

 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	0009	V01

طرح نگهداشت و افزایش تولید 27 مخزن

THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)

نگهداشت و افزایش تولید میدان نفتی بینک

V01	MAR. 2025	IFI	MFS	M.Fakharian	S.Faramarzpour	
V00	DEC. 2024	IFA	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

 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	0009	V01

REVISION RECORD SHEET

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	BK	GCS	MF	120	ME	CN	0009	V01

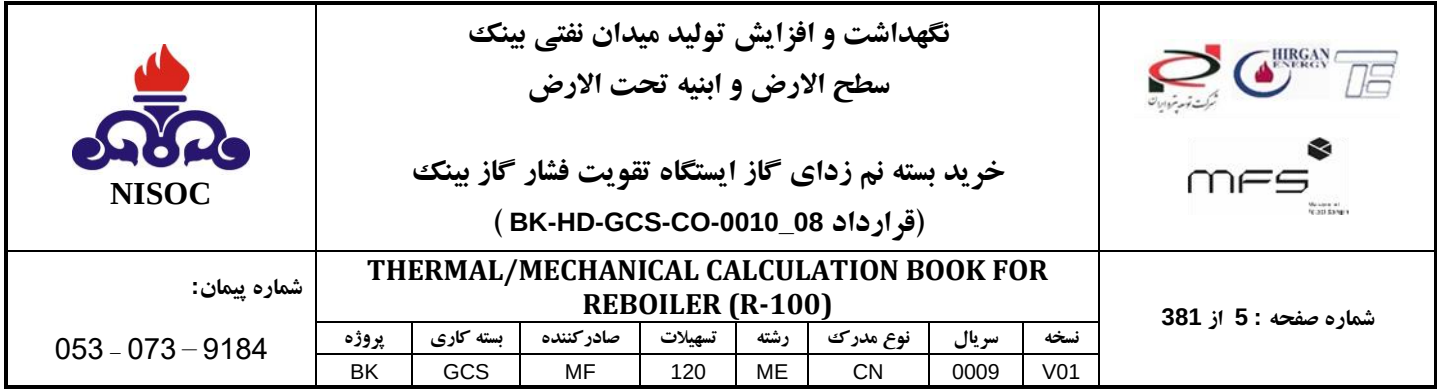
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 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)							
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							V01	

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2019

Analysis Performed by :

Job File : C:\USERS\TECHNICAL2\DESKTOP\R-100.Pvdb

Date of Analysis : Mar 9, 2025 1:47pm

PV Elite 2020, January 2020

 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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V01	0009	CN	ME	120	MF	GCS	BK																			

ASME Code, Section VIII Division 1, 2019

Diameter Spec : 1200.000 mm. ID	
Vessel Design Length, Tangent to Tangent	6479.52 mm.
Specified Datum Line Distance	0.00 mm.
Internal Design Temperature	234 °C
Internal Design Pressure	4.100 bars
External Design Temperature	100 °C
External Design Pressure	1.034 bars
Maximum Allowable Working Pressure	7.893 bars
External Max. Allowable Working Pressure	1.311 bars
Hydrostatic Test Pressure	5.330 bars
Required Minimum Design Metal Temperature	5.0 °C
Warmest Computed Minimum Design Metal Temperature	3.0 °C
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-516 70	...	...	K02700	Yes	No
Head	SA-516 70	...	...	K02700	Yes	No
Flange	SA-105	...	...	K03504	No	No
Nozzle	SA-105	...	...	K03504	No	No
Nozzle	SA-106 B	...	...	K03006	No	No
Nozzle	SA-516 70	...	...	K02700	Yes	No
Re-Pad	SA-516 70	...	...	K02700	Yes	No
Nozzle Flg	SA-105	...	...	K03504	No	No
Rings	SA-516 70	...	...	K02700	No	No
Flg Bolting	SA-193 B7M	...	<= 2 1/2	G41400	No	No
Hrz Bolting	SA-325	...	...		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
Ellipse	4.198	1.03	16.000	3.0000	No	No
Cylinder	4.198	1.03	16.000	3.0000	N/A	No
Cylinder	4.198	1.03	16.000	3.0000	N/A	No
Cylinder	4.195	1.03	16.000	3.0000	N/A	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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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Cylinder		4.195		1.03		16.000		3.0000		N/A		No	
Cylinder		4.195		1.03		16.000		3.0000		N/A		No	
Body Flg		4.195		1.03		16.000		3.0000		N/A		No	
Body Flg		4.100		1.03		8.000		3.0000		N/A		No	

Liquid Level: 980.00 mm. Dens.: 0.001 kg./cm³ Sp. Gr.: 1.020

Stiffener Ring Specifications:

Elevation mm.	Selected Type	User Description
3850.00	Bar 100.0 x 15.	Ring R1 Fr4

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
Ellipse	50.0	50.0	12.0	10.0	4.8	...	1.00	1.00
Cylinder	900.0	850.0	...	10.0	4.8	...	1.00	1.00
Cylinder	2400.0	1500.0	...	10.0	4.8	...	1.00	1.00
Cylinder	3900.0	1500.0	...	10.0	4.8	...	1.00	1.00
Cylinder	5400.0	1500.0	...	10.0	4.8	...	1.00	1.00
Cylinder	6250.0	850.0	...	10.0	4.8	...	1.00	1.00
Body Flg	6410.0	160.0	...	130.0	122.3	...	1.00	1.00
Body Flg	6479.5	60.0	...	60.0	46.2	...	1.00	1.00

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	10	6.15855	1.034	4.97328
20	30	10	9.38068	1.034	1.3109
30	40	10	9.38068	1.034	1.3109
40	Ring	10	9.38068	1.034	1.3109
Ring	50	10	8.17754	1.034	2.21252
50	60	10	8.17754	1.034	2.21252
60	70	10	8.17754	1.034	2.21252
70	80	130	122.276	1.034	No Calc
80	90	60	46.228	1.034	No Calc

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	3950	4946.45	No Calc	No Calc
30	40	3950	4946.45	No Calc	No Calc
40	Ring	3950	4946.45	No Calc	No Calc
Ring	50	2400	4945.12	41.1436	263.43

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V01	0009	CN	ME	120	MF	GCS	BK											

50	60	2400	4945.12	No Calc	No Calc
60	70	2400	4945.12	No Calc	No Calc
70	80	No Calc	No Calc	No Calc	No Calc
80	90	No Calc	No Calc	No Calc	No Calc

Saddle Parameters:

Saddle Width	150.000	mm.
Saddle Bearing Angle	120.000	deg.
Centerline Dimension	1200.000	mm.
Wear Pad Width	260.000	mm.
Wear Pad Thickness	10.000	mm.
Wear Pad Bearing Angle	145.000	deg.
Distance from Saddle to Tangent	650.000	mm.
Baseplate Length	1200.000	mm.
Baseplate Thickness	15.000	mm.
Baseplate Width	170.000	mm.
Number of Ribs (including outside ribs)	4	
Rib Thickness	15.000	mm.
Web Thickness	15.000	mm.
Height of Center Web	585.000	mm.
Number of Bolts in Baseplate	4	

Baseplate Sketch

----- 1200.000 mm. -----	
	170.000 mm.

Baseplate Plan View

	15.000 mm.

Baseplate Side View

Maximum Tensile Bolt Load	587. N

Summary of Maximum Saddle Loads, Operating Case:

Maximum Vertical Saddle Load	206427.92	N
Maximum Transverse Saddle Shear Load	28754.09	N
Maximum Longitudinal Saddle Shear Load	57508.18	N

Summary of Maximum Saddle Loads, Operating Case, Un-Factored:

Maximum Vertical Saddle Load	247739.62	N
Maximum Transverse Saddle Shear Load	96393.95	N
Maximum Longitudinal Saddle Shear Load	82154.55	N

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V01	0009	CN	ME	120	MF	GCS	BK											

Summary of Maximum Saddle Loads, Hydrotest Case :

Maximum Vertical Saddle Load	101802.48	N
Maximum Transverse Saddle Shear Load	1741.08	N
Maximum Longitudinal Saddle Shear Load	1395.62	N

Local Stress Analysis Results:

Description	Analysis Type	Max Stress Ratio	High Stress Location	Pass Fail
N22 (2in)	WRC-107/537	0.392	n/a	Passed
N5 (2in)	WRC-107/537	0.392	n/a	Passed
N1 (10in)	WRC-107/537	0.883	n/a	Passed

Weights:

Fabricated - Bare W/O Removable Internals	7099.6	kg.
Shop Test - Fabricated + Water (Full)	14573.6	kg.
Shipping - Fab. + Rem. Intls.+ Shipping App.	7099.6	kg.
Erected - Fab. + Rem. Intls.+ Insul. (etc)	7099.6	kg.
Empty - Fab. + Intls. + Details + Wghts.	9502.6	kg.
Operating - Empty + Operating Liquid (No CA)	17061.8	kg.
Field Test - Empty Weight + Water (Full)	16416.7	kg.

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	BK	GCS	MF	120	ME	CN	0009	V01

Nozzle Calculation Summary:

Description	MAWP bars	Ext	MAPNC bars	UG-45	[tr] mm.	Weld Path	Areas or Stresses
N8 (2in)	16	OK	...	OK	4.82	OK	Passed
N8 (2in)	16	OK	...	OK	4.82	OK	Passed
N7C (2in)	16	OK	...	OK	4.84	OK	Passed
N12 (1in)	16	OK	...	OK	4.80	OK	Passed
N22 (2in)	16	OK	...	OK	4.84	OK	Passed
K9B (3in)	16	OK	...	OK	4.84	OK	Passed
K9B (3in)	16	OK	...	OK	4.84	OK	Passed
K9A (3in)	16	OK	...	OK	4.80	OK	Passed
K10A (2in)	16	OK	...	OK	4.82	OK	Passed
K10A (2in)	16	OK	...	OK	4.82	OK	Passed
K10B (2in)	16	OK	...	OK	4.83	OK	Passed
K10B (2in)	16	OK	...	OK	4.83	OK	Passed
K11B (2in)	16	OK	...	OK	4.81	OK	Passed
K11B (2in)	16	OK	...	OK	4.81	OK	Passed
K11A (2in)	16	OK	...	OK	4.80	OK	Passed
K11A (2in)	16	OK	...	OK	4.80	OK	Passed
K4 (2in)	16	OK	...	OK	4.80	OK	Passed
K4 (2in)	16	OK	...	OK	4.80	OK	Passed
N11 (1in)	16	OK	...	OK	4.80	OK	Passed
M1 (24in)	11	OK	...	...		OK	Passed
N7B (2in)	16	OK	...	OK	4.84	OK	Passed
N5 (2in)	16	OK	...	OK	4.84	OK	Passed
K8A (2in)	16	OK	...	OK	4.80	OK	Passed
K8A (2in)	16	OK	...	OK	4.80	OK	Passed
K8B (2in)	16	OK	...	OK	4.84	OK	Passed
M2 (24in)	11	OK	...	...		OK	Passed
N4 (6in)	16	OK	...	OK	4.80	OK	Passed
K5 (2in)	16	OK	...	OK	4.80	OK	Passed
K5 (2in)	16	OK	...	OK	4.80	OK	Passed
K7 (2in)	16	OK	...	OK	4.80	OK	Passed
N7A (2in)	16	OK	...	OK	4.84	OK	Passed
N9A (1.5in)	16	OK	...	OK	4.84	OK	Passed
N9A (1.5in)	16	OK	...	OK	4.84	OK	Passed
N9B (1.5in)	16	OK	...	OK	4.84	OK	Passed
N9B (1.5in)	16	OK	...	OK	4.84	OK	Passed
K2A (2in)	16	OK	...	OK	4.80	OK	Passed
K2A (2in)	16	OK	...	OK	4.80	OK	Passed
K6 (2in)	16	OK	...	OK	7.50	OK	Passed
K2B (2in)	16	OK	...	OK	4.81	OK	Passed
K2B (2in)	16	OK	...	OK	4.81	OK	Passed
K1 (2in)	16	OK	...	OK	4.80	OK	Passed
K3A (3in)	16	OK	...	OK	4.80	OK	Passed
K3B (3in)	16	OK	...	OK	4.82	OK	Passed
K3B (3in)	16	OK	...	OK	4.82	OK	Passed
K12 (2in)	16	OK	...	OK	4.84	OK	Passed
N1 (10in)	12	OK	...	OK	4.80	OK	Passed
N3 (10in)	8	OK	...	OK	11.10	OK	Passed
Chimney Nozzle	8	OK	...	OK	11.10	OK	Passed

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Nozzle MAWP Summary:

Minimum MAWP Nozzles : 8 Nozzle : Chimney Nozzle
Minimum MAWP Shells/Flanges : 8 Element :
Minimum MAPnc Shells/Flanges : 9 Element :

