

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)							 
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)							شماره صفحه : 1 از 99
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	BK	GCS	MF	120	ME	CN	0006	V00

طرح نگهداشت و افزایش تولید 27 مخزن

THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)

نگهداشت و افزایش تولید میدان نفتی بینک

V00	DEC. 2024	IFI	MFS	M.Fakharian	S.Faramarzpour	
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

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DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2019

Analysis Performed by :

Job File : C:\USERS\TECHNICAL2\DESKTOP\BINAK\DESIGN\E-100\E

Date of Analysis : Dec 24,2024 3:55pm

PV Elite 2020, January 2020

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ASME Code, Section VIII Division 1, 2019

Diameter Spec :	273.050 mm. OD
Vessel Design Length, Tangent to Tangent	2025.68 mm.
Distance of Bottom Tangent above Grade	100.00 mm.
Distance of Base above Grade	100.00 mm.
Specified Datum Line Distance	0.00 mm.
Shell Side Design Temperature	152 °C
Channel Side Design Temperature	100 °C
Shell Side Design Pressure	6.600 bars
Channel Side Design Pressure	8.500 bars
Shell Side Hydrostatic Test Pressure	10.220 bars
Channel Side Hydrostatic Test Pressure	11.050 bars
Wind Design Code	ASCE-2010
Earthquake Design Code	ASCE 7-2010

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normal ized	Impact Tested
Shell	SA-312 TP316L	...	...	S31603	No	No
Head	SA-403 316L	...	...	S31603	No	No
Flange	SA-182 F316L	...	<= 5	S31603	No	No
Nozzle	SA-182 F316L	...	<= 5	S31603	No	No
Nozzle Flg	SA-182 F316L	...	<= 5	S31603	No	No
Tubes	SA-213 TP316L	...	...	S31603	No	No
Tubesheet	SA-182 F316L	...	<= 5	S31603	No	No
Flg Bolting	SA-193 B8M	1	...	S31600	No	No

Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.
Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (bars & mm.):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Shell FLG.	6.641	1.03	11.900	0.0000	N/A	?
Shell Barrel	6.641	1.03	53.000	0.0000	N/A	?
Shell FLG.	6.641	1.03	11.900	0.0000	N/A	?
Channel FLG.	8.541	1.03	13.300	0.0000	N/A	?
Channel Barrel	8.531	1.03	58.800	0.0000	N/A	?
Channel Cover	8.511	1.03	72.200	0.0000	No	?

Liquid Level: 415.81 mm. Dens.: 999.542 kg/m³ Sp. Gr.: 1.000

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	BK	GCS	MF	120	ME	CN	0006		V00

Element Types and Properties:

Element Type	"To" Elev mm.	Element Length mm.	Nominal Thickness mm.	Finished Thickness mm.	Reqd Thk Internal mm.	Reqd Thk External mm.	Long Eff	Circ Eff
Body Flg	108.0	101.6	...	30.2	...	...	1.00	1.00
Cylinder	1508.0	1400.0	9.3	8.1	1.5	1.9	1.00	1.00
Body Flg	1609.6	101.6	...	30.2	...	...	1.00	1.00
Body Flg	1775.7	101.6	...	30.2	...	...	1.00	1.00
Cylinder	1975.7	200.0	9.3	8.1	1.5	1.0	1.00	1.00
Ellipse	2025.7	50.0	9.3	8.1	1.5	1.5	1.00	1.00

Factored Loads:

Un-Factored Loads:

Local Stress Analysis Results:

Description	Analysis Type	Max Stress Ratio	High Stress Location	Pass / Fail
S2 (2in)	WRC-107/537	0.297	n/a	Passed

Weights:

Fabricated - Bare W/O Removable Internals	341.4 kg.
Shop Test - Fabricated + Water (Full)	431.6 kg.
Shipping - Fab. + Rem. Intls.+ Shipping App.	352.4 kg.
Erected - Fab. + Rem. Intls.+ Insul. (etc)	352.4 kg.
Empty - Fab. + Intls. + Details + Wghts.	352.4 kg.
Operating - Empty + Operating Liquid (No CA)	386.3 kg.
Field Test - Empty Weight + Water (Full)	442.6 kg.

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Nozzle Calculation Summary:

Description	MAWP bars	Ext	MAPNC bars	UG-45	[tr] mm.	Weld Path	Areas or Stresses
S2 (2in)	11.9	OK	...	OK	1.50	OK	Passed
V (1in)	13.2	OK	...	OK	1.50	OK	Passed
T1	13.2	OK	...	OK	1.50	OK	Passed
T1	13.2	OK	...	OK	1.50	OK	Passed
T2	13.2	OK	...	OK	1.50	OK	Passed
T2	13.2	OK	...	OK	1.50	OK	Passed

Nozzle MAWP Summary:

Minimum MAWP Nozzles : 11.9 Nozzle : S2 (2in) [Shellside]
Minimum MAWP Nozzles : 13.2 Nozzle : V (1in) [Tubeside]

Note: MAWPs (Internal Case) shown above are at the High Point.

Check the Spatial Relationship between the Nozzles:

From Node	Nozzle Description	Y Coordinate mm.	Layout Angle deg	Dia. Limit mm.
20	S2 (2in)	1407.950	0.000	101.600
50	V (1in)	1875.675	0.000	67.224
60	T1	0.000	0.000	67.224
60	T2	0.000	180.000	67.224

The nozzle spacing is computed by the following:

= Sqrt($l_l^2 + l_c^2$) where

l_l - Arc length along the inside vessel surface in the long. direction.

l_c - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.

No interference violations have been detected !

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Bill of Materials:

QTY	DESCRIPTION	MATERIAL
1	BODY FLANGE: 30.2mm. THK X 254.5mm. OD	SA-182 F316L
1	CYLINDER: 9.3mm. THK X 256.8mm. ID X 1400.0mm.	SA-312 TP316L
2	BODY FLANGE: 30.2mm. THK X 256.8mm. OD	SA-182 F316L
1	CYLINDER: 9.3mm. THK X 256.8mm. ID X 200.0mm.	SA-312 TP316L
1	ELLIPTICAL HEAD: 2.0 X 1, 9.3mm. THK X 256.8mm. ID X 50.0mm.	SA-403 316L
3	INSULATION: 101mm X 40mm THK	
1	INSULATION: 1400mm X 40mm THK	
5	BAFFLES: 170mm DIA X 8mm THK	SA-240 316L
1	TUBESHEET: 406mm X 54mm THK	SA-182 F316L
44	TUBES: 1400mm X 19mm DIA X 1mm THK	SA-213 TP316L
1	INSULATION: 200mm X 40mm THK	
1	INSULATION: 118mm X 40mm THK	
1	GASKET: 317mm. OD X 287mm. ID	...
12	BODY FLANGE BOLTS: 24mm. DIA	SA-193 B8M
24	NUTS FOR BODY FLANGE BOLTS: 24mm. DIA	...
1	NAMEPLATE	...

Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia in	Wall Thk mm	Reinforcing Diameter	Pad Thk mm	Cut Length in	Flg Class
V (1in)	1.000 in	Actual	LW	2.008	12.800	...	...	160.6	150
T1	1.000 in	Actual	LW	2.008	12.800	...	...	169.4	150
T2	1.000 in	Actual	LW	2.008	12.800	...	...	169.4	150
S2 (2in)	2.000 in	Actual	LW	3.248	15.850	...	...	164.9	150

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

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In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows:
Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm.):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
V (1in)	SA-182 F316L	8.112	10.000	...	...	...
T1	SA-182 F316L	8.112	10.000	...	...	...
T2	SA-182 F316L	8.112	10.000	...	...	...
S2 (2in)	SA-182 F316L	8.112	10.000	...	...	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm.	Layout Angle deg	Proj Outside mm.	Proj Inside mm.	Installed in Component
V (1in)	1875.675	0.0	150.00	0.00	Channel Barrel
T1	...	0.0	150.00	0.00	Channel Cover
T2	...	180.0	150.00	0.00	Channel Cover
S2 (2in)	1407.950	0.0	150.00	0.00	Shell Barrel

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Minimum Design Metal Temperature Results Summary :

Description	Curve	Basic MDMT °C	Reduced MDMT °C	UG-20 (f) MDMT °C	Thickness ratio	Gov Thk mm.	E*	PWHT reqd
Notes								

Nozzle Flg [5]		-196						
Nozzle Flg [5]		-196						
Shell Barrel [16]		-196						
S2 (2in) [15]		-196						
Nozzle Flg [5]		-196						
Tubesheet: SS[13]		-196						

Warmest MDMT:		-196						

Nozzle Flg [5]		-196						
Channel Barre[16]		-196						
Channel Cover[16]		-196						
V (1in) [15]		-196						
Nozzle Flg [5]		-196						
T1 [15]		-196						
Nozzle Flg [5]		-196						
T2 [15]		-196						
Nozzle Flg [5]		-196						

Warmest MDMT:		-196						

Exchanger Side		Computed MDMT °C		Required MDMT °C		Pass/Fail		

Shell		-196.0		5.0		Pass		
Channel/Tube		-196.0		5.0		Pass		

Notes:

- [!] - This was an impact tested material.
- [1] - Governing Nozzle Weld.
- [4] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-c).
- [5] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-b).
- [6] - MDMT Calculations at the Shell/Head Joint.
- [7] - MDMT Calculations for the Straight Flange.
- [8] - Cylinder/Cone/Flange Junction MDMT.
- [9] - Calculations in the Spherical Portion of the Head.
- [10] - Calculations in the Knuckle Portion of the Head.
- [11] - Calculated (Body Flange) Flange MDMT.
- [12] - Calculated Flat Head MDMT per UCS-66.3
- [13] - Tubesheet MDMT, shell side, if applicable
- [14] - Tubesheet MDMT, tube side, if applicable
- [15] - Nozzle Material
- [16] - Shell or Head Material
- [17] - Impact Testing required
- [18] - Impact Testing not required, see UCS-66(b)(3)
- [20] - Cylinder/Cone Junction MDMT based on Longitudinal Stress considerations

	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نیم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد 08_0010-CO-GCS-HD-BK)								
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[21] - Bolting Material

UG-84(b)(2) was not considered.

UCS-66(g) was not considered.

UCS-66(i) was not considered.

Notes:

Impact test temps were not entered in and not considered in the analysis.

UCS-66(i) applies to impact tested materials not by specification and

UCS-66(g) applies to materials impact tested per UG-84.1 General Note (c).

The Basic MDMT includes the (30F) PWHT credit if applicable.

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	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادرکننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
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BK	GCS	MF	120	ME	CN	0006	V00											

Class From To : Basic Element Checks.

Class From To: Check of Additional Element Data

Warning: Shell FLG. and Channel FLG.

There are mating flanges in this model that have different design pressures. This will generate different bolt loads. If a tubesheet is in between these flanges, PV Elite will compute the mating flange loads for you. If there is not a tubesheet physically separating these flanges, you must enter in the mating flange loads into the flange dialog.

Warning:

There is a flange in this model connected to an element whose temperature is different. The bolt allowable stress is based on it's parent design temperature. You may need to manually adjust the operating bolt allowable stress to a value based upon a representative maximum temperature the bolts will be subject to.

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PV Elite Vessel Analysis Program: Input Data

Exchanger Design Pressures and Temperatures

Shell Side Design Pressure	6.6	bars
Channel Side Design Pressure	8.4997	bars
Shell Side Design Temperature	152.0	°C
Channel Side Design Temperature	100.0	°C
Radiography, Shell Side	RT-1	
Radiography, Channel Side	RT-1	
Service Type, Shell Side	Lethal	
Service Type, Channel Side	Lethal	
MDMT (CET), Shell Side	5.0	°C
MDMT (CET), Tube Side	5.0	°C
User defined MAWP, Shell Side	11.85	bars
User defined MAWP, Channel Side	13.25	bars
User defined MAPnc, Shell Side	0	bars
User defined MAPnc, Channel Side	0	bars
User defined Test Pres., Shell Side	0	bars
User defined Test Pres., Channel Side	0	bars

Type of Hydrotest	UG-99(b) Note [36]
Hydrotest Position	Horizontal
Projection of Nozzle from Vessel Top	0 mm.
Projection of Nozzle from Vessel Bottom	0 mm.
Type of Construction	Welded
Use Higher Longitudinal Stresses (Flag)	N
Select t for Internal Pressure (Flag)	N
Select t for External Pressure (Flag)	N
Select t for Axial Stress (Flag)	N
Select Location for Stiff. Rings (Flag)	N
Consider Vortex Shedding	N
Perform a Corroded Hydrotest	Y

Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE
Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW

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Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW
Wind Design Code	ASCE-7 2010
Wind Load Reduction Scale Factor	0.600
Basic Wind Speed	120 Km/hr
Surface Roughness Category	C: Open Terrain
Importance Factor	1.0
Type of Surface	Moderately Smooth
Base Elevation	100 mm.
Percent Wind for Hydrotest	33.0
Using User defined Wind Press. Vs Elev.	N
Height of Hill or Escarpment H or Hh	0 mm.
Distance Upwind of Crest Lh	0 mm.
Distance from Crest to the Vessel x	0 mm.
Type of Terrain (Hill, Escarpment)	Flat
Damping Factor (Beta) for Wind (Ope)	0.0100
Damping Factor (Beta) for Wind (Empty)	0.0000
Damping Factor (Beta) for Wind (Filled)	0.0000
Seismic Design Code	ASCE 7-2010
Seismic Load Reduction Scale Factor	0.700
Importance Factor	1.250
Table Value Fa	1.111
Table Value Fv	1.575
Short Period Acceleration value Ss	1.377
Long Period Acceleration Value Sl	0.367
Moment Reduction Factor Tau	1.000
Force Modification Factor R	3.000
Site Class	C
Component Elevation Ratio z/h	0.000
Amplification Factor Ap	0.000
Force Factor	0.000
Consider Vertical Acceleration	No
Minimum Acceleration Multiplier	0.000
User Value of Sds (used if > 0)	1.020
User Value of Sd1 (used if > 0)	0.385
Design Pressure + Static Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Use ASME VIII-1 Appendix 1-9	N

Material Database Year Current w/Addenda or Code Year

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	Yes
Shell Head Joints are Tapered	Yes
Compute "K" in corroded condition	Yes
Use Code Case 2286	No
Use the MAWP to compute the MDMT	Yes
For thickness ratios <= 0.35, MDMT will be -155F (-104C)	Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)	No

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Using Metric Material Databases, ASME II D No
Calculate B31.3 type stress for Nozzles with Loads Yes
Reduce the MDMT due to lower membrane stress Yes
Consider Longitudinal Stress in MDMT calcs. (Div. 1) Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Flange	
Description	Shell FLG.	
Distance "FROM" to "TO"	101.6	mm.
Flange Inside Diameter	254.51	mm.
Element Thickness	30.226	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	0	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	6.6	bars
Design Temperature Internal Pressure	152	°C
Design External Pressure	1.034	bars
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-182 F316L	
Allowable Stress, Ambient	115.1	N./mm ²
Allowable Stress, Operating	87.2	N./mm ²
Allowable Stress, Hydrotest	155.1	N./mm ²
Material Density	8027.2	kg/m ³
P Number Thickness	0	mm.
Yield Stress, Operating	130.4	N./mm ²
External Pressure Chart Name	HA-4	
UNS Number	S31603	
Class / Thickness / Grade	:: <= 5	
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	Y	
Weight of Standard Flange	0	kN
Class of Standard Flange		
Grade of Standard Flange		
Weld is pre-Heated	No	

Element From Node	10	
Detail Type	Insulation	
Detail ID	Ins: 10	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Insulation	101.6	mm.
Thickness of Insulation	40	mm.
Density	125	kg/m ³

Element From Node	20	
Element To Node	30	
Element Type	Cylinder	
Description	Shell Barrel	
Distance "FROM" to "TO"	1400	mm.

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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	BK	GCS	MF	120	ME	CN	0006		V00

Element Outside Diameter	273.05	mm.
Element Thickness	8.1121	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	9.271	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	6.6	bars
Design Temperature Internal Pressure	152	°C
Design External Pressure	1.034	bars
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-312 TP316L	
Allowable Stress, Ambient	115.1	N./mm ²
Allowable Stress, Operating	87.2	N./mm ²
Allowable Stress, Hydrotest	155.1	N./mm ²
Material Density	8027.2	kg/m ³
P Number Thickness	0	mm.
Yield Stress, Operating	130.4	N./mm ²
External Pressure Chart Name	HA-4	
UNS Number	S31603	
Product Form	Smls. pipe	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	
Element From Node	20	
Detail Type	Insulation	
Detail ID	Ins: 20	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Insulation	1400	mm.
Thickness of Insulation	40	mm.
Density	125	kg/m ³
Element From Node	20	
Detail Type	Nozzle	
Detail ID	S2 (2in)	
Dist. from "FROM" Node / Offset dist	1300	mm.
Nozzle Diameter	2	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.07334	kN
Grade of Attached Flange	GR 2.3	
Nozzle Matl	SA-182 F316L	

Element From Node	30	
Element To Node	40	
Element Type	Flange	
Description	Shell FLG.	
Distance "FROM" to "TO"	101.6	mm.
Flange Inside Diameter	256.83	mm.
Element Thickness	30.226	mm.
Internal Corrosion Allowance	0	mm.

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Nominal Thickness 0 mm.
External Corrosion Allowance 0 mm.
Design Internal Pressure 6.6 bars
Design Temperature Internal Pressure 152 °C
Design External Pressure 1.034 bars
Design Temperature External Pressure 100 °C
Effective Diameter Multiplier 1.2
Material Name SA-182 F316L
Allowable Stress, Ambient 115.1 N./mm²
Allowable Stress, Operating 87.2 N./mm²
Allowable Stress, Hydrotest 155.1 N./mm²
Material Density 8027.2 kg/m³
P Number Thickness 0 mm.
Yield Stress, Operating 130.4 N./mm²
External Pressure Chart Name HA-4
UNS Number S31603
Class / Thickness / Grade :: <= 5
Product Form Forgings
Perform Flange Stress Calculation (Y/N) Y
Weight of Standard Flange 0 kN
Class of Standard Flange
Grade of Standard Flange
Weld is pre-Heated No

Element From Node 30
Detail Type Insulation
Detail ID Ins: 30
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Insulation 101.6 mm.
Thickness of Insulation 40 mm.
Density 125 kg/m³

Element From Node 40
Element To Node 50
Element Type Flange
Description Channel FLG.
Distance "FROM" to "TO" 101.6 mm.
Flange Inside Diameter 256.83 mm.
Element Thickness 30.226 mm.
Internal Corrosion Allowance 0 mm.
Nominal Thickness 0 mm.
External Corrosion Allowance 0 mm.
Design Internal Pressure 8.5 bars
Design Temperature Internal Pressure 100 °C
Design External Pressure 1.034 bars
Design Temperature External Pressure 100 °C
Effective Diameter Multiplier 1.2
Material Name SA-182 F316L
Perform Flange Stress Calculation (Y/N) Y
Weight of Standard Flange 0 kN
Class of Standard Flange
Grade of Standard Flange
Weld is pre-Heated No

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
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BK	GCS	MF	120	ME	CN	0006	V00											

Element From Node 40
Detail Type Liquid
Detail ID Liquid: 40
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Liquid 101.6 mm.
Liquid Density 999.54 kg/m³

Element From Node 40
Detail Type Insulation
Detail ID Ins: 40
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Insulation 101.6 mm.
Thickness of Insulation 40 mm.
Density 125 kg/m³

Element From Node 50
Element To Node 60
Element Type Cylinder
Description Channel Barrel
Distance "FROM" to "TO" 200 mm.
Element Outside Diameter 273.05 mm.
Element Thickness 8.1121 mm.
Internal Corrosion Allowance 0 mm.
Nominal Thickness 9.271 mm.
External Corrosion Allowance 0 mm.
Design Internal Pressure 8.5 bars
Design Temperature Internal Pressure 100 °C
Design External Pressure 1.034 bars
Design Temperature External Pressure 100 °C
Effective Diameter Multiplier 1.2
Material Name SA-312 TP316L
Allowable Stress, Ambient 115.15 N./mm²
Allowable Stress, Operating 96.67 N./mm²
Allowable Stress, Hydrotest 155.14 N./mm²
Material Density 8027.2 kg/m³
P Number Thickness 0 mm.
Yield Stress, Operating 144.88 N./mm²
External Pressure Chart Name HA-4
UNS Number S31603
Product Form Smls. pipe
Efficiency, Longitudinal Seam 1.0
Efficiency, Circumferential Seam 1.0
Weld is pre-Heated No

Element From Node 50
Detail Type Liquid
Detail ID Liquid: 50
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Liquid 200 mm.
Liquid Density 999.54 kg/m³

Element From Node 50

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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Detail Type	Insulation
Detail ID	Ins: 50
Dist. from "FROM" Node / Offset dist	0 mm.
Height/Length of Insulation	200 mm.
Thickness of Insulation	40 mm.
Density	125 kg/m ³

Element From Node	50
Detail Type	Nozzle
Detail ID	V (1in)
Dist. from "FROM" Node / Offset dist	100 mm.
Nozzle Diameter	1 in.
Nozzle Schedule	None
Nozzle Class	150
Layout Angle	0.0
Blind Flange (Y/N)	N
Weight of Nozzle (Used if > 0)	0.03314 kN
Grade of Attached Flange	GR 2.3
Nozzle Matl	SA-182 F316L

Element From Node	60
Element To Node	70
Element Type	Elliptical
Description	Channel Cover
Distance "FROM" to "TO"	50 mm.
Element Outside Diameter	273.05 mm.
Element Thickness	8.1121 mm.
Internal Corrosion Allowance	0 mm.
Nominal Thickness	9.271 mm.
External Corrosion Allowance	0 mm.
Design Internal Pressure	8.5 bars
Design Temperature Internal Pressure	100 °C
Design External Pressure	1.034 bars
Design Temperature External Pressure	100 °C
Effective Diameter Multiplier	1.2
Material Name	SA-403 316L
Allowable Stress, Ambient	115.1 N./mm ²
Allowable Stress, Operating	115.1 N./mm ²
Allowable Stress, Hydrotest	155.1 N./mm ²
Material Density	8027.2 kg/m ³
P Number Thickness	0 mm.
Yield Stress, Operating	144.9 N./mm ²
External Pressure Chart Name	HA-4
UNS Number	S31603
Product Form	Smls. & wld. fittings
Efficiency, Longitudinal Seam	1.0
Efficiency, Circumferential Seam	1.0
Elliptical Head Factor	2.0
Weld is pre-Heated	No

Element From Node	60
Detail Type	Liquid
Detail ID	Liquid: 60

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100) <table><tr><td>پروژه</td><td>بسته کاری</td><td>صادرکننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00	شماره صفحه : 20 از 99
پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0006	V00											

Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Liquid 114.21 mm.
Liquid Density 999.54 kg/m³

Element From Node 60
Detail Type Insulation
Detail ID Ins: 60
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Insulation 118.26 mm.
Thickness of Insulation 40 mm.
Density 125 kg/m³

Element From Node 60
Detail Type Nozzle
Detail ID T1
Dist. from "FROM" Node / Offset dist 80 mm.
Nozzle Diameter 1 in.
Nozzle Schedule None
Nozzle Class 150
Layout Angle 0.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 0.03314 kN
Grade of Attached Flange GR 2.3
Nozzle Matl SA-182 F316L

Element From Node 60
Detail Type Nozzle
Detail ID T2
Dist. from "FROM" Node / Offset dist 80 mm.
Nozzle Diameter 1 in.
Nozzle Schedule None
Nozzle Class 150
Layout Angle 180.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 0.03314 kN
Grade of Attached Flange GR 2.3
Nozzle Matl SA-182 F316L

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)	شماره صفحه : 21 از 99																
	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادرکننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
	پروژه		بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											

XY Coordinate Calculations:

From	To	X (Horiz.) mm.	Y (Vert.) mm.	DX (Horiz.) mm.	DY (Vert.) mm.
Shell FLG.	...	107.95	...	101.6	...
Shell Barrel	...	1507.95	...	1400	...
Shell FLG.	...	1609.55	...	101.6	...
Channel FLG.	...	1775.68	...	101.6	...
Channel Barrel	...	1975.68	...	200	...
Channel Cover	...	2025.68	...	50	...

