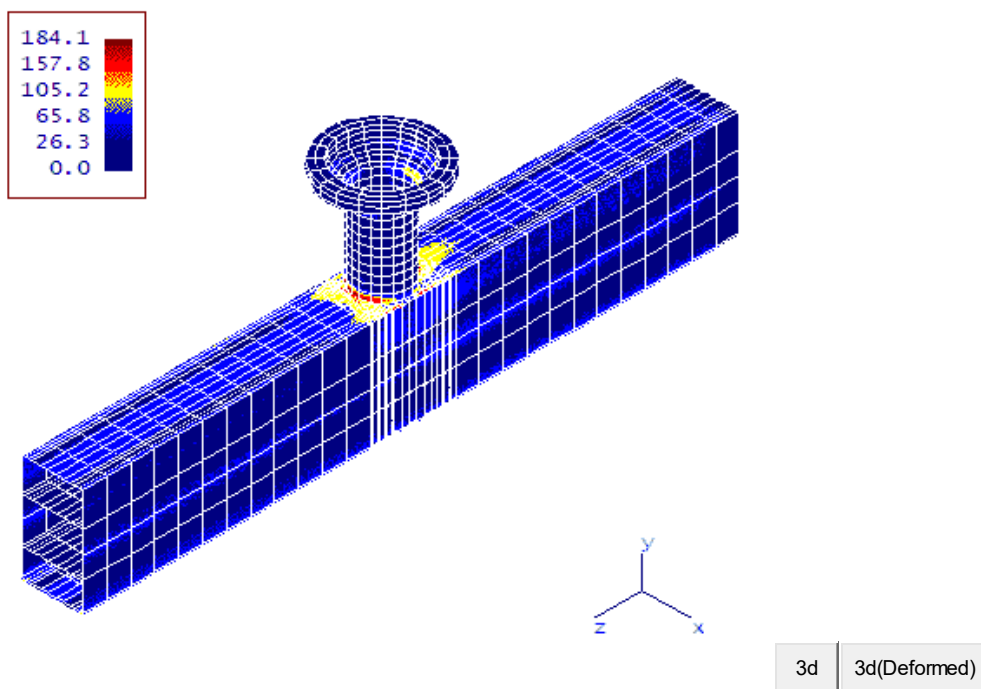
053-073-9184

Thermal/Mechanical Calculation Book

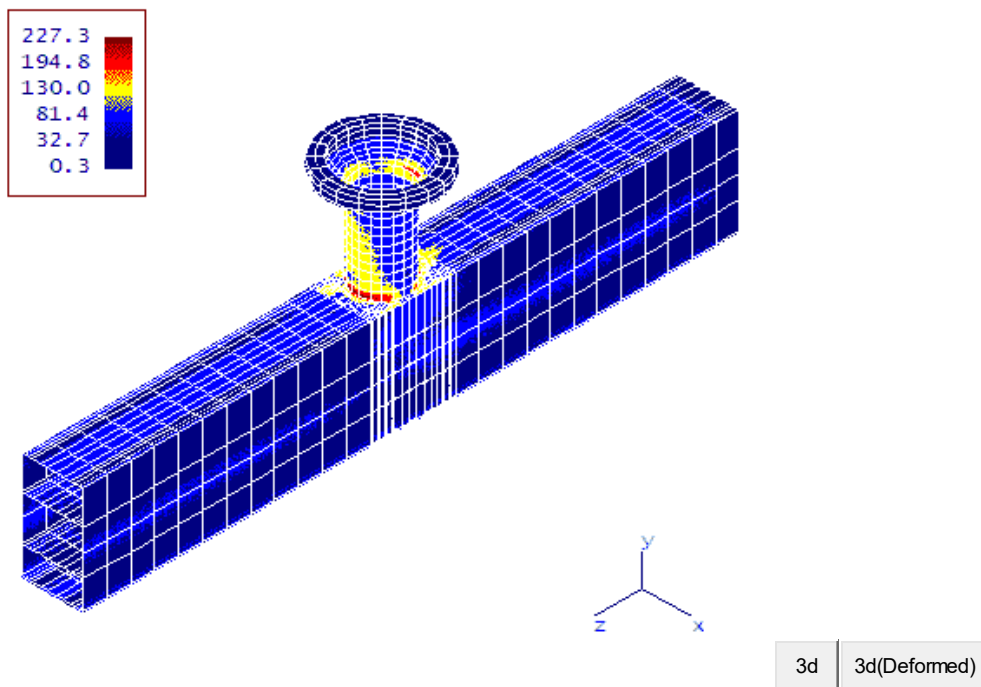
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه
V05	0001	CN	PR	120	AA	GCS	BK