Computed Vessel M.A.W.P. : 8 bars

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

Check the Spatial Relationship between the Nozzles:

From Node	Nozzle Description	X Coordinate mm.	Layout Angle deg	Dia. Limit mm.
10	N8 (2in)	0.000	270.000	113.600
20	N7C (2in)	200.000	270.000	113.600
20	N12 (1in)	150.000	90.000	65.000
20	N22 (2in)	450.000	270.000	113.600
20	K9B (3in)	400.000	289.139	136.460
20	K9A (3in)	400.000	90.000	136.460
20	K10A (2in)	150.000	-13.655	113.600
20	K10B (2in)	150.000	-55.052	113.600
20	K11B (2in)	650.000	13.655	113.600
20	K11A (2in)	650.000	55.052	90.000
30	K4 (2in)	2250.000	24.195	113.600
30	N11 (1in)	2200.000	90.000	65.000
30	M1 (24in)	1450.000	90.000	920.000
30	N7B (2in)	1700.000	270.000	113.600
30	N5 (2in)	1415.000	270.000	113.600
30	K8A (2in)	1000.000	65.483	113.600
30	K8B (2in)	1000.000	270.000	113.600
40	M2 (24in)	3150.000	0.000	1000.000
40	N4 (6in)	3150.000	90.000	310.145
40	K5 (2in)	2550.000	24.195	113.600
50	K7 (2in)	4800.000	90.000	113.600
50	N7A (2in)	5200.000	270.000	113.600
50	N9A (1.5in)	4100.000	289.139	88.200
50	N9B (1.5in)	4100.000	250.861	88.200
50	K2A (2in)	5000.000	55.052	113.600
50	K6 (2in)	4500.000	90.000	125.600
50	K2B (2in)	5000.000	13.655	113.600
50	K1 (2in)	5100.000	90.000	113.600
50	K3A (3in)	4150.000	90.000	136.460
50	K3B (3in)	4150.000	-29.459	136.460
50	K12 (2in)	4650.000	270.000	113.600
60	N1 (10in)	5800.000	90.000	525.651
80	N3 (10in)	0.000	320.000	450.000
80	Chimney Nozzle	0.000	220.000	450.000

The nozzle spacing is computed by the following:

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

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

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lc - 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 !](#)

Checking Multiple Nozzles on Flat Head per ASME Sec. VIII Div. 1 UG-39

Comparing Nozzles on Element from Node: 80 to: 90

UG-39 Average Nozzle Diameter and Ligament Checks:

Nozzle	Avg.	Head Dia.	Ligament	Min. dn
Pair Description	dia.	/4	Width	/4
	mm.	mm.	mm.	mm.
N3 (10in) & Chimney N	229.04	312.02	217.22	57.261

UG-39 Nozzle Spacing and Average Area Checks:

Nozzle	Center	Avg. dia.	Avg. Area	Avg. Area
Pair Description	Spacing	* 1.25	Available	Reqd.
	mm.	mm.	cm ²	cm ²
N3 (10in) & Chimney N	490.27	286.3	No Calc	No Calc

UG-39 Nozzle Diameter and Distance to Edge Checks:

Nozzle	Nozzle	Head Dia.	Distance	Nozzle
Description	dia.	/2	from Edge	dia./4
	mm.	mm.	mm.	mm.
N3 (10in)	229.04	624.05	253.48	57.261
Chimney Nozzle	229.04	624.05	253.48	57.261

[No Multiple Nozzle spacing violations detected!](#)

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	BK	GCS	MF	120	ME	CN	0009	V01

Bill of Materials:

QTY	DESCRIPTION	MATERIAL
1	ELLIPTICAL HEAD: 2.0 X 1, 12.0mm. THK X 1200.0mm. ID X 50.0mm.	SA-516 70
2	CYLINDER: 10.0mm. THK X 1200.0mm. ID X 850.0mm.	SA-516 70
3	CYLINDER: 10.0mm. THK X 1200.0mm. ID X 1500.0mm.	SA-516 70
1	BODY FLANGE: 130.0mm. THK X 1200.0mm. OD	SA-105
1	BODY FLANGE: 60.0mm. THK X 1420.0mm. OD	SA-105
1	PLATFORM: 1100mm X 1200mm WIDE	
1	LADDER: 2000mm	...
1	INSULATION: 350mm X 90mm THK	
2	SADDLE: 150mm X 120 DEG	
2	INSULATION: 850mm X 90mm THK	
3	INSULATION: 1500mm X 90mm THK	
1	BAR RING STIFFENER: 1200mm ID X 1400mm OD X 15mm	SA-516 70
1	INSULATION: 188mm X 90mm THK	
1	INSULATION: 106mm X 90mm THK	
2	CLASS 150 GR 1.1, 24.0" BLIND FLANGE(S)	SA-516 70
1	GASKET: 1265mm. OD X 1220mm. ID	...
44	BODY FLANGE BOLTS: 38mm. DIA	SA-193 B7M
88	NUTS FOR BODY FLANGE BOLTS: 38mm. DIA	...
1	NAMEPLATE	...

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پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0009	V01											

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
N12 (1in)	1.000 in	Actual	LW	2.008	12.800	...	...	160.5	150
N11 (1in)	1.000 in	Actual	LW	2.008	12.800	...	...	160.5	150
N9A (1.5in)	1.500 in	Actual	LW	2.638	14.450	...	...	173.5	150
N9B (1.5in)	1.500 in	Actual	LW	2.638	14.450	...	...	173.5	150
N8 (2in)	2.000 in	Actual	LW	3.248	15.850	...	...	178.0	150
N7C (2in)	2.000 in	Actual	LW	3.248	15.850	...	...	161.4	150
N22 (2in)	2.000 in	Actual	LW	3.248	15.850	...	...	161.4	150
K10A (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	172.3	300
K10B (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	442.0	300
K11B (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	172.3	300
K11A (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	392.0	300
K4 (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	182.2	300
N7B (2in)	2.000 in	Actual	LW	3.248	15.850	...	...	161.4	150
N5 (2in)	2.000 in	Actual	LW	3.248	15.850	...	...	161.4	150
K8A (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	343.2	300
K8B (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	161.4	300
K5 (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	182.2	300
K7 (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	161.4	300
N7A (2in)	2.000 in	Actual	LW	3.248	15.850	...	...	161.4	150
K2A (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	292.0	300
K6 (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	161.4	300
K2B (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	222.3	300
K1 (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	161.4	300
K12 (2in)	2.000 in	Actual	LW	3.307	16.600	...	...	161.4	300
K9B (3in)	3.000 in	XXS	WN	3.500	15.240	200.00	10.00	178.3	150
K9A (3in)	3.000 in	XXS	WN	3.500	15.240	200.00	10.00	161.6	150
K3A (3in)	3.000 in	XXS	WN	3.500	15.240	200.00	10.00	161.6	150
K3B (3in)	3.000 in	XXS	WN	3.500	15.240	200.00	10.00	239.8	150
N4 (6in)	6.000 in	80	WN	6.625	10.973	300.00	10.00	165.9	150
N1 (10in)	10.000 in	40	WN	10.750	9.271	450.00	10.00	175.7	150
N3 (10in)	10.000 in	160	WN	10.750	28.575	450.00	15.00	4260.0	150
Chimney Nozzle	10.000 in	160	Non	10.750	28.575	450.00	15.00	4260.0	150
M1 (24in)	24.000 in	Actual	WN	24.000	10.000	800.00	10.00	243.1	150
M2 (24in)	24.000 in	Actual	WN	24.000	10.000	800.00	10.00	243.1	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.

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.

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 18 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

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
N12 (1in)	SA-105	10.000	10.000	...	...	...
N11 (1in)	SA-105	10.000	8.000	...	...	...
N9A (1.5in)	SA-105	10.000	10.000	...	...	...
N9B (1.5in)	SA-105	10.000	10.000	...	...	...
N8 (2in)	SA-105	10.000	10.000	...	...	...
N7C (2in)	SA-105	10.000	10.000	...	...	...
N22 (2in)	SA-105	10.000	10.000	...	...	...
K10A (2in)	SA-105	10.000	10.000	...	...	...
K10B (2in)	SA-105	10.000	10.000	...	...	...
K11B (2in)	SA-105	10.000	10.000	...	...	...
K11A (2in)	SA-105	10.000	10.000	...	...	...
K4 (2in)	SA-105	10.000	10.000	...	...	...
N7B (2in)	SA-105	10.000	10.000	...	...	...
N5 (2in)	SA-105	10.000	10.000	...	...	...
K8A (2in)	SA-105	10.000	10.000	...	...	...
K8B (2in)	SA-105	10.000	10.000	...	...	...
K5 (2in)	SA-105	10.000	10.000	...	...	...
K7 (2in)	SA-105	10.000	10.000	...	...	...
N7A (2in)	SA-105	10.000	10.000	...	...	...
K2A (2in)	SA-105	10.000	10.000	...	...	...
K6 (2in)	SA-105	10.000	10.000	...	...	...
K2B (2in)	SA-105	10.000	10.000	...	...	...
K1 (2in)	SA-105	10.000	10.000	...	...	...
K12 (2in)	SA-105	10.000	10.000	...	...	...
K9B (3in)	SA-106 B	10.000	10.000	8.000	10.000	...
K9A (3in)	SA-106 B	10.000	10.000	8.000	10.000	...
K3A (3in)	SA-106 B	10.000	10.000	8.000	10.000	...
K3B (3in)	SA-106 B	10.000	10.000	8.000	10.000	...
N4 (6in)	SA-106 B	10.000	8.000	6.000	10.000	...
N1 (10in)	SA-106 B	10.000	10.000	10.000	10.000	...
N3 (10in)	SA-106 B	26.000	20.000	12.000	15.000	20.000
Chimney Noz	SA-106 B	26.000	20.000	12.000	15.000	20.000
M1 (24in)	SA-516 70	10.000	10.000	8.000	10.000	...
M2 (24in)	SA-516 70	10.000	10.000	8.000	10.000	...

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

 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 REBOILER (R-100) <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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 19 از 381
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه											
V01	0009	CN	ME	120	MF	GCS	BK											

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm.	Layout Angle deg	Proj Outside mm.	Proj Inside mm.	Installed in Component
N12 (1in)	150.000	90.0	150.00	0.00	Node: 20
N11 (1in)	2200.000	90.0	150.00	0.00	Node: 30
N9A (1.5in)	4100.000	289.1	150.00	0.00	Node: 50
N9B (1.5in)	4100.000	250.9	150.00	0.00	Node: 50
N8 (2in)	...	270.0	150.00	0.00	Node: 10
N7C (2in)	200.000	270.0	150.00	0.00	Node: 20
N22 (2in)	450.000	270.0	150.00	0.00	Node: 20
K10A (2in)	150.000	-13.7	150.00	0.00	Node: 20
K10B (2in)	150.000	-55.1	350.00	0.00	Node: 20
K11B (2in)	650.000	13.7	150.00	0.00	Node: 20
K11A (2in)	650.000	55.1	300.00	0.00	Node: 20
K4 (2in)	2250.000	24.2	150.00	0.00	Node: 30
N7B (2in)	1700.000	270.0	150.00	0.00	Node: 30
N5 (2in)	1415.000	270.0	150.00	0.00	Node: 30
K8A (2in)	1000.000	65.5	150.00	0.00	Node: 30
K8B (2in)	1000.000	270.0	150.00	0.00	Node: 30
K5 (2in)	2550.000	24.2	150.00	0.00	Node: 40
K7 (2in)	4800.000	90.0	150.00	0.00	Node: 50
N7A (2in)	5200.000	270.0	150.00	0.00	Node: 50
K2A (2in)	5000.000	55.1	200.00	0.00	Node: 50
K6 (2in)	4500.000	90.0	150.00	0.00	Node: 50
K2B (2in)	5000.000	13.7	200.00	0.00	Node: 50
K1 (2in)	5100.000	90.0	150.00	0.00	Node: 50
K12 (2in)	4650.000	270.0	150.00	0.00	Node: 50
K9B (3in)	400.000	289.1	150.00	0.00	Node: 20
K9A (3in)	400.000	90.0	150.00	0.00	Node: 20
K3A (3in)	4150.000	90.0	150.00	0.00	Node: 50
K3B (3in)	4150.000	-29.5	200.00	0.00	Node: 50
N4 (6in)	3150.000	90.0	150.00	0.00	Node: 40
N1 (10in)	5800.000	90.0	150.00	0.00	Node: 60
N3 (10in)	...	320.0	200.00	4000.00	Node: 80
Chimney Nozzle	...	220.0	200.00	4000.00	Node: 80
M1 (24in)	1450.000	90.0	150.00	0.00	Node: 30
M2 (24in)	3150.000	0.0	150.00	0.00	Node: 40