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)							شماره صفحه : 22 از 99	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0006		V00

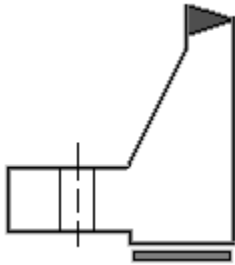
Flange Input Data Values

Description: FLANGE :

Shell FLG.

Description of Flange Geometry (Type)		Integral Weld Neck	
Design Pressure	P	6.64	bars
Design Temperature		152	°C
Internal Corrosion Allowance	ci	0.0000	mm.
External Corrosion Allowance	ce	0.0000	mm.
Use Corrosion Allowance in Thickness Calcs.		Yes	
Flange Inside Diameter	B	254.508	mm.
Flange Outside Diameter	A	406.400	mm.
Flange Thickness	t	30.2260	mm.
Thickness of Hub at Small End	go	9.2710	mm.
Thickness of Hub at Large End	gl	23.9871	mm.
Length of Hub	h	71.3740	mm.
Flange Material		SA-182 F316L	
Flange Material UNS number		S31603	
Flange Allowable Stress At Temperature	Sfo	87.20	N./mm ²
Flange Allowable Stress At Ambient	Sfa	115.10	N./mm ²
Bolt Material		SA-193 B8M	
Bolt Allowable Stress At Temperature	Sb	107.06	N./mm ²
Bolt Allowable Stress At Ambient	Sa	129.63	N./mm ²
Diameter of Bolt Circle	C	361.950	mm.
Nominal Bolt Diameter	a	24.0000	mm.
Type of Threads		TEMA Metric	
Number of Bolts		12	
Flange Face Outside Diameter	Fod	323.850	mm.
Flange Face Inside Diameter	Fid	254.508	mm.
Flange Facing Sketch		1, Code Sketch 1a	
Gasket Outside Diameter	Go	317.500	mm.
Gasket Inside Diameter	Gi	287.274	mm.
Gasket Factor	m	3.0000	
Gasket Design Seating Stress	y	68.95	N./mm ²
Column for Gasket Seating		2, Code Column II	
Gasket Thickness	tg	3.1750	mm.
Axial Force on Flange		14.00	kN
Bending Moment on Flange		0.00	N-m
Flange Class		150	
Flange Grade		GR 2.3	
Flange Series	Series	A	

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)							شماره صفحه : 23 از 99	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0006		V00



ASME Code, Section VIII Division 1, 2019

Hub Small End Required Thickness due to Internal Pressure:

$$\begin{aligned}
 &= (P \cdot (D/2 + C_a)) / (S \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (6.64 \cdot (255/2 + 0)) / (87.2 \cdot 1 - 0.6 \cdot 6.64) + C_a \\
 &= 0.9736 \text{ mm.}
 \end{aligned}$$

Hub Small End Hub MAWP:

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (87.2 \cdot 1 \cdot 9.27) / (127 + 0.6 \cdot 9.27) \\
 &= 60.865 \text{ bars}
 \end{aligned}$$

Corroded Flange ID,	Bcor = B + 2 * Fcor	254.508	mm.
Corroded Large Hub,	glCor = gl - ci	23.987	mm.
Corroded Small Hub,	g0Cor = go - ci	9.271	mm.
Code R Dimension,	R = (C - B) / 2 - gl	29.734	mm.
Gasket Contact Width,	N = (Go - Gi) / 2	15.113	mm.
Basic Gasket Width,	bo = N / 2	7.557	mm.
Effective Gasket Width,	b = Cb sqrt (bo)	6.927	mm.
Gasket Reaction Diameter,	G = Go - 2 * b	303.646	mm.
Original Design Pressure for Flange		6.641	bars
Axial Force Equiv. Pressure (4 * max (F, 0) / (pi * G^2))		1.933	bars
Bending Moment Equiv. Pressure (16 * abs (M) / (pi * G^3))		0.000	bars
Final Equivalent Design Pressure		8.574	bars

Note:

Per ASME NC-3658.1(b), the equivalent pressure is used only to compute the Hydrostatic End Load H. The original design pressure is used in the remaining calculations.

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:

$$\begin{aligned}
 &= 0.785 \cdot G^2 \cdot P_{eq} \\
 &= 0.79 \cdot 304^2 \cdot 8.57 \\
 &= 62.087 \text{ kN}
 \end{aligned}$$

Contact Load on Gasket Surfaces [Hp]:

$$\begin{aligned}
 &= 2 \cdot b \cdot P_i \cdot G \cdot m \cdot P \\
 &= 2 \cdot 6.93 \cdot 3.14 \cdot 304 \cdot 3 \cdot 6.64
 \end{aligned}$$

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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0006		V00

$$= 26.328 \text{ kN}$$

Hydrostatic End Load at Flange ID [Hd]:

$$= \pi \cdot B_{cor}^2 \cdot P / 4$$

$$= 3.14 \cdot 255^2 \cdot 6.64 / 4$$

$$= 33.783 \text{ kN}$$

Pressure Force on Flange Face [Ht]:

$$= H - H_d$$

$$= 62.1 - 33.8$$

$$= 28.304 \text{ kN}$$

Operating Bolt Load [Wm1]:

$$= \max(H + H_p + H'p, 0)$$

$$= \max(62.1 + 26.3 + 0, 0)$$

$$= 88.416 \text{ kN}$$

Gasket Seating Bolt Load [Wm2]:

$$= y \cdot b \cdot \pi \cdot G + y_{Part} \cdot b_{Part} \cdot l_p$$

$$= 68.9 \cdot 6.93 \cdot 3.141 \cdot 304 + 0 \cdot 0 \cdot 0$$

$$= 455.577 \text{ kN}$$

Required Bolt Area [Am]:

$$= \text{Maximum of } W_{m1}/S_b, W_{m2}/S_a$$

$$= \text{Maximum of } 88.4/107, 456/130$$

$$= 35.148 \text{ cm}^2$$

Min. Gasket Contact Width (Brownell Young) [Not an ASME Calc] [Nmin]:

$$= A_b \cdot S_a / (y \cdot \pi \cdot (G_o + G_i))$$

$$= 37.5 \cdot 130 / (68.9 \cdot 3.14 \cdot (318 + 287))$$

$$= 3.714 \text{ mm.}$$

Flange Design Bolt Load, Gasket Seating [W]:

$$= S_a \cdot (A_m + A_b) / 2$$

$$= 130 \cdot (35.1 + 37.5) / 2$$

$$= 471.01 \text{ kN}$$

Gasket Load for the Operating Condition [HG]:

$$= W_{m1} - H$$

$$= 88.4 - 62.1$$

$$= 26.33 \text{ kN}$$

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:

$$= (C - G) / 2$$

$$= (362 - 304) / 2$$

$$= 29.1520 \text{ mm.}$$

Distance to Face Pressure Reaction [ht]:

$$= (R + g_1 + h_g) / 2$$

$$= (29.7 + 24 + 29.2) / 2$$

$$= 41.4365 \text{ mm.}$$

Distance to End Pressure Reaction [hd]:

$$= R + (g_1 / 2)$$

$$= 29.7 + (24 / 2.0)$$

$$= 41.7275 \text{ mm.}$$

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	<table><tr><td>نسخه</td><td>سریال</td><td>نوع مدرک</td><td>رشته</td><td>تسهیلات</td><td>صادر کننده</td><td>بسته کاری</td><td>پروژه</td></tr><tr><td>V00</td><td>0006</td><td>CN</td><td>ME</td><td>120</td><td>MF</td><td>GCS</td><td>BK</td></tr></table>		نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V00	0006	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V00	0006	CN	ME	120	MF	GCS	BK											

Summary of Moments for Internal Pressure: (N-m)

Loading	Force	Distance	Bolt Corr	Moment
End Pressure, Md	34.	41.7275	1.0943	1543.
Face Pressure, Mt	28.	41.4365	1.0943	1284.
Gasket Load, Mg	26.	29.1520	1.0943	840.
Gasket Seating, Matm	471.	29.1520	1.0943	15032.
Total Moment for Operation, Mop				3668. N-m
Total Moment for Gasket seating, Matm				15032. N-m

*You chose not to perform Stress Calculations on this Standard Flange.
The pressure rating of the flange will be used to check code compliance.*

Estimated Finished Weight of Flange at given Thk.	27.2 kg.
Estimated Unfinished Weight of Forging at given Thk	64.3 kg.

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100) <table><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>V00</td><td>0006</td><td>CN</td><td>ME</td><td>120</td><td>MF</td><td>GCS</td><td>BK</td></tr></table>	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V00	0006	CN	ME	120	MF	GCS	BK	شماره صفحه : 26 از 99
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه											
V00	0006	CN	ME	120	MF	GCS	BK											

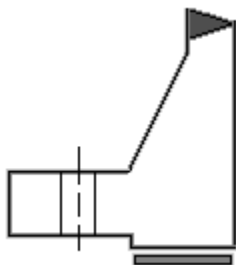
Flange Input Data Values

Description: New Flange :

Shell FLG.

Description of Flange Geometry (Type)		Integral Weld Neck	
Design Pressure	P	6.64	bars
Design Temperature		152	°C
Internal Corrosion Allowance	ci	0.0000	mm.
External Corrosion Allowance	ce	0.0000	mm.
Use Corrosion Allowance in Thickness Calcs.		Yes	
Flange Inside Diameter	B	256.826	mm.
Flange Outside Diameter	A	406.400	mm.
Flange Thickness	t	30.2260	mm.
Thickness of Hub at Small End	go	9.2710	mm.
Thickness of Hub at Large End	gl	23.9871	mm.
Length of Hub	h	71.3740	mm.
Flange Material		SA-182 F316L	
Flange Material UNS number		S31603	
Flange Allowable Stress At Temperature	Sfo	87.20	N./mm ²
Flange Allowable Stress At Ambient	Sfa	115.10	N./mm ²
Bolt Material		SA-193 B8M	
Bolt Allowable Stress At Temperature	Sb	107.06	N./mm ²
Bolt Allowable Stress At Ambient	Sa	129.63	N./mm ²
Diameter of Bolt Circle	C	361.950	mm.
Nominal Bolt Diameter	a	24.0000	mm.
Type of Threads		TEMA Metric	
Number of Bolts		12	
Flange Face Outside Diameter	Fod	323.850	mm.
Flange Face Inside Diameter	Fid	256.826	mm.
Flange Facing Sketch		1, Code Sketch 1a	
Gasket Outside Diameter	Go	317.500	mm.
Gasket Inside Diameter	Gi	287.274	mm.
Gasket Factor	m	3.0000	
Gasket Design Seating Stress	y	68.95	N./mm ²
Column for Gasket Seating		2, Code Column II	
Gasket Thickness	tg	3.1750	mm.
Flange Class		150	
Flange Grade		GR 2.3	
Flange Series	Series	A	

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)	شماره صفحه : 27 از 99																
	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادرکننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
	پروژه		بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											



ASME Code, Section VIII Division 1, 2019

Hub Small End Required Thickness due to Internal Pressure:

$$\begin{aligned}
 &= (P * (D/2 + Ca)) / (S * E - 0.6 * P) \text{ per UG-27 (c) (1)} \\
 &= (6.64 * (257/2 + 0)) / (87.2 * 1 - 0.6 * 6.64) + Ca \\
 &= 0.9825 \text{ mm.}
 \end{aligned}$$

Hub Small End Hub MAWP:

$$\begin{aligned}
 &= (S * E * t) / (R + 0.6 * t) \text{ per UG-27 (c) (1)} \\
 &= (87.2 * 1 * 9.27) / (128 + 0.6 * 9.27) \\
 &= 60.338 \text{ bars}
 \end{aligned}$$

Corroded Flange ID,	Bcor = B + 2 * Fcor	256.826	mm.
Corroded Large Hub,	glCor = gl - ci	23.987	mm.
Corroded Small Hub,	g0Cor = go - ci	9.271	mm.
Code R Dimension,	R = (C - B) / 2 - gl	28.575	mm.
Gasket Contact Width,	N = (Go - Gi) / 2	15.113	mm.
Basic Gasket Width,	bo = N / 2	7.557	mm.
Effective Gasket Width,	b = Cb * sqrt(bo)	6.927	mm.
Gasket Reaction Diameter,	G = Go - 2 * b	303.646	mm.

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:

$$\begin{aligned}
 &= 0.785 * G^2 * Peq \\
 &= 0.79 * 304^2 * 6.64 \\
 &= 48.087 \text{ kN}
 \end{aligned}$$

Contact Load on Gasket Surfaces [Hp]:

$$\begin{aligned}
 &= 2 * b * Pi * G * m * P \\
 &= 2 * 6.93 * 3.14 * 304 * 3 * 6.64 \\
 &= 26.328 \text{ kN}
 \end{aligned}$$

Hydrostatic End Load at Flange ID [Hd]:

$$\begin{aligned}
 &= Pi * Bcor^2 * P / 4 \\
 &= 3.14 * 257^2 * 6.64 / 4 \\
 &= 34.401 \text{ kN}
 \end{aligned}$$

Pressure Force on Flange Face [Ht]:

$$\begin{aligned}
 &= H - Hd \\
 &= 48.1 - 34.4 \\
 &= 13.686 \text{ kN}
 \end{aligned}$$

Operating Bolt Load [Wm1]:

$$= \max(H + Hp + H'p, 0)$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)	شماره صفحه : 28 از 99																
	<table><tr><td>نسخه</td><td>سریال</td><td>نوع مدرک</td><td>رشته</td><td>تسهیلات</td><td>صادرکننده</td><td>بسته کاری</td><td>پروژه</td></tr><tr><td>V00</td><td>0006</td><td>CN</td><td>ME</td><td>120</td><td>MF</td><td>GCS</td><td>BK</td></tr></table>		نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V00	0006	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V00	0006	CN	ME	120	MF	GCS	BK											

$$= \max(48.1 + 26.3 + 0, 0)$$

$$= 74.416 \text{ kN}$$

Gasket Seating Bolt Load [Wm2]:

$$= y * b * \pi * G + y_{Part} * b_{Part} * l_p$$

$$= 68.9 * 6.93 * 3.141 * 304 + 0 * 0 * 0$$

$$= 455.577 \text{ kN}$$

Required Bolt Area [Am]:

$$= \text{Maximum of } W_{m1}/S_b, W_{m2}/S_a$$

$$= \text{Maximum of } 74.4/107, 456/130$$

$$= 35.148 \text{ cm}^2$$

Min. Gasket Contact Width (Brownell Young) [Not an ASME Calc] [Nmin]:

$$= A_b * S_a / (y * \pi * (G_o + G_i))$$

$$= 37.5 * 130 / (68.9 * 3.14 * (318 + 287))$$

$$= 3.714 \text{ mm.}$$

Flange Design Bolt Load, Gasket Seating [W]:

$$= S_a * (A_m + A_b) / 2$$

$$= 130 * (35.1 + 37.5) / 2$$

$$= 471.01 \text{ kN}$$

Gasket Load for the Operating Condition [HG]:

$$= W_{m1} - H$$

$$= 74.4 - 48.1$$

$$= 26.33 \text{ kN}$$

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:

$$= (C - G) / 2$$

$$= (362 - 304) / 2$$

$$= 29.1520 \text{ mm.}$$

Distance to Face Pressure Reaction [ht]:

$$= (R + g_1 + h_g) / 2$$

$$= (28.6 + 24 + 29.2) / 2$$

$$= 40.8570 \text{ mm.}$$

Distance to End Pressure Reaction [hd]:

$$= R + (g_1 / 2)$$

$$= 28.6 + (24 / 2.0)$$

$$= 40.5685 \text{ mm.}$$

Summary of Moments for Internal Pressure: (N-m)

Loading	Force	Distance	Bolt Corr	Moment
End Pressure, Md	34.	40.5685	1.0943	1528.
Face Pressure, Mt	14.	40.8570	1.0943	612.
Gasket Load, Mg	26.	29.1520	1.0943	840.
Gasket Seating, Matm	471.	29.1520	1.0943	15032.
Total Moment for Operation, Mop				2980. N-m
Total Moment for Gasket seating, Matm				15032. N-m

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)	شماره صفحه : 29 از 99																
	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادرکننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
	پروژه		بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											

*You chose not to perform Stress Calculations on this Standard Flange.
The pressure rating of the flange will be used to check code compliance.*

Estimated Finished Weight of Flange at given Thk. 27.1 kg.
Estimated Unfinished Weight of Forging at given Thk 63.5 kg.

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 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100) <table><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>V00</td><td>0006</td><td>CN</td><td>ME</td><td>120</td><td>MF</td><td>GCS</td><td>BK</td></tr></table>	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V00	0006	CN	ME	120	MF	GCS	BK	شماره صفحه : 30 از 99
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه											
V00	0006	CN	ME	120	MF	GCS	BK											

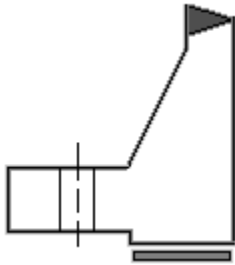
Flange Input Data Values

Description: New Flange :

Channel FLG.

Description of Flange Geometry (Type)		Integral Weld Neck	
Design Pressure	P	8.54	bars
Design Temperature		100	°C
Internal Corrosion Allowance	ci	0.0000	mm.
External Corrosion Allowance	ce	0.0000	mm.
Use Corrosion Allowance in Thickness Calcs.		Yes	
Flange Inside Diameter	B	256.826	mm.
Flange Outside Diameter	A	406.400	mm.
Flange Thickness	t	30.2260	mm.
Thickness of Hub at Small End	go	9.2710	mm.
Thickness of Hub at Large End	gl	23.9871	mm.
Length of Hub	h	71.3740	mm.
Flange Material		SA-182 F316L	
Flange Material UNS number		S31603	
Flange Allowable Stress At Temperature	Sfo	96.67	N./mm ²
Flange Allowable Stress At Ambient	Sfa	115.15	N./mm ²
Bolt Material		SA-193 B8M	
Bolt Allowable Stress At Temperature	Sb	107.06	N./mm ²
Bolt Allowable Stress At Ambient	Sa	129.63	N./mm ²
Diameter of Bolt Circle	C	361.950	mm.
Nominal Bolt Diameter	a	24.0000	mm.
Type of Threads		TEMA Metric	
Number of Bolts		12	
Flange Face Outside Diameter	Fod	323.850	mm.
Flange Face Inside Diameter	Fid	256.826	mm.
Flange Facing Sketch		1, Code Sketch 1a	
Gasket Outside Diameter	Go	317.500	mm.
Gasket Inside Diameter	Gi	287.274	mm.
Gasket Factor	m	0.0000	
Gasket Design Seating Stress	y	0.00	N./mm ²
Column for Gasket Seating		2, Code Column II	
Gasket Thickness	tg	3.1750	mm.
Flange Class		150	
Flange Grade		GR 2.3	
Flange Series	Series	A	

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	BK	GCS	MF	120	ME	CN	0006		V00



ASME Code, Section VIII Division 1, 2019

Hub Small End Required Thickness due to Internal Pressure:

$$\begin{aligned}
 &= (P \cdot (D/2 + Ca)) / (S \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (8.54 \cdot (257/2 + 0)) / (96.7 \cdot 1 - 0.6 \cdot 8.54) + Ca \\
 &= 1.1406 \text{ mm.}
 \end{aligned}$$

Hub Small End Hub MAWP:

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (96.7 \cdot 1 \cdot 9.27) / (128 + 0.6 \cdot 9.27) \\
 &= 66.891 \text{ bars}
 \end{aligned}$$

Corroded Flange ID,	Bcor = B + 2 * Fcor	256.826	mm.
Corroded Large Hub,	glCor = gl - ci	23.987	mm.
Corroded Small Hub,	g0Cor = go - ci	9.271	mm.
Code R Dimension,	R = (C - B) / 2 - gl	28.575	mm.
Gasket Contact Width,	N = (Go - Gi) / 2	15.113	mm.
Basic Gasket Width,	bo = N / 2	7.557	mm.
Effective Gasket Width,	b = Cb sqrt(bo)	6.927	mm.
Gasket Reaction Diameter,	G = Go (Self-Energizing)	317.500	mm.