شماره صفحه : 115 از 148

2) Qb < SPS (SUS Bending) Case 2

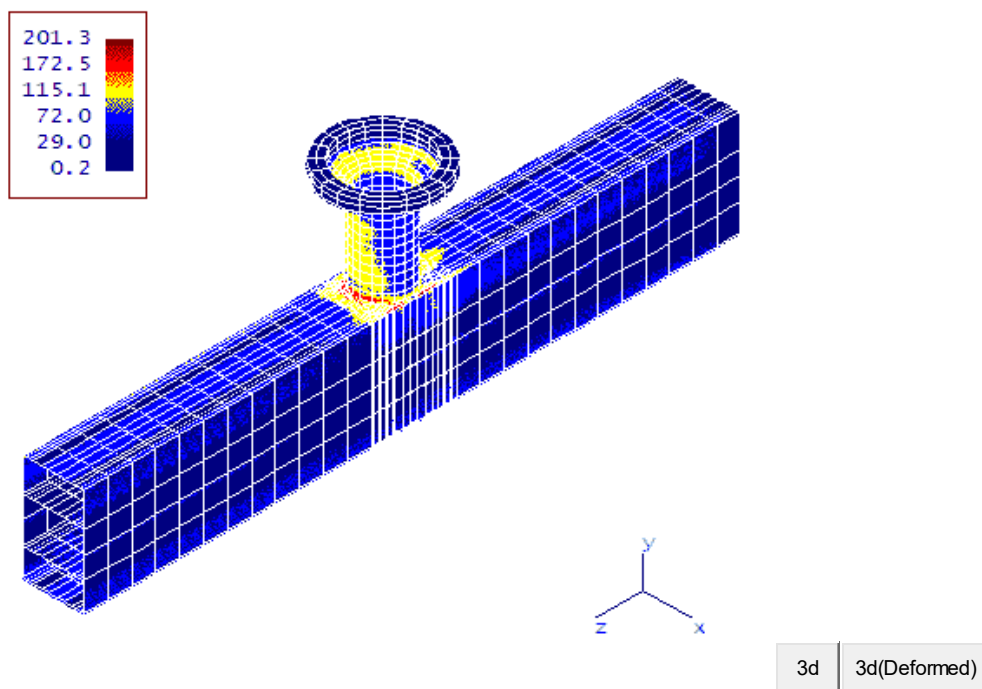


3) P1+Pb+Q < SPS (SUS Inside) Case 2

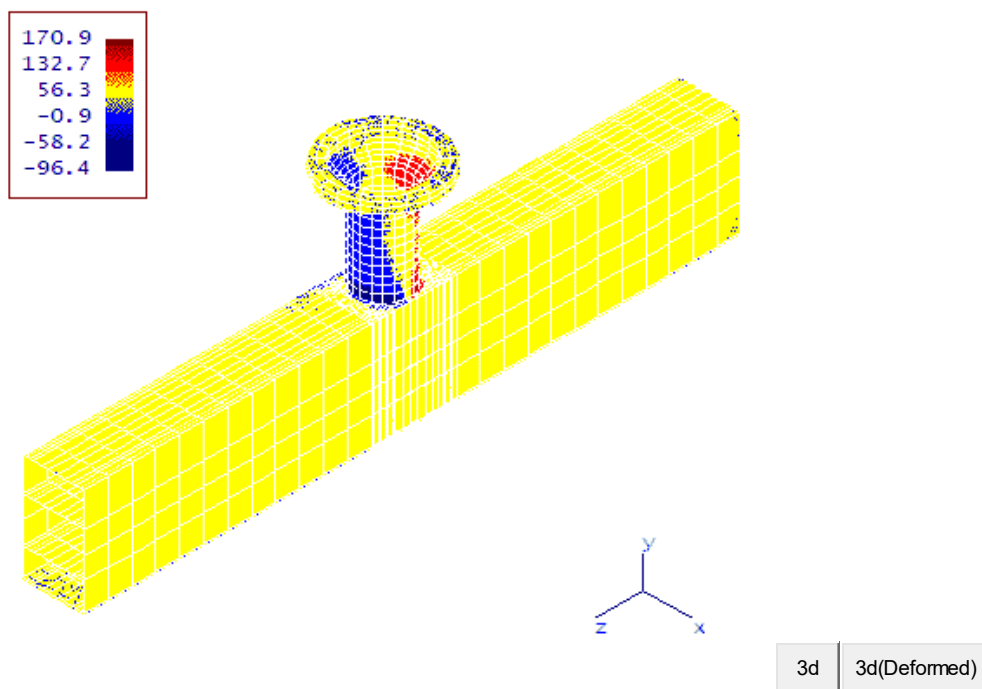


 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

4) $P1+Pb+Q < SPS$ (SUS Outside) Case 2

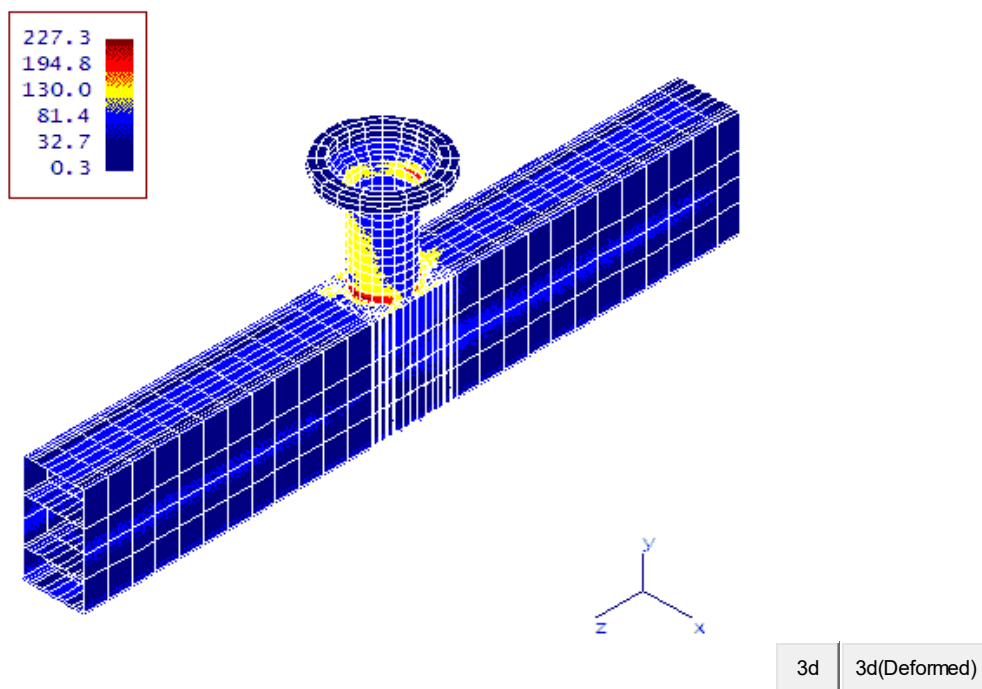


5) $S1+S2+S3 < 4S$ (SUS $S1+S2+S3$) Case 2

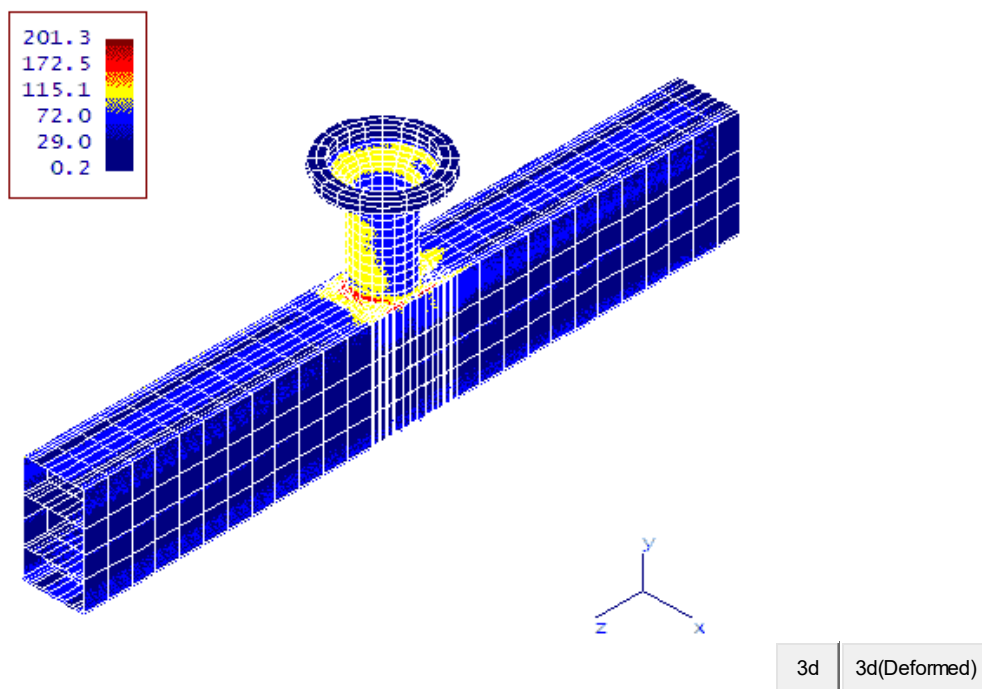


 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

6) P1+Pb+Q < SPS (OPE Inside) Case 3

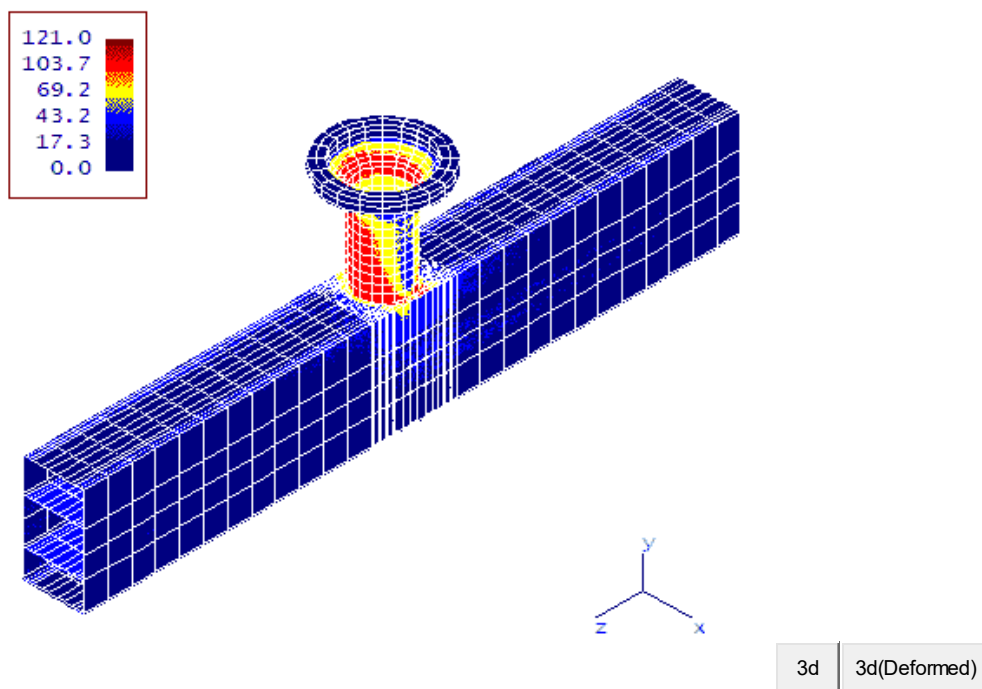


7) P1+Pb+Q < SPS (OPE Outside) Case 3

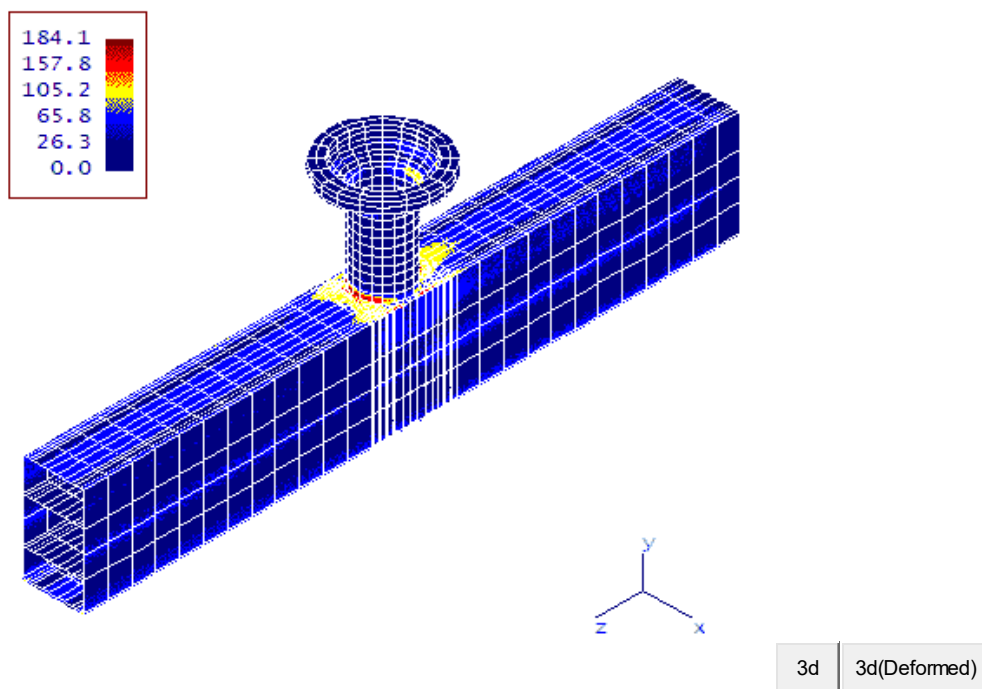


 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)																									