 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 REBOILER (R-100)	شماره صفحه : 20 از 381																
	<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>0009</td><td>V01</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01
	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

Minimum Design Metal Temperature Results Summary :

Description	Notes	Curve	Basic MDMT °C	Reduced MDMT °C	UG-20 (f) MDMT °C	Thickness ratio	Gov Thk mm.	E*	PWHT reqd
	[11]	A	-8	-104	-29	0.317	10.000	1.00	Yes
	[11]	A	4	3		0.989	15.000	1.00	Yes
	[10]	D	-48	-48	-29	0.496	10.000	1.00	Yes
	[7]	D	-48	-48	-29	0.390	12.000	1.00	Yes
	[8]	D	-48	-48	-29	0.501	10.000	1.00	Yes
	[8]	D	-48	-48	-29	0.501	10.000	1.00	Yes
	[8]	D	-48	-48	-29	0.501	10.000	1.00	Yes
	[8]	D	-48	-48	-29	0.501	10.000	1.00	Yes
	[8]	D	-48	-48	-29	0.501	10.000	1.00	Yes
N8 (2in)	[1]	A	-8	-104	-29	0.234	10.000	1.00	Yes
Nozzle Flg	[5]	A	-18	-104					
N7C (2in)	[1]	A	-8	-104	-29	0.263	10.000	1.00	Yes
Nozzle Flg	[5]	A	-29	-104					
N12 (1in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes
Nozzle Flg	[5]	A	-29	-104					
N22 (2in)	[1]	A	-8	-104	-29	0.263	10.000	1.00	Yes
Nozzle Flg	[5]	A	-29	-104					
K9B (3in)	[1]	B	0	-104		0.012	13.335	1.00	Yes
Nozzle Flg	[5]	A	-29	-104					
K9A (3in)	[1]	B	0	-104		0.012	13.335	1.00	Yes
Nozzle Flg	[5]	A	-29	-104					
K10A (2in)	[1]	A	-8	-104	-29	0.260	10.000	1.00	Yes
Nozzle Flg	[5]	A	-29	-104					
K10B (2in)	[1]	A	-8	-104	-29	0.262	10.000	1.00	Yes
Nozzle Flg	[5]	A	-29	-104					
K11B (2in)	[1]	A	-8	-104	-29	0.258	10.000	1.00	Yes
Nozzle Flg	[5]	A	-29	-104					
K11A (2in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes
Nozzle Flg	[5]	A	-29	-104					
K4 (2in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes
Nozzle Flg	[5]	A	-18	-104					
N11 (1in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes
Nozzle Flg	[5]	A	-18	-104					
M1 (24in)	[1]	D	-29	-104		0.129	10.000	1.00	Yes
Nozzle Flg	[5]	B	-18	-104					
N7B (2in)	[1]	A	-8	-104	-29	0.263	10.000	1.00	Yes
Nozzle Flg	[5]	A	-18	-104					
N5 (2in)	[1]	A	-8	-104	-29	0.263	10.000	1.00	Yes
Nozzle Flg	[5]	A	-18	-104					
K8A (2in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes
Nozzle Flg	[5]	A	-18	-104					
K8B (2in)	[1]	A	-8	-104	-29	0.263	10.000	1.00	Yes
Nozzle Flg	[5]	A	-18	-104					
M2 (24in)	[1]	D	-29	-104		0.130	10.000	1.00	Yes
Nozzle Flg	[5]	B	-18	-104					
N4 (6in)	[1]	B	-29	-104		0.041	9.601	1.00	Yes
Nozzle Flg	[5]	B	-18	-104					
K5 (2in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes

 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 REBOILER (R-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>0009</td><td>V01</td></tr></table>	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 21 از 381
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه										
BK	GCS	MF	120	ME	CN	0009	V01											

Nozzle Flg	[5]	A	-18	-104						
K7 (2in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
N7A (2in)	[1]	A	-8	-104	-29	0.263	10.000	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
N9A (1.5in)	[1]	A	-8	-104	-29	0.262	10.000	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
N9B (1.5in)	[1]	A	-8	-104	-29	0.262	10.000	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
K2A (2in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
K6 (2in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
K2B (2in)	[1]	A	-8	-104	-29	0.258	10.000	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
K1 (2in)	[1]	A	-8	-104	-29	0.257	10.000	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
K3A (3in)	[1]	B	0	-104		0.012	13.335	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
K3B (3in)	[1]	B	0	-104		0.012	13.335	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
K12 (2in)	[1]	A	-8	-104	-29	0.263	10.000	1.00	Yes	
Nozzle Flg	[5]	A	-18	-104						
N1 (10in)	[1]	B	-29	-104		0.090	8.112	1.00	Yes	
Nozzle Flg	[5]	B	-18	-104						
N3 (10in)	[1]	A	-1	-104		0.018	25.003	1.00	Yes	
Nozzle Flg	[5]	B	-18	-104						
Chimney Nozzle	[1]	A	-16	-104	-29	0.037	15.000	1.00	Yes	
Nozzle Flg	[5]	B	-18	-104						
Bolting	[21]		-48							

Warmest MDMT:

4 3

Required Minimum Design Metal Temperature 5.0 °C
Warmest Computed Minimum Design Metal Temperature 3.0 °C

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)

 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 REBOILER (R-100)							شماره صفحه : 22 از 381
	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	
	V01	0009	CN	ME	120	MF	GCS	BK

[20] - Cylinder/Cone Junction MDMT based on Longitudinal Stress considerations

[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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 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	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

Class From To : Basic Element Checks.

Class From To: Check of Additional Element Data

There were no geometry errors or warnings.

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V01	0009	CN	ME	120	MF	GCS	BK											

PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)	4.1	bars
Design Internal Temperature	234.0	°C
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.
Minimum Design Metal Temperature	5.0	°C
Type of Construction	Welded	
Special Service	Lethal	
Degree of Radiography	RT-1	
Use Higher Longitudinal Stresses (Flag)	Y	
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	Y	
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	
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	232	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	0	mm.
Distance Upwind of Crest	0	mm.
Distance from Crest to the Vessel	0	mm.
Type of Terrain (Hill, Escarpment)	Flat	

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V01	0009	CN	ME	120	MF	GCS	BK											

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	1.000
Table Value Fv	1.330
Short Period Acceleration value Ss	1.125
Long Period Acceleration Value Sl	0.460
Moment Reduction Factor Tau	1.000
Force Modification Factor R	3.000
Site Class	D
Component Elevation Ratio	z/h
Amplification Factor	Ap
Force Factor	0.000
Consider Vertical Acceleration	Yes
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
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	Elliptical
Description	
Distance "FROM" to "TO"	50 mm.
Inside Diameter	1200 mm.
Element Thickness	10 mm.
Internal Corrosion Allowance	3 mm.

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V01	0009	CN	ME	120	MF	GCS	BK																			

Nominal Thickness	12	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	4.1	bars
Design Temperature Internal Pressure	234	°C
Design External Pressure	1.034	bars
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	[Normalized]
Allowable Stress, Ambient	137.9	N./mm ²
Allowable Stress, Operating	137.9	N./mm ²
Allowable Stress, Hydrotest	235.8	N./mm ²
Material Density	0.00775	kg./cm ³
P Number Thickness	30.988	mm.
Yield Stress, Operating	218.6	N./mm ²
UCS-66 Chart Curve Designation	D	
External Pressure Chart Name	CS-2	
UNS Number	K02700	
Product Form	Plate	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	

Element From Node	10	
Detail Type	Platform	
Detail ID	PLAT:[1 OF 1]	
Dist. from "FROM" Node / Offset dist	0	mm.
Platform Start Angle (degrees)	0.0	
Platform End Angle (degrees)	0.0	
Platform Wind Area	31680	cm ²
Platform Weight	19243	N
Platform Railing Weight	0	N/mm.
Platform Grating Weight	0.025	Kgs/cm ²
Platform Width	1200	mm.
Platform Height	1100	mm.
Platform Clearance or End Offset	150	mm.
Platform Force Coefficient	1.2	
Ladder Layout Angle	0.0	
Ladder Start Elevation	0	mm.
Ladder End Elevation	2000	mm.
Unit Weight of Ladder	0.35	N/mm.
Platform Length (top head platform)	6300	mm.

Element From Node	10	
Detail Type	Liquid	
Detail ID	Liquid: 10	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Liquid	980	mm.
Liquid Density	0.001018	kg./cm ³

Element From Node	10	
Detail Type	Insulation	
Detail ID	Ins: 20	
Dist. from "FROM" Node / Offset dist	-300	mm.
Height/Length of Insulation	350	mm.

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پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0009	V01											

Thickness of Insulation 90 mm.
Density 0.0001249 kg./cm³

Element From Node 10
Detail Type Nozzle
Detail ID N8 (2in)
Dist. from "FROM" Node / Offset dist 400 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 150
Layout Angle 270.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 70.808 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 20
Element To Node 30
Element Type Cylinder
Description
Distance "FROM" to "TO" 850 mm.
Inside Diameter 1200 mm.
Element Thickness 10 mm.
Internal Corrosion Allowance 3 mm.
Nominal Thickness 0 mm.
External Corrosion Allowance 0 mm.
Design Internal Pressure 4.1 bars
Design Temperature Internal Pressure 234 °C
Design External Pressure 1.034 bars
Design Temperature External Pressure 100 °C
Effective Diameter Multiplier 1.2
Material Name SA-516 70 [Normalized]
Efficiency, Longitudinal Seam 1.0
Efficiency, Circumferential Seam 1.0
Weld is pre-Heated No

Element From Node 20
Detail Type Saddle
Detail ID Lft Sdl
Dist. from "FROM" Node / Offset dist 650 mm.
Width of Saddle 150 mm.
Height of Saddle at Bottom 1200 mm.
Saddle Contact Angle 120.0
Height of Composite Ring Stiffener 0 mm.
Width of Wear Plate 260 mm.
Thickness of Wear Plate 10 mm.
Contact Angle, Wear Plate (degrees) 145.0
Friction coefficient 0.30000001
Moment Factor 3.0
Dimension E at base (optional) 0 mm.
Circumferential Eff. over Saddle 1.0
Circumferential Eff. at Midspan 1.0
Tangent to Tangent dist. (optional) 0 mm.

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پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0009	V01											

Element From Node 20
Detail Type Liquid
Detail ID Liquid: 20
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Liquid 980 mm.
Liquid Density 0.001018 kg./cm³

Element From Node 20
Detail Type Insulation
Detail ID Ins: 20
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Insulation 850 mm.
Thickness of Insulation 90 mm.
Density 0.0001249 kg./cm³

Element From Node 20
Detail Type Nozzle
Detail ID N7C (2in)
Dist. from "FROM" Node / Offset dist 150 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 150
Layout Angle 270.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 70.808 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 20
Detail Type Nozzle
Detail ID N12 (1in)
Dist. from "FROM" Node / Offset dist 100 mm.
Nozzle Diameter 1 in.
Nozzle Schedule None
Nozzle Class 150
Layout Angle 90.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 31.998 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 20
Detail Type Nozzle
Detail ID N22 (2in)
Dist. from "FROM" Node / Offset dist 400 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 150
Layout Angle 270.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 70.808 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Element From Node 20
Detail Type Nozzle
Detail ID K9B (3in)
Dist. from "FROM" Node / Offset dist 350 mm.
Nozzle Diameter 3 in.
Nozzle Schedule XXS
Nozzle Class 150
Layout Angle 289.13901
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 102.79 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-106 B

Element From Node 20
Detail Type Nozzle
Detail ID K9A (3in)
Dist. from "FROM" Node / Offset dist 350 mm.
Nozzle Diameter 3 in.
Nozzle Schedule XXS
Nozzle Class 150
Layout Angle 90.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 102.79 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-106 B

Element From Node 20
Detail Type Nozzle
Detail ID K10A (2in)
Dist. from "FROM" Node / Offset dist 100 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300
Layout Angle -13.6545
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 84.586 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 20
Detail Type Nozzle
Detail ID K10B (2in)
Dist. from "FROM" Node / Offset dist 100 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300
Layout Angle -55.051998
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 138.01 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 20
Detail Type Nozzle
Detail ID K11B (2in)

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پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0009	V01											

Dist. from "FROM" Node / Offset dist 600 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300
Layout Angle 13.6545
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 84.586 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 20
Detail Type Nozzle
Detail ID K11A (2in)
Dist. from "FROM" Node / Offset dist 600 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300
Layout Angle 55.051998
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 124.66 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 20
Detail Type Weight
Detail ID WEIR 1
Dist. from "FROM" Node / Offset dist 700 mm.
Miscellaneous Weight 980.6 N
Offset from Element Centerline 0 mm.