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:

$$\begin{aligned}
 &= 0.785 \cdot G^2 \cdot Peq \\
 &= 0.79 \cdot 318^2 \cdot 8.54 \\
 &= 67.618 \text{ kN}
 \end{aligned}$$

Contact Load on Gasket Surfaces [Hp]:

$$\begin{aligned}
 &= 2 \cdot b \cdot Pi \cdot G \cdot m \cdot P \\
 &= 2 \cdot 6.93 \cdot 3.14 \cdot 318 \cdot 0 \cdot 8.54 \\
 &= 0.000 \text{ kN}
 \end{aligned}$$

Hydrostatic End Load at Flange ID [Hd]:

$$\begin{aligned}
 &= Pi \cdot Bcor^2 \cdot P / 4 \\
 &= 3.14 \cdot 257^2 \cdot 8.54 / 4 \\
 &= 44.244 \text{ kN}
 \end{aligned}$$

Pressure Force on Flange Face [Ht]:

$$\begin{aligned}
 &= H - Hd \\
 &= 67.6 - 44.2 \\
 &= 23.374 \text{ kN}
 \end{aligned}$$

Operating Bolt Load [Wm1]:

$$= \max(H + Hp + H'p, 0)$$

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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0006		V00

$= \max(67.6 + 0 + 0, 0)$
 $= 67.618 \text{ kN}$
 $= 74.416 \text{ kN, Mating Flange Load Governs}$

Gasket Seating Bolt Load [Wm2]:

$= y * b * \pi * G + y_{Part} * b_{Part} * l_p$
 $= 0 * 6.93 * 3.141 * 318 + 0 * 0 * 0$
 $= 0.000 \text{ kN}$
 $= 455.577 \text{ kN, Mating Flange Load Governs}$

Required Bolt Area [Am]:

$= \text{Maximum of } W_{m1}/S_b, W_{m2}/S_a$
 $= \text{Maximum of } 74.4/107, 456/130$
 $= 35.148 \text{ cm}^2$

Flange Design Bolt Load, Gasket Seating [W]:

$= S_a * (A_m + A_b) / 2$
 $= 130 * (35.1 + 37.5) / 2$
 $= 471.01 \text{ kN}$

Gasket Load for the Operating Condition [HG]:

$= W_{m1} - H$
 $= 74.4 - 67.6$
 $= 6.80 \text{ kN}$

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:

$= (C - G) / 2$
 $= (362 - 318) / 2$
 $= 22.2250 \text{ mm.}$

Distance to Face Pressure Reaction [ht]:

$= (R + g_1 + h_g) / 2$
 $= (28.6 + 24 + 22.2) / 2$
 $= 37.3935 \text{ mm.}$

Distance to End Pressure Reaction [hd]:

$= R + (g_1 / 2)$
 $= 28.6 + (24 / 2.0)$
 $= 40.5685 \text{ mm.}$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																									
شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)</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>V00</td><td>0006</td><td>CN</td><td>ME</td><td>120</td><td>MF</td><td>GCS</td><td>BK</td></tr></table>	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V00	0006	CN	ME	120	MF	GCS	BK	شماره صفحه : 33 از 99
THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V00	0006	CN	ME	120	MF	GCS	BK																			

Summary of Moments for Internal Pressure: (N-m)

Loading	Force	Distance	Bolt Corr	Moment
End Pressure, Md	44.	40.5685	1.0943	1965.
Face Pressure, Mt	23.	37.3935	1.0943	957.
Gasket Load, Mg	7.	22.2250	1.0943	165.
Gasket Seating, Matm	471.	22.2250	1.0943	11460.
Total Moment for Operation, Mop				3087. N-m
Total Moment for Gasket seating, Matm				11460. N-m

*You chose not to perform Stress Calculations on this Standard Flange.
The pressure rating of the flange will be used to check code compliance.*

Estimated Finished Weight of Flange at given Thk. 27.1 kg.
Estimated Unfinished Weight of Forging at given Thk 63.5 kg.

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 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
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	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادرکننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
	پروژه		بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd bars	Nominal Thickness mm.	Total Corr Allowance mm.	Element Diameter mm.	Allowable Stress (SE) N./mm ²
Shell FLG.		6.6408	...	...	254.51	87.2
Shell Barrel		6.6408	9.271	...	273.05	87.2
Shell FLG.		6.6408	...	...	256.83	87.2
Channel FLG.		8.5408	...	...	256.83	96.67
Channel Barrel		8.5308	9.271	...	273.05	96.67
Channel Cover		8.5112	9.271	...	273.05	115.1

Element Required Thickness and MAWP :

From	To	Design Pressure bars	M.A.W.P. Corroded bars	M.A.P. New & Cold bars	Minimum Thickness mm.	Required Thickness mm.
Shell FLG.		6.6	11.9	15.9	30.226	No Calc
Shell Barrel		6.6	53	70.1	8.11212	1.5
Shell FLG.		6.6	11.9	15.9	30.226	No Calc
Channel FLG.		8.5	13.3	15.9	30.226	No Calc
Channel Barrel		8.5	58.8	70.1	8.11212	1.5
Channel Cover		8.5	72.2	72.3	8.11212	1.5

Summary of Heat Exchanger Maximum Allowable Working Pressures :

Note:

For Exchanger designs, the following values include MAWPs that consider the tubesheet, tubes, tube/tubesheet joint etc. These values were determined by iteration. Review the tubesheet analysis report for more information.

Shell Side MAWP	=	11.9 bars
Shell Side MAPnc	=	15.9 bars
Channel Side MAWP	=	13.2 bars
Channel Side MAPnc	=	15.9 bars

Elements Suitable for Design Internal Pressure.

Internal Pressure Calculation Results:

ASME Code, Section VIII Division 1, 2019

Cylindrical Shell From 20 To 30 SA-312 TP316L at 152 °C

Shell Barrel

Material UNS Number: S31603

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																									
شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)</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>V00</td><td>0006</td><td>CN</td><td>ME</td><td>120</td><td>MF</td><td>GCS</td><td>BK</td></tr></table>	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V00	0006	CN	ME	120	MF	GCS	BK	شماره صفحه : 35 از 99
THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V00	0006	CN	ME	120	MF	GCS	BK																			

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot Ro) / (S \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)} \\
 &= (6.64 \cdot 137) / (87.2 \cdot 1 + 0.4 \cdot 6.64) \\
 &= 1.0366 + 0.0000 = 1.0366 \text{ mm.}
 \end{aligned}$$

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5000 mm. per UG-16 will be used.

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

Less Operating Hydrostatic Head Pressure of 0.041 bars

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (Ro - 0.4 \cdot t) \text{ per Appendix 1-1 (a) (1)} \\
 &= (87.2 \cdot 1 \cdot 8.11) / (137 - 0.4 \cdot 8.11) \\
 &= 53.1 - 0.041 = 53 \text{ bars}
 \end{aligned}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (Ro - 0.4 \cdot t) \text{ per Appendix 1-1 (a) (1)} \\
 &= (115 \cdot 1 \cdot 8.11) / (137 - 0.4 \cdot 8.11) \\
 &= 70.1 \text{ bars}
 \end{aligned}$$

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

$$\begin{aligned}
 &= (P \cdot (Ro - 0.4 \cdot t)) / (E \cdot t) \\
 &= (6.64 \cdot ((137 - 0.4 \cdot 8.11)) / (1 \cdot 8.11) \\
 &= 10.911 \text{ N./mm}^2
 \end{aligned}$$

SA-312 TP316L, Min Metal Temp without impact per UHA-51: -196 °C

Cylindrical Shell From 50 To 60 SA-312 TP316L at 100 °C

Channel Barrel

Material UNS Number: S31603

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot Ro) / (S \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)} \\
 &= (8.53 \cdot 137) / (96.7 \cdot 1 + 0.4 \cdot 8.53) \\
 &= 1.2006 + 0.0000 = 1.2006 \text{ mm.}
 \end{aligned}$$

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5000 mm. per UG-16 will be used.

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

Less Operating Hydrostatic Head Pressure of 0.031 bars

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (Ro - 0.4 \cdot t) \text{ per Appendix 1-1 (a) (1)} \\
 &= (96.7 \cdot 1 \cdot 8.11) / (137 - 0.4 \cdot 8.11) \\
 &= 58.8 - 0.031 = 58.8 \text{ bars}
 \end{aligned}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (Ro - 0.4 \cdot t) \text{ per Appendix 1-1 (a) (1)} \\
 &= (115 \cdot 1 \cdot 8.11) / (137 - 0.4 \cdot 8.11) \\
 &= 70.1 \text{ bars}
 \end{aligned}$$

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

$$\begin{aligned}
 &= (P \cdot (Ro - 0.4 \cdot t)) / (E \cdot t) \\
 &= (8.53 \cdot ((137 - 0.4 \cdot 8.11)) / (1 \cdot 8.11) \\
 &= 14.017 \text{ N./mm}^2
 \end{aligned}$$

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	BK	GCS	MF	120	ME	CN	0006		V00

SA-312 TP316L, Min Metal Temp without impact per UHA-51: -196 °C

Elliptical Head From 60 To 70 SA-403 316L at 100 °C

Channel Cover

Material UNS Number: S31603

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot Do \cdot K_{cor}) / (2 \cdot S \cdot E + 2 \cdot P \cdot (K_{cor} - 0.1)) \text{ per Appendix 1-4 (c)} \\
 &= (8.51 \cdot 273 \cdot 1) / (2 \cdot 115 \cdot 1 + 2 \cdot 8.51 \cdot (1 - 0.1)) \\
 &= 1.0024 + 0.0000 = 1.0024 \text{ mm.}
 \end{aligned}$$

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5000 mm. per UG-16 will be used.

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

Less Operating Hydrostatic Head Pressure of 0.006 bars

$$\begin{aligned}
 &= (2 \cdot S \cdot E \cdot t) / (K_{cor} \cdot Do - 2 \cdot t \cdot (K_{cor} - 0.1)) \text{ per Appendix 1-4 (c)} \\
 &= (2 \cdot 115 \cdot 1 \cdot 8.11) / (1 \cdot 273 - 2 \cdot 8.11 \cdot (1 - 0.1)) \\
 &= 72.3 - 0.0063 = 72.2 \text{ bars}
 \end{aligned}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$\begin{aligned}
 &= (2 \cdot S \cdot E \cdot t) / (K \cdot Do - 2 \cdot t \cdot (K - 0.1)) \text{ per Appendix 1-4 (c)} \\
 &= (2 \cdot 115 \cdot 1 \cdot 8.11) / (1 \cdot 273 - 2 \cdot 8.11 \cdot (1 - 0.1)) \\
 &= 72.3 \text{ bars}
 \end{aligned}$$

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

$$\begin{aligned}
 &= (P \cdot (K_{cor} \cdot Do - 2 \cdot t \cdot (K_{cor} - 0.1))) / (2 \cdot E \cdot t) \\
 &= (8.51 \cdot (1 \cdot 273 - 2 \cdot 8.11 \cdot (1 - 0.1))) / (2 \cdot 1 \cdot 8.11) \\
 &= 13.551 \text{ N./mm}^2
 \end{aligned}$$

Straight Flange Required Thickness:

$$\begin{aligned}
 &= (P \cdot Ro) / (S \cdot E + 0.4 \cdot P) + ca \text{ per Appendix 1-1 (a) (1)} \\
 &= (8.51 \cdot 137) / (115 \cdot 1 + 0.4 \cdot 8.51) + 0 \\
 &= 1.006 \text{ mm.}
 \end{aligned}$$

Straight Flange Maximum Allowable Working Pressure:

Less Operating Hydrostatic Head Pressure of 0.006 bars

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (Ro - 0.4 \cdot t) \text{ per Appendix 1-1 (a) (1)} \\
 &= (115 \cdot 1 \cdot 9.27) / (137 - 0.4 \cdot 9.27) \\
 &= 80.3 - 0.0063 = 80.3 \text{ bars}
 \end{aligned}$$

SA-403 316L, Min Metal Temp without impact per UHA-51: -196 °C

Hydrostatic Test Pressure Results:

Exchanger Shell Side Hydrostatic Test Pressures:

Pressure per UG99b	= 1.30 * M.A.W.P. * Sa/S	18.349 bars
Pressure per UG99b[36]	= 1.30 * Design Pres * Sa/S	10.220 bars
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	20.670 bars
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	15.526 bars
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	9.827 bars

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	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادرکننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
	پروژه		بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											

Pressure per App 27-4 = M.A.W.P. 11.850 bars

Exchanger Channel Side Hydrostatic Test Pressures:

Pressure per UG99b = 1.30 * M.A.W.P. * Sa/S 17.225 bars
 Pressure per UG99b[36] = 1.30 * Design Pres * Sa/S 11.050 bars
 Pressure per UG99c = 1.30 * M.A.P. - Head(Hyd) 20.670 bars
 Pressure per UG100 = 1.10 * M.A.W.P. * Sa/S 14.575 bars
 Pressure per PED = max(1.43*DP, 1.25*DP*ratio) 12.155 bars
 Pressure per App 27-4 = M.A.W.P. 13.250 bars

UG-99(b) Note 36, Test Pressure Calculation [Shell Side]:

= Test Factor * Design Pressure * Stress Ratio
 = 1.3 * 6.6 * 1.19
 = 10.220 bars

UG-99(b) Note 36, Test Pressure Calculation [Channel Side]:

= Test Factor * Design Pressure * Stress Ratio
 = 1.3 * 8.5 * 1
 = 11.050 bars

Horizontal Test performed per: UG-99b (Note 36)

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (N./mm² & bars):

From To	Stress	Allowable	Ratio	Pressure
Shell Barrel	16.8	155.1	0.109	10.25
Channel Barrel	18.2	155.1	0.117	11.08
Channel Cover	17.6	155.1	0.114	11.08

Stress ratios for Nozzle and Pad Materials (N./mm²):

Description	Pad/Nozzle	Ambient	Operating	Ratio
S2 (2in)	Nozzle	115.15	87.18	1.321
V (1in)	Nozzle	115.15	96.67	1.191
T1	Nozzle	115.15	96.67	1.191
T2	Nozzle	115.15	96.67	1.191
Minimum				1.191

Stress ratios for Pressurized Vessel Elements (N./mm²):

Description	Ambient	Operating	Ratio
Shell FLG.	115.10	87.20	1.320
Shell Barrel	115.10	87.20	1.320
Shell FLG.	115.10	87.20	1.320

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	BK	GCS	MF	120	ME	CN	0006		V00

Channel FLG.		115.15		96.67		1.191	
Channel Barrel		115.15		96.67		1.191	
Channel Cover		115.10		115.10		1.000	

Minimum						1.000	

Stress ratios for Exchanger Materials (N./mm²):

Description		Ambient		Operating		Ratio	

Tube Material		115.15		96.67		1.191	
Tubesheet Material		115.15		96.67		1.191	

Minimum						1.191	

Hoop Stress in Nozzle Wall during Pressure Test (N./mm²):

Description		Ambient		Operating		Ratio	

S2 (2in)		2.26		155.14		0.015	
V (1in)		1.76		155.14		0.011	
T1		1.76		155.14		0.011	
T2		1.76		155.14		0.011	

Elements Suitable for Test Pressure.

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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه											
V00	0006	CN	ME	120	MF	GCS	BK											

External Pressure Calculation Results :

External Pressure Calculations:

From	To	Section Length mm.	Outside Diameter mm.	Corroded Thickness mm.	Factor A	Factor B N./mm ²
10	20	No Calc	...	30.226	No Calc	No Calc
20	30	1603.2	273.05	8.11212	0.0011419	58.6617
30	40	No Calc	...	30.226	No Calc	No Calc
40	50	No Calc	...	30.226	No Calc	No Calc
50	60	373.002	273.05	8.11212	0.005061	76.4896
60	70	No Calc	273.05	8.11212	0.0041263	74.1804

External Pressure Calculations:

From	To	External Actual T. mm.	External Required T. mm.	External Design Pressure bars	External M.A.W.P. bars
10	20	30.226	No Calc	1.034	No Calc
20	30	8.11212	1.90549	1.034	23.2
30	40	30.226	No Calc	1.034	No Calc
40	50	30.226	No Calc	1.034	No Calc
50	60	8.11212	1.02405	1.034	30.3
60	70	8.11212	1.5	1.034	24.5
Minimum					23.2

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm.	Allowable Length Bet. Stiffeners mm.	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	1603.2	35499.3	No Calc	No Calc
30	40	No Calc	No Calc	No Calc	No Calc
40	50	No Calc	No Calc	No Calc	No Calc
50	60	373.002	9498	No Calc	No Calc
60	70	No Calc	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

ASME Code, Section VIII Division 1, 2019

Cylindrical Shell From 20 to 30 Ext. Chart: HA-4 at 100 °C

Shell Barrel

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V00	0006	CN	ME	120	MF	GCS	BK											

Elastic Modulus from Chart: HA-4 at 100 °C: 186872176.000 KPa.

Results for Maximum Allowable Ext. Pressure							MAEP
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
8.112	273.05	1603.20	33.66	5.8715	0.0011419	58.66	
MAEP = (4*B)/(3*(Do/t)) = (4*58.7)/(3*33.7) = 23.2 bars							

Results for Required Thickness							Tca
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
1.905	273.05	1603.20	143.30	5.8715	0.0001189	11.11	
MAEP = (4*B)/(3*(Do/t)) = (4*11.1)/(3*143) = 1.03 bars							

Results for Maximum Stiffened Length							Slen
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
8.112	273.05	35499.31	33.66	50.0000	0.0009977	56.93	
MAEP = (4*B)/(3*(Do/t)) = (4*56.9)/(3*33.7) = 22.6 bars							

Cylindrical Shell From 50 to 60 Ext. Chart: HA-4 at 100 °C

Channel Barrel

Elastic Modulus from Chart: HA-4 at 100 °C: 186872176.000 KPa.

Results for Maximum Allowable Ext. Pressure							MAEP
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
8.112	273.05	373.00	33.66	1.3661	0.0050610	76.49	
MAEP = (4*B)/(3*(Do/t)) = (4*76.5)/(3*33.7) = 30.3 bars							

Results for Required Thickness							Tca
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
1.024	273.05	373.00	266.64	1.3661	0.0002213	20.68	
MAEP = (4*B)/(3*(Do/t)) = (4*20.7)/(3*267) = 1.03 bars							

Results for Maximum Stiffened Length							Slen
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	

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	V00	0006	CN	ME	120	MF	GCS		BK

8.112 | 273.05 | 9498.01 | 33.66 | 34.7849 | 0.0009980 | 56.94 |

$$MAEP = (4*B) / (3*(Do/t)) = (4*56.9) / (3*33.7) = 22.6 \text{ bars}$$

Elliptical Head From 60 to 70 Ext. Chart: HA-4 at 100 °C

Channel Cover

Elastic Modulus from Chart: HA-4 at 100 °C: 186872176.000 KPa.

Results for Maximum Allowable Ext. Pressure					MAEP
Tca	Outer Dia	Do/t	Factor A	Factor B	
8.112	273.05	33.66	0.0041263	74.18	

$$MAEP = B / (K0*Do/t) = 74.2 / (0.9 * 33.7) = 24.5 \text{ bars}$$

Results for Required Thickness					Tca
Tca	Outer Dia	Do/t	Factor A	Factor B	
0.731	273.05	373.42	0.0003719	34.75	

$$MAEP = B / (K0*Do/t) = 34.8 / (0.9 * 373) = 1.03 \text{ bars}$$

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

Material UNS Number: S31603

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P*D*Kcor) / (2*S*E-0.2*P) \text{ Appendix 1-4 (c)} \\
 &= (1.73*257*1) / (2*115*1-0.2*1.73) \\
 &= 0.1927 + 0.0000 = 0.1927 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= ((2*S*E*t) / (Kcor*D+0.2*t)) / 1.67 \text{ per Appendix 1-4 (c)} \\
 &= ((2*115*1*8.11) / (1*257+0.2*8.11)) / 1.67 \\
 &= 43.3 \text{ bars}
 \end{aligned}$$

Maximum Allowable External Pressure [MAEP]:

$$\begin{aligned}
 &= \min(MAEP, MAWP) \\
 &= \min(24.5, 43.3) \\
 &= 24.486 \text{ bars}
 \end{aligned}$$

Thickness requirements per UG-33(a)(1) govern the required thickness of this head.