شماره پیمان: 053-073-9184	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 118 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

8) Membrane < User (OPE Membrane) Case 3

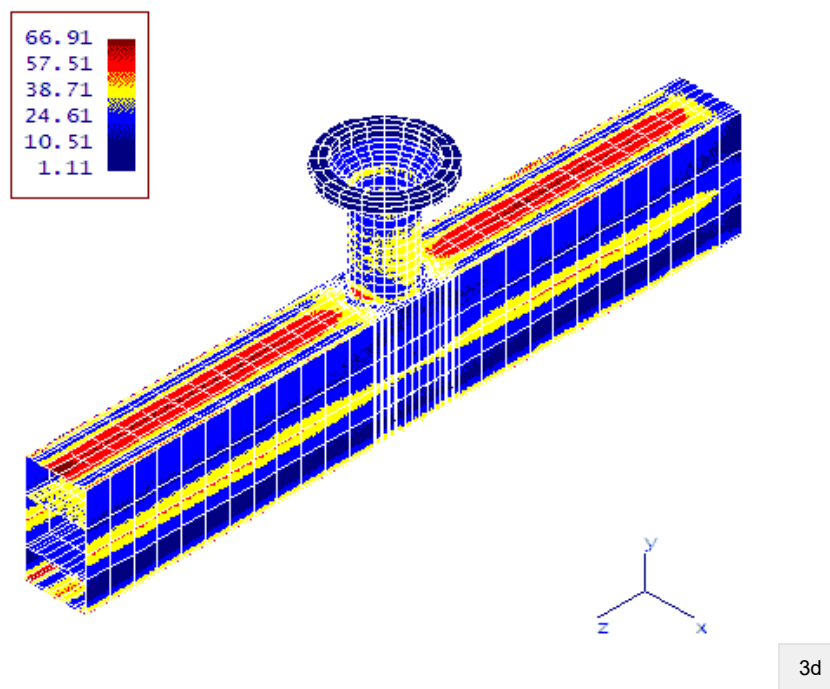


9) Bending < User (OPE Bending) Case 3

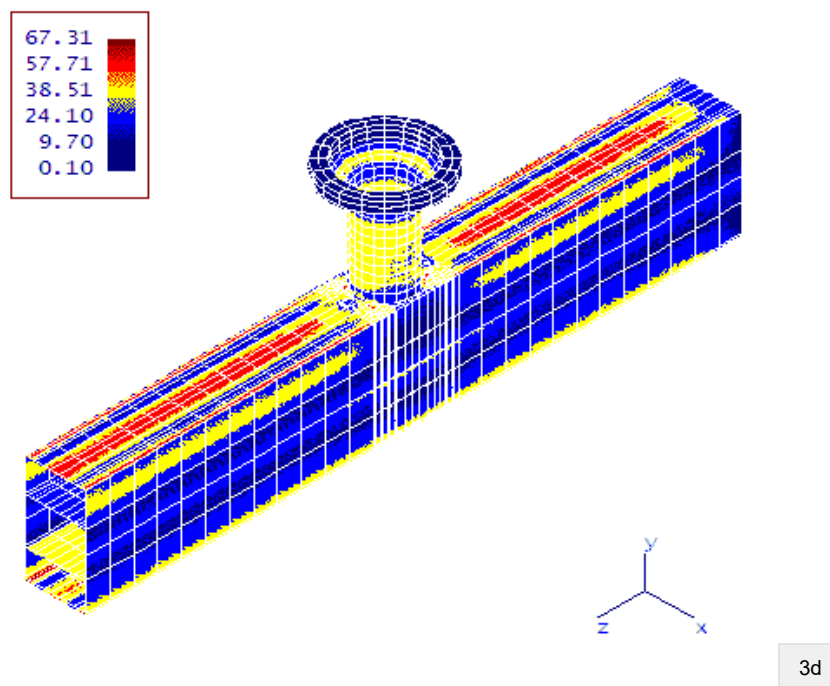


 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	BK	GCS	AA	120	PR	CN	0001	V05	

10) P1+Pb+Q < SPS (EXP Inside) Case 4



11) P1+Pb+Q < SPS (EXP Outside) 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)



شماره پیمان:

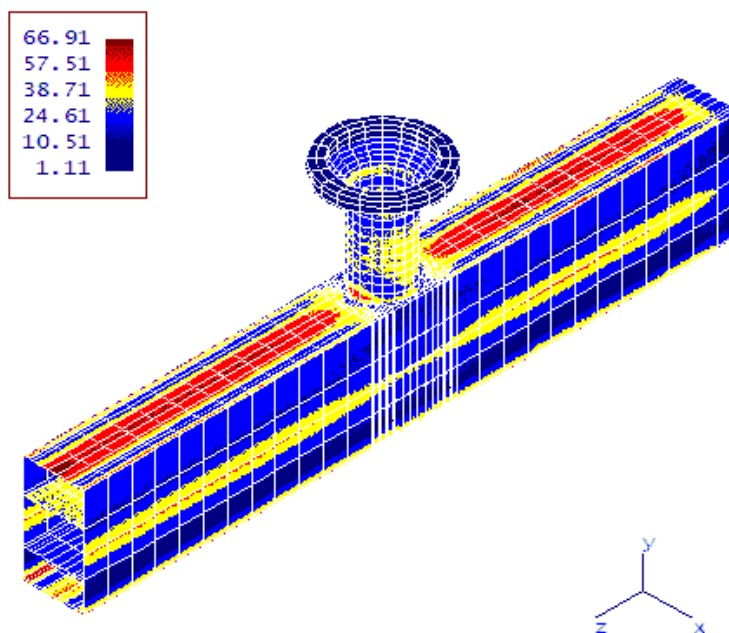
053-073-9184

Thermal/Mechanical Calculation Book

نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه
V05	0001	CN	PR	120	AA	GCS	BK