Element From Node 30
Element To Node 40
Element Type Cylinder
Description
Distance "FROM" to "TO" 1500 mm.
Inside Diameter 1200 mm.
Element Thickness 10 mm.
Internal Corrosion Allowance 3 mm.
Nominal Thickness 0 mm.
External Corrosion Allowance 0 mm.
Design Internal Pressure 4.1 bars
Design Temperature Internal Pressure 234 °C
Design External Pressure 1.034 bars
Design Temperature External Pressure 100 °C
Effective Diameter Multiplier 1.2
Material Name SA-516 70 [Normalized]
Efficiency, Longitudinal Seam 1.0
Efficiency, Circumferential Seam 1.0
Weld is pre-Heated No

Element From Node 30
Detail Type Liquid
Detail ID Liquid: 30

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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Liquid 980 mm.
Liquid Density 0.001018 kg./cm³

Element From Node 30
Detail Type Insulation
Detail ID Ins: 30
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Insulation 1500 mm.
Thickness of Insulation 90 mm.
Density 0.0001249 kg./cm³

Element From Node 30
Detail Type Nozzle
Detail ID K4 (2in)
Dist. from "FROM" Node / Offset dist 1350 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300
Layout Angle 24.194599
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 84.586 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 30
Detail Type Nozzle
Detail ID N11 (1in)
Dist. from "FROM" Node / Offset dist 1300 mm.
Nozzle Diameter 1 in.
Nozzle Schedule None
Nozzle Class 150
Layout Angle 90.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 31.998 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 30
Detail Type Nozzle
Detail ID M1 (24in)
Dist. from "FROM" Node / Offset dist 550 mm.
Nozzle Diameter 24 in.
Nozzle Schedule STD
Nozzle Class 150
Layout Angle 90.0
Blind Flange (Y/N) Y
Weight of Nozzle (Used if > 0) 3502.1 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-516 70 [Normalized]

Element From Node 30
Detail Type Nozzle
Detail ID N7B (2in)
Dist. from "FROM" Node / Offset dist 800 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	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-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>0009</td><td>V01</td></tr></table>	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 32 از 381
پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0009	V01											

Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 150
Layout Angle 270.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 70.808 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 30
Detail Type Nozzle
Detail ID N5 (2in)
Dist. from "FROM" Node / Offset dist 515 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 150
Layout Angle 270.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 70.808 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 30
Detail Type Nozzle
Detail ID K8A (2in)
Dist. from "FROM" Node / Offset dist 100 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300
Layout Angle 65.482697
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 84.586 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 30
Detail Type Nozzle
Detail ID K8B (2in)
Dist. from "FROM" Node / Offset dist 100 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300
Layout Angle 270.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 84.586 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 30
Detail Type Weight
Detail ID WEIR 2
Dist. from "FROM" Node / Offset dist 1080 mm.
Miscellaneous Weight 980.6 N
Offset from Element Centerline 0 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	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-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>0009</td><td>V01</td></tr></table>	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 33 از 381
پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0009	V01											

Element From Node 30
Detail Type Weight
Detail ID SMOKE BOX
Dist. from "FROM" Node / Offset dist 1500 mm.
Miscellaneous Weight 1961.2 N
Offset from Element Centerline 200 mm.

Element From Node 30
Detail Type Weight
Detail ID GAS SPARGER
Dist. from "FROM" Node / Offset dist 515 mm.
Miscellaneous Weight 490.3 N
Offset from Element Centerline 400 mm.

Element From Node 40
Element To Node 50
Element Type Cylinder
Description
Distance "FROM" to "TO" 1500 mm.
Inside Diameter 1200 mm.
Element Thickness 10 mm.
Internal Corrosion Allowance 3 mm.
Nominal Thickness 0 mm.
External Corrosion Allowance 0 mm.
Design Internal Pressure 4.1 bars
Design Temperature Internal Pressure 234 °C
Design External Pressure 1.034 bars
Design Temperature External Pressure 100 °C
Effective Diameter Multiplier 1.2
Material Name SA-516 70 [Normalized]
Efficiency, Longitudinal Seam 1.0
Efficiency, Circumferential Seam 1.0
Weld is pre-Heated No

Element From Node 40
Detail Type Liquid
Detail ID Liquid: 40
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Liquid 950 mm.
Liquid Density 0.001018 kg./cm³

Element From Node 40
Detail Type Insulation
Detail ID Ins.0
Dist. from "FROM" Node / Offset dist 0 mm.
Height/Length of Insulation 1500 mm.
Thickness of Insulation 90 mm.
Density 0.0001249 kg./cm³

Element From Node 40
Detail Type Ring
Detail ID Ring R1 Fr4
Dist. from "FROM" Node / Offset dist 1450 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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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Inside Diameter of Ring	1200	mm.
Thickness of Ring	15	mm.
Outside Diameter of Ring	1400	mm.
Material Name	SA-516 70	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	
Element From Node	40	
Detail Type	Nozzle	
Detail ID	M2 (24in)	
Dist. from "FROM" Node / Offset dist	750	mm.
Nozzle Diameter	24	in.
Nozzle Schedule	STD	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	3502.1	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-516 70	[Normalized]
Element From Node	40	
Detail Type	Nozzle	
Detail ID	N4 (6in)	
Dist. from "FROM" Node / Offset dist	750	mm.
Nozzle Diameter	6	in.
Nozzle Schedule	80	
Nozzle Class	150	
Layout Angle	90.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	214.72	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	40	
Detail Type	Nozzle	
Detail ID	K5 (2in)	
Dist. from "FROM" Node / Offset dist	150	mm.
Nozzle Diameter	2	in.
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	24.194599	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	84.586	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-105	

Element From Node	50
Element To Node	60
Element Type	Cylinder
Description	
Distance "FROM" to "TO"	1500 mm.
Inside Diameter	1200 mm.
Element Thickness	10 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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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Internal Corrosion Allowance	3	mm.
Nominal Thickness	0	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	4.1	bars
Design Temperature Internal Pressure	234	°C
Design External Pressure	1.034	bars
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	[Normalized]
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	950	mm.
Liquid Density	0.001018	kg./cm ³

Element From Node	50	
Detail Type	Insulation	
Detail ID	Ins: 40	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Insulation	1500	mm.
Thickness of Insulation	90	mm.
Density	0.0001249	kg./cm ³

Element From Node	50	
Detail Type	Nozzle	
Detail ID	K7 (2in)	
Dist. from "FROM" Node / Offset dist	900	mm.
Nozzle Diameter	2	in.
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	90.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	84.586	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-105	

Element From Node	50	
Detail Type	Nozzle	
Detail ID	N7A (2in)	
Dist. from "FROM" Node / Offset dist	1300	mm.
Nozzle Diameter	2	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	270.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	70.808	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-105	

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)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)	شماره صفحه : 36 از 381																
	<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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Detail Type	Nozzle
Detail ID	N9A (1.5in)
Dist. from "FROM" Node / Offset dist	200 mm.
Nozzle Diameter	1.5 in.
Nozzle Schedule	None
Nozzle Class	150
Layout Angle	289.13901
Blind Flange (Y/N)	N
Weight of Nozzle (Used if > 0)	50.094 N
Grade of Attached Flange	GR 1.1
Nozzle Matl	SA-105

Element From Node	50
Detail Type	Nozzle
Detail ID	N9B (1.5in)
Dist. from "FROM" Node / Offset dist	200 mm.
Nozzle Diameter	1.5 in.
Nozzle Schedule	None
Nozzle Class	150
Layout Angle	250.86099
Blind Flange (Y/N)	N
Weight of Nozzle (Used if > 0)	50.094 N
Grade of Attached Flange	GR 1.1
Nozzle Matl	SA-105

Element From Node	50
Detail Type	Nozzle
Detail ID	K2A (2in)
Dist. from "FROM" Node / Offset dist	1100 mm.
Nozzle Diameter	2 in.
Nozzle Schedule	None
Nozzle Class	300
Layout Angle	55.051998
Blind Flange (Y/N)	N
Weight of Nozzle (Used if > 0)	97.943 N
Grade of Attached Flange	GR 1.1
Nozzle Matl	SA-105

Element From Node	50
Detail Type	Nozzle
Detail ID	K6 (2in)
Dist. from "FROM" Node / Offset dist	600 mm.
Nozzle Diameter	2 in.
Nozzle Schedule	None
Nozzle Class	300
Layout Angle	90.0
Blind Flange (Y/N)	N
Weight of Nozzle (Used if > 0)	84.586 N
Grade of Attached Flange	GR 1.1
Nozzle Matl	SA-105

Element From Node	50
Detail Type	Nozzle
Detail ID	K2B (2in)
Dist. from "FROM" Node / Offset dist	1100 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	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)							شماره صفحه : 37 از 381	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0009		V01

Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300
Layout Angle 13.6545
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 97.943 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 50
Detail Type Nozzle
Detail ID K1 (2in)
Dist. from "FROM" Node / Offset dist 1200 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300
Layout Angle 90.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 84.586 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 50
Detail Type Nozzle
Detail ID K3A (3in)
Dist. from "FROM" Node / Offset dist 250 mm.
Nozzle Diameter 3 in.
Nozzle Schedule XXS
Nozzle Class 150
Layout Angle 90.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 102.79 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-106 B

Element From Node 50
Detail Type Nozzle
Detail ID K3B (3in)
Dist. from "FROM" Node / Offset dist 250 mm.
Nozzle Diameter 3 in.
Nozzle Schedule XXS
Nozzle Class 150
Layout Angle -29.4592
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 114.22 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-106 B

Element From Node 50
Detail Type Nozzle
Detail ID K12 (2in)
Dist. from "FROM" Node / Offset dist 750 mm.
Nozzle Diameter 2 in.
Nozzle Schedule None
Nozzle Class 300

 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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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Layout Angle 270.0
Blind Flange (Y/N) N
Weight of Nozzle (Used if > 0) 84.586 N
Grade of Attached Flange GR 1.1
Nozzle Matl SA-105

Element From Node 50
Detail Type Weight
Detail ID SPARGER 2
Dist. from "FROM" Node / Offset dist 1000 mm.
Miscellaneous Weight 980.6 N
Offset from Element Centerline 400 mm.

Element From Node 60
Element To Node 70
Element Type Cylinder
Description
Distance "FROM" to "TO" 850 mm.
Inside Diameter 1200 mm.
Element Thickness 10 mm.
Internal Corrosion Allowance 3 mm.
Nominal Thickness 0 mm.
External Corrosion Allowance 0 mm.
Design Internal Pressure 4.1 bars
Design Temperature Internal Pressure 234 °C
Design External Pressure 1.034 bars
Design Temperature External Pressure 100 °C
Effective Diameter Multiplier 1.2
Material Name SA-516 70 [Normalized]
Efficiency, Longitudinal Seam 1.0
Efficiency, Circumferential Seam 1.0
Weld is pre-Heated No

Element From Node 60
Detail Type Saddle
Detail ID New Sdl
Dist. from "FROM" Node / Offset dist 300 mm.
Width of Saddle 150 mm.
Height of Saddle at Bottom 1200 mm.
Saddle Contact Angle 120.0
Height of Composite Ring Stiffener 0 mm.
Width of Wear Plate 260 mm.
Thickness of Wear Plate 10 mm.
Contact Angle, Wear Plate (degrees) 145.0
Friction coefficient 0.0
Moment Factor 3.0
Dimension E at base (optional) 0 mm.
Circumferential Eff. over Saddle 1.0
Circumferential Eff. at Midspan 1.0
Tangent to Tangent dist. (optional) 0 mm.

Element From Node 60
Detail Type Liquid

 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	0009	V01											

Detail ID	Liquid: 60
Dist. from "FROM" Node / Offset dist	0 mm.
Height/Length of Liquid	950 mm.
Liquid Density	0.001018 kg./cm ³

Element From Node	60
Detail Type	Insulation
Detail ID	Ins: 50
Dist. from "FROM" Node / Offset dist	0 mm.
Height/Length of Insulation	850 mm.
Thickness of Insulation	90 mm.
Density	0.0001249 kg./cm ³

Element From Node	60
Detail Type	Nozzle
Detail ID	N1 (10in)
Dist. from "FROM" Node / Offset dist	400 mm.
Nozzle Diameter	10 in.
Nozzle Schedule	40
Nozzle Class	150
Layout Angle	90.0
Blind Flange (Y/N)	N
Weight of Nozzle (Used if > 0)	579.55 N
Grade of Attached Flange	GR 1.1
Nozzle Matl	SA-106 B

Element From Node	60
Detail Type	Weight
Detail ID	E-100 & C-200
Dist. from "FROM" Node / Offset dist	400 mm.
Miscellaneous Weight	9806 N
Offset from Element Centerline	600 mm.