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	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											

Element and Detail Weights:

From	To	Element Metal Wgt. kg.	Element ID Volume Cm.	Corroded Metal Wgt. kg.	Corroded ID Volume Cm.	Extra due Misc % kg.
10	20	27.2456	5169.69	27.2456	5169.69	2.72456
20	30	87.0991	45896.5	87.0991	45896.5	8.70991
30	40	27.0891	5264.28	27.0891	5264.28	2.70891
40	50	27.0891	5264.28	27.0891	5264.28	2.70891
50	60	12.4427	10362.7	12.4427	10362.7	1.24427
60	70	9.41758	4808.54	9.41758	4808.54	0.94176
Total		190	76766.04	190	76766.04	19

For elements specified as shell side elements, the volume(s) shown above for those elements, reflects the displacement of the tubes.

Weight of Details:

From	Type	Weight of Detail kg.	X Offset, Dtl. Cent. mm.	Y Offset, Dtl. Cent. mm.	Description
10	Ins1	0.76995	...	50.8	Ins: 10
20	Ins1	6.88452	...	700	Ins: 20
20	Noz1	8.22666	153.813	1300	S2 (2in)
30	Ins1	0.7643	...	50.8	Ins: 30
40	Liqd	5.26107	...	50.8	Liquid: 40
40	Ins1	0.7643	...	50.8	Ins: 40
50	Liqd	10.3564	...	100	Liquid: 50
50	Ins1	0.9835	...	100	Ins: 50
50	Noz1	3.71765	141.113	100	V (1in)
60	Liqd	4.8056	...	82.103	Liquid: 60
60	Ins1	0.85445	...	59.1312	Ins: 60
60	Noz1	3.71765	...	175.23	T1
60	Noz1	3.71765	...	175.23	T2
30	FTsh	56.9068	...	135.45	ts
30	Tube	53.9823	...	-592.05	Tubes
10	Bafl	0.34261	...	150	Baffles
10	Bafl	0.34261	...	428	Baffles
10	Bafl	0.34261	...	706	Baffles
10	Bafl	0.34261	...	984	Baffles
10	Bafl	0.34261	...	1262	Baffles

Total Weight of Each Detail Type:

Liquid	20.4
Insulation	11.0
Nozzles	19.4
Exchanger Components	112.6
Liquid in Tubes	13.5

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V00	0006	CN	ME	120	MF	GCS	BK											

Sum of the Detail Weights 176.9 kg.

Weight Summation Results: (kg.)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	209.4	209.4	209.4	209.4	209.4	209.4
Nozzles	19.4	19.4	19.4	19.4	19.4	19.4
Exchanger	112.6	112.6	112.6	112.6	112.6	112.6
Insulation	...	...	11.0	11.0	11.0	11.0
Ope. Liquid	...	...	...	...	...	20.4
Tube Ope Lqd	...	...	...	...	...	13.5
Test Liquid	...	76.7	...	...	...	...
Tube Tst Lqd	...	13.5	...	...	...	...
Totals	341.4	431.6	352.4	352.4	352.4	386.3

Field Installation Options:

Miscellaneous Weight Percent: 10.0 %

Note that the above value for the miscellaneous weight percent has been applied to the shells/heads/flange/tubesheets/tubes etc. in the weight calculations for metallic components.

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	341.4 kg.
Shop Test Wt.	- Fabricated Weight + Water (Full)	431.6 kg.
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	352.4 kg.
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	352.4 kg.
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	352.4 kg.
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	386.3 kg.
Field Test Wt.	- Empty Weight + Water (Full)	442.6 kg.
Mass of the Upper 1/3 of the Vertical Vessel		138.4 kg.

Exchanger Tube Data

Volume of Exchanger tubes :	13469.2 Cm.
Weight of Ope Liq in tubes :	13.5 kg.
Weight of Water in tubes :	13.5 kg.

Note: The Field Test weight as computed in the corroded condition.

Outside Surface Areas of Elements:

From	To	Surface Area cm ²
10	20	1852.59
20	30	12111.3
30	40	1848.48
40	50	1848.48

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																									
شماره پیمان: 053-073-9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)</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>V00</td><td>0006</td><td>CN</td><td>ME</td><td>120</td><td>MF</td><td>GCS</td><td>BK</td></tr></table>	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V00	0006	CN	ME	120	MF	GCS	BK	شماره صفحه : 44 از 99
THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V00	0006	CN	ME	120	MF	GCS	BK																			

50 | 60 | 1730.19 |
60 | 70 | 1254.5 |

Total 20645.553 cm²

Element and Detail Weights:

From	To	Total Ele. Empty Wgt. kg.	Total. Ele. Oper. Wgt. kg.	Total. Ele. Hydro. Wgt. kg.	Total Dtl. Offset Mom. N-m	Oper. Wgt. No Liquid kg.
10	20	30.7401	30.7401	35.9066	...	30.7401
20	30	110.92	110.92	156.789	12.4132	110.92
30	40	141.451	141.451	146.713	...	141.451
40	50	30.5623	35.8234	35.8234	...	30.5623
50	60	18.3882	28.7446	28.7446	5.14639	18.3882
60	70	18.6491	23.4547	23.4547	...	18.6491

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kg.	Cumulative Oper. Wgt. kg.	Cumulative Hydro. Wgt. kg.
10	20	350.711	371.134	427.43
20	30	319.971	340.394	391.524
30	40	209.051	229.474	234.735
40	50	67.5995	88.0226	88.0226
50	60	37.0372	52.1993	52.1993
60	70	18.6491	23.4547	23.4547

Note: The cumulative operating weights no liquid in the column above are the cumulative operating weights minus the operating liquid weight minus any weights absent in the empty condition.

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. N-m	Cumulative Oper. Mom. N-m	Cumulative Hydro. Mom. N-m
10	20	17.5596	17.5596	17.5596
20	30	17.5596	17.5596	17.5596
30	40	5.14639	5.14639	5.14639
40	50	5.14639	5.14639	5.14639
50	60	5.14639	5.14639	5.14639
60	70	...	...	...

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
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	<table><tr><td>نسخه</td><td>سریال</td><td>نوع مدرک</td><td>رشته</td><td>تسهیلات</td><td>صادرکننده</td><td>بسته کاری</td><td>پروژه</td></tr><tr><td>V00</td><td>0006</td><td>CN</td><td>ME</td><td>120</td><td>MF</td><td>GCS</td><td>BK</td></tr></table>		نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V00	0006	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V00	0006	CN	ME	120	MF	GCS	BK											

Nozzle Flange MAWP Results: (bars & °C)

Nozzle Description	Flange Rating		Design Temp	Class	Grade/Group	Equiv. Press	UG-44 (b)	Max Pressure 50%	DNV
	Ope.	Ambient							
S2 (2in)	11.97	15.90	152	150	GR 2.3	...	...	...	...
V (1in)	13.30	15.90	100	150	GR 2.3	...	...	...	...
T1	13.30	15.90	100	150	GR 2.3	...	...	...	...
T2	13.30	15.90	100	150	GR 2.3	...	...	...	...

Shellside Flange Rating

Lowest Flange Pressure Rating was (Ope) [ShellSide]: 11.968 bars
Lowest Flange Pressure Rating was (Amb) [ShellSide]: 15.900 bars

Channelside Flange Rating

Lowest Flange Pressure Rating was (Ope) [TubeSide]: 13.300 bars
Lowest Flange Pressure Rating was (Amb) [TubeSide]: 15.900 bars

ANSI Ratings are per ANSI/ASME B16.5 2013 Metric Edition

Warning:

There are nozzles in this model, but no flange MAWPs were de-rated. Be sure this is what you intended. There is a check box in the nozzle dialog that instructs PV Elite to perform the de-rating for each nozzle flange. See ASME VIII-1, UG-44(b) for more information.

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	پروژه	بسته کاری	صادر کننده	تسهيلات	رشته	نوع مدرک	سريال		نسخه
	BK	GCS	MF	120	ME	CN	0006		V00

Shop/Field Installation Options :

Insulation is installed in the Shop.

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

Center of Gravity of the Liquid	1879.678 mm.
Center of Gravity of the Insulation	1061.110 mm.
Center of Gravity of the Nozzles	1782.722 mm.
Center of Gravity of the Tubesheet(s)	1643.400 mm.
Center of Gravity of the Tubes	915.900 mm.
Center of Gravity of the Baffles	706.000 mm.
Center of Gravity of Bare Shell New and Cold	1065.552 mm.
Center of Gravity of Bare Shell Corroded	1065.552 mm.
Vessel CG in the Operating Condition	1201.845 mm.
Vessel CG in the Fabricated (Shop/Empty) Condition	1173.486 mm.

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100) <table><tr><td>پروژه</td><td>بسته کاری</td><td>صادرکننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00	شماره صفحه : 47 از 99
پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0006	V00											

Input, Nozzle Desc: S2 (2in)

From: 20

Pressure for Reinforcement Calculations	P	6.600	bars
Temperature for Internal Pressure	Temp	152	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material	SA-312 TP316L		
Shell Allowable Stress at Temperature	Sv	87.20	N./mm ²
Shell Allowable Stress At Ambient	Sva	115.10	N./mm ²
Inside Diameter of Cylindrical Shell	D	254.51	mm.
Design Length of Section	L	1603.2001	mm.
Shell Finished (Minimum) Thickness	t	8.1121	mm.
Shell Internal Corrosion Allowance	c	0.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1407.95	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

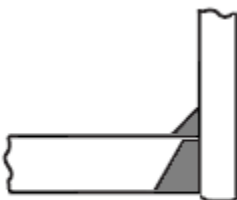
Type of Element Connected to the Shell : Nozzle

Material	SA-182 F316L		
Material UNS Number	S31603		
Material Specification/Type	Forgings		
Allowable Stress at Temperature	Sn	87.18	N./mm ²
Allowable Stress At Ambient	Sna	115.15	N./mm ²
Diameter Basis (for tr calc only)	ID		
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis	Actual		
Actual Thickness	tn	15.8500	mm.
Flange Material	SA-182 F316L		
Flange Type	Long Weld Neck		
Corrosion Allowance	can	0.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.1121	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class	150		
Flange Grade	GR 2.3		

The Pressure Design option was Design Pressure + static head.

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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0006		V00

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: S2 (2in)

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

Actual Inside Diameter Used in Calculation 2.000 in.
Actual Thickness Used in Calculation 0.624 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

$$= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)}$$

$$= (6.6 \cdot 127) / (87.2 \cdot 1 - 0.6 \cdot 6.6)$$

$$= 0.9676 \text{ mm.}$$

Reqd thk per App. 1 of Nozzle Wall, Trn [Int. Press]

$$= R \left(\exp \left(\frac{P}{S_n \cdot E} \right) - 1 \right) \text{ per Appendix 1-2 (a) (1)}$$

$$= 25.4 \left(\exp \left(\frac{6.6}{87.2 \cdot 1} \right) - 1 \right)$$

$$= 0.1930 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3482 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit) D1 101.6000 mm.
Parallel to Vessel Wall, opening length d 50.8000 mm.
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 20.2803 mm.

Weld Strength Reduction Factor [fr1]:

$$= \min(1, S_n / S_v)$$

$$= \min(1, 87.2 / 87.2)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr2]:

$$= \min(1, S_n / S_v)$$

$$= \min(1, 87.2 / 87.2)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr3]:

$$= \min(fr2, fr4)$$

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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0006		V00

= min(1, 1)
= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.492	0.484	NA
Area in Shell	A1	3.629	3.153	NA
Area in Nozzle Wall	A2	6.349	6.286	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.998	0.998	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	10.976	10.437	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(50.8*1.91*1+2*15.8*1.91*1(1-1))
= 0.484 cm²

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

= d(E1*t - F*tr) - 2 * tn(E1*t - F*tr) * (1 - fr1)
= 50.8 (1 * 8.11 - 1 * 1.91) - 2 * 15.8
(1 * 8.11 - 1 * 1.91) * (1 - 1)
= 3.153 cm²

Area Available in Nozzle Projecting Outward [A2]:

= (2 * tlnp) (tn - trn) fr2
= (2 * 20.3) (15.8 - 0.35) 1
= 6.286 cm²

Area Available in Inward Weld + Outward Weld [A41 + A43]:

= (Wo² - Area Lost) * fr2 + ((Wi-can/0.707)² - Area Lost) * fr2
= (10² - 0.002) * 1 + (0² - 0) * 1
= 0.998 cm²

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures ta = 0.3482 mm.
Wall Thickness per UG16(b), tr16b = 1.5000 mm.
Wall Thickness, shell/head, internal pressure trb1 = 0.9676 mm.
Wall Thickness tb1 = max(trb1, tr16b) = 1.5000 mm.
Wall Thickness tb2 = max(trb2, tr16b) = 1.5000 mm.
Wall Thickness per table UG-45 tb3 = 4.8000 mm.

Determine Nozzle Thickness candidate [tb]:

= min[tb3, max(tb1,tb2)]

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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0006	
							V00	

$$= \min[4.8, \max(1.5, 1.5)]$$

$$= 1.5000 \text{ mm.}$$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

$$= \max(t_a, t_b)$$

$$= \max(0.35, 1.5)$$

$$= 1.5000 \text{ mm.}$$

Available Nozzle Neck Thickness = 15.8500 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME

B31.3 Piping Code (see 319.4.4 and 302.3.5):

Sustained	:	10.9,	Allowable	:	87.2 N./mm ²	Passed
Expansion	:	0.0,	Allowable	:	242.0 N./mm ²	Passed
Occasional	:	0.4,	Allowable	:	116.0 N./mm ²	Passed
Shear	:	2.8,	Allowable	:	61.0 N./mm ²	Passed

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

SA-312 TP316L, Min Metal Temp without impact per UHA-51: -196 °C

SA-182 F316L, Min Metal Temp without impact per UHA-51: -196 °C

Weld Size Calculations, Description: S2 (2in)

Intermediate Calc. for nozzle/shell Welds Tmin 9.2710 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	7.0700 = 0.7 * Wo mm.

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$$

$$= \max(0, (0.48 - 3.15 + 2 * 15.8 * 1 * (1 * 8.11 - 1.91)) 87.2)$$

$$= \max(0, -6.12) \text{ kN}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$$

$$= (6.29 + 0 + 1 - 0 * 1) * 87.2$$

$$= 63.51 \text{ kN}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$$

$$= (6.29 + 0 + 1 + (2.57)) * 87.2$$

$$= 85.93 \text{ kN}$$

Weld Load [W3]:

$$= (A2+A3+A4+A5+(2*tn*t*fr1))*S$$

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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0006		V00

$$= (6.29 + 0 + 1 + 0 + (2.57)) * 87.2$$

$$= 85.93 \text{ kN}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$= (\pi/2) * D_{lo} * W_o * 0.49 * S_{nw}$$

$$= (3.14/2.0) * 82.5 * 10 * 0.49 * 87.2$$

$$= 55. \text{ kN}$$

Shear, Nozzle Wall [Snw]:

$$= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - Can) * 0.7 * S_n$$

$$= (3.14 * 33.3) * (15.8 - 0) * 0.7 * 87.2$$

$$= 101. \text{ kN}$$

Tension, Shell Groove Weld [Tngw]:

$$= (\pi/2) * D_{lo} * (W_{gnvi} - Cas) * 0.74 * S_{ng}$$

$$= (3.14/2.0) * 82.5 * (8.11 - 0) * 0.74 * 87.2$$

$$= 68. \text{ kN}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (55.4 + 101) = 157 \text{ kN}$$

$$PATH22 = (Sonw + Tpgw + Tngw + Sinw)$$

$$= (55.4 + 0 + 67.8 + 0) = 123 \text{ kN}$$

$$PATH33 = (Sonw + Tngw + Sinw)$$

$$= (55.4 + 67.8 + 0) = 123 \text{ kN}$$

Summary of Failure Path Calculations:

Path 1-1 = 156 kN , must exceed W = 0 kN or W1 = 63 kN
 Path 2-2 = 123 kN , must exceed W = 0 kN or W2 = 85 kN
 Path 3-3 = 123 kN , must exceed W = 0 kN or W3 = 85 kN

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 11.9 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure 1.03 bars

The Drop for this Nozzle is : 6.8712 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 164.9833 mm.

Input Echo, WRC107/537 Item 1, Description: S2 (2in) :

Diameter Basis for Vessel	Vbasis	ID
Cylindrical or Spherical Vessel	Cylsph	Cylindrical
Internal Corrosion Allowance	Cas	0.0000 mm.
Vessel Diameter	Dv	254.508 mm.
Vessel Thickness	Tv	8.112 mm.
Design Temperature	T1	152.0 °C
Vessel Material	SA-312	TP316L
Vessel UNS Number		S31603

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
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پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0006	V00											

Longitudinal Shear	VL	2.8	kN
Circumferential Moment	MC	-280.0	N-m
Longitudinal Moment	ML	-360.0	N-m
Torsional Moment	MT	-420.0	N-m

Dimensionless Parameters used : Gamma = 16.19

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.275	4C	2.406	(A,B)
N(PHI) / (P/Rm)	0.275	3C	1.725	(C,D)
M(PHI) / (P)	0.275	2C1	0.040	(A,B)
M(PHI) / (P)	0.275	1C !	0.068	(C,D)
N(PHI) / (MC/ (Rm**2 * Beta))	0.275	3A	0.683	(A,B,C,D)
M(PHI) / (MC/ (Rm * Beta))	0.275	1A	0.084	(A,B,C,D)
N(PHI) / (ML/ (Rm**2 * Beta))	0.275	3B	1.756	(A,B,C,D)
M(PHI) / (ML/ (Rm * Beta))	0.275	1B	0.029	(A,B,C,D)
N(x) / (P/Rm)	0.275	3C	1.725	(A,B)
N(x) / (P/Rm)	0.275	4C	2.406	(C,D)
M(x) / (P)	0.275	1C1	0.069	(A,B)
M(x) / (P)	0.275	2C !	0.040	(C,D)
N(x) / (MC/ (Rm**2 * Beta))	0.275	4A	1.260	(A,B,C,D)
M(x) / (MC/ (Rm * Beta))	0.275	2A	0.042	(A,B,C,D)
N(x) / (ML/ (Rm**2 * Beta))	0.275	4B	0.658	(A,B,C,D)
M(x) / (ML/ (Rm * Beta))	0.275	2B	0.048	(A,B,C,D)

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		-6.3	-6.3	-6.3	-6.3	-4.5	-4.5	-4.5	-4.5
Circ. Bend. P		-10.2	10.2	-10.2	10.2	-17.4	17.4	-17.4	17.4
Circ. Memb. MC		0.0	0.0	0.0	0.0	5.0	5.0	-5.0	-5.0
Circ. Memb. ML		0.0	0.0	0.0	0.0	59.1	-59.1	-59.1	59.1
Circ. Bend. ML		16.4	16.4	-16.4	-16.4	0.0	0.0	0.0	0.0
Tot. Circ. Str.		26.1	-5.9	-59.3	13.7	42.1	-41.2	-86.0	66.9
Long. Memb. P		-4.5	-4.5	-4.5	-4.5	-6.3	-6.3	-6.3	-6.3
Long. Bend. P		-17.6	17.6	-17.6	17.6	-10.2	10.2	-10.2	10.2
Long. Memb. MC		0.0	0.0	0.0	0.0	9.2	9.2	-9.2	-9.2
Long. Bend. MC		0.0	0.0	0.0	0.0	30.0	-30.0	-30.0	30.0

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BK	GCS	MF	120	ME	CN	0006	V00											

Long. Memb. ML	6.2	6.2	-6.2	-6.2	0.0	0.0	0.0	0.0
Long. Bend. ML	43.5	-43.5	-43.5	43.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	27.5	-24.2	-71.8	50.4	22.6	-16.9	-55.7	24.7
Shear VC	-2.0	-2.0	2.0	2.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-2.7	-2.7	2.7	2.7
Shear MT	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8
Tot. Shear	-6.8	-6.8	-2.8	-2.8	-7.5	-7.5	-2.2	-2.2
Str. Int.	33.7	26.5	72.4	50.6	44.6	43.3	86.1	67.1

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N./mm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		10.0	10.7	10.0	10.7	10.0	10.7	10.0	10.7
Circ. Pl (SUS)		10.1	10.1	-22.8	-22.8	0.4	0.4	-9.5	-9.5
Circ. Q (SUS)		16.0	-16.0	-36.5	36.5	41.7	-41.7	-76.5	76.5
Long. Pm (SUS)		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Long. Pl (SUS)		1.6	1.6	-10.7	-10.7	2.9	2.9	-15.5	-15.5
Long. Q (SUS)		25.8	-25.8	-61.1	61.1	19.8	-19.8	-40.2	40.2
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		-2.0	-2.0	2.0	2.0	-2.7	-2.7	2.7	2.7
Shear Q (SUS)		-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8
Pm (SUS)		10.0	10.7	10.0	10.7	10.0	10.7	10.0	10.7
Pm+Pl (SUS)		20.4	21.1	13.3	12.6	12.1	12.6	12.2	12.8
Pm+Pl+Q (Total)		41.4	27.6	67.2	55.7	54.2	33.2	76.1	77.7

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	10.69	87.20	Passed
Pm+Pl (SUS)	21.08	130.80	Passed
Pm+Pl+Q (TOTAL)	77.74	261.60	Passed

Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 * Smh.