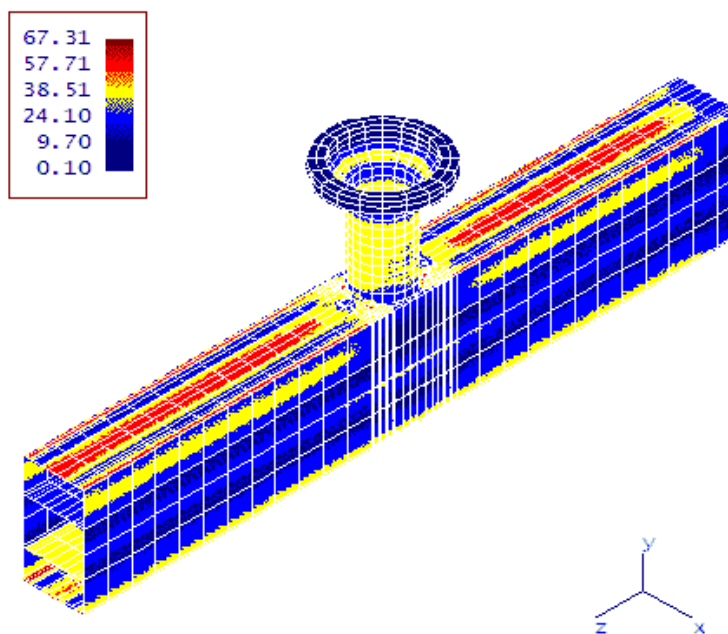
شماره صفحه : 120 از 148

12) $P1+Pb+Q+F < 2Sa$ (EXP Inside) Case 4



3d

13) $P1+Pb+Q+F < 2Sa$ (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	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 121 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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)								
شماره پیمان: 053 – 073 – 9184	Thermal/Mechanical Calculation Book							شماره صفحه : 123 از 148	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		
	BK	GCS	AA	120	PR	CN	0001	V05	

User Defined Loads:

	Forces [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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\$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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V05	0001	CN	PR	120	AA	GCS	BK																			

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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Released Jan. 2021

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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
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ASME Code Stress Output Plots \$X

- 1) $P_L < S_{PL}$ (SUS, Membrane) Case 2
- 2) $Q_b < S_{PS}$ (SUS, Bending) Case 2
- 3) $P_L + P_b + Q < S_{PS}$ (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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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

- 4) Pl+Pb+Q < SPS (SUS,Outside) Case 2
- 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
- 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3
- 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3
- 8) Membrane < User (OPE,Membrane) Case 3
- 9) Bending < User (OPE,Bending) Case 3
- 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4
- 11) Pl+Pb+Q < SPS (EXP,Outside) Case 4
- 12) Pl+Pb+Q+F < 2Sa (EXP,Inside) Case 4
- 13) Pl+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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Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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

 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 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%

Circ Plate for Plate # 5

PL 118 MPa	SPL 126 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -7. (10% Neg, 2% NegHi) Plot Reference: 1) PL < SPL (SUS,Membrane) Case 2
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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 126 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 4) PL+Pb+Q < SPS (SUS,Outside) Case 2
-----------------------	-------------------	--

36%

PL+Pb+Q 126 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 7) PL+Pb+Q < SPS (OPE,Outside) Case 3
-----------------------	-------------------	--

36%

Long Plate for Plate # 1

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%

PL+Pb+Q 241 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -125. (92% Neg, 27% NegHi) 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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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
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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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	BK	GCS	AA	120	PR	CN	0001	V05

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
		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 = 2,294,650.
		WRC 474 99% Probability Cycles = 533,068.
		WRC 474 95% Probability Cycles = 740,098.
17%		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
		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 = 4,468,199.
		WRC 474 99% Probability Cycles = 1,038,003.
		WRC 474 95% Probability Cycles = 1,441,137.
13%		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
		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 = 63,477,656.
		WRC 474 99% Probability Cycles = 14,746,436.
		WRC 474 95% Probability Cycles = 20,473,570.
4%		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
		Cycles Allowed for this Stress = 1.3893E8
Allowable		"B31" Fatigue Stress Allowable = 0.0
526.2		Markl Fatigue Stress Allowable = 575.0
MPa		WRC 474 Mean Cycles to Failure = 2,470,444.
		WRC 474 99% Probability Cycles = 573,907.
		WRC 474 95% Probability Cycles = 796,797.
22%		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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Highest Stress Ratios Per Region
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Highest Stress Ratios Per Region \$X

Circ Plate for Plate # 1

PL 41 MPa	SPL 168 MPa	Primary Membrane Load Case 2 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 1) PL < SPL (SUS,Membrane) Case 2
24%		
Qb 104 MPa	SPS 340 MPa	Primary Bending Load Case 2 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 2) Qb < SPS (SUS,Bending) Case 2
30%		
PL+Pb+Q 97 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 2 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 3) PL+Pb+Q < SPS (SUS,Inside) Case 2
28%		
PL+Pb+Q 126 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 2 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 4) PL+Pb+Q < SPS (SUS,Outside) Case 2
36%		
S1+S2+S3 71 MPa	4S 448 MPa	Part 5 (5.3.2) Load Case 2 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2
15%		
PL+Pb+Q 97 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 6) PL+Pb+Q < SPS (OPE,Inside) Case 3
28%		
PL+Pb+Q 126 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 7) PL+Pb+Q < SPS (OPE,Outside) Case 3
36%		
Membrane 41 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -51. (57% Neg, 0% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3
11%		
Bending 104 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -51. (57% Neg, 0% NegHi) 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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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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 Markl 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 Markl 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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	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	
	V05	0001	CN	PR	120	AA	GCS	BK

27%			
Pl+Pb+Q 175 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 3 Min Prin. Stress = -125. (92% Neg, 27% NegHi) Plot Reference: 6) Pl+Pb+Q < SPS (OPE,Inside) Case 3	
51%			
Pl+Pb+Q 241 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 3 Min Prin. Stress = -125. (92% Neg, 27% NegHi) Plot Reference: 7) Pl+Pb+Q < SPS (OPE,Outside) Case 3	
70%			
Membrane 109 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -125. (92% Neg, 27% NegHi) Plot Reference: 8) Membrane < User (OPE,Membrane) Case 3	
32%			
Bending 194 MPa	User 340 MPa	Component Evaluation Load Case 3 Min Prin. Stress = -125. (92% Neg, 27% NegHi) Plot Reference: 9) Bending < User (OPE,Bending) Case 3	
57%			
Pl+Pb+Q 124 MPa	SPS 340 MPa	Primary+Secondary (Inner) Load Case 4 Min Prin. Stress = -64. (90% Neg, 22% NegHi) Plot Reference: 10) Pl+Pb+Q < SPS (EXP,Inside) Case 4	
36%			
Pl+Pb+Q 164 MPa	SPS 340 MPa	Primary+Secondary (Outer) Load Case 4 Min Prin. Stress = -64. (90% Neg, 22% NegHi) Plot Reference: 11) Pl+Pb+Q < SPS (EXP,Outside) Case 4	
48%			
Pl+Pb+Q+F 124 MPa	Damage Ratio 0.000 Life 0.161 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 Markl Fatigue Stress Allowable = 659.5 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	Allowable 771.0 MPa 16%
Pl+Pb+Q+F 164 MPa	Damage Ratio 0.000 Life 0.213 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 = 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	Allowable 771.0 MPa 21%

Circ Plate for Plate # 2

PL 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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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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 Markl Fatigue Stress Allowable = 659.5 WRC 474 Mean Cycles to Failure = 6,294,933.
Allowable 770.9 MPa		