Element From Node	70
Element To Node	80
Element Type	Flange
Description	
Distance "FROM" to "TO"	160 mm.
Flange Inside Diameter	1200 mm.
Element Thickness	130 mm.
Internal Corrosion Allowance	3 mm.
Nominal Thickness	0 mm.
External Corrosion Allowance	0 mm.
Design Internal Pressure	4.1 bars
Design Temperature Internal Pressure	234 °C
Design External Pressure	1.034 bars
Design Temperature External Pressure	100 °C
Effective Diameter Multiplier	1.2
Material Name	SA-105
Allowable Stress, Ambient	137.9 N./mm ²
Allowable Stress, Operating	136.4 N./mm ²
Allowable Stress, Hydrotest	223.4 N./mm ²
Material Density	0.00775 kg./cm ³

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P Number Thickness	30.988	mm.
Yield Stress, Operating	206.9	N./mm ²
UCS-66 Chart Curve Designation	A	
External Pressure Chart Name	CS-2	
UNS Number	K03504	
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	Y	
Weight of Standard Flange	0	N
Class of Standard Flange		
Grade of Standard Flange		
Weld is pre-Heated	No	

Element From Node	70	
Detail Type	Liquid	
Detail ID	Liquid: 70	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Liquid	950	mm.
Liquid Density	0.001018	kg./cm ³

Element From Node	70	
Detail Type	Insulation	
Detail ID	Ins: 60	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Insulation	188.98	mm.
Thickness of Insulation	90	mm.
Density	0.0001249	kg./cm ³

Element From Node	80	
Element To Node	90	
Element Type	Flange	
Description		
Distance "FROM" to "TO"	60	mm.
Flange Outside Diameter	1420	mm.
Element Thickness	60	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	0	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	4.1	bars
Design Temperature Internal Pressure	234	°C
Design External Pressure	1.034	bars
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-105	
Perform Flange Stress Calculation (Y/N)	Y	
Weight of Standard Flange	0	N
Class of Standard Flange		
Grade of Standard Flange		
Weld is pre-Heated	No	

Element From Node	80	
Detail Type	Insulation	
Detail ID	Ins: 70	
Dist. from "FROM" Node / Offset dist	0	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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Height/Length of Insulation	106.43	mm.
Thickness of Insulation	90	mm.
Density	0.0001249	kg./cm ³

Element From Node	80	
Detail Type	Nozzle	
Detail ID	N3 (10in)	
Dist. from "FROM" Node / Offset dist	320	mm.
Nozzle Diameter	10	in.
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	320.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	3775.6	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	80	
Detail Type	Nozzle	
Detail ID	Chimney Nozzle	
Dist. from "FROM" Node / Offset dist	320	mm.
Nozzle Diameter	10	in.
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	220.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	3775.6	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	80	
Detail Type	Weight	
Detail ID	CHIMNEY	
Dist. from "FROM" Node / Offset dist	60	mm.
Miscellaneous Weight	7844.8	N
Offset from Element Centerline	320	mm.

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V01	0009	CN	ME	120	MF	GCS	BK											

XY Coordinate Calculations:

From	To	X (Horiz.) mm.	Y (Vert.) mm.	DX (Horiz.) mm.	DY (Vert.) mm.
10	20	50	...	50	...
20	30	900	...	850	...
30	40	2400	...	1500	...
40	50	3900	...	1500	...
50	60	5400	...	1500	...
60	70	6250	...	850	...
70	80	6410	...	160	...
80	90	6479.52	...	60	...

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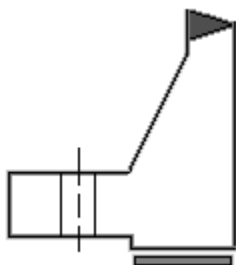
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							V01	

Flange Input Data Values

Description: FLANGE :

Item: Node 70 to 80

Description of Flange Geometry (Type)		Integral Weld Neck	
Design Pressure	P	4.19	bars
Design Temperature		234	°C
Internal Corrosion Allowance	ci	3.0000	mm.
External Corrosion Allowance	ce	0.0000	mm.
Use Corrosion Allowance in Thickness Calcs.		Yes	
Flange Inside Diameter	B	1200.000	mm.
Flange Outside Diameter	A	1420.000	mm.
Flange Thickness	t	130.0000	mm.
Thickness of Hub at Small End	go	10.0000	mm.
Thickness of Hub at Large End	gl	15.0000	mm.
Length of Hub	h	30.0000	mm.
Flange Material		SA-105	
Flange Material UNS number		K03504	
Flange Allowable Stress At Temperature	Sfo	136.40	N./mm ²
Flange Allowable Stress At Ambient	Sfa	137.90	N./mm ²
Bolt Material		SA-193 B7M	
Bolt Allowable Stress At Temperature	Sb	137.90	N./mm ²
Bolt Allowable Stress At Ambient	Sa	137.90	N./mm ²
Diameter of Bolt Circle	C	1335.000	mm.
Nominal Bolt Diameter	a	38.1000	mm.
Type of Threads	TEMA Thread Series		
Number of Bolts		44	
Flange Face Outside Diameter	Fod	1270.000	mm.
Flange Face Inside Diameter	Fid	1200.000	mm.
Flange Facing Sketch		1, Code Sketch 1a	
Gasket Outside Diameter	Go	1265.000	mm.
Gasket Inside Diameter	Gi	1220.000	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.



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V01	0009	CN	ME	120	MF	GCS	BK											

ASME Code, Section VIII Division 1, 2019

Hub Small End Required Thickness due to Internal Pressure:

$$= (P \cdot (D/2 + C_a)) / (S \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)}$$

$$= (4.19 \cdot (1200.0/2 + 3.0)) / (136.4 \cdot 1.0 - 0.6 \cdot 4.19) + C_a$$

$$= 4.8581 \text{ mm.}$$

Hub Small End Hub MAWP:

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)}$$

$$= (136.4 \cdot 1.0 \cdot 7.0) / (603.0 + 0.6 \cdot 7.0)$$

$$= 15.724 \text{ bars}$$

Corroded Flange Thickness, $t_c = T - c_i$	127.000	mm.
Corroded Flange ID, $B_{cor} = B + 2 \cdot F_{cor}$	1206.000	mm.
Corroded Large Hub, $g1_{cor} = g1 - c_i$	12.000	mm.
Corroded Small Hub, $g0_{cor} = g0 - c_i$	7.000	mm.
Code R Dimension, $R = ((C - B_{cor})/2) - g1_{cor}$	52.500	mm.
Gasket Contact Width, $N = (G_o - G_i) / 2$	22.500	mm.
Basic Gasket Width, $b_o = N / 2$	11.250	mm.
Effective Gasket Width, $b = C_b \cdot \sqrt{b_o}$	8.452	mm.
Gasket Reaction Diameter, $G = G_o - 2 \cdot b$	1248.096	mm.

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:

$$= 0.785 \cdot G^2 \cdot P_{eq}$$

$$= 0.785 \cdot 1248.0959^2 \cdot 4.195$$

$$= 513220.656 \text{ N}$$

Contact Load on Gasket Surfaces [Hp]:

$$= 2 \cdot b \cdot P_i \cdot G \cdot m \cdot P$$

$$= 2 \cdot 8.4521 \cdot 3.1416 \cdot 1248.0959 \cdot 3.0 \cdot 4.19$$

$$= 83412.352 \text{ N}$$

Hydrostatic End Load at Flange ID [Hd]:

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

$$= 3.1416 \cdot 1206.0^2 \cdot 4.195 / 4$$

$$= 479184.594 \text{ N}$$

Pressure Force on Flange Face [Ht]:

$$= H - H_d$$

$$= 513221 - 479185$$

$$= 34036.062 \text{ N}$$

Operating Bolt Load [Wm1]:

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

$$= \max(513221 + 83412 + 0, 0)$$

$$= 596633.000 \text{ N}$$

Gasket Seating Bolt Load [Wm2]:

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

$$= 68.95 \cdot 8.4521 \cdot 3.1416 \cdot 1248.096 + 0.0 \cdot 0.0 \cdot 0.0$$

$$= 2284852.250 \text{ N}$$

Required Bolt Area [Am]:

$$= \text{Maximum of } Wm1/S_b, Wm2/S_a$$

$$= \text{Maximum of } 596633/138, 2284852/138$$

$$= 165.703 \text{ cm}^2$$

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ASME Maximum Circumferential Spacing between Bolts per App. 2 eq. (3) [Bsmax]:

$$= 2a + 6t / (m + 0.5)$$

$$= 2 * 38.1 + 6 * 127.0 / (3.0 + 0.5)$$

$$= 293.914 \text{ mm.}$$

Actual Circumferential Bolt Spacing [Bs]:

$$= C * \sin(\pi / n)$$

$$= 1335.0 * \sin(3.142/44)$$

$$= 95.238 \text{ mm.}$$

ASME Moment Multiplier for Bolt Spacing per App. 2 eq. (7) [Bsc]:

$$= \max(\sqrt{ Bs / (2a + t) }, 1)$$

$$= \max(\sqrt{ 95.238 / (2 * 38.1 + 127.0) }, 1)$$

$$= 1.0000$$

Bolting Information for TEMA Imperial Thread Series (Non Mandatory):

	Minimum	Actual	Maximum
Bolt Area, cm ²	165.703	398.838	
Radial Distance between Hub and Bolts:	50.800	52.500	
Radial Distance between Bolts and Edge:	38.100	42.500	
Circ. Spacing between the Bolts:	82.550	95.238	293.914

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

$$= Ab * Sa / (y * \pi * (Go + Gi))$$

$$= 398.838 * 137.9 / (68.95 * 3.14 * (1265.0 + 1220.0))$$

$$= 10.218 \text{ mm.}$$

Note: Recommended Min. Width for Sheet and Composite Gaskets per table 2-4 :

$$= 32.000 \text{ mm. [Note: Exceeds actual gasket width, 22.500]}$$

Flange Design Bolt Load, Gasket Seating [W]:

$$= Sa * (Am + Ab) / 2$$

$$= 137.9 * (165.7032 + 398.8379) / 2$$

$$= 3892179.75 \text{ N}$$

Gasket Load for the Operating Condition [HG]:

$$= Wm1 - H$$

$$= 596633 - 513221$$

$$= 83412.37 \text{ N}$$

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:

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

$$= (1335.0 - 1248.0959) / 2$$

$$= 43.4520 \text{ mm.}$$

Distance to Face Pressure Reaction [ht]:

$$= (R + g1 + hg) / 2$$

$$= (52.5 + 12.0 + 43.452) / 2$$

$$= 53.9760 \text{ mm.}$$

Distance to End Pressure Reaction [hd]:

$$= R + (g1 / 2)$$

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$$= 52.5 + (12.0/2.0)$$

$$= 58.5000 \text{ mm.}$$

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

Loading	Force	Distance	Bolt Corr	Moment
End Pressure, Md	479185.	58.5000	1.0000	28044.
Face Pressure, Mt	34036.	53.9760	1.0000	1838.
Gasket Load, Mg	83412.	43.4520	1.0000	3626.
Gasket Seating, Matm	3892180.	43.4520	1.0000	169192.
Total Moment for Operation, Mop				33507. N-m
Total Moment for Gasket seating, Matm				169192. N-m

Effective Hub Length, $h_0 = \sqrt{B_{cor} \cdot g_{oCor}}$ 91.880 mm.