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پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0006	V00											

Input, Nozzle Desc: V (1in)

From: 50

Pressure for Reinforcement Calculations	P	8.521	bars
Temperature for Internal Pressure	Temp	100	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-312	TP316L
Shell Allowable Stress at Temperature	Sv	96.67	N./mm ²
Shell Allowable Stress At Ambient	Sva	115.15	N./mm ²
Inside Diameter of Cylindrical Shell	D	254.51	mm.
Design Length of Section	L	373.0022	mm.
Shell Finished (Minimum) Thickness	t	8.1121	mm.
Shell Internal Corrosion Allowance	c	0.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1875.68	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

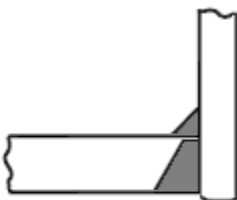
Type of Element Connected to the Shell : Nozzle

Material		SA-182	F316L
Material UNS Number		S31603	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	96.67	N./mm ²
Allowable Stress At Ambient	Sna	115.15	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		0.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.8000	mm.
Flange Material		SA-182	F316L
Flange Type		Long Weld Neck	
Corrosion Allowance	can	0.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.1121	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 2.3	

The Pressure Design option was Design Pressure + static head.

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Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: V (1in)

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	1.000 in.
Actual Thickness Used in Calculation	0.504 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (8.52 \cdot 127) / (96.7 \cdot 1 - 0.6 \cdot 8.52) \\
 &= 1.1277 \text{ mm.}
 \end{aligned}$$

Reqd thk per App. 1 of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= R \left(\exp \left(\frac{P}{S_n \cdot E} \right) - 1 \right) \text{ per Appendix 1-2 (a) (1)} \\
 &= 12.7 \left(\exp \left(\frac{8.52}{96.7 \cdot 1} \right) - 1 \right) \\
 &= 0.1124 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.2635 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	67.2242 mm.
Parallel to Vessel Wall	Rn+tn+t	33.6121 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	20.2803 mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 96.7 / 96.7) \\
 &= 1.000
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 96.7 / 96.7) \\
 &= 1.000
 \end{aligned}$$

Weld Strength Reduction Factor [fr3]:

$$= \min(fr2, fr4)$$

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	BK	GCS	MF	120	ME	CN	0006		V00

= min(1, 1)
= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.286	0.130	NA
Area in Shell	A1	2.921	2.965	NA
Area in Nozzle Wall	A2	5.146	5.085	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.964	0.964	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	9.032	9.014	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

= (d * tr*F + 2 * tn * tr*F * (1-fr1)) UG-37(c)
= (25.4*1.13*1+2*12.8*1.13*1*(1-1))
= 0.286 cm²

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

= d(E1*t - F*tr) - 2 * tn(E1*t - F*tr) * (1 - fr1)
= 41.8 (1 * 8.11 - 1 * 1.13) - 2 * 12.8
(1 * 8.11 - 1 * 1.13) * (1 - 1)
= 2.921 cm²

Area Available in Nozzle Projecting Outward [A2]:

= (2 * tlnp) (tn - trn) fr2
= (2 * 20.3) (12.8 - 0.11) 1
= 5.146 cm²

Area Available in Inward Weld + Outward Weld [A41 + A43]:

= (Wo² - Area Lost) * fr2 + ((Wi-can/0.707)² - Area Lost) * fr2
= (10² - 0.036) * 1 + (0² - 0) * 1
= 0.964 cm²

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures ta = 0.2635 mm.
Wall Thickness per UG16(b), tr16b = 1.5000 mm.
Wall Thickness, shell/head, internal pressure trb1 = 1.1277 mm.
Wall Thickness tb1 = max(trb1, tr16b) = 1.5000 mm.
Wall Thickness tb2 = max(trb2, tr16b) = 1.5000 mm.
Wall Thickness per table UG-45 tb3 = 3.4200 mm.

Determine Nozzle Thickness candidate [tb]:

= min[tb3, max(tb1,tb2)]

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	BK	GCS	MF	120	ME	CN	0006		V00

$$= \min[3.42, \max(1.5, 1.5)]$$

$$= 1.5000 \text{ mm.}$$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

$$= \max(t_a, t_b)$$

$$= \max(0.26, 1.5)$$

$$= 1.5000 \text{ mm.}$$

Available Nozzle Neck Thickness = 12.8000 mm. --> OK

SA-312 TP316L, Min Metal Temp without impact per UHA-51: -196 °C

SA-182 F316L, Min Metal Temp without impact per UHA-51: -196 °C

Weld Size Calculations, Description: V (1in)

Intermediate Calc. for nozzle/shell Welds Tmin 9.2710 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	7.0700 = 0.7 * Wo mm.

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$= \max(0, (A-A1+2*t_n*fr1*(E1*t-tr))Sv)$$

$$= \max(0, (0.29 - 2.92 + 2 * 12.8 * 1 * (1 * 8.11 - 1.13)) 96.7)$$

$$= \max(0, -8.18) \text{ kN}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$$

$$= (5.15 + 0 + 0.96 - 0 * 1) * 96.7$$

$$= 59.07 \text{ kN}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * fr1)) * Sv$$

$$= (5.15 + 0 + 0.96 + (2.08)) * 96.7$$

$$= 79.14 \text{ kN}$$

Weld Load [W3]:

$$= (A2+A3+A4+A5+(2*t_n*t*fr1))*S$$

$$= (5.15 + 0 + 0.96 + 0 + (2.08)) * 96.7$$

$$= 79.14 \text{ kN}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$= (\pi/2) * D_{lo} * W_o * 0.49 * S_{nw}$$

$$= (3.14/2.0) * 51 * 10 * 0.49 * 96.7$$

$$= 38. \text{ kN}$$

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	BK	GCS	MF	120	ME	CN	0006		V00

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - Can) * 0.7 * S_n \\
 &= (3.14 * 19.1) * (12.8 - 0) * 0.7 * 96.7 \\
 &= 52. \text{ kN}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (W_{gwni} - Cas) * 0.74 * S_{ng} \\
 &= (3.14/2.0) * 51 * (8.11 - 0) * 0.74 * 96.7 \\
 &= 46. \text{ kN}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (SONW + SNW) = (37.9 + 52) = 89.9 \text{ kN} \\
 \text{PATH22} &= (Sonw + Tpgw + Tngw + Sinw) \\
 &= (37.9 + 0 + 46.5 + 0) = 84.4 \text{ kN} \\
 \text{PATH33} &= (Sonw + Tngw + Sinw) \\
 &= (37.9 + 46.5 + 0) = 84.4 \text{ kN}
 \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 89 kN , must exceed W = 0 kN or W1 = 59 kN
 Path 2-2 = 84 kN , must exceed W = 0 kN or W2 = 79 kN
 Path 3-3 = 84 kN , must exceed W = 0 kN or W3 = 79 kN

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 13.3 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure 1.03 bars

The Drop for this Nozzle is : 2.5811 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 160.6932 mm.

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)	شماره صفحه : 60 از 99																
	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادر کننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											

Input, Nozzle Desc: T1

From: 60

Pressure for Reinforcement Calculations	P	8.501	bars
Temperature for Internal Pressure	Temp	100	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-403	316L
Shell Allowable Stress at Temperature	Sv	115.10	N./mm ²
Shell Allowable Stress At Ambient	Sva	115.10	N./mm ²
Inside Diameter of Elliptical Head	D	256.83	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	8.1121	mm.
Head Internal Corrosion Allowance	c	0.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.
Distance from Head Centerline	L1	80.0000	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

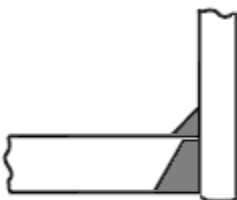
Type of Element Connected to the Shell : Nozzle

Material		SA-182	F316L
Material UNS Number		S31603	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	96.67	N./mm ²
Allowable Stress At Ambient	Sna	115.15	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		0.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.8000	mm.
Flange Material		SA-182	F316L
Flange Type		Long Weld Neck	
Corrosion Allowance	can	0.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.1121	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 2.3	

The Pressure Design option was Design Pressure + static head.

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	پروژه		بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle No Pad, no Inside projection

Note : Checking Nozzle in the Meridional direction.

Reinforcement CALCULATION, Description: T1

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	1.000 in.
Actual Thickness Used in Calculation	0.504 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]
 $= (P \cdot D \cdot K) / (2 \cdot S_v \cdot E - 0.2 \cdot P)$ Appendix 1-4 (c)
 $= (8.5 \cdot 257 \cdot 1) / (2 \cdot 115 \cdot 1 - 0.2 \cdot 8.5)$
 $= 0.9492 \text{ mm.}$

Reqd thk per App. 1 of Nozzle Wall, Trn [Int. Press]
 $= R \cdot (\exp([P / (S_n \cdot E)]) - 1)$ per Appendix 1-2 (a) (1)
 $= 12.7 \cdot (\exp([8.5 / (96.7 \cdot 1)] - 1))$
 $= 0.1122 \text{ mm.}$

Required Nozzle thickness under External Pressure per UG-28 : 0.2635 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	69.2530 mm.
Parallel to Vessel Wall	Rn+tn+t	34.6265 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	20.2803 mm.

Weld Strength Reduction Factor [fr1]:

$= \min(1, S_n / S_v)$
 $= \min(1, 96.7 / 115)$
 $= 0.840$

Weld Strength Reduction Factor [fr2]:

$= \min(1, S_n / S_v)$
 $= \min(1, 96.7 / 115)$
 $= 0.840$

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	BK	GCS	MF	120	ME	CN	0006		V00

Weld Strength Reduction Factor [fr3]:

$$\begin{aligned}
 &= \min(fr2, fr4) \\
 &= \min(0.84, 1) \\
 &= 0.840
 \end{aligned}$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.299	0.236	NA
Area in Shell	A1	2.702	2.494	NA
Area in Nozzle Wall	A2	4.492	4.439	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.810	0.810	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.004	7.743	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 67.82 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$\begin{aligned}
 &= 0.5(d * tr * F + 2 * tn * tr * F(1-fr1)) \text{ per UG-37(d)} \\
 &= 0.5(27.4 * 1.5 * 1 + 2 * 12.8 * 1.5 * 1(1-0.84)) \\
 &= 0.236 \text{ cm}^2
 \end{aligned}$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$\begin{aligned}
 &= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1) \\
 &= 41.8 (1 * 8.11 - 1 * 1.5) - 2 * 12.8 \\
 &\quad (1 * 8.11 - 1 * 1.5) * (1 - 0.84) \\
 &= 2.494 \text{ cm}^2
 \end{aligned}$$

Area Available in Nozzle Projecting Outward [A2]:

$$\begin{aligned}
 &= (2 * tlnp) (tn - trn) fr2 / \sin(alpha3) \\
 &= (2 * 20.3) (12.8 - 0.26) 0.84 / \sin(74.2) \\
 &= 4.439 \text{ cm}^2
 \end{aligned}$$

Note: See ASME VIII-1 2011(a) Appendix L, L-7.7.7(b) for more information.

Area Available in Inward Weld + Outward Weld [A41 + A43]:

$$\begin{aligned}
 &= (Wo^2 - Area Lost) * fr2 + ((Wi-can/0.707)^2 - Area Lost) * fr2 \\
 &= (10^2 - 0.036) * 0.84 + (0^2 - 0) * 0.84 \\
 &= 0.810 \text{ cm}^2
 \end{aligned}$$

SA-403 316L, Min Metal Temp without impact per UHA-51: -196 °C

SA-182 F316L, Min Metal Temp without impact per UHA-51: -196 °C

Weld Size Calculations, Description: T1

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	BK	GCS	MF	120	ME	CN	0006		V00

Intermediate Calc. for nozzle/shell Welds T_{min} 9.2710 mm.

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld 6.0000 = Min per Code 7.0700 = 0.7 * W_o mm.

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A - A_1 + 2 \cdot t_n \cdot f_{r1} \cdot (E_1 \cdot t - t_r)) \cdot S_v) \\
 &= \max(0, (0.24 - 2.49 + 2 \cdot 12.8 \cdot 0.84 \cdot (1 \cdot 8.11 - 1.5)) \cdot 115) \\
 &= \max(0, -9.63) \text{ kN}
 \end{aligned}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$\begin{aligned}
 &= (A_2 + A_5 + A_4 - (W_i - C_{an} / .707)^2 \cdot f_{r2}) \cdot S_v \\
 &= (4.44 + 0 + 0.81 - 0 \cdot 0.84) \cdot 115 \\
 &= 60.41 \text{ kN}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A_2 + A_3 + A_4 + (2 \cdot t_n \cdot t \cdot f_{r1})) \cdot S_v \\
 &= (4.44 + 0 + 0.81 + (1.74)) \cdot 115 \\
 &= 80.48 \text{ kN}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A_2 + A_3 + A_4 + A_5 + (2 \cdot t_n \cdot t \cdot f_{r1})) \cdot S \\
 &= (4.44 + 0 + 0.81 + 0 + (1.74)) \cdot 115 \\
 &= 80.48 \text{ kN}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) \cdot D_{lo} \cdot W_o \cdot 0.49 \cdot S_{nw} \\
 &= (3.14/2.0) \cdot 55.1 \cdot 10 \cdot 0.49 \cdot 96.7 \\
 &= 41. \text{ kN}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi \cdot (D_{lr} + D_{lo}) / 4) \cdot (Thk - C_{an}) \cdot 0.7 \cdot S_n \\
 &= (3.14 \cdot 20.6) \cdot (12.8 - 0) \cdot 0.7 \cdot 96.7 \\
 &= 56. \text{ kN}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) \cdot D_{lo} \cdot (W_{gnvi} - C_{as}) \cdot 0.74 \cdot S_{ng} \\
 &= (3.14/2.0) \cdot 55.1 \cdot (8.11 - 0) \cdot 0.74 \cdot 115 \\
 &= 60. \text{ kN}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (SONW + SNW) = (41 + 56.1) = 97.1 \text{ kN} \\
 \text{PATH22} &= (Sonw + Tpgw + Tngw + Sinw) \\
 &= (41 + 0 + 59.8 + 0) = 101 \text{ kN} \\
 \text{PATH33} &= (Sonw + Tngw + Sinw)
 \end{aligned}$$

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$$= (41 + 59.8 + 0) = 101 \text{ kN}$$

Summary of Failure Path Calculations:

Path 1-1 = 97 kN , must exceed W = 0 kN or W1 = 60 kN
 Path 2-2 = 100 kN , must exceed W = 0 kN or W2 = 80 kN
 Path 3-3 = 100 kN , must exceed W = 0 kN or W3 = 80 kN

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 13.3 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure 1.03 bars

Note : Checking Nozzle in the Latitudinal direction.

Reinforcement CALCULATION, Description: T1

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

Actual Inside Diameter Used in Calculation 1.000 in.
 Actual Thickness Used in Calculation 0.504 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]
 $= (P \cdot D \cdot K) / (2 \cdot S_v \cdot E - 0.2 \cdot P)$ Appendix 1-4 (c)
 $= (8.5 \cdot 257 \cdot 1) / (2 \cdot 115 \cdot 1 - 0.2 \cdot 8.5)$
 $= 0.9492 \text{ mm.}$

Reqd thk per App. 1 of Nozzle Wall, Trn [Int. Press]
 $= R \cdot (\exp([P / (S_n \cdot E)]) - 1)$ per Appendix 1-2 (a) (1)
 $= 12.7 \cdot (\exp([8.5 / (96.7 \cdot 1)] - 1)$
 $= 0.1122 \text{ mm.}$

Required Nozzle thickness under External Pressure per UG-28 : 0.2635 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	67.2242	mm.
Parallel to Vessel Wall	Rn+tn+t	33.6121	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	20.2803	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.280	0.221	NA
Area in Shell	A1	2.702	2.494	NA
Area in Nozzle Wall	A2	4.322	4.271	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.810	0.810	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	7.834	7.575	NA

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BK	GCS	MF	120	ME	CN	0006	V00											

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$\begin{aligned}
 &= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)} \\
 &= 0.5(25.4 * 1.5 * 1 + 2 * 12.8 * 1.5 * 1(1 - 0.84)) \\
 &= 0.221 \text{ cm}^2
 \end{aligned}$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$\begin{aligned}
 &= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1) \\
 &= 41.8 (1 * 8.11 - 1 * 1.5) - 2 * 12.8 \\
 &\quad (1 * 8.11 - 1 * 1.5) * (1 - 0.84) \\
 &= 2.494 \text{ cm}^2
 \end{aligned}$$

Area Available in Nozzle Projecting Outward [A2]:

$$\begin{aligned}
 &= (2 * tlnp) (tn - trn) fr2 \\
 &= (2 * 20.3) (12.8 - 0.26) 0.84 \\
 &= 4.271 \text{ cm}^2
 \end{aligned}$$

Area Available in Inward Weld + Outward Weld [A41 + A43]:

$$\begin{aligned}
 &= (Wo^2 - \text{Area Lost}) * fr2 + ((Wi - can / 0.707)^2 - \text{Area Lost}) * fr2 \\
 &= (10^2 - 0.036) * 0.84 + (0^2 - 0) * 0.84 \\
 &= 0.810 \text{ cm}^2
 \end{aligned}$$

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 0.2635 mm.
Wall Thickness per UG16(b),	tr16b = 1.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 0.9492 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 1.5000 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 1.5000 mm.
Wall Thickness per table UG-45	tb3 = 3.4200 mm.

Determine Nozzle Thickness candidate [tb]:

$$\begin{aligned}
 &= \min[tb3, \max(tb1, tb2)] \\
 &= \min[3.42, \max(1.5, 1.5)] \\
 &= 1.5000 \text{ mm.}
 \end{aligned}$$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

$$\begin{aligned}
 &= \max(ta, tb) \\
 &= \max(0.26, 1.5) \\
 &= 1.5000 \text{ mm.}
 \end{aligned}$$

Available Nozzle Neck Thickness = 12.8000 mm. --> OK

Weld Size Calculations, Description: T1

Intermediate Calc. for nozzle/shell Welds	Tmin	9.2710 mm.
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V00	0006	CN	ME	120	MF	GCS	BK																			

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld 6.0000 = Min per Code 7.0700 = 0.7 * Wo mm.

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (0.22 - 2.49 + 2 * 12.8 * 0.84 * \\
 &\quad (1 * 8.11 - 1.5)) 115) \\
 &= \max(0, -9.80) \text{ kN}
 \end{aligned}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (4.27 + 0 + 0.81 - 0 * 0.84) * 115 \\
 &= 58.47 \text{ kN}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (4.27 + 0 + 0.81 + (1.74)) * 115 \\
 &= 78.55 \text{ kN}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (4.27 + 0 + 0.81 + 0 + (1.74)) * 115 \\
 &= 78.55 \text{ kN}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.14/2.0) * 51 * 10 * 0.49 * 96.7 \\
 &= 38. \text{ kN}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.14 * 19.1) * (12.8 - 0) * 0.7 * 96.7 \\
 &= 52. \text{ kN}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng \\
 &= (3.14/2.0) * 51 * (8.11 - 0) * 0.74 * 115 \\
 &= 55. \text{ kN}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (37.9 + 52) = 89.9 \text{ kN} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (37.9 + 0 + 55.3 + 0) = 93.3 \text{ kN} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (37.9 + 55.3 + 0) = 93.3 \text{ kN}
 \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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	BK	GCS	MF	120	ME	CN	0006		V00

Summary of Failure Path Calculations:

Path 1-1 = 89 kN , must exceed W = 0 kN or W1 = 58 kN

Path 2-2 = 93 kN , must exceed W = 0 kN or W2 = 78 kN

Path 3-3 = 93 kN , must exceed W = 0 kN or W3 = 78 kN

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 13.3 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure 1.03 bars

The Drop for this Nozzle is : 10.8320 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 169.4289 mm.

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100) <table><tr><td>پروژه</td><td>بسته کاری</td><td>صادر کننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00	شماره صفحه : 68 از 99
پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0006	V00											

Input, Nozzle Desc: T2

From: 60

Pressure for Reinforcement Calculations	P	8.501	bars
Temperature for Internal Pressure	Temp	100	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-403	316L
Shell Allowable Stress at Temperature	Sv	115.10	N./mm ²
Shell Allowable Stress At Ambient	Sva	115.10	N./mm ²
Inside Diameter of Elliptical Head	D	256.83	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	8.1121	mm.
Head Internal Corrosion Allowance	c	0.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.
Distance from Head Centerline	L1	80.0000	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

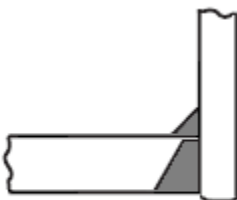
Type of Element Connected to the Shell : Nozzle

Material		SA-182	F316L
Material UNS Number		S31603	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	96.67	N./mm ²
Allowable Stress At Ambient	Sna	115.15	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		180.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.8000	mm.
Flange Material		SA-182	F316L
Flange Type		Long Weld Neck	
Corrosion Allowance	can	0.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.1121	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 2.3	

The Pressure Design option was Design Pressure + static head.

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	BK	GCS	MF	120	ME	CN	0006		V00

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle No Pad, no Inside projection

Note : Checking Nozzle in the Meridional direction.

Reinforcement CALCULATION, Description: T2

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	1.000 in.
Actual Thickness Used in Calculation	0.504 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]
 $= (P \cdot D \cdot K) / (2 \cdot S_v \cdot E - 0.2 \cdot P)$ Appendix 1-4 (c)
 $= (8.5 \cdot 257 \cdot 1) / (2 \cdot 115 \cdot 1 - 0.2 \cdot 8.5)$
 $= 0.9492 \text{ mm.}$

Reqd thk per App. 1 of Nozzle Wall, Trn [Int. Press]
 $= R \cdot (\exp([P / (S_n \cdot E)]) - 1)$ per Appendix 1-2 (a) (1)
 $= 12.7 \cdot (\exp([8.5 / (96.7 \cdot 1)] - 1))$
 $= 0.1122 \text{ mm.}$

Required Nozzle thickness under External Pressure per UG-28 : 0.2635 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	69.2530 mm.
Parallel to Vessel Wall	Rn+tn+t	34.6265 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	20.2803 mm.