 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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	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	
	V05	0001	CN	PR	120	AA	GCS	BK

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	Damage Ratio	Primary+Secondary+Peak (Outer) Load Case 4	
73	0.000 Life	Stress Concentration Factor = 1.000	
MPa	0.094 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	
9%		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	
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%			
Qb	SPS	Primary Bending Load Case 2	
162	340	Min Prin. Stress = -189. (76% Neg, 47% NegHi)	
MPa	MPa	Plot Reference:	
		2) Qb < SPS (SUS,Bending) Case 2	
47%			
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 (Outer) Load Case 2	
154	340	Min Prin. Stress = -189. (76% Neg, 47% NegHi)	
MPa	MPa	Plot Reference:	
		4) Pl+Pb+Q < SPS (SUS,Outside) Case 2	
45%			
S1+S2+S3	4S	Part 5 (5.3.2) Load Case 2	
147	448	Min Prin. Stress = -189. (76% Neg, 47% NegHi)	
MPa	MPa	Plot Reference:	
		5) S1+S2+S3 < 4S (SUS,S1+S2+S3) Case 2	
32%			
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%			
Pl+Pb+Q	SPS	Primary+Secondary (Outer) Load Case 3	
154	340	Min Prin. Stress = -189. (76% Neg, 47% NegHi)	
MPa	MPa	Plot Reference:	
		7) Pl+Pb+Q < SPS (OPE,Outside) Case 3	
45%			
Membrane	User	Component Evaluation Load Case 3	
146	340	Min Prin. Stress = -189. (76% Neg, 47% NegHi)	
MPa	MPa	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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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	AA	120	PR	CN	0001	V05	

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		Markl 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		Markl 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	

 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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Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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 Markl 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 Markl 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%		

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید پکیج کولرهای هوایی ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0015_02)								
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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		
	BK	GCS	AA	120	PR	CN	0001	V05	

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	<table><tr><th colspan="8">Thermal/Mechanical Calculation Book</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادرکننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V05</td><td>0001</td><td>CN</td><td>PR</td><td>120</td><td>AA</td><td>GCS</td><td>BK</td></tr></table>	Thermal/Mechanical Calculation Book								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V05	0001	CN	PR	120	AA	GCS	BK	شماره صفحه : 139 از 148
Thermal/Mechanical Calculation Book																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V05	0001	CN	PR	120	AA	GCS	BK																			

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
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 = 63,477,656.
4% 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

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
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 = 3.3666E8
2% WRC 474 99% Probability Cycles = 78,208,688.
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

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	BK	GCS	AA	120	PR	CN	0001	V05	

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 Markl 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 Markl 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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	BK	GCS	AA	120	PR	CN	0001	V05	

>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)



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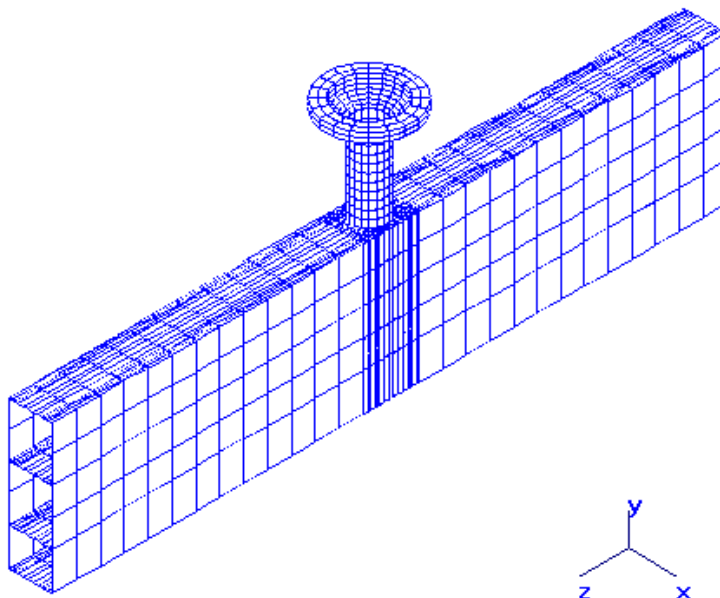
053-073-9184

Thermal/Mechanical Calculation Book

نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه
V05	0001	CN	PR	120	AA	GCS	BK

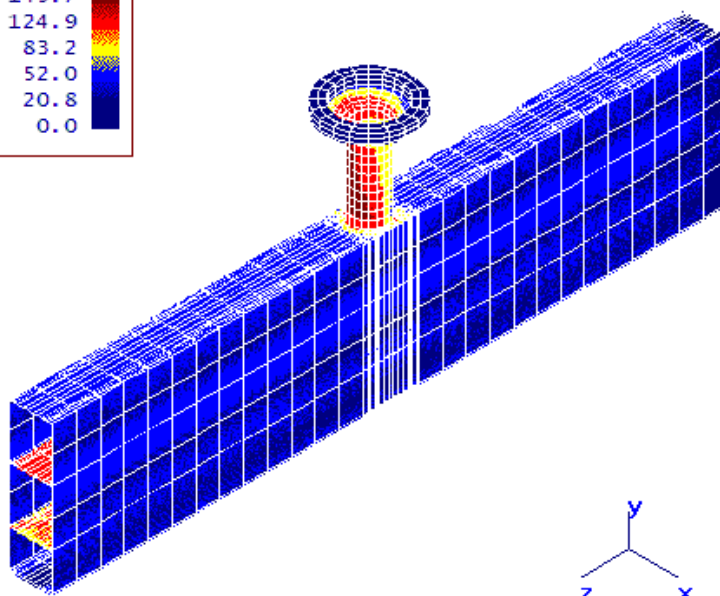
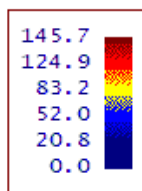
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Finite Element Model



3d

1) P1 < SPL (SUS Membrane) Case 2



3d

3d(Deformed)



نگهداشت و افزایش تولید میدان نفتی بینک
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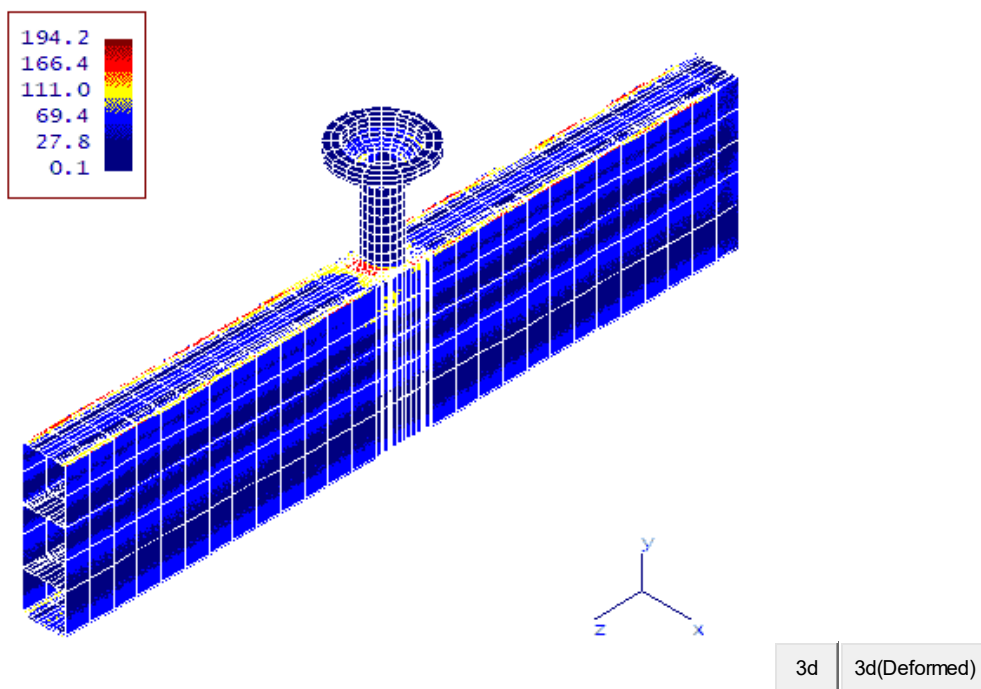
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Thermal/Mechanical Calculation Book