Hub Ratio, $h/h_0 = H_L / H_0$ 0.327

Thickness Ratio, $g_1/g_0 = (g_{1Cor}/g_{oCor})$ 1.714

Flange Factors for Integral Flange:

Factor F	0.869
Factor V	0.323
Factor f	1.417
Factors from Figure 2-7.1	K = 1.177
T = 1.848	U = 13.152
Y = 11.968	Z = 6.176
d = 0.18312E+06 mm. ³	e = 0.0095 mm. ⁻¹
Stress Factors	ALPHA = 2.201
BETA = 2.601	GAMMA = 1.191
DELTA = 11.186	Lamda = 12.377

Longitudinal Hub Stress, Operating [SHo]:

$$= (f \cdot M_{op} / B_{cor}) / (L \cdot g_1^2)$$

$$= (1.4167 \cdot 33507 / 1206.0) / (12.377 \cdot 12.0^2)$$

$$= 22.08 \text{ N./mm}^2$$

Longitudinal Hub Stress, Seating [SHa]:

$$= (f \cdot M_{atm} / B_{cor}) / (L \cdot g_1^2)$$

$$= (1.4167 \cdot 169192 / 1206.0) / (12.377 \cdot 12.0^2)$$

$$= 111.48 \text{ N./mm}^2$$

Radial Flange Stress, Operating [SRo]:

$$= (Beta \cdot M_{op} / B_{cor}) / (L \cdot t^2)$$

$$= (2.6013 \cdot 33507 / 1206.0) / (12.377 \cdot 127.0^2)$$

$$= 0.36 \text{ N./mm}^2$$

Radial Flange Stress, Seating [SRa]:

$$= (Beta \cdot M_{atm} / B_{cor}) / (L \cdot t^2)$$

$$= (2.6013 \cdot 169192 / 1206.0) / (12.377 \cdot 127.0^2)$$

$$= 1.83 \text{ N./mm}^2$$

Tangential Flange Stress, Operating [STo]:

$$= (Y \cdot M_o / (t^2 \cdot B_{cor})) - Z \cdot S_{Ro}$$

$$= (11.9679 \cdot 33507 / (127.0^2 \cdot 1206.0)) - 6.1763 \cdot 0.4$$

$$= 18.37 \text{ N./mm}^2$$

Tangential Flange Stress, Seating [STa]:

 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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$$= (y * Matm / (t^2 * Bcor)) - Z * SRa$$

$$= (11.9679 * 169192 / (127.0^2 * 1206.0)) - 6.1763 * 2$$

$$= 92.78 \text{ N./mm}^2$$

Average Flange Stress, Operating [SAo]:

$$= (SHo + \max(SRo, STo)) / 2$$

$$= (22 + \max(0.4, 18)) / 2$$

$$= 20.23 \text{ N./mm}^2$$

Average Flange Stress, Seating [SAa]:

$$= (SHA + \max(SRa, STa)) / 2$$

$$= (111 + \max(2, 93)) / 2$$

$$= 102.13 \text{ N./mm}^2$$

Bolt Stress, Operating [BSo]:

$$= Wm1 / Ab$$

$$= 596633 / 398.8379$$

$$= 14.96 \text{ N./mm}^2$$

Bolt Stress, Seating [BSa]:

$$= (Wm2 / Ab)$$

$$= (2284852 / 398.8379)$$

$$= 57.29 \text{ N./mm}^2$$

Flange Stress Analysis Results: N./mm²

	Actual	Operating Allowed	Gasket Seating Actual	Gasket Seating Allowed
Longitudinal Hub	22.08	204.60	111.48	206.85
Radial Flange	0.36	136.40	1.83	137.90
Tangential Flange	18.37	136.40	92.78	137.90
Maximum Average	20.23	136.40	102.13	137.90
Bolting	14.96	137.90	57.29	137.90

Minimum Required Flange Thickness [Rigidity] 122.276 mm.
 Estimated M.A.W.P. (Operating) 24 bars
 Estimated Finished Weight of Flange at given Thk. 467.2 kg.
 Estimated Unfinished Weight of Forging at given Thk 561.4 kg.

Flange Rigidity Based on Required Thickness [ASME]:

Flange Rigidity Index, Seating (rotation check) per APP. 2 [Js]:

$$= 52.14 * Ma / Bsc * Cnv\_fac * V / (Lambda * Eamb * go^2 * ho * Ki)$$

$$= 52.14 * 169191.7 / 1.0 * 999.68 * 0.323 / (10.414 * 202713 * 7.0^2 * 91.88 * 0.3)$$

$$= 1.000 \quad (\text{should be } \leq 1)$$

Flange Rigidity Index Operating (rotation check) per APP. 2 [J]:

$$= 52.14 * Mo / Bsc * Cnv\_fac * V / (Lambda * Eop * goc^2 * ho * Ki)$$

$$= 52.14 * 33507.4 / 1.0 * 999.68 * 0.323 / (10.414 * 190171 * 7.0^2 * 91.88 * 0.3)$$

$$= 0.211 \quad (\text{should be } \leq 1)$$

Flange Rigidity Based on Given Thickness [ASME]:

Flange Rigidity Index, Seating (rotation check) per APP. 2 [Js]:

$$= 52.14 * Ma / Bsc * Cnv\_fac * V / (Lambda * Eamb * go^2 * ho * Ki)$$

 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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V01	0009	CN	ME	120	MF	GCS	BK											

$$= 52.14 * 169191.7 / 1.0 * 999.68 * 0.323 / (12.377 * 202713 * 7.0^2 * 91.88 * 0.3)$$

$$= 0.841 \quad (\text{should be } \leq 1)$$

Flange Rigidity Index Operating (rotation check) per APP. 2 [J]:

$$= 52.14 * Mo / Bsc * Cnv\_fac * V / (\text{Lambda} * Eop * goc^2 * ho * Ki)$$

$$= 52.14 * 33507.4 / 1.0 * 999.68 * 0.323 / (12.377 * 190171 * 7.0^2 * 91.88 * 0.3)$$

$$= 0.178 \quad (\text{should be } \leq 1)$$

Minimum Design Metal Temperature Results:

Thickness Ratio = 0.317, Temperature Reduction per Fig. UCS 66.1 = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20 (f)	-29 °C

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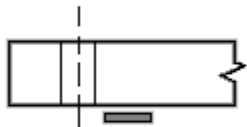
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	پروژه		بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

Flange Input Data Values

Description: FLANGE :

Item: Node 80 to 90

Description of Flange Geometry (Type)		Blind	
Design Pressure	P	4.10	bars
Design Temperature		234	°C
Internal Corrosion Allowance	ci	3.0000	mm.
External Corrosion Allowance	ce	0.0000	mm.
Use Corrosion Allowance in Thickness Calcs.		Yes	
Flange Outside Diameter	A	1420.000	mm.
Flange Thickness	t	60.0000	mm.
Flange Material		SA-105	
Flange Material UNS number		K03504	
Flange Allowable Stress At Temperature	Sfo	136.40	N./mm ²
Flange Allowable Stress At Ambient	Sfa	137.90	N./mm ²
Bolt Material		SA-193 B7M	
Bolt Allowable Stress At Temperature	Sb	137.90	N./mm ²
Bolt Allowable Stress At Ambient	Sa	137.90	N./mm ²
Diameter of the Load Reaction, Long Span	D	0.000	mm.
Diameter of the Load Reaction, Short Span	d	0.000	mm.
Perimeter along the Center of the Bolts	L	4194.026	mm.
Diameter of Bolt Circle	C	1335.000	mm.
Nominal Bolt Diameter	a	38.1000	mm.
Type of Threads	TEMA Thread Series		
Number of Bolts		44	
Flange Face Outside Diameter	Fod	1270.000	mm.
Flange Face Inside Diameter	Fid	1200.000	mm.
Flange Facing Sketch	1, Code Sketch 1a		
Gasket Outside Diameter	Go	1265.000	mm.
Gasket Inside Diameter	Gi	1220.000	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.



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BK	GCS	MF	120	ME	CN	0009	V01											

ASME Code, Section VIII Division 1, 2019

Gasket Contact Width,	$N = (G_o - G_i) / 2$	22.500	mm.
Basic Gasket Width,	$b_o = N / 2$	11.250	mm.
Effective Gasket Width,	$b = C_b \sqrt{b_o}$	8.452	mm.
Gasket Reaction Diameter,	$G = G_o - 2 * b$	1248.096	mm.

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:

$$= 0.785 * G^2 * P_{eq}$$

$$= 0.785 * 1248.0959^2 * 4.1$$

$$= 501600.500 \text{ N}$$

Contact Load on Gasket Surfaces [Hp]:

$$= 2 * b * \pi * G * m * P$$

$$= 2 * 8.4521 * 3.1416 * 1248.0959 * 3.0 * 4.1$$

$$= 81523.750 \text{ N}$$

Operating Bolt Load [Wm1]:

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

$$= \max(501601 + 81524 + 0, 0)$$

$$= 583124.250 \text{ N}$$

Gasket Seating Bolt Load [Wm2]:

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

$$= 68.95 * 8.4521 * 3.141 * 1248.096 + 0.0 * 0.0 * 0.0$$

$$= 2284852.250 \text{ N}$$

Required Bolt Area [Am]:

$$= \max(W_{m1}/S_b, W_{m2}/S_a)$$

$$= \max(583124/138, 2284852/138)$$

$$= 165.703 \text{ cm}^2$$

ASME Maximum Circumferential Spacing between Bolts per App. 2 eq. (3) [Bsmax]:

$$= 2a + 6t / (m + 0.5)$$

$$= 2 * 38.1 + 6 * 57.0 / (3.0 + 0.5)$$

$$= 173.914 \text{ mm.}$$

Actual Circumferential Bolt Spacing [Bs]:

$$= C * \sin(\pi / n)$$

$$= 1335.0 * \sin(3.142/44)$$

$$= 95.238 \text{ mm.}$$

ASME Moment Multiplier for Bolt Spacing per App. 2 eq. (7) [Bsc]:

$$= \max(\sqrt{Bs / (2a + t)}, 1)$$

$$= \max(\sqrt{95.238 / (2 * 38.1 + 57.0)}, 1)$$

$$= 1.0000$$

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Bolting Information for TEMA Imperial Thread Series (Non Mandatory):

	Minimum	Actual	Maximum
Bolt Area, cm ²	165.703	398.838	
Radial Distance between Bolts and Edge:	38.100	42.500	
Circ. Spacing between the Bolts:	82.550	95.238	173.914

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

$$\begin{aligned}
 &= A_b * S_a / (y * \pi * (G_o + G_i)) \\
 &= 398.838 * 137.9 / (68.95 * 3.14 * (1265.0 + 1220.0)) \\
 &= 10.218 \text{ mm.}
 \end{aligned}$$

Flange Design Bolt Load, Gasket Seating [W]:

$$\begin{aligned}
 &= S_a * (A_m + A_b) / 2 \\
 &= 137.9 * (165.7032 + 398.8379) / 2 \\
 &= 3892179.75 \text{ N}
 \end{aligned}$$

Gasket Load for the Operating Condition [HG]:

$$\begin{aligned}
 &= W_{m1} \\
 &= 583124.25 \text{ N}
 \end{aligned}$$

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:

$$\begin{aligned}
 &= (C - G) / 2 \\
 &= (1335.0 - 1248.0959) / 2 \\
 &= 43.4520 \text{ mm.}
 \end{aligned}$$

Tangential Flange Stress, Flat Head (UG-34), Operating [STo]:

$$\begin{aligned}
 &= 1.9 * W_{m1} * h_g * B_{sc} / (t^2 * G) + C * Z * P_{eq} * G^2 / t^2 \\
 &= 1.9 * 583124 * 43.452 * 1.0 / (57.0^2 * 1248.0959) + \\
 &\quad 0.3 * 1.0 * 4.1 * 1248.0959^2 / 57.0^2 \\
 &= 70.85 \text{ N./mm}^2
 \end{aligned}$$

Tangential Flange Stress, Flat Head (UG-34), Seating [STa]:

$$\begin{aligned}
 &= 1.9 * W * h_g * B_{sc} / (t^2 * G) \\
 &= 1.9 * 3892180 * 43.452 * 1.0 / (57.0^2 * 1248.0959) \\
 &= 79.25 \text{ N./mm}^2
 \end{aligned}$$

Bolt Stress, Operating [BSO]:

$$\begin{aligned}
 &= W_{m1} / A_b \\
 &= 583124 / 398.8379 \\
 &= 14.62 \text{ N./mm}^2
 \end{aligned}$$

Bolt Stress, Seating [BSa]:

$$\begin{aligned}
 &= (W_{m2} / A_b) \\
 &= (2284852 / 398.8379) \\
 &= 57.29 \text{ N./mm}^2
 \end{aligned}$$

 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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BK	GCS	MF	120	ME	CN	0009	V01											

Flange Stress Analysis Results: N./mm²

	Actual	Operating Allowed	Gasket Seating Actual Allowed
Tangential Flange	70.85	136.40	79.25 137.90
Bolting	14.62	137.90	57.29 137.90
Reqd. Blind Flange Thickness at Center	46.211 mm.		
Reqd. Blind Flange Thickness at Gasket	46.211 mm.		
Estimated M.A.W.P. (Operating)	8 bars		
Estimated Finished Weight of Flange at given Thk.	736.5 kg.		
Estimated Unfinished Weight of Forging at given Thk	736.5 kg.		