Weld Strength Reduction Factor [fr1]:

$= \min(1, S_n / S_v)$
 $= \min(1, 96.7 / 115)$
 $= 0.840$

Weld Strength Reduction Factor [fr2]:

$= \min(1, S_n / S_v)$
 $= \min(1, 96.7 / 115)$
 $= 0.840$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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	BK	GCS	MF	120	ME	CN	0006		V00

Weld Strength Reduction Factor [fr3]:

$$\begin{aligned}
 &= \min(fr2, fr4) \\
 &= \min(0.84, 1) \\
 &= 0.840
 \end{aligned}$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.299	0.236	NA
Area in Shell	A1	2.702	2.494	NA
Area in Nozzle Wall	A2	4.492	4.439	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.810	0.810	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.004	7.743	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 67.82 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$\begin{aligned}
 &= 0.5(d * tr * F + 2 * tn * tr * F(1-fr1)) \text{ per UG-37(d)} \\
 &= 0.5(27.4 * 1.5 * 1 + 2 * 12.8 * 1.5 * 1(1-0.84)) \\
 &= 0.236 \text{ cm}^2
 \end{aligned}$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$\begin{aligned}
 &= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1) \\
 &= 41.8 (1 * 8.11 - 1 * 1.5) - 2 * 12.8 \\
 &\quad (1 * 8.11 - 1 * 1.5) * (1 - 0.84) \\
 &= 2.494 \text{ cm}^2
 \end{aligned}$$

Area Available in Nozzle Projecting Outward [A2]:

$$\begin{aligned}
 &= (2 * tlnp) (tn - trn) fr2 / \sin(alpha3) \\
 &= (2 * 20.3) (12.8 - 0.26) 0.84 / \sin(74.2) \\
 &= 4.439 \text{ cm}^2
 \end{aligned}$$

Note: See ASME VIII-1 2011(a) Appendix L, L-7.7.7(b) for more information.

Area Available in Inward Weld + Outward Weld [A41 + A43]:

$$\begin{aligned}
 &= (Wo^2 - Area Lost) * fr2 + ((Wi-can/0.707)^2 - Area Lost) * fr2 \\
 &= (10^2 - 0.036) * 0.84 + (0^2 - 0) * 0.84 \\
 &= 0.810 \text{ cm}^2
 \end{aligned}$$

SA-403 316L, Min Metal Temp without impact per UHA-51: -196 °C

SA-182 F316L, Min Metal Temp without impact per UHA-51: -196 °C

Weld Size Calculations, Description: T2

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	BK	GCS	MF	120	ME	CN	0006		V00

Intermediate Calc. for nozzle/shell Welds T_{min} 9.2710 mm.

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld 6.0000 = Min per Code 7.0700 = 0.7 * W_o mm.

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A - A_1 + 2 \cdot t_n \cdot f_{r1} \cdot (E_1 \cdot t - t_r)) \cdot S_v) \\
 &= \max(0, (0.24 - 2.49 + 2 \cdot 12.8 \cdot 0.84 \cdot (1 \cdot 8.11 - 1.5)) \cdot 115) \\
 &= \max(0, -9.63) \text{ kN}
 \end{aligned}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$\begin{aligned}
 &= (A_2 + A_5 + A_4 - (W_i - C_{an} / .707)^2 \cdot f_{r2}) \cdot S_v \\
 &= (4.44 + 0 + 0.81 - 0 \cdot 0.84) \cdot 115 \\
 &= 60.41 \text{ kN}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A_2 + A_3 + A_4 + (2 \cdot t_n \cdot t \cdot f_{r1})) \cdot S_v \\
 &= (4.44 + 0 + 0.81 + (1.74)) \cdot 115 \\
 &= 80.48 \text{ kN}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A_2 + A_3 + A_4 + A_5 + (2 \cdot t_n \cdot t \cdot f_{r1})) \cdot S \\
 &= (4.44 + 0 + 0.81 + 0 + (1.74)) \cdot 115 \\
 &= 80.48 \text{ kN}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) \cdot D_{lo} \cdot W_o \cdot 0.49 \cdot S_{nw} \\
 &= (3.14/2.0) \cdot 55.1 \cdot 10 \cdot 0.49 \cdot 96.7 \\
 &= 41. \text{ kN}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi \cdot (D_{lr} + D_{lo}) / 4) \cdot (Thk - C_{an}) \cdot 0.7 \cdot S_n \\
 &= (3.14 \cdot 20.6) \cdot (12.8 - 0) \cdot 0.7 \cdot 96.7 \\
 &= 56. \text{ kN}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) \cdot D_{lo} \cdot (W_{gnvi} - C_{as}) \cdot 0.74 \cdot S_{ng} \\
 &= (3.14/2.0) \cdot 55.1 \cdot (8.11 - 0) \cdot 0.74 \cdot 115 \\
 &= 60. \text{ kN}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (SONW + SNW) = (41 + 56.1) = 97.1 \text{ kN} \\
 \text{PATH22} &= (Sonw + Tpgw + Tngw + Sinw) \\
 &= (41 + 0 + 59.8 + 0) = 101 \text{ kN} \\
 \text{PATH33} &= (Sonw + Tngw + Sinw)
 \end{aligned}$$

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$$= (41 + 59.8 + 0) = 101 \text{ kN}$$

Summary of Failure Path Calculations:

Path 1-1 = 97 kN , must exceed W = 0 kN or W1 = 60 kN
 Path 2-2 = 100 kN , must exceed W = 0 kN or W2 = 80 kN
 Path 3-3 = 100 kN , must exceed W = 0 kN or W3 = 80 kN

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 13.3 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure 1.03 bars

Note : Checking Nozzle in the Latitudinal direction.

Reinforcement CALCULATION, Description: T2

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

Actual Inside Diameter Used in Calculation 1.000 in.
 Actual Thickness Used in Calculation 0.504 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]

$$= (P \cdot D \cdot K) / (2 \cdot S_v \cdot E - 0.2 \cdot P) \text{ Appendix 1-4 (c)}$$

$$= (8.5 \cdot 257 \cdot 1) / (2 \cdot 115 \cdot 1 - 0.2 \cdot 8.5)$$

$$= 0.9492 \text{ mm.}$$

Reqd thk per App. 1 of Nozzle Wall, Trn [Int. Press]

$$= R \left(\exp \left(\frac{P}{S_n \cdot E} \right) - 1 \right) \text{ per Appendix 1-2 (a) (1)}$$

$$= 12.7 \left(\exp \left(\frac{8.5}{96.7 \cdot 1} \right) - 1 \right)$$

$$= 0.1122 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.2635 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	67.2242	mm.
Parallel to Vessel Wall	Rn+tn+t	33.6121	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	20.2803	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.280	0.221	NA
Area in Shell	A1	2.702	2.494	NA
Area in Nozzle Wall	A2	4.322	4.271	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.810	0.810	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	7.834	7.575	NA

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	BK	GCS	MF	120	ME	CN	0006		V00

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$\begin{aligned}
 &= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)} \\
 &= 0.5(25.4 * 1.5 * 1 + 2 * 12.8 * 1.5 * 1(1 - 0.84)) \\
 &= 0.221 \text{ cm}^2
 \end{aligned}$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$\begin{aligned}
 &= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1) \\
 &= 41.8 (1 * 8.11 - 1 * 1.5) - 2 * 12.8 \\
 &\quad (1 * 8.11 - 1 * 1.5) * (1 - 0.84) \\
 &= 2.494 \text{ cm}^2
 \end{aligned}$$

Area Available in Nozzle Projecting Outward [A2]:

$$\begin{aligned}
 &= (2 * tlnp) (tn - trn) fr2 \\
 &= (2 * 20.3) (12.8 - 0.26) 0.84 \\
 &= 4.271 \text{ cm}^2
 \end{aligned}$$

Area Available in Inward Weld + Outward Weld [A41 + A43]:

$$\begin{aligned}
 &= (Wo^2 - \text{Area Lost}) * fr2 + ((Wi - can / 0.707)^2 - \text{Area Lost}) * fr2 \\
 &= (10^2 - 0.036) * 0.84 + (0^2 - 0) * 0.84 \\
 &= 0.810 \text{ cm}^2
 \end{aligned}$$

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 0.2635 mm.
Wall Thickness per UG16(b),	tr16b = 1.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 0.9492 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 1.5000 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 1.5000 mm.
Wall Thickness per table UG-45	tb3 = 3.4200 mm.

Determine Nozzle Thickness candidate [tb]:

$$\begin{aligned}
 &= \min[tb3, \max(tb1, tb2)] \\
 &= \min[3.42, \max(1.5, 1.5)] \\
 &= 1.5000 \text{ mm.}
 \end{aligned}$$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

$$\begin{aligned}
 &= \max(ta, tb) \\
 &= \max(0.26, 1.5) \\
 &= 1.5000 \text{ mm.}
 \end{aligned}$$

Available Nozzle Neck Thickness = 12.8000 mm. --> OK

Weld Size Calculations, Description: T2

Intermediate Calc. for nozzle/shell Welds	Tmin	9.2710 mm.
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Results Per UW-16.1:

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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	BK	GCS	MF	120	ME	CN	0006		V00

Required Thickness Actual Thickness
 Nozzle Weld 6.0000 = Min per Code 7.0700 = 0.7 * Wo mm.

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (0.22 - 2.49 + 2 * 12.8 * 0.84 * \\
 &\quad (1 * 8.11 - 1.5)) 115) \\
 &= \max(0, -9.80) \text{ kN}
 \end{aligned}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (4.27 + 0 + 0.81 - 0 * 0.84) * 115 \\
 &= 58.47 \text{ kN}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (4.27 + 0 + 0.81 + (1.74)) * 115 \\
 &= 78.55 \text{ kN}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (4.27 + 0 + 0.81 + 0 + (1.74)) * 115 \\
 &= 78.55 \text{ kN}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.14/2.0) * 51 * 10 * 0.49 * 96.7 \\
 &= 38. \text{ kN}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.14 * 19.1) * (12.8 - 0) * 0.7 * 96.7 \\
 &= 52. \text{ kN}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng \\
 &= (3.14/2.0) * 51 * (8.11 - 0) * 0.74 * 115 \\
 &= 55. \text{ kN}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (37.9 + 52) = 89.9 \text{ kN} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (37.9 + 0 + 55.3 + 0) = 93.3 \text{ kN} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (37.9 + 55.3 + 0) = 93.3 \text{ kN}
 \end{aligned}$$

	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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	BK	GCS	MF	120	ME	CN	0006		V00

Summary of Failure Path Calculations:

Path 1-1 = 89 kN , must exceed W = 0 kN or W1 = 58 kN
 Path 2-2 = 93 kN , must exceed W = 0 kN or W2 = 78 kN
 Path 3-3 = 93 kN , must exceed W = 0 kN or W3 = 78 kN

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 13.3 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure 1.03 bars

The Drop for this Nozzle is : 10.8320 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 169.4289 mm.

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 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
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	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادرکننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
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Input Echo, Tubesheet Number 1, Description: ts

Shell Data:

Main Shell Description: Shell Barrel

Shell Maximum Design Pressure	Psd,max	6.60	bars
Shell Maximum Operating Pressure	Psox,max	6.60	bars
Shell Minimum Operating Pressure	Psox,min	0.00	bars
Shell Thickness	ts	9.2710	mm.
Shell Internal Corrosion Allowance	cas	0.0000	mm.
Shell External Corrosion Allowance	caext	0.0000	mm.
Inside Diameter of Shell	Ds	254.508	mm.
Shell Temperature for Internal Pressure	Ts	152.00	°C
Shell Material	SA-312	TP316L	
Shell Material UNS Number		S31603	
Shell Allowable Stress at Temperature	Ss	87.18	N./mm ²
Shell Allowable Stress at Ambient		115.15	N./mm ²

Channel Description: Channel Barrel

Channel Type:	Cylinder		
Channel Maximum Design Pressure	Ptd,max	8.50	bars
Channel Maximum Operating Pressure	Ptox,max	8.50	bars
Channel Minimum Operating Pressure	Ptox,min	0.00	bars
Channel Thickness	tc	9.2710	mm.
Channel Corrosion Allowance	cac	0.0000	mm.
Inside Diameter of Channel	Dc	254.508	mm.
Channel Design Temperature	TEMPC	100.00	°C
Channel Material	SA-312	TP316L	
Channel Material UNS Number		S31603	
Channel Allowable Stress at Temperature	Sc	96.67	N./mm ²
Channel Allowable Stress at Ambient		115.15	N./mm ²

Tube Data:

Number of Tube Holes	Nt	44	
Tube Wall Thickness	et	1.6500	mm.
Tube Outside Diameter	D	19.0500	mm.
Total Straight Tube Length	Lt	1400.00	mm.
Straight Tube Length (bet. inner tubsht faces) L		1345.00	mm.
Design Temperature of the Tubes		100.00	°C
Tube Material	SA-213	TP316L	
Tube Material UNS Number		S31603	
Is this a Welded Tube		No	
Tube Material Specification used	Smls. tube		
Tube Allowable Stress at Temperature		96.67	N./mm ²
Tube Allowable Stress At Ambient		115.15	N./mm ²
Tube Yield Stress At design Temperature	Syt	144.88	N./mm ²
Tube Pitch (Center to Center Spacing)	P	28.5000	mm.
Tube Layout Pattern		Square	
Fillet Weld Leg	af	2.0000	mm.
Groove Weld Leg	ag	2.0000	mm.
Tube-Tubesheet Joint Weld Type		Full Strength	
Method for Tube-Tubesheet Jt. Allow.		UW-20	

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	BK	GCS	MF	120	ME	CN	0006		V00

Radius to Outermost Tube Hole Center	ro	108.823	mm.
Largest Center-to-Center Tube Distance	U1	0.0000	mm.
Length of Expanded Portion of Tube	ltx	40.0000	mm.
Distance from Channel Side where Exp. Starts		12.0000	mm.
Min. Distance from Shell Side where Exp. Stops		3.0000	mm.
Tube-side pass partition groove depth	hg	5.0000	mm.
Area of Tube Layout	Ap	294.2	cm ²
Perimeter of Tube Layout	Cp	628.5	mm.

Tubesheet Data:

Tubesheet TYPE: U-tube, Gasketed both Sides, Conf. d

Tubesheet Design Metal Temperature	T	100.00	°C
Tubesheet Material	SA-182	F316L	
Tubesheet Material UNS Number		S31603	
Tubesheet Allowable Stress at Temperature	S	96.67	N./mm ²
Tubesheet Allowable Stress at Ambient	Tt	115.15	N./mm ²
Thickness of Tubesheet	h	55.0000	mm.
Tubesheet Corr. Allowance (Shell side)	Cats	0.0000	mm.
Tubesheet Corr. Allowance (Channel side)	Catc	0.0000	mm.
Tubesheet Outside Diameter	A	406.400	mm.

Additional Data for Stepped Tubesheets:

Is the Tubesheet Stepped?		YES	
Is the Tubesheet Flat on Tubeside?		NO	
Step 1 Diameter on the Tubeside	dt1	320.60	mm.
Step 1 Depth on the Tubeside	ht1	7.00	mm.
Step 2 Diameter on the Tubeside	dt2	251.40	mm.
Step 2 Depth on the Tubeside	ht2	5.00	mm.
Is the Tubesheet Flat on Shellside?		NO	
Step 1 Diameter on the Shellside	ds1	320.60	mm.
Step 1 Depth on the Shellside	hs1	7.00	mm.
Step 2 Diameter on the Shellside	ds2	251.40	mm.
Step 2 Depth on the Shellside	hs2	5.00	mm.
Calculated Tubesheet Diameter as per UHX-10(b)		320.60	mm.

Note: Tubesheet diameter is now: 320.600 mm. per UHX-10(b).

Dimension G for the Channel Side	Gc	317.500	mm.
Area of the Untubed Lanes	AL	0.0	cm ²

Junction Stress Reduction option		Increase Tubesheet thickness	
Perform Differential Pressure Design		NO	
Run Multiple Load Cases		YES	
Shell Side Min. Design Pressure	Psd,min	1.0340	bars
Channel Side Min. Design Pressure	Ptd,min	1.0340	bars

Additional Data for Gasketed Tubesheets:

Tubesheet Gasket on which Side		Both	
Flange Outside Diameter	A	406.400	mm.
Flange Inside Diameter	B	256.826	mm.
Flange Face Outside Diameter	Fod	323.850	mm.
Flange Face Inside Diameter	Fid	256.826	mm.
Gasket Outside Diameter	Go	317.500	mm.

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BK	GCS	MF	120	ME	CN	0006	V00											

Gasket Inside Diameter	Gi	287.274	mm.
Small end Hub thk.	g0	9.2710	mm.
Large end Hub thk.	g1	23.9871	mm.
Gasket Factor,	m	3.00	
Gasket Design Seating Stress	y	68.95	N./mm ²
Flange Facing Sketch	Code Sketch 1a		
Column for Gasket Seating	Code Column II		
Gasket Thickness	tg	3.1750	mm.
Full face Gasket Flange Option	Program Selects		

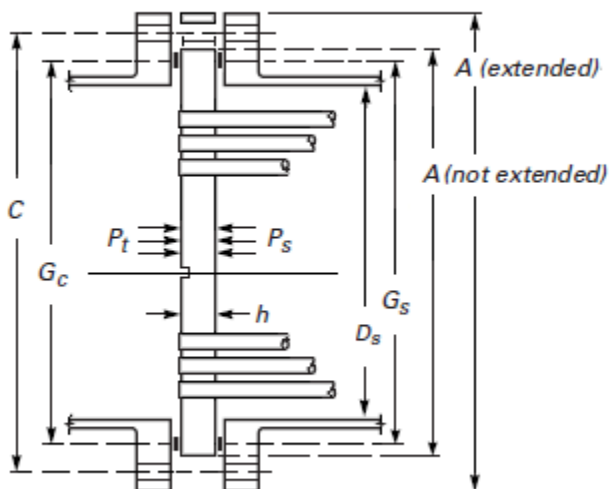
Bolting Information:

Diameter of Bolt Circle	C	361.950	mm.
Nominal Bolt Diameter	dB	24.0000	mm.
Type of Thread Series	TEMA Metric Thread		
Number of Bolts	n	12	
Bolt Material	SA-193 B8M		
Bolt Allowable Stress At Temperature	Sb	120.31	N./mm ²
Bolt Allowable Stress At Ambient	Sa	129.63	N./mm ²
Weld between Flange and Shell/Channel		0.0000	mm.

Alternate Flange Operating Bolt Load, Wm1	74.42	kN
Alternate Flange Seating Bolt Load, Wm2	455.58	kN
Alternate Flange Design Bolt Load, W	471.01	kN

Tubesheet Integral with		None	
Tubesheet Extended as Flange		Yes	
Thickness of Extended Portion of Tubesheet	Tf	31.0000	mm.
Is Bolt Load Transferred to the Tubesheet		Yes	

Tubesheet Gasketed With Shell and Channel



Configuration d:

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BK	GCS	MF	120	ME	CN	0006	V00											

Elasticity/Expansion Material Properties :

Shell - TM-1 Material Group G

Elastic Mod. at Design Temperature 152.0 °C 0.18592E+09 KPa.
Elastic Mod. at Ambient Temperature 21.1 °C 0.19512E+09 KPa.

Channel - TM-1 Material Group G

Elastic Mod. at Design Temperature 100.0 °C 0.18919E+09 KPa.
Elastic Mod. at Ambient Temperature 21.1 °C 0.19512E+09 KPa.

Tubes - TM-1 Material Group G

Elastic Mod. at Tubsht. Design Temp. 100.0 °C 0.18919E+09 KPa.
Elastic Mod. at Ambient Temperature 21.1 °C 0.19512E+09 KPa.

TubeSheet - TM-1 Material Group G

Elastic Mod. at Design Temperature 100.0 °C 0.18919E+09 KPa.
Elastic Mod. at Ambient Temperature 21.1 °C 0.19512E+09 KPa.

Tube Required Thickness under Internal Pressure (Tubeside pressure):

Thickness Due to Internal Pressure:

$$= (P \cdot (D/2 - CAE)) / (S \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)}$$

$$= (9.53 \cdot (19/2 - 0)) / (96.7 \cdot 1 + 0.4 \cdot 9.53)$$

$$= 0.0936 + 0.0000 = 0.0936 \text{ mm.}$$

Tube Required Thickness under External Pressure (Shellside pressure) :

External Pressure Chart HA-4 at 100.00 °C
Elastic Modulus for Material 186872176.00 KPa.

Results for Max. Allowable External Pressure (Emawp):

TCA	ODCA	SLEN	D/T	L/D	Factor A	B
1.6500	19.05	1453.82	11.55	50.0000	0.0082522	81.84

$$EMAWP = (4 \cdot B) / (3 \cdot (D/T)) = (4 \cdot 81.8) / (3 \cdot 11.5) = 94.5 \text{ bars}$$

Results for Req'd Thickness for Ext. Pressure (Tca):

TCA	ODCA	SLEN	D/T	L/D	Factor A	B
0.3377	19.05	1453.82	56.41	50.0000	0.0003457	32.30

$$EMAWP = (4 \cdot B) / (3 \cdot (D/T)) = (4 \cdot 32.3) / (3 \cdot 56.4) = 7.63 \text{ bars}$$

Summary of Tube Required Thickness Results:

Total Required Thickness including Corrosion all.	0.3377 mm.
Allowable Internal Pressure at Corroded thickness	179.92 bars
Required Internal Design Pressure	9.53 bars
Allowable External Pressure at Corroded thickness	94.51 bars
Required External Design Pressure	7.63 bars
Required Thickness due to Shell Side pressure	0.3377 mm.