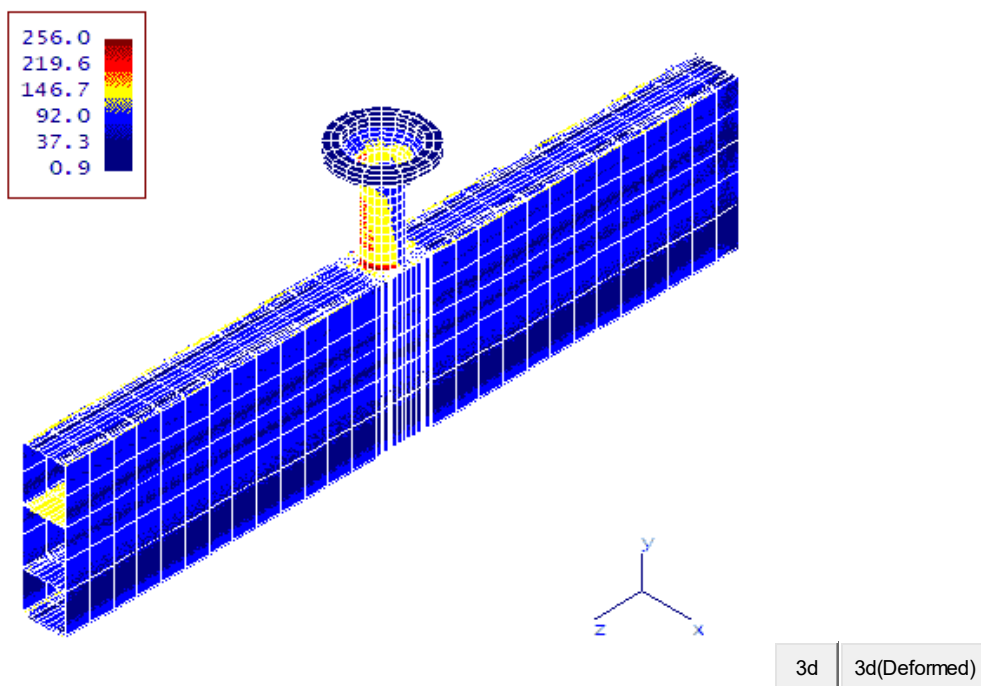
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V05	0001	CN	PR	120	AA	GCS	BK

شماره صفحه : 143 از 148

2) Qb < SPS (SUS Bending) Case 2



3) P1+Pb+Q < SPS (SUS Inside) Case 2





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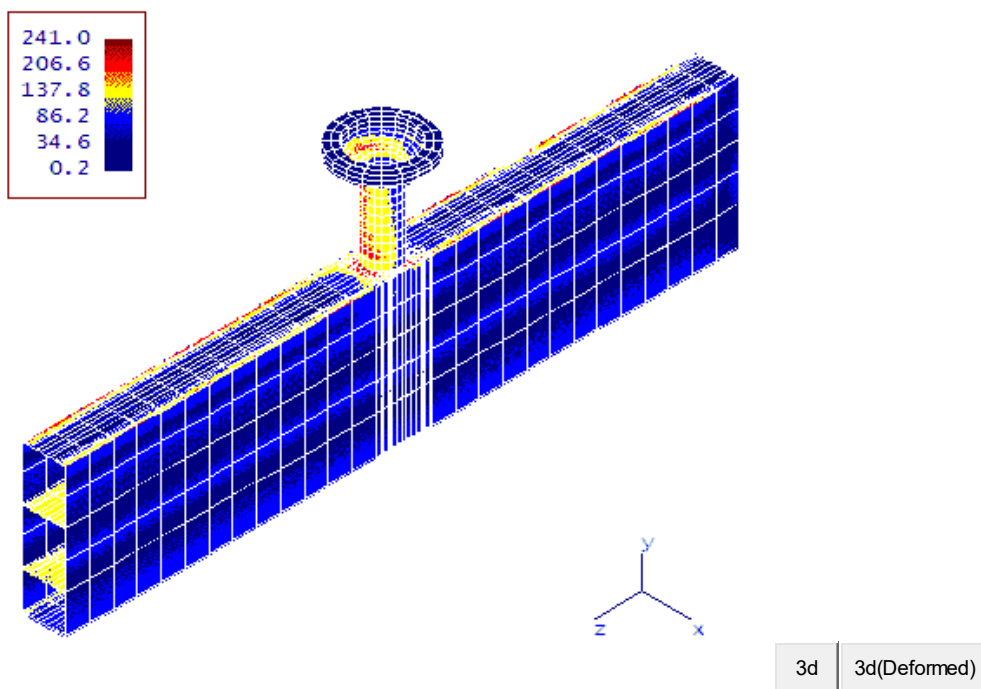
053-073-9184

Thermal/Mechanical Calculation Book

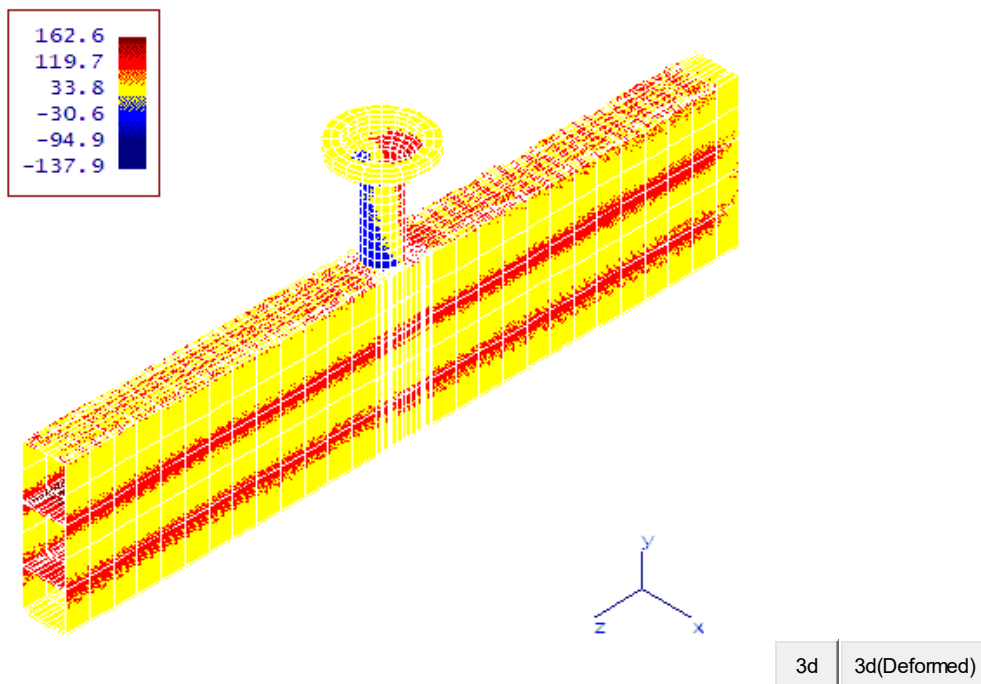
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BK	GCS	AA	120	PR	CN	0001	V05

شماره صفحه : 144 از 148

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
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(قرارداد BK-HD-GCS-CO-0015_02)



شماره پیمان:

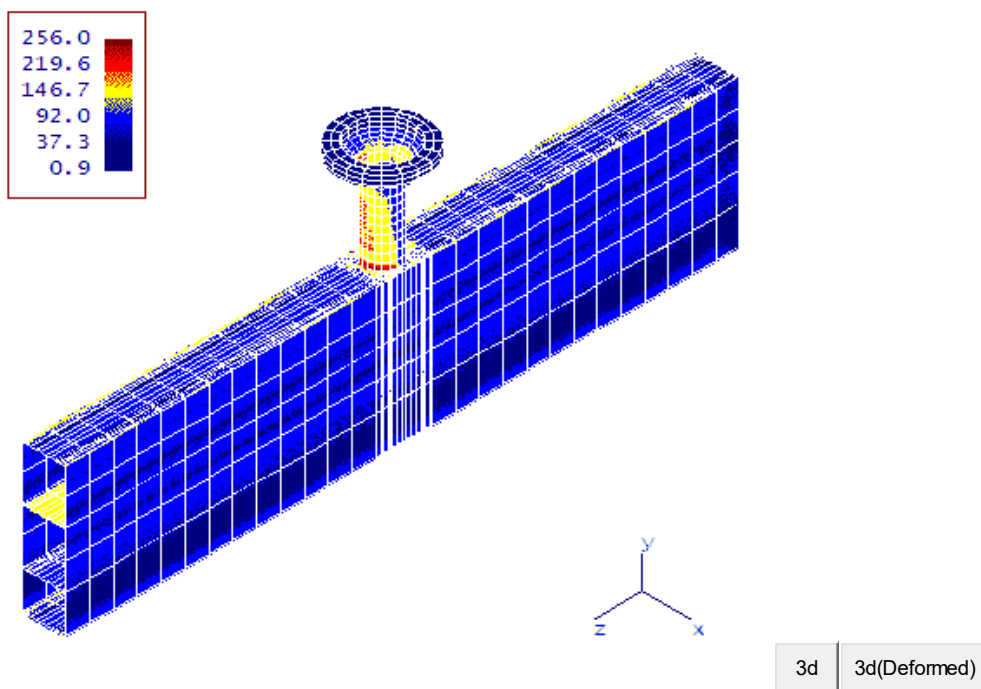
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Thermal/Mechanical Calculation Book

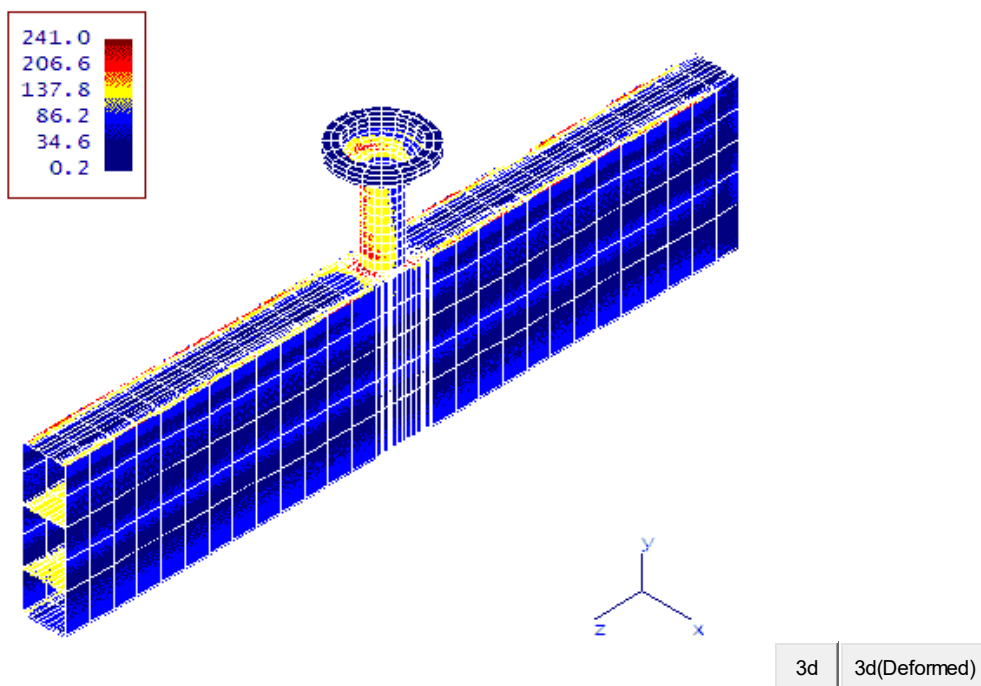
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BK	GCS	AA	120	PR	CN	0001	V05

شماره صفحه : 145 از 148

6) P1+Pb+Q < SPS (OPE Inside) Case 3



7) P1+Pb+Q < SPS (OPE Outside) Case 3





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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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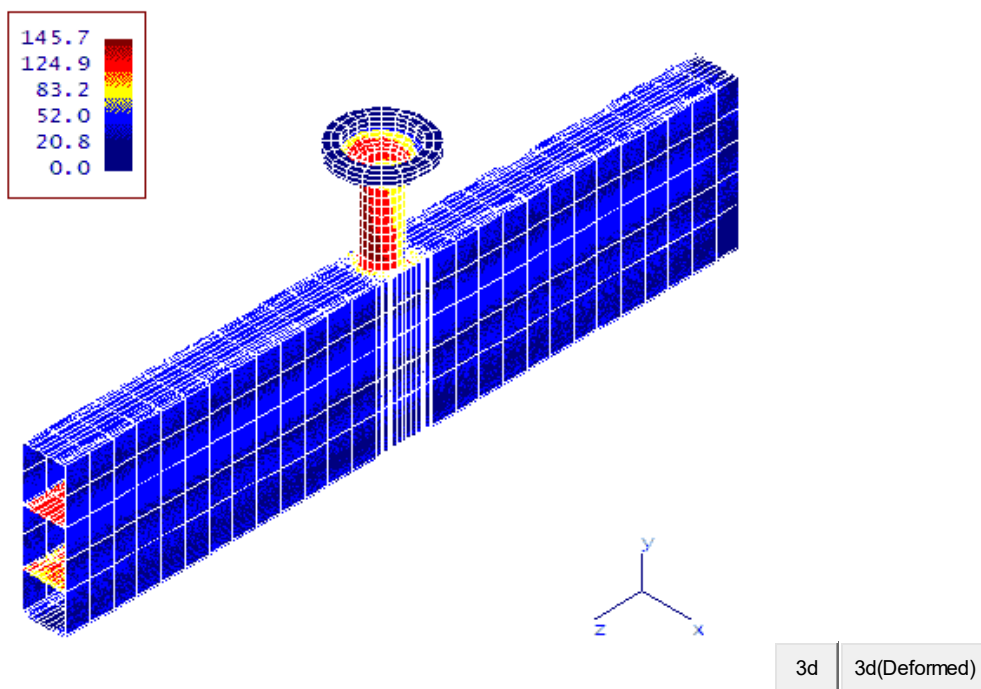
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Thermal/Mechanical Calculation Book

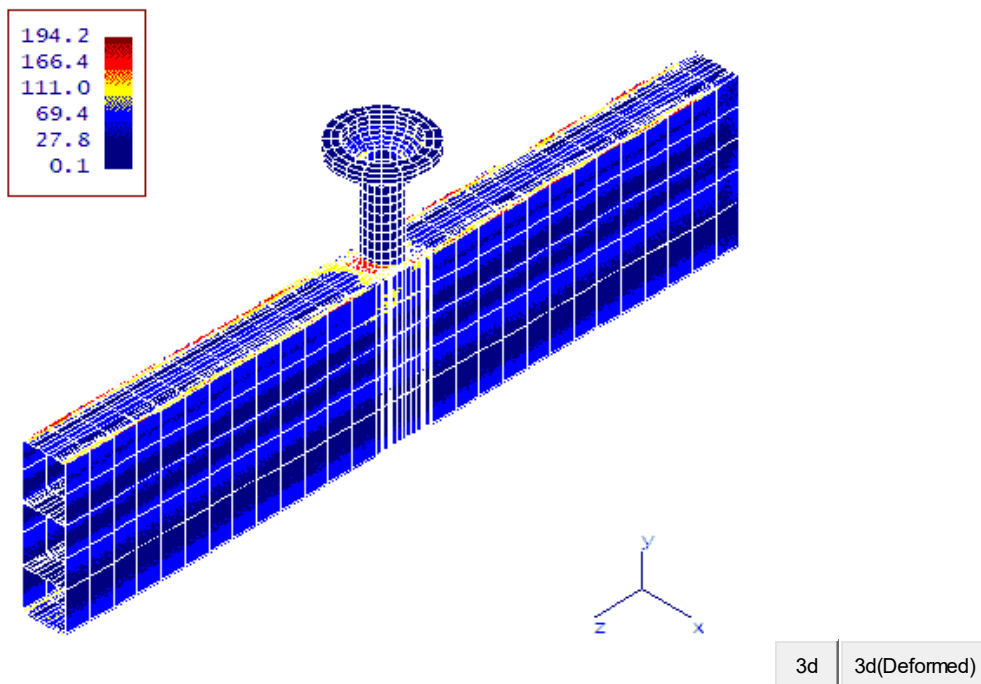
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V05	0001	CN	PR	120	AA	GCS	BK