Minimum Design Metal Temperature Results:

Thickness Ratio = 0.989, Temperature Reduction per Fig. UCS 66.1 = 1 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	4 °C
Min Metal Temp. at Required thickness (UCS 66.1)	3 °C

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شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 53 از 381
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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
10	20	4.1983	12	3	1200	137.9
20	30	4.1983	...	3	1200	137.9
30	40	4.1983	...	3	1200	137.9
40	50	4.1953	...	3	1200	137.9
50	60	4.1953	...	3	1200	137.9
60	70	4.1953	...	3	1200	137.9
70	80	4.195	...	3	1200	136.4
80	90	4.1	...	3	1420	136.4

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.
10	20	4.1	15.9964	22.9438	10	4.82437
20	30	4.1	15.7984	22.7544	10	4.83926
30	40	4.1	15.7984	22.7544	10	4.83926
40	50	4.1	15.8014	22.7544	10	4.83795
50	60	4.1	15.8014	22.7544	10	4.83795
60	70	4.1	15.8014	22.7544	10	4.83795
70	80	4.1	15.6287	27.3405	130	122.276
80	90	4.1	7.89294	8.84163	60	46.2106

Minimum

8

9

MAWP: 8 bars, limited by: Flange.

Elements Suitable for Design Internal Pressure.

Internal Pressure Calculation Results:

ASME Code, Section VIII Division 1, 2019

Elliptical Head From 10 To 20 SA-516 70 , UCS-66 Crv. D at 234 °C

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot D \cdot K_{cor}) / (2 \cdot S \cdot E - 0.2 \cdot P) \text{ Appendix 1-4 (c)} \\
 &= (4.198 \cdot 1206.0 \cdot 0.993) / (2 \cdot 137.9 \cdot 1.0 - 0.2 \cdot 4.198) \\
 &= 1.8244 + 3.0000 = 4.8244 \text{ mm.}
 \end{aligned}$$

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

Less Operating Hydrostatic Head Pressure of 0.098 bars

$$\begin{aligned}
 &= (2 \cdot S \cdot E \cdot t) / (K_{cor} \cdot D + 0.2 \cdot t) \text{ per Appendix 1-4 (c)} \\
 &= (2 \cdot 137.9 \cdot 1.0 \cdot 7.0) / (0.993 \cdot 1206.0 + 0.2 \cdot 7.0)
 \end{aligned}$$

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V01	0009	CN	ME	120	MF	GCS	BK											

$$= 16 - 0.1 = 16 \text{ bars}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (2 * S * E * t) / (K * D + 0.2 * t) \text{ per Appendix 1-4 (c)}$$

$$= (2 * 137.9 * 1.0 * 10.0) / (1.0 * 1200.0 + 0.2 * 10.0)$$

$$= 23 \text{ bars}$$

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

$$= (P * (K_{cor} * D + 0.2 * t)) / (2 * E * t)$$

$$= (4.198 * (0.993 * 1206.0 + 0.2 * 7.0)) / (2 * 1.0 * 7.0)$$

$$= 35.971 \text{ N./mm}^2$$

Straight Flange Required Thickness:

$$= (P * R) / (S * E - 0.6 * P) + c \text{ per UG-27 (c) (1)}$$

$$= (4.198 * 603.0) / (137.9 * 1.0 - 0.6 * 4.198) + 3.0$$

$$= 4.839 \text{ mm.}$$

Straight Flange Maximum Allowable Working Pressure:

Less Operating Hydrostatic Head Pressure of 0.098 bars

$$= (S * E * t) / (R + 0.6 * t) \text{ per UG-27 (c) (1)}$$

$$= (137.9 * 1.0 * 9.0) / (603.0 + 0.6 * 9.0)$$

$$= 20 - 0.1 = 20 \text{ bars}$$

Factor K, corroded condition [Kcor]:

$$= (2 + (\text{Inside Diameter} / (2 * \text{Inside Head Depth}))^2) / 6$$

$$= (2 + (1206.0 / (2 * 303.0))^2) / 6$$

$$= 0.993416$$

Percent Elong. per UCS-79, VIII-1-01-57 $(75 * t_{nom} / R_f) * (1 - R_f / R_o)$ 4.286 %

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 10.0, tr = 3.474, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E^*) / (tg - c) = 0.496$, Temp. Reduction = 33 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 12.0, tr = 3.507, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E^*) / (tg - c) = 0.39$, Temp. Reduction = 53 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Note:

Post Weld Heat Treatment is required for this Element/Joint and it was specified as being heat treated.

 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 REBOILER (R-100)							شماره صفحه : 55 از 381
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

Cylindrical Shell From 20 To 30 SA-516 70 , UCS-66 Crv. D at 234 °C

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

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

$$= (4.198 \cdot 603.0) / (137.9 \cdot 1.0 - 0.6 \cdot 4.198)$$

$$= 1.8393 + 3.0000 = 4.8393 \text{ mm.}$$

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

Less Operating Hydrostatic Head Pressure of 0.098 bars

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)}$$

$$= (137.9 \cdot 1.0 \cdot 7.0) / (603.0 + 0.6 \cdot 7.0)$$

$$= 16 - 0.1 = 16 \text{ bars}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)}$$

$$= (137.9 \cdot 1.0 \cdot 10.0) / (600.0 + 0.6 \cdot 10.0)$$

$$= 23 \text{ bars}$$

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

$$= (P \cdot (R + 0.6 \cdot t)) / (E \cdot t)$$

$$= (4.198 \cdot (603.0 + 0.6 \cdot 7.0)) / (1.0 \cdot 7.0)$$

$$= 36.419 \text{ N./mm}^2$$

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.826 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10.0, tr = 3.507, c = 3.0 mm., E* = 1.0

Thickness Ratio = tr * (E*) / (tg - c) = 0.501, Temp. Reduction = 32 °C

Min Metal Temp. w/o impact per UCS-66, Curve D

-48 °C

Note:

Post Weld Heat Treatment is required for this Element/Joint and it was specified as being heat treated.

Cylindrical Shell From 30 To 40 SA-516 70 , UCS-66 Crv. D at 234 °C

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

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

$$= (4.198 \cdot 603.0) / (137.9 \cdot 1.0 - 0.6 \cdot 4.198)$$

$$= 1.8393 + 3.0000 = 4.8393 \text{ mm.}$$

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

Less Operating Hydrostatic Head Pressure of 0.098 bars

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)}$$

$$= (137.9 \cdot 1.0 \cdot 7.0) / (603.0 + 0.6 \cdot 7.0)$$

$$= 16 - 0.1 = 16 \text{ bars}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)}$$

$$= (137.9 \cdot 1.0 \cdot 10.0) / (600.0 + 0.6 \cdot 10.0)$$

 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 REBOILER (R-100)							شماره صفحه : 56 از 381	
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0009		V01

= 23 bars

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

$$= (P * (R + 0.6 * t)) / (E * t)$$

$$= (4.198 * (603.0 + 0.6 * 7.0)) / (1.0 * 7.0)$$

$$= 36.419 \text{ N./mm}^2$$

% Elongation per Table UG-79-1 $(50 * t_{nom} / R_f * (1 - R_f / R_o))$ 0.826 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10.0, tr = 3.507, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E*) / (tg - c) = 0.501$, Temp. Reduction = 32 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Note:

Post Weld Heat Treatment is required for this Element/Joint and it was specified as being heat treated.

Cylindrical Shell From 40 To 50 SA-516 70 , UCS-66 Crv. D at 234 °C

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

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

$$= (4.195 * 603.0) / (137.9 * 1.0 - 0.6 * 4.195)$$

$$= 1.8379 + 3.0000 = 4.8379 \text{ mm.}$$

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

Less Operating Hydrostatic Head Pressure of 0.095 bars

$$= (S * E * t) / (R + 0.6 * t) \text{ per UG-27 (c) (1)}$$

$$= (137.9 * 1.0 * 7.0) / (603.0 + 0.6 * 7.0)$$

$$= 16 - 0.1 = 16 \text{ bars}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (S * E * t) / (R + 0.6 * t) \text{ per UG-27 (c) (1)}$$

$$= (137.9 * 1.0 * 10.0) / (600.0 + 0.6 * 10.0)$$

$$= 23 \text{ bars}$$

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

$$= (P * (R + 0.6 * t)) / (E * t)$$

$$= (4.195 * (603.0 + 0.6 * 7.0)) / (1.0 * 7.0)$$

$$= 36.393 \text{ N./mm}^2$$

% Elongation per Table UG-79-1 $(50 * t_{nom} / R_f * (1 - R_f / R_o))$ 0.826 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10.0, tr = 3.505, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E*) / (tg - c) = 0.501$, Temp. Reduction = 32 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

 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 REBOILER (R-100) <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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 57 از 381
	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه										
V01	0009	CN	ME	120	MF	GCS	BK											

Note:

Post Weld Heat Treatment is required for this Element/Joint and it was specified as being heat treated.

Cylindrical Shell From 50 To 60 SA-516 70 , UCS-66 Crv. D at 234 °C

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot R) / (S \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.195 \cdot 603.0) / (137.9 \cdot 1.0 - 0.6 \cdot 4.195) \\
 &= 1.8379 + 3.0000 = 4.8379 \text{ mm.}
 \end{aligned}$$

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

Less Operating Hydrostatic Head Pressure of 0.095 bars

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (137.9 \cdot 1.0 \cdot 7.0) / (603.0 + 0.6 \cdot 7.0) \\
 &= 16 - 0.1 = 16 \text{ bars}
 \end{aligned}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (137.9 \cdot 1.0 \cdot 10.0) / (600.0 + 0.6 \cdot 10.0) \\
 &= 23 \text{ bars}
 \end{aligned}$$

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

$$\begin{aligned}
 &= (P \cdot (R + 0.6 \cdot t)) / (E \cdot t) \\
 &= (4.195 \cdot (603.0 + 0.6 \cdot 7.0)) / (1.0 \cdot 7.0) \\
 &= 36.393 \text{ N./mm}^2
 \end{aligned}$$

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.826 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10.0, tr = 3.505, c = 3.0 mm., E* = 1.0

Thickness Ratio = tr * (E*)/(tg - c) = 0.501, Temp. Reduction = 32 °C

Min Metal Temp. w/o impact per UCS-66, Curve D

-48 °C

Note:

Post Weld Heat Treatment is required for this Element/Joint and it was specified as being heat treated.

Cylindrical Shell From 60 To 70 SA-516 70 , UCS-66 Crv. D at 234 °C

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot R) / (S \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.195 \cdot 603.0) / (137.9 \cdot 1.0 - 0.6 \cdot 4.195) \\
 &= 1.8379 + 3.0000 = 4.8379 \text{ mm.}
 \end{aligned}$$

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

Less Operating Hydrostatic Head Pressure of 0.095 bars

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (137.9 \cdot 1.0 \cdot 7.0) / (603.0 + 0.6 \cdot 7.0) \\
 &= 16 - 0.1 = 16 \text{ bars}
 \end{aligned}$$

 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)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)	شماره صفحه : 58 از 381																
	<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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)}$$

$$= (137.9 \cdot 1.0 \cdot 10.0) / (600.0 + 0.6 \cdot 10.0)$$

$$= 23 \text{ bars}$$

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

$$= (P \cdot (R + 0.6 \cdot t)) / (E \cdot t)$$

$$= (4.195 \cdot (603.0 + 0.6 \cdot 7.0)) / (1.0 \cdot 7.0)$$

$$= 36.393 \text{ N./mm}^2$$

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.826 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10.0, tr = 3.505, c = 3.0 mm., E* = 1.0

Thickness Ratio = tr * (E*)/(tg - c) = 0.501, Temp. Reduction = 32 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Note:

Post Weld Heat Treatment is required for this Element/Joint and it was specified as being heat treated.

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

Pressure per UG99b	= 1.30 * M.A.W.P. * Sa/S	10.261 bars
Pressure per UG99b[36]	= 1.30 * Design Pres * Sa/S	5.330 bars
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	11.355 bars
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	8.682 bars
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	5.863 bars
Pressure per App 27-4	= M.A.W.P.	7.893 bars

UG-99(b) Note 36, Test Pressure Calculation:

$$= \text{Test Factor} * \text{Design Pressure} * \text{Stress Ratio}$$

$$= 1.3 * 4.1 * 1.0$$

$$= 5.330 \text{ bars}$$

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.