Detailed Results for load Case D1 un-corr. (Psd,min + Ptd,max)

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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V00	0006	CN	ME	120	MF	GCS	BK																			

Intermediate Calculations For Tubesheets Extended As Flanges:

ASME Code, Section VIII Division 1, 2019

Gasket Contact Width,	$N = (G_{oc} - G_{ic}) / 2$	15.113	mm.
Basic Gasket Width,	$b_0 = N / 2.0$	7.557	mm.
Effective Gasket Width,	$b = \text{SQRT}(b_0) * 2.5$	6.925	mm.
Gasket Reaction Diameter,	$G = G_o \text{ (Self-Energizing)}$	317.500	mm.

Flange Design Bolt Load, Seating Condition	W :	471.01	kN
Flange Design Bolt Load, Operating Condition	Wm1:	67.30	kN

Required Tubesheet Flanged Extension thk. per UHX-9 (operating) [hr_opr]:

$$\begin{aligned}
 &= \text{sqrt}(1.9 * W_{m1} * h_g / (S * G)) \\
 &= \text{sqrt}(1.9 * 67.3 * 29.1 / (96.7 * 304)) \\
 &= 11.269 \text{ mm.}
 \end{aligned}$$

Required Tubesheet Flanged Extension thk. per UHX-9 (seating) [hr_seat]:

$$\begin{aligned}
 &= \text{sqrt}(1.9 * W * h_g / (S_a * G)) \\
 &= \text{sqrt}(1.9 * 471 * 29.1 / (115 * 304)) \\
 &= 27.316 \text{ mm.}
 \end{aligned}$$

Gasket Reaction Diameter (Gc or Gs as applicable): 317.500 mm.

Results for ASME U-tube Tubesheet Calculations for Configuration d, Per Edition 2019, Original Thickness :

Minimum Required Thickness for Shear [HreqS]:

$$\begin{aligned}
 &= 1 / (4 * \mu) * (D_o / (0.8 * S)) * [P_s - P_t] + C_{ats} + C_{atc} \\
 &= 1 / (4 * 0.33) * (237 / (0.8 * 96.7)) * [-1.03 - 8.5] + 0 \\
 &= 2.2035 \text{ mm.}
 \end{aligned}$$

UHX-12.5.1 Step 1:

Compute the Equivalent Outer Tube Limit Circle Diameter [Do]:

$$\begin{aligned}
 &= 2 * r_o + d_t \\
 &= 2 * 109 + 19 = 237 \text{ mm.}
 \end{aligned}$$

Determine the Basic Ligament Efficiency for Shear [mu]:

$$\begin{aligned}
 &= (p - d_t) / p \\
 &= (28.5 - 19) / 28.5 = 0.33
 \end{aligned}$$

UHX-12.5.2 Step 2:

Compute the Ratio [Rhos]:

$$\begin{aligned}
 &= G_s / D_o \text{ (Configurations d, e, f)} \\
 &= 318 / 237 = 1.34
 \end{aligned}$$

Compute the Ratio [Rhoc]:

$$= G_c / D_o \text{ (Configurations d)}$$

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$$= 318/237 = 1.34$$

Moment on Tubesheet due to Pressures (Ps, Pt) [Mts]:

$$= Do^2/16 * [(Rhos-1)*(Rhos^2+1)*Ps - (Rhoc-1)*(Rhoc^2+1)*Pt]$$

$$= 237^2/16 * [(1.34 - 1) * (1.34^2 + 1) * -1.03 - (1.34 - 1) * (1.34^2 + 1) * 8.5]$$

$$= -31902.8730 \text{ bars*mm.}^2$$

UHX-12.5.3 Step 3, Determination of Effective Elastic Properties :

Compute the Ratio [rho]:

$$= l_{tx}/h = 40/55 = 0.73 \text{ (must be } 0 \leq \rho \leq 1 \text{)}$$

Compute the Effective Tube Hole Diameter [d*]:

$$= \max(dt - 2t_{tt} * (E_t/E) * (S_t/S) * (\rho), dt - 2t_{tt})$$

$$= \max(19 - 2 * 1.65 * (189188400/189188400) * (96.7/96.7) * (0.73), 19 - 2 * 1.65)$$

$$= 16.6500 \text{ mm.}$$

Compute the Effective Tube Pitch [p*]:

$$= p / \sqrt{1 - 4 * \min(AL * CNV_factor, 4 * Do * p) / (\pi * Do^2) }$$

$$= 28.5 / \sqrt{1 - 4 * \min(0 * 100, 4 * 237 * 28.5) / (3.141 * 237^2) }$$

$$= 28.5000 \text{ mm.}$$

Compute the Effective Ligament Efficiency for Bending [mu*]:

$$= (p^* - d^*)/p^* = (28.5 - 16.6)/28.5 = 0.42$$

E*/E, nu* for Square pattern from Fig. UHX-11.4.

$$h/p = 1.929824 ; \mu^* = 0.415790$$

$$E^*/E = 0.480343 ; \nu^* = 0.313379 ; E^* = 90875312. \text{ KPa.}$$

Skip Step 4 for Configuration d :

UHX-12.5.5 Step 5:

Diameter ratio [K]:

$$= A/Do = 321/237 = 1.35$$

Determine Coefficient [F]:

$$= (1 - \nu^*)/E^* * (E * \ln(K))$$

$$= (1 - 0.31) / 90875312 * (189188400 * \ln(1.35))$$

$$= 0.4337$$

UHX-12.5.6 Step 6:

Moment Acting on Unperforated Tubesheet Rim [M*]

$$= M_{ts} + W^* * (G_c - G_s) / (2 * \pi * Do)$$

$$= -31903 + 67.3 * (318 - 304) / (2 * \pi * 237)$$

$$= -25633.8047 \text{ bars*mm.}^2$$

UHX-12.5.7 Step 7:

Maximum Bending Moment acting on Periphery of Tubesheet [Mp]:

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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	BK	GCS	MF	120	ME	CN	0006		V00

$$= ((M^*) - Do^2/32 * F * (Ps - Pt)) / (1 + F)$$

$$= ((-25634) - 237^2/32 * 0.43 * (-1.03 - 8.5)) / (1 + 0.43)$$

$$= -12829.7422 \text{ bars*mm}^2$$

Maximum Bending Moment acting on Center of Tubesheet [Mo]:

$$= Mp + Do^2/64 * (3 + rnu*) (Ps - Pt)$$

$$= -12830 + 237^2/64 * (3 + 0.31) (-1.03 - 8.5)$$

$$= -40483.1133 \text{ bars*mm}^2$$

Maximum Bending Moment acting on Tubesheet [M]:

$$= \text{Max}(\text{abs}(Mp) , \text{abs}(Mo))$$

$$= \text{Max}(\text{abs}(-12830) , \text{abs}(-40483))$$

$$= 40483.1133 \text{ bars*mm}^2$$

UHX-12.5.8 Step 8:

Tubesheet Bending Stress at Original Thickness:

$$= 6 * M / ((\mu*) * (h - hg')^2)$$

$$= 6 * 40483 / ((0.42) * (55 - 5)^2)$$

$$= 23.3688 \text{ N./mm}^2$$

The Allowable Tubesheet Bending Stress [SigmaAll]:

$$= 2 * S = 2 * 96.7 = 193 \text{ N./mm}^2$$

Tubesheet Bending Stress at Final Thickness [Sigma]:

$$= 6 * M / ((\mu*) * (h - hg')^2)$$

$$= 6 * 41003 / ((0.45) * (21.9 - 5)^2)$$

$$= 193.2059 \text{ N./mm}^2$$

Required Tubesheet Thickness, for Bending Stress [HreqB]:

$$= H + CATS + CATC = 21.9 + 0 + 0 = 21.9 \text{ mm.}$$

Required Tubesheet Thickness for Given Loadings (includes CA) [Hreq]:

$$= \text{Max}(HreqB, HreqS) = \text{Max}(21.9, 2.2) = 21.9 \text{ mm.}$$

UHX-12.5.9 Step 9:

$$\text{abs}(Ps - Pt) = \text{abs}(-1.03 - 8.5) = 9.53 \text{ bars}$$

Shear Stress check [Tau_limit]:

$$= 3.2 * S * \mu * h/Do$$

$$= 3.2 * 96.7 * 0.33 * 55/237 = 238 \text{ bars}$$

Average Shear Stress at the Outer Edge of Perforated Region [Tau]:

$$= 1/(4* \mu) * (Do/h) * [Ps - Pt]$$

$$= 1/(4*0.33) * (237/55) * [-1.03-8.5] \text{ N./mm}^2$$

$$= 3.09 \text{ N./mm}^2$$

Note: Analysis Completed for Tubesheet Configuration d.

Tube Metal Area [At]:

$$= \pi(do - t) t$$

$$= \pi(19 - 1.65) 1.65$$

$$= 0.902 \text{ cm}^2$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
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	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادر کننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											

Tube Weld Size Results per UW-20:

Tube Strength [Ft]:

$$= 3.1415 * t * (d_o - t) * S_a$$

$$= 3.1415 * 1.65 * (19 - 1.65) * 96.7 = 8.72 \text{ kN}$$

Fillet Weld Strength [Ff]:

$$= 0.55 * 3.1415 * a_f * (d_o + 0.67 * a_f) * S_w \text{ (but not } > F_t)$$

$$= 0.55 * 3.1415 * 2 * (19 + 0.67 * 2) * 96.7$$

$$= 6.8110 \text{ kN}$$

Groove Weld Strength [Fg]:

$$= 0.85 * 3.1415 * a_g * (d_o + 0.67 * a_g) * S_w \text{ (but not } > F_t)$$

$$= 0.85 * 3.1415 * 2 * (19 + 0.67 * 2) * 96.7$$

$$= 8.7184 \text{ kN}$$

Max. Allow. Tube-Tubesheet Joint load, L_{max}

$$= F_t = 8.7184 \text{ kN}$$

Design Strength Ratio [fd]:

$$= 1.0000$$

Weld Strength Factor [fw]:

$$= S_{ot} / (\text{Min}(S_{ot}, S)) = 1.0000$$

Min Weld Length [ar]:

$$= 2 * ((0.75 * d_o)^2 + 1.07 * t * (d_o - t) * f_w * f_d)^{1/2} - 0.75 * d_o$$

$$= 2.0748 \text{ mm.}$$

Minimum Required Fillet Weld Leg afr 1.0374 mm.

Minimum Required Groove Weld Leg agr 1.0374 mm.

Tube-Tubesheet Jt allowable, 8.72 is >= tube strength 8.72 kN

Note: This tube-tubesheet joint is a Full Strength joint

Stress/Force summary for loadcase D1 un-corr. (Psd,min + Ptd,max):

Stress Description	Actual	Allowable	Pass/Fail
Tubesheet bend. stress	23.4 <=	193.3 N./mm ²	Ok
Tubesheet shear stress	3.1 <=	77.2 N./mm ²	Ok

Thickness results for loadcase D1 un-corr. (Psd,min + Ptd,max):

Thickness (mm.)	Required	Actual	P/F	
Tubesheet Thickness :	21.872	55.000	Ok	
Tube-Tubesheet Fillet Weld Leg :	1.037	2.000	Ok	
Tube-Tubesheet Groove Weld Leg :	1.037	2.000	Ok	

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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Detailed Results for load Case D2 un-corr. (Psd,max + Ptd,min)

Intermediate Calculations For Tubesheets Extended As Flanges:

ASME Code, Section VIII Division 1, 2019

Gasket Contact Width,	$N = (Goc - Gic) / 2$	15.113	mm.
Basic Gasket Width,	$b0 = N / 2.0$	7.557	mm.
Effective Gasket Width,	$b = \text{SQRT}(b0) * 2.5$	6.925	mm.
Gasket Reaction Diameter,	$G = Go - 2.0 * b$	303.651	mm.

Flange Design Bolt Load, Seating Condition	W :	471.01	kN
Flange Design Bolt Load, Operating Condition	Wm1:	73.95	kN

Results for ASME U-tube Tubesheet Calculations for Configuration d, Per Edition 2019, Original Thickness :

Minimum Required Thickness for Shear [HreqS]:

$$\begin{aligned}
 &= 1 / (4 * \text{Mu}) * (\text{Do} / (0.8 * S)) * [Ps - Pt] + \text{Cats} + \text{Catc} \\
 &= 1 / (4 * 0.33) * (237 / (0.8 * 96.7)) * [6.6 - -1.03] + 0 \\
 &= 1.7643 \text{ mm.}
 \end{aligned}$$

UHX-12.5.1 Step 1:

Compute the Equivalent Outer Tube Limit Circle Diameter [Do]:

$$\begin{aligned}
 &= 2 * ro + dt \\
 &= 2 * 109 + 19 = 237 \text{ mm.}
 \end{aligned}$$

Determine the Basic Ligament Efficiency for Shear [mu]:

$$\begin{aligned}
 &= (p - dt) / p \\
 &= (28.5 - 19) / 28.5 = 0.33
 \end{aligned}$$

UHX-12.5.2 Step 2:

Compute the Ratio [Rhos]:

$$\begin{aligned}
 &= Gs / Do \text{ (Configurations d, e, f)} \\
 &= 304 / 237 = 1.28
 \end{aligned}$$

Compute the Ratio [Rhoc]:

$$\begin{aligned}
 &= Gc / Do \text{ (Configurations d)} \\
 &= 318 / 237 = 1.34
 \end{aligned}$$

Moment on Tubesheet due to Pressures (Ps, Pt) [Mts]:

$$\begin{aligned}
 &= \text{Do}^2 / 16 * [(Rhos - 1) * (Rhos^2 + 1) * Ps - (Rhoc - 1) * (Rhoc^2 + 1) * Pt] \\
 &= 237^2 / 16 * [(1.28 - 1) * (1.28^2 + 1) * 6.6 - \\
 &\quad (1.34 - 1) * (1.34^2 + 1) * -1.03] \\
 &= 20756.1230 \text{ bars*mm.}^2
 \end{aligned}$$

UHX-12.5.3 Step 3, Determination of Effective Elastic Properties :

Compute the Ratio [rho]:

$$= ltx / h = 40 / 55 = 0.73 \text{ (must be } 0 \leq \rho \leq 1 \text{)}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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Compute the Effective Tube Hole Diameter [d*]:

$$\begin{aligned}
 &= \max(dt - 2t_t * (E_t / E) (S_t / S) (\rho) , dt - 2t_t) \\
 &= \max(19 - 2 * 1.65 * (189188400 / 189188400) * \\
 &\quad (96.7 / 96.7) * (0.73) , 19 - 2 * 1.65) \\
 &= 16.6500 \text{ mm.}
 \end{aligned}$$

Compute the Effective Tube Pitch [p*]:

$$\begin{aligned}
 &= p / \sqrt{ 1 - 4 * \min(AL * CNV_factor , 4 * Do * p) / (\pi * Do^2) } \\
 &= 28.5 / \sqrt{ 1 - 4 * \min(0 * 100 , 4 * 237 * 28.5) \\
 &\quad (3.141 * 237^2) } \\
 &= 28.5000 \text{ mm.}
 \end{aligned}$$

Compute the Effective Ligament Efficiency for Bending [μ^*]:

$$= (p^* - d^*) / p^* = (28.5 - 16.6) / 28.5 = 0.42$$

E*/E, μ^* for Square pattern from Fig. UHX-11.4.

$$\begin{aligned}
 h/p &= 1.929824 ; \quad \mu^* = 0.415790 \\
 E^*/E &= 0.480343 ; \quad \mu^* = 0.313379 ; \quad E^* = 90875312. \text{ KPa.}
 \end{aligned}$$

Skip Step 4 for Configuration d :

UHX-12.5.5 Step 5:

Diameter ratio [K]:

$$= A / Do = 321 / 237 = 1.35$$

Determine Coefficient [F]:

$$\begin{aligned}
 &= (1 - \mu^*) / E^* * (E * \ln(K)) \\
 &= (1 - 0.31) / 90875312 * (189188400 * \ln(1.35)) \\
 &= 0.4337
 \end{aligned}$$

UHX-12.5.6 Step 6:

Moment Acting on Unperforated Tubesheet Rim [M*]

$$\begin{aligned}
 &= M_{ts} + W^* * (G_c - G_s) / (2 * \pi * Do) \\
 &= 20756 + 74 * (318 - 304) / (2 * \pi * 237) \\
 &= 27645.2520 \text{ bars*mm.}^2
 \end{aligned}$$

UHX-12.5.7 Step 7:

Maximum Bending Moment acting on Periphery of Tubesheet [Mp]:

$$\begin{aligned}
 &= ((M^*) - Do^2 / 32 * F * (P_s - P_t)) / (1 + F) \\
 &= ((27645) - 237^2 / 32 * 0.43 * (6.6 - -1.03)) / (1 + 0.43) \\
 &= 15239.0029 \text{ bars*mm.}^2
 \end{aligned}$$

Maximum Bending Moment acting on Center of Tubesheet [Mo]:

$$\begin{aligned}
 &= M_p + Do^2 / 64 * (3 + r\mu^*) (P_s - P_t) \\
 &= 15239 + 237^2 / 64 * (3 + 0.31) (6.6 - -1.03) \\
 &= 37381.4219 \text{ bars*mm.}^2
 \end{aligned}$$

Maximum Bending Moment acting on Tubesheet [M]:

$$\begin{aligned}
 &= \max(\text{abs}(M_p) , \text{abs}(M_o)) \\
 &= \max(\text{abs}(15239) , \text{abs}(37381)) \\
 &= 37381.4219 \text{ bars*mm.}^2
 \end{aligned}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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UHX-12.5.8 Step 8:

Tubesheet Bending Stress at Original Thickness:

$$= 6 * M / ((\mu *) * (h - hg')^2)$$

$$= 6 * 37381 / ((0.42) * (55 - 5)^2)$$

$$= 21.5784 \text{ N./mm}^2$$

The Allowable Tubesheet Bending Stress [SigmaAll]:

$$= 2 * S = 2 * 96.7 = 193 \text{ N./mm}^2$$

Tubesheet Bending Stress at Final Thickness [Sigma]:

$$= 6 * M / ((\mu *) * (h - hg')^2)$$

$$= 6 * 37909 / ((0.45) * (21.2 - 5)^2)$$

$$= 193.1582 \text{ N./mm}^2$$

Required Tubesheet Thickness, for Bending Stress [HreqB]:

$$= H + CATS + CATC = 21.2 + 0 + 0 = 21.2 \text{ mm.}$$

Required Tubesheet Thickness for Given Loadings (includes CA) [Hreq]:

$$= \text{Max}(HreqB, HreqS) = \text{Max}(21.2, 1.76) = 21.2 \text{ mm.}$$

UHX-12.5.9 Step 9:

$$\text{abs}(Ps - Pt) = \text{abs}(6.6 - -1.03) = 7.63 \text{ bars}$$

Shear Stress check [Tau_limit]:

$$= 3.2 * S * \mu * h / Do$$

$$= 3.2 * 96.7 * 0.33 * 55 / 237 = 238 \text{ bars}$$

Average Shear Stress at the Outer Edge of Perforated Region [Tau]:

$$= 1 / (4 * \mu) * (Do / h) * [Ps - Pt]$$

$$= 1 / (4 * 0.33) * (237 / 55) * [6.6 - -1.03] \text{ N./mm}^2$$

$$= 2.48 \text{ N./mm}^2$$

[Note: Analysis Completed for Tubesheet Configuration d.](#)

Tube Metal Area [At]:

$$= \pi (do - t) t$$

$$= \pi (19 - 1.65) 1.65$$

$$= 0.902 \text{ cm}^2$$

Tube Weld Size Results per UW-20:

Tube Strength [Ft]:

$$= 3.1415 * t * (do - t) * Sa$$

$$= 3.1415 * 1.65 * (19 - 1.65) * 96.7 = 8.72 \text{ kN}$$

Fillet Weld Strength [Ff]:

$$= 0.55 * 3.1415 * af * (do + 0.67 * af) * Sw \text{ (but not } > Ft)$$

$$= 0.55 * 3.1415 * 2 * (19 + 0.67 * 2) * 96.7$$

$$= 6.8110 \text{ kN}$$

Groove Weld Strength [Fg]:

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Flange Design Bolt Load, Seating Condition W : 471.01 kN
Flange Design Bolt Load, Operating Condition Wm1: 73.95 kN

Results for ASME U-tube Tubesheet Calculations for Configuration d,
Per Edition 2019, Original Thickness :

Minimum Required Thickness for Shear [HreqS]:

$$= 1/(4 * \mu) * (Do/(0.8 * S)) * [Ps - Pt] + Cats + Catc$$

$$= 1/(4 * 0.33) * (237/(0.8 * 96.7)) * [6.6 - 8.5] + 0$$

$$= 0.4391 \text{ mm.}$$

UHX-12.5.1 Step 1:

Compute the Equivalent Outer Tube Limit Circle Diameter [Do]:

$$= 2 * ro + dt$$

$$= 2 * 109 + 19 = 237 \text{ mm.}$$

Determine the Basic Ligament Efficiency for Shear [μ]:

$$= (p - dt) / p$$

$$= (28.5 - 19) / 28.5 = 0.33$$

UHX-12.5.2 Step 2:

Compute the Ratio [Rhos]:

$$= Gs / Do \text{ (Configurations d, e, f)}$$

$$= 304/237 = 1.28$$

Compute the Ratio [Rhoc]:

$$= Gc / Do \text{ (Configurations d)}$$

$$= 318/237 = 1.34$$

Moment on Tubesheet due to Pressures (Ps, Pt) [Mts]:

$$= Do^2/16 * [(Rhos-1)*(Rhos^2+1)* Ps - (Rhoc-1) * (Rhoc^2+1) * Pt]$$

$$= 237^2/16 * [(1.28 - 1) * (1.28^2 + 1) * 6.6 -$$

$$(1.34 - 1) * (1.34^2 + 1) * 8.5]$$

$$= -11146.7471 \text{ bars*mm.}^2$$

UHX-12.5.3 Step 3, Determination of Effective Elastic Properties :

Compute the Ratio [rho]:

$$= ltx/h = 40/55 = 0.73 \text{ (must be } 0 \leq \rho \leq 1 \text{)}$$

Compute the Effective Tube Hole Diameter [d*]:

$$= \max(dt - 2tt*(Et/E) (St/S) (\rho), dt - 2tt)$$

$$= \max(19 - 2*1.65 * (189188400/189188400) *$$

$$(96.7/96.7) * (0.73) , 19 - 2*1.65)$$

$$= 16.6500 \text{ mm.}$$

Compute the Effective Tube Pitch [p*]:

$$= p / \sqrt{1 - 4 * \min(AL * CNV_factor, 4*Do*p) / (\pi * Do^2) }$$

$$= 28.5 / \sqrt{1 - 4 * \min(0 * 100, 4*237 * 28.5)$$

$$(3.141 * 237^2) }$$

$$= 28.5000 \text{ mm.}$$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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Compute the Effective Ligament Efficiency for Bending [μ^*]:
 $= (p^* - d^*)/p^* = (28.5 - 16.6) / 28.5 = 0.42$

E^*/E , ν^* for Square pattern from Fig. UHX-11.4.
 $h/p = 1.929824$; $\mu^* = 0.415790$
 $E^*/E = 0.480343$; $\nu^* = 0.313379$; $E^* = 90875312$. KPa.