شماره صفحه : 146 از 148

8) Membrane < User (OPE Membrane) Case 3



9) Bending < User (OPE Bending) Case 3





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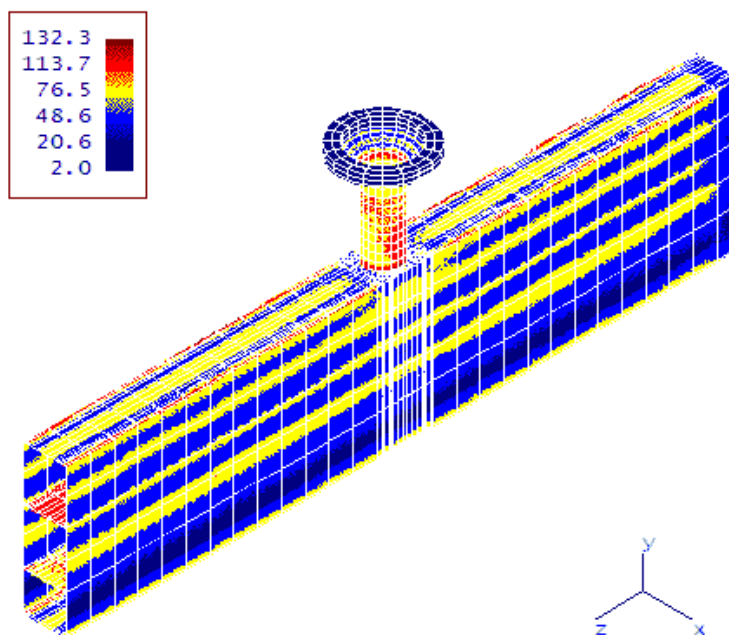
053-073-9184

Thermal/Mechanical Calculation Book

نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه
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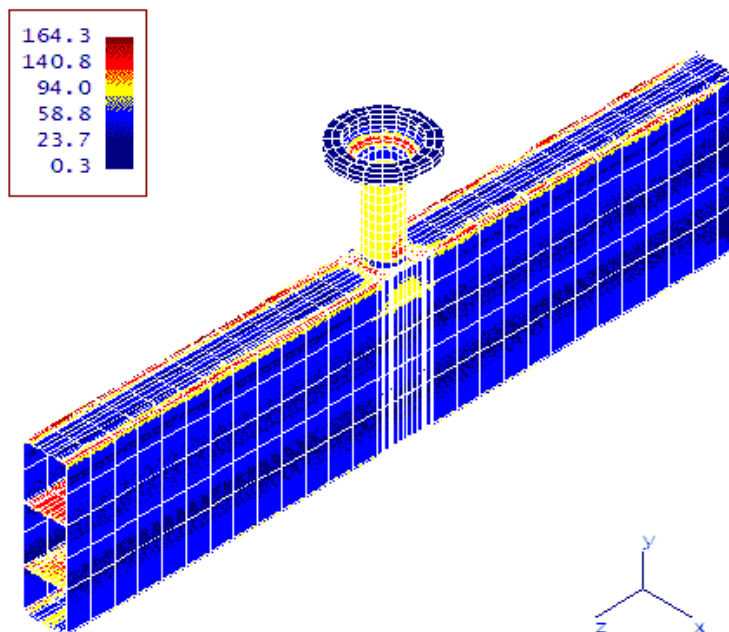
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10) P1+Pb+Q < SPS (EXP Inside) Case 4



3d

11) P1+Pb+Q < SPS (EXP Outside) Case 4



3d



نگهداشت و افزایش تولید میدان نفتی بینک
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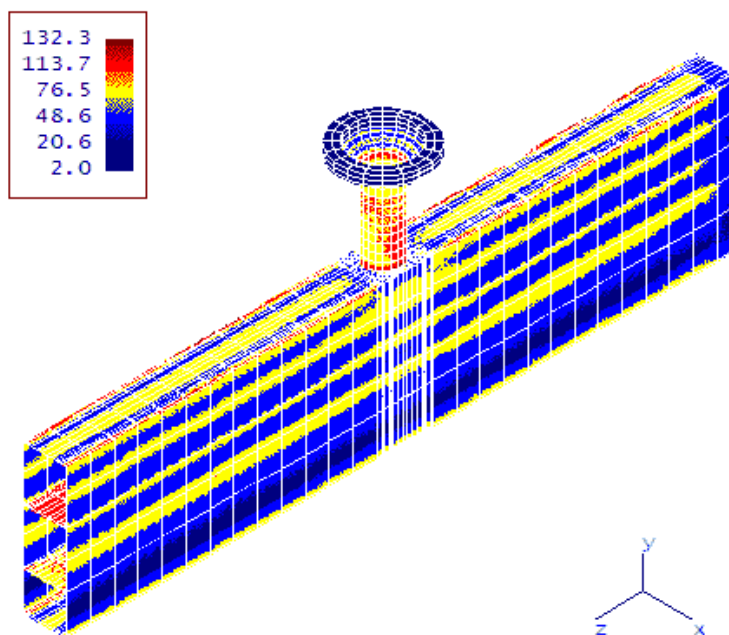
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Thermal/Mechanical Calculation Book

پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
BK	GCS	AA	120	PR	CN	0001	V05

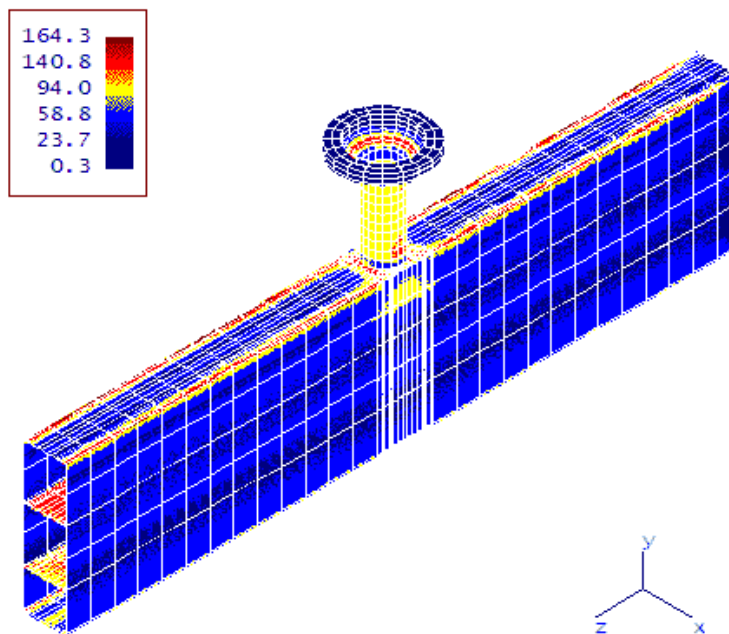
شماره صفحه : 148 از 148

12) $P1+Pb+Q+F < 2Sa$ (EXP Inside) Case 4



3d

13) $P1+Pb+Q+F < 2Sa$ (EXP Outside) Case 4



3d