Skip Step 4 for Configuration d :

UHX-12.5.5 Step 5:

Diameter ratio [K]:
 $= A/Do = 321/237 = 1.35$

Determine Coefficient [F]:
 $= (1 - \nu^*)/E^* * (E * \ln(K))$
 $= (1 - 0.31) / 90875312 * (189188400 * \ln(1.35))$
 $= 0.4337$

UHX-12.5.6 Step 6:

Moment Acting on Unperforated Tubesheet Rim [M^*]:
 $= M_{ts} + W^* * (G_c - G_s) / (2 * \pi * Do)$
 $= -11147 + 74.4 * (318 - 304) / (2 * \pi * 237)$
 $= -4214.3696 \text{ bars*mm.}^2$

Note: W^ is the maximum of the bolt loads between the shell and channel sides.*

UHX-12.5.7 Step 7:

Maximum Bending Moment acting on Periphery of Tubesheet [Mp]:
 $= ((M^*) - Do^2/32 * F * (P_s - P_t)) / (1 + F)$
 $= ((-4214) - 237^2/32 * 0.43 * (6.6 - 8.5)) / (1 + 0.43)$
 $= -1933.1682 \text{ bars*mm.}^2$

Maximum Bending Moment acting on Center of Tubesheet [Mo]:
 $= M_p + Do^2/64 * (3 + \nu^*) (P_s - P_t)$
 $= -1933 + 237^2/64 * (3 + 0.31) (6.6 - 8.5)$
 $= -7444.1187 \text{ bars*mm.}^2$

Maximum Bending Moment acting on Tubesheet [M]:
 $= \text{Max}(\text{abs}(M_p), \text{abs}(M_o))$
 $= \text{Max}(\text{abs}(-1933), \text{abs}(-7444))$
 $= 7444.1187 \text{ bars*mm.}^2$

UHX-12.5.8 Step 8:

Tubesheet Bending Stress at Original Thickness:
 $= 6 * M / ((\mu^*) * (h - h_g')^2)$
 $= 6 * 7444 / ((0.42) * (55 - 5)^2)$
 $= 4.2971 \text{ N./mm}^2$

The Allowable Tubesheet Bending Stress [σ_{All}]:
 $= 2 * S = 2 * 96.7 = 193 \text{ N./mm}^2$

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)								
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	BK	GCS	MF	120	ME	CN	0006		V00

Tube-sheet Bending Stress at Final Thickness [Sigma]:

$$= 6 * M / ((\mu *) * (h - h_g')^2)$$

$$= 6 * 7433 / ((0.45) * (12.2 - 5)^2)$$

$$= 192.3648 \text{ N./mm}^2$$

Required Tube-sheet Thickness, for Bending Stress [HreqB]:

$$= H + CATS + CATC = 12.2 + 0 + 0 = 12.2 \text{ mm.}$$

Required Tube-sheet Thickness for Given Loadings (includes CA) [Hreq]:

$$= \text{Max}(HreqB, HreqS) = \text{Max}(12.2, 0.44) = 12.2 \text{ mm.}$$

UHX-12.5.9 Step 9:

$$\text{abs}(P_s - P_t) = \text{abs}(6.6 - 8.5) = 1.9 \text{ bars}$$

Shear Stress check [Tau_limit]:

$$= 3.2 * S * \mu * h / D_o$$

$$= 3.2 * 96.7 * 0.33 * 55 / 237 = 238 \text{ bars}$$

Average Shear Stress at the Outer Edge of Perforated Region [Tau]:

$$= 1 / (4 * \mu) * (D_o / h) * [P_s - P_t]$$

$$= 1 / (4 * 0.33) * (237 / 55) * [6.6 - 8.5] \text{ N./mm}^2$$

$$= 0.62 \text{ N./mm}^2$$

Note: Analysis Completed for Tube-sheet Configuration d.

Tube Metal Area [At]:

$$= \pi (d_o - t) t$$

$$= \pi (19 - 1.65) 1.65$$

$$= 0.902 \text{ cm}^2$$

Tube Weld Size Results per UW-20:

Tube Strength [Ft]:

$$= 3.1415 * t * (d_o - t) * S_a$$

$$= 3.1415 * 1.65 * (19 - 1.65) * 96.7 = 8.72 \text{ kN}$$

Fillet Weld Strength [Ff]:

$$= 0.55 * 3.1415 * a_f * (d_o + 0.67 * a_f) * S_w \text{ (but not } > F_t)$$

$$= 0.55 * 3.1415 * 2 * (19 + 0.67 * 2) * 96.7$$

$$= 6.8110 \text{ kN}$$

Groove Weld Strength [Fg]:

$$= 0.85 * 3.1415 * a_g * (d_o + 0.67 * a_g) * S_w \text{ (but not } > F_t)$$

$$= 0.85 * 3.1415 * 2 * (19 + 0.67 * 2) * 96.7$$

$$= 8.7184 \text{ kN}$$

Max. Allow. Tube-Tube-sheet Joint load, Lmax

$$= F_t = 8.7184 \text{ kN}$$

Design Strength Ratio [fd]:

$$= 1.0000$$

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Weld Strength Factor [fw]:

$$= Sot / (\text{Min}(Sot, S)) = 1.0000$$

Min Weld Length [ar]:

$$= 2 * ((0.75 * do)^2 + 1.07 * t * (do - t) * fw * fd)^{1/2} - 0.75 * do$$

$$= 2.0748 \text{ mm.}$$

Minimum Required Fillet Weld Leg afr 1.0374 mm.

Minimum Required Groove Weld Leg agr 1.0374 mm.

Tube-Tubesheet Jt allowable, 8.72 is >= tube strength 8.72 kN

Note: This tube-tubesheet joint is a Full Strength joint

Stress/Force summary for loadcase D3 un-corr. (Psd,max + Ptd,max):

Stress Description	Actual	Allowable	Pass/Fail
Tubesheet bend. stress	4.3 <=	193.3 N./mm ²	Ok
Tubesheet shear stress	0.6 <=	77.2 N./mm ²	Ok

Thickness results for loadcase D3 un-corr. (Psd,max + Ptd,max):

Thickness (mm.)	Required	Actual	P/F
Tubesheet Thickness :	12.199	55.000	Ok
Tube-Tubesheet Fillet Weld Leg :	1.037	2.000	Ok
Tube-Tubesheet Groove Weld Leg :	1.037	2.000	Ok

U-Tube Tubesheet results per ASME UHX-12 2019

Results for 3 Load Cases:

Case#	--Reqd. Thk. + CA Tbsht Extnsn	----- Tubesheet Stresses Bend Allwd Shear Allwd	Case Type	Pass/ Fail
D1uc	21.872 27.316	23 193 3 77	Ps+Pt D1	Ok
D2uc	21.225 ...	22 193 2 77	Ps+Pt D2	Ok
D3uc	12.199 ...	4 193 1 77	Ps+Pt D3	Ok
Max:	21.8715 27.316 mm.	0.121 0.040 (Str. Ratio)		

Load Case Definitions:

[Ps & Pt]:

Shell-side and Tube-side Design or Operating Pressures
derived from Psd,min Ptd,max, Psox,min, Ptox,max etc. per the
Load Case Tables

[c]:

With or Without Corrosion Allowance

[D1, D2, D3]:

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Design Load Cases using the Maximum and Minimum Design Pressures

[D4]:

Design Load Case using the Minimum (Vacuum) Pressures (if specified)

Note:

Because there was no net pressure differential across the tubesheet due to the specified pressures psd,min and ptd,min; load case D4 was not processed as the resulting tubesheet bending stress would be zero.

Summary of Thickness Comparisons for 3 Load Cases:

Thickness (mm.)	Required	Actual	P/F	
Tubesheet Thickness :	21.872	55.000	Ok	
Tubesheet Thickness Flanged Extension :	27.316	31.000	Ok	
Tube Thickness :	0.338	1.650	Ok	
Tube-Tubesheet Fillet Weld Leg :	1.037	2.000	Ok	
Tube-Tubesheet Groove Weld Leg :	1.037	2.000	Ok	

Note: This is a full strength Tube to Tubesheet Joint.

Tubesheet MAWP used to Compute Hydrotest Pressure:

Stress / Force Condition	Tubeside MAWP	0 shellside Stress Rat.	Shellside MAWP	0 tubeside Stress Rat.
Tubesheet Bending Stress	79.928	1.000	67.981	1.000
Tubesheet Shear Stress	300.630	0.999	300.711	1.000
Tube Pressure Stress	179.915	1.000	94.511	1.000
Tubesheet Extension Stress	50.746	...	No Calc	No Calc
Minimum MAWP	50.746		67.981	

Tubesheet MAPnc used to Compute Hydrotest Pressure:

Stress / Force Condition	Tubeside MAPnc	0 shellside Stress Rat.	Shellside MAPnc	0 tubeside Stress Rat.
Tubesheet Bending Stress	95.205	1.000	80.975	1.000
Tubesheet Shear Stress	283.135	1.000	283.135	1.000
Tube Pressure Stress	214.303	1.000	107.747	1.000
Tubesheet Extension Stress	61.441	...	No Calc	No Calc
Minimum MAPnc	61.441		80.975	

(*) Only the design load cases were analyzed to compute the MAWP for determining the test pressure.

SA-182 F316L, Min Metal Temp without impact per UHA-51: -196 °C

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Vertical Hydrotest Case

Hydrostatic Test Pressure Results:

Exchanger Shell Side Hydrostatic Test Pressures:

Pressure per UG99b	= 1.30 * M.A.W.P. * Sa/S	18.349	bars
Pressure per UG99b[36]	= 1.30 * Design Pres * Sa/S	10.220	bars
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	20.670	bars
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	15.526	bars
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	9.827	bars
Pressure per App 27-4	= M.A.W.P.	11.850	bars

User defined Hydrostatic Test Pressures:

Shell Side Test Pressure at High Point	10.630	bars
Channel Side Test Pressure at High Point	11.530	bars

Exchanger Channel Side Hydrostatic Test Pressures:

Pressure per UG99b	= 1.30 * M.A.W.P. * Sa/S	17.225	bars
Pressure per UG99b[36]	= 1.30 * Design Pres * Sa/S	11.050	bars
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	20.670	bars
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	14.575	bars
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	12.155	bars
Pressure per App 27-4	= M.A.W.P.	13.250	bars

Vertical Test performed per: User Hydro Pressure

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (N./mm² & bars):

From To	Stress	Allowable	Ratio	Pressure
Shell Barrel	17.8	155.1	0.115	10.82
Channel Barrel	19.0	155.1	0.122	11.56
Channel Cover	18.4	155.1	0.119	11.54

Stress ratios for Nozzle and Pad Materials (N./mm²):

Description	Pad/Nozzle	Ambient	Operating	Ratio
S2 (2in)	Nozzle	115.15	87.18	1.321
V (1in)	Nozzle	115.15	96.67	1.191
T1	Nozzle	115.15	96.67	1.191
T2	Nozzle	115.15	96.67	1.191
Minimum				1.191

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Stress ratios for Pressurized Vessel Elements (N./mm²):

Description	Ambient	Operating	Ratio
Shell FLG.	115.10	87.20	1.320
Shell Barrel	115.10	87.20	1.320
Shell FLG.	115.10	87.20	1.320
Channel FLG.	115.15	96.67	1.191
Channel Barrel	115.15	96.67	1.191
Channel Cover	115.10	115.10	1.000
Minimum			1.000

Stress ratios for Exchanger Materials (N./mm²):

Description	Ambient	Operating	Ratio
Tube Material	115.15	96.67	1.191
Tubesheet Material	115.15	96.67	1.191
Minimum			1.191

Hoop Stress in Nozzle Wall during Pressure Test (N./mm²):

Description	Ambient	Operating	Ratio
S2 (2in)	2.35	155.14	0.015
V (1in)	1.84	155.14	0.012
T1	1.84	155.14	0.012
T2	1.84	155.14	0.012

Elements Suitable for Test Pressure.

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Combined Loads

Stress Combination Load Cases for Vertical Vessels:

Load Case Definition Key

IP = Longitudinal Stress due to Internal Pressure
 EP = Longitudinal Stress due to External Pressure
 HP = Longitudinal Stress due to Hydrotest Pressure
 NP = No Pressure
 EW = Longitudinal Stress due to Weight (No Liquid)
 OW = Longitudinal Stress due to Weight (Operating)
 HW = Longitudinal Stress due to Weight (Hydrotest)
 WI = Bending Stress due to Wind Moment (Operating)
 EQ = Bending Stress due to Earthquake Moment (Operating)
 EE = Bending Stress due to Earthquake Moment (Empty)
 HI = Bending Stress due to Wind Moment (Hydrotest)
 HE = Bending Stress due to Earthquake Moment (Hydrotest)
 WE = Bending Stress due to Wind Moment (Empty) (no CA)
 WF = Bending Stress due to Wind Moment (Filled) (no CA)
 CW = Longitudinal Stress due to Weight (Empty) (no CA)
 VO = Bending Stress due to Vortex Shedding Loads (Ope)
 VE = Bending Stress due to Vortex Shedding Loads (Emp)
 VF = Bending Stress due to Vortex Shedding Loads (Test No CA.)
 FW = Axial Stress due to Vertical Forces for the Wind Case
 FS = Axial Stress due to Vertical Forces for the Seismic Case
 BW = Bending Stress due to Lat. Forces for the Wind Case, Corroded
 BS = Bending Stress due to Lat. Forces for the Seismic Case, Corroded
 BN = Bending Stress due to Lat. Forces for the Wind Case, UnCorroded
 BU = Bending Stress due to Lat. Forces for the Seismic Case, UnCorroded

General Notes:

Case types HI and HE are in the Corroded condition.

Case types WE, WF, and CW are in the Un-Corroded condition.

A blank stress and stress ratio indicates that the corresponding stress comprising those components that did not contribute to that type of stress.

An asterisk (*) in the final column denotes overstress.

Analysis of Load Case 1 : NP+EW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.01	87.20	-0.51	75.82	0.0002	0.0068
20	0.00	87.20	-0.93	71.23	0.0000	0.0131
50		96.67	-0.08	80.71		0.0010
60		115.10	-0.03	80.71		0.0004

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Analysis of Load Case 2 : NP+EW+EE+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.00	87.20	-2.50	75.82	0.0230	0.0330
20	3.51	87.20	-4.44	71.23	0.0403	0.0623
50	0.05	96.67	-0.15	80.71	0.0005	0.0019
60		115.10	-0.04	80.71		0.0006

Analysis of Load Case 3 : NP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.53	75.82		0.0070
20	0.00	87.20	-0.93	71.23	0.0000	0.0131
50		96.67	-0.08	80.71		0.0010
60		115.10	-0.03	80.71		0.0004

Analysis of Load Case 4 : NP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.25	87.20	-2.78	75.82	0.0258	0.0367
20	3.98	87.20	-4.91	71.23	0.0457	0.0689
50	0.08	96.67	-0.19	80.71	0.0008	0.0023
60		115.10	-0.05	80.71		0.0006

Analysis of Load Case 5 : NP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	155.10	0.00	117.45	0.0000	0.0000
20	0.00	155.10	0.00	110.43	0.0000	0.0000
50	0.00	155.14	0.00	110.43	0.0000	0.0000
60	0.00	155.10	0.00	110.43	0.0000	0.0000

Analysis of Load Case 6 : NP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	155.10	0.00	117.45	0.0000	0.0000
20	0.00	155.10	0.00	110.43	0.0000	0.0000
50	0.00	155.14	0.00	110.43	0.0000	0.0000
60	0.00	155.10	0.00	110.43	0.0000	0.0000

Analysis of Load Case 7 : IP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.53	75.82		0.0070
20	5.09	87.20		71.23	0.0584	
50	6.53	96.67		80.71	0.0675	
60	6.53	115.10		80.71	0.0568	

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Analysis of Load Case 8 : IP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.25	87.20	-2.78	75.82	0.0258	0.0367
20	9.07	87.20		71.23	0.1040	
50	6.64	96.67		80.71	0.0686	
60	6.55	115.10		80.71	0.0569	

Analysis of Load Case 9 : EP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.53	75.82		0.0070
20		87.20	-1.83	71.23		0.0257
50		96.67	-0.98	80.71		0.0121
60		115.10	-0.93	80.71		0.0115

Analysis of Load Case 10 : EP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.25	87.20	-2.78	75.82	0.0258	0.0367
20	3.08	87.20	-5.81	71.23	0.0354	0.0815
50		96.67	-1.08	80.71		0.0134
60		115.10	-0.95	80.71		0.0117

Analysis of Load Case 11 : HP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	155.10	0.00	117.45	0.0000	0.0000
20	7.89	155.10		110.43	0.0508	
50	8.53	155.14		110.43	0.0550	
60	8.53	155.10		110.43	0.0550	

Analysis of Load Case 12 : HP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	155.10	0.00	117.45	0.0000	0.0000
20	7.89	155.10		110.43	0.0508	
50	8.53	155.14		110.43	0.0550	
60	8.53	155.10		110.43	0.0550	

Analysis of Load Case 13 : IP+WE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.27	75.82		0.0036
20	4.67	87.20		71.23	0.0535	
50	6.52	96.67		80.71	0.0674	
60	6.53	115.10		80.71	0.0567	

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)	شماره صفحه : 98 از 99																
	<table><tr><td>پروژه</td><td>بسته کاری</td><td>صادر کننده</td><td>تسهیلات</td><td>رشته</td><td>نوع مدرک</td><td>سریال</td><td>نسخه</td></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0006</td><td>V00</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0006	V00
	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0006	V00											

Analysis of Load Case 14 : IP+WF+CW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.27	75.82		0.0035
20	4.63	87.20		71.23	0.0531	
50	6.50	96.67		80.71	0.0673	
60	6.53	115.10		80.71	0.0567	

Analysis of Load Case 15 : IP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.29	75.82		0.0038
20	4.67	87.20		71.23	0.0535	
50	6.52	96.67		80.71	0.0674	
60	6.53	115.10		80.71	0.0567	

Analysis of Load Case 16 : IP+VE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.27	75.82		0.0036
20	4.67	87.20		71.23	0.0535	
50	6.52	96.67		80.71	0.0674	
60	6.53	115.10		80.71	0.0567	

Analysis of Load Case 17 : NP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.29	75.82		0.0038
20		87.20	-0.51	71.23		0.0071
50		96.67	-0.07	80.71		0.0008
60		115.10	-0.03	80.71		0.0003

Analysis of Load Case 18 : FS+BS+IP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.29	75.82		0.0038
20	4.67	87.20		71.23	0.0535	
50	6.52	96.67		80.71	0.0674	
60	6.53	115.10		80.71	0.0567	

Analysis of Load Case 19 : FS+BS+EP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		87.20	-0.29	75.82		0.0038
20		87.20	-1.40	71.23		0.0197
50		96.67	-0.96	80.71		0.0119
60		115.10	-0.92	80.71		0.0114

 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)							
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR GLYCOL REFLUX CONDENSER (E-100)							شماره صفحه : 99 از 99
	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	
	V00	0006	CN	ME	120	MF	GCS	
BK								

Absolute Maximum of the all of the Stress Ratio's

0.1040

Governing Element: Shell Barrel

Governing Load Case 8 : IP+OW+EQ+FS+BS

Element Description	Long Pressure Stress	Weight + Axial Load Stress	Eccentric Moment Stress	Wind or Earthquake Stress	Combined Stress	Which Side
Shell Barrel	...	-0.3	...	2.5	2.3	+ Tens
Shell Barrel	...	-0.3	-0.0	-2.5	-2.8	- Comp
Shell Barrel	5.1	-0.5	...	4.4	9.1	+ Tens
Shell Barrel	5.1	-0.5	-0.0	-4.4	...	- Comp
Channel Barrel	6.6	-0.1	...	0.1	6.6	+ Tens
Channel Barrel	6.6	-0.1	-0.0	-0.1	...	- Comp
Channel Cover	6.6	-0.0	...	...	6.6	+ Tens
Channel Cover	6.6	-0.0	...	-0.0	...	- Comp

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