 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 REBOILER (R-100) <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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 59 از 381
	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه										
	V01	0009	CN	ME	120	MF	GCS	BK										

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

From	To	Stress	Allowable	Ratio	Pressure
10	20	46.7	235.8	0.198	5.45
20	30	47.3	235.8	0.200	5.45
30	40	47.3	235.8	0.200	5.45
40	50	47.3	235.8	0.200	5.45
50	60	47.3	235.8	0.200	5.45
60	70	47.3	235.8	0.200	5.45

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

Description	Pad/Nozzle	Ambient	Operating	Ratio
N8 (2in)	Nozzle	137.90	136.43	1.011
N7C (2in)	Nozzle	137.90	136.43	1.011
N12 (1in)	Nozzle	137.90	136.43	1.011
N22 (2in)	Nozzle	137.90	136.43	1.011
K9B (3in)	Nozzle	117.90	117.90	1.000
K9B (3in)	Pad	137.90	137.90	1.000
K9A (3in)	Nozzle	117.90	117.90	1.000
K9A (3in)	Pad	137.90	137.90	1.000
K10A (2in)	Nozzle	137.90	136.43	1.011
K10B (2in)	Nozzle	137.90	136.43	1.011
K11B (2in)	Nozzle	137.90	136.43	1.011
K11A (2in)	Nozzle	137.90	136.43	1.011
K4 (2in)	Nozzle	137.90	136.43	1.011
N11 (1in)	Nozzle	137.90	136.43	1.011
M1 (24in)	Nozzle	137.90	137.90	1.000
M1 (24in)	Pad	137.90	137.90	1.000
N7B (2in)	Nozzle	137.90	136.43	1.011
N5 (2in)	Nozzle	137.90	136.43	1.011
K8A (2in)	Nozzle	137.90	136.43	1.011
K8B (2in)	Nozzle	137.90	136.43	1.011
M2 (24in)	Nozzle	137.90	137.90	1.000
M2 (24in)	Pad	137.90	137.90	1.000
N4 (6in)	Nozzle	117.90	117.90	1.000
N4 (6in)	Pad	137.90	137.90	1.000
K5 (2in)	Nozzle	137.90	136.43	1.011
K7 (2in)	Nozzle	137.90	136.43	1.011
N7A (2in)	Nozzle	137.90	136.43	1.011
N9A (1.5in)	Nozzle	137.90	136.43	1.011
N9B (1.5in)	Nozzle	137.90	136.43	1.011
K2A (2in)	Nozzle	137.90	136.43	1.011
K6 (2in)	Nozzle	137.90	136.43	1.011
K2B (2in)	Nozzle	137.90	136.43	1.011
K1 (2in)	Nozzle	137.90	136.43	1.011
K3A (3in)	Nozzle	117.90	117.90	1.000
K3A (3in)	Pad	137.90	137.90	1.000
K3B (3in)	Nozzle	117.90	117.90	1.000
K3B (3in)	Pad	137.90	137.90	1.000
K12 (2in)	Nozzle	137.90	136.43	1.011

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 60 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

N1 (10in)	Nozzle	117.90	117.90	1.000
N1 (10in)	Pad	137.90	137.90	1.000
N3 (10in)	Nozzle	117.90	117.90	1.000
N3 (10in)	Pad	137.90	137.90	1.000
Chimney Nozzle	Nozzle	117.90	117.90	1.000
Chimney Nozzle	Pad	137.90	137.90	1.000
Minimum				1.000

Stress ratios for Stiffening Ring Materials (N./mm²):

Description	Ambient	Operating	Ratio
Ring R1 Fr4	137.90	137.90	1.000
Minimum			1.000

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

Description	Ambient	Operating	Ratio
	137.90	137.90	1.000
	137.90	137.90	1.000
	137.90	137.90	1.000
	137.90	137.90	1.000
	137.90	137.90	1.000
	137.90	136.40	1.011
	137.90	136.40	1.011
Minimum			1.000

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

Description	Ambient	Operating	Ratio
N8 (2in)	1.53	223.40	0.007
N7C (2in)	1.53	223.40	0.007
N12 (1in)	1.20	223.40	0.005
N22 (2in)	1.53	223.40	0.007
K9B (3in)	2.13	217.19	0.010
K9A (3in)	2.13	217.19	0.010
K10A (2in)	1.46	223.40	0.007
K10B (2in)	1.46	223.40	0.007
K11B (2in)	1.46	223.40	0.007
K11A (2in)	1.46	223.40	0.007
K4 (2in)	1.46	223.40	0.007
N11 (1in)	1.20	223.40	0.005
M1 (24in)	23.50	235.80	0.100
N7B (2in)	1.53	223.40	0.007
N5 (2in)	1.53	223.40	0.007
K8A (2in)	1.46	223.40	0.007
K8B (2in)	1.46	223.40	0.007
M2 (24in)	23.50	235.80	0.100

 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 REBOILER (R-100)							شماره صفحه : 61 از 381
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

N4 (6in)	6.73	217.19	0.031
K5 (2in)	1.46	223.40	0.007
K7 (2in)	1.46	223.40	0.007
N7A (2in)	1.53	223.40	0.007
N9A (1.5in)	1.38	223.40	0.006
N9B (1.5in)	1.38	223.40	0.006
K2A (2in)	1.46	223.40	0.007
K6 (2in)	1.94	223.40	0.009
K2B (2in)	1.46	223.40	0.007
K1 (2in)	1.46	223.40	0.007
K3A (3in)	2.13	217.19	0.010
K3B (3in)	2.13	217.19	0.010
K12 (2in)	1.46	223.40	0.007
N1 (10in)	14.33	217.19	0.066
N3 (10in)	3.17	217.19	0.015
Chimney Nozzle	3.17	217.19	0.015

Elements Suitable for Test Pressure.

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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 REBOILER (R-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>0009</td><td>V01</td></tr></table>	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 62 از 381
پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0009	V01											

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	1220	7	0.0007969	78.0139
20	30	3950	1220	7	0.0001714	17.1364
30	40	3950	1220	7	0.0001714	17.1364
40	Ring	3950	1220	7	0.0001714	17.1364
Ring	50	2400	1220	7	0.00028929	28.9225
50	60	2400	1220	7	0.00028929	28.9225
60	70	2400	1220	7	0.00028929	28.9225
70	80	No Calc	...	127	No Calc	No Calc
80	90	No Calc	...	57	No Calc	No Calc

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	10	6.15855	1.034	4.97328
20	30	10	9.38068	1.034	1.3109
30	40	10	9.38068	1.034	1.3109
40	Ring	10	9.38068	1.034	1.3109
Ring	50	10	8.17754	1.034	2.21252
50	60	10	8.17754	1.034	2.21252
60	70	10	8.17754	1.034	2.21252
70	80	130	122.276	1.034	No Calc
80	90	60	46.228	1.034	No Calc

Minimum

1

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	3950	4946.45	No Calc	No Calc
30	40	3950	4946.45	No Calc	No Calc
40	Ring	3950	4946.45	No Calc	No Calc
Ring	50	2400	4945.12	41.1436	263.43
50	60	2400	4945.12	No Calc	No Calc
60	70	2400	4945.12	No Calc	No Calc
70	80	No Calc	No Calc	No Calc	No Calc
80	90	No Calc	No Calc	No Calc	No Calc

 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 REBOILER (R-100)							شماره صفحه : 63 از 381
	پروژه	بسته کاری	صادر کننده	تسهيلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

Elements Suitable for External Pressure.

ASME Code, Section VIII Division 1, 2019

Elliptical Head From 10 to 20 Ext. Chart: CS-2 at 100 °C

Elastic Modulus from Chart: CS-2 at 100 °C: 199943392.000 KPa.

Results for Maximum Allowable Ext. Pressure					MAEP
Tca	Outer Dia	Do/t	Factor A	Factor B	
7.000	1220.00	174.29	0.0007969	78.01	
MAEP = B/ (K0*Do/t) = 78.0139/ (0.9 *174.2857) = 4.9733 bars					
Results for Required Thickness					Tca
Tca	Outer Dia	Do/t	Factor A	Factor B	
3.159	1220.00	386.25	0.0003596	35.95	
MAEP = B/ (K0*Do/t) = 35.9499/ (0.9 *386.2534) = 1.0341 bars					

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

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot D \cdot K_{cor}) / (2 \cdot S \cdot E - 0.2 \cdot P) \text{ Appendix 1-4 (c)} \\
 &= (1.727 \cdot 1206.0 \cdot 0.993) / (2 \cdot 137.9 \cdot 1.0 - 0.2 \cdot 1.727) \\
 &= 0.7502 + 3.0000 = 3.7502 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= ((2 \cdot S \cdot E \cdot t) / (K_{cor} \cdot D + 0.2 \cdot t)) / 1.67 \text{ per Appendix 1-4 (c)} \\
 &= ((2 \cdot 137.9 \cdot 1.0 \cdot 7.0) / (0.993 \cdot 1206.0 + 0.2 \cdot 7.0)) / 1.67 \\
 &= 10 \text{ bars}
 \end{aligned}$$

Maximum Allowable External Pressure [MAEP]:

$$\begin{aligned}
 &= \min(\text{MAEP}, \text{MAWP}) \\
 &= \min(4.97, 9.6375) \\
 &= 4.973 \text{ bars}
 \end{aligned}$$

Thickness requirements per UG-33(a)(1) do not govern the required thickness of this head.

 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 REBOILER (R-100) <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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 64 از 381
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه											
V01	0009	CN	ME	120	MF	GCS	BK											

Cylindrical Shell From 20 to 30 Ext. Chart: CS-2 at 100 °C

Elastic Modulus from Chart: CS-2 at 100 °C: 199943392.000 KPa.

Results for Maximum Allowable Ext. Pressure							MAEP
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
7.000	1220.00	3950.00	174.29	3.2377	0.0001714	17.14	

$$MAEP = (4*B) / (3*(Do/t)) = (4*17.1364) / (3*174.2857) = 1.3109 \text{ bars}$$

Results for Required Thickness							Tca
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
6.381	1220.00	3950.00	191.20	3.2377	0.0001483	14.83	

$$MAEP = (4*B) / (3*(Do/t)) = (4*14.8292) / (3*191.2023) = 1.034 \text{ bars}$$

Results for Maximum Stiffened Length							Slen
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
7.000	1220.00	4946.45	174.29	4.0545	0.0001353	13.52	

$$MAEP = (4*B) / (3*(Do/t)) = (4*13.5238) / (3*174.2857) = 1.0345 \text{ bars}$$

Cylindrical Shell From 30 to 40 Ext. Chart: CS-2 at 100 °C

Elastic Modulus from Chart: CS-2 at 100 °C: 199943392.000 KPa.

Results for Maximum Allowable Ext. Pressure							MAEP
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
7.000	1220.00	3950.00	174.29	3.2377	0.0001714	17.14	

$$MAEP = (4*B) / (3*(Do/t)) = (4*17.1364) / (3*174.2857) = 1.3109 \text{ bars}$$

Results for Required Thickness							Tca
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
6.381	1220.00	3950.00	191.20	3.2377	0.0001483	14.83	

$$MAEP = (4*B) / (3*(Do/t)) = (4*14.8292) / (3*191.2023) = 1.034 \text{ bars}$$

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

 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 REBOILER (R-100)							شماره صفحه : 65 از 381
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

7.000 | 1220.00 | 4946.45 | 174.29 | 4.0545 | 0.0001353 | 13.52 |

$$MAEP = (4*B) / (3*(Do/t)) = (4*13.5238) / (3*174.2857) = 1.0345 \text{ bars}$$

Cylindrical Shell From 40 to Ring R1 Fr4 Ext. Chart: CS-2 at 100 °C

Elastic Modulus from Chart: CS-2 at 100 °C: 199943392.000 KPa.

Results for Maximum Allowable Ext. Pressure	MAEP

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
7.000	1220.00	3950.00	174.29	3.2377	0.0001714	17.14

$$MAEP = (4*B) / (3*(Do/t)) = (4*17.1364) / (3*174.2857) = 1.3109 \text{ bars}$$

Results for Required Thickness	Tca

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
6.381	1220.00	3950.00	191.20	3.2377	0.0001483	14.83

$$MAEP = (4*B) / (3*(Do/t)) = (4*14.8292) / (3*191.2023) = 1.034 \text{ bars}$$

Results for Maximum Stiffened Length	Slen

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
7.000	1220.00	4946.45	174.29	4.0545	0.0001353	13.52

$$MAEP = (4*B) / (3*(Do/t)) = (4*13.5238) / (3*174.2857) = 1.0345 \text{ bars}$$

Cylindrical Shell From Ring R1 Fr4 to 50 Ext. Chart: CS-2 at 100 °C

Elastic Modulus from Chart: CS-2 at 100 °C: 199943392.000 KPa.

Results for Maximum Allowable Ext. Pressure	MAEP

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
7.000	1220.00	2400.00	174.29	1.9672	0.0002893	28.92

$$MAEP = (4*B) / (3*(Do/t)) = (4*28.9225) / (3*174.2857) = 2.2125 \text{ bars}$$

Results for Required Thickness	Tca

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
5.178	1220.00	2400.00	235.63	1.9672	0.0001828	18.28

 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 REBOILER (R-100)							شماره صفحه : 66 از 381	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0009		V01

$$MAEP = (4*B)/(3*(Do/t)) = (4*18.2757)/(3*235.6333) = 1.0341 \text{ bars}$$

Results for Maximum Stiffened Length							Slen
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
7.000	1220.00	4945.12	174.29	4.0534	0.0001353	13.53	

$$MAEP = (4*B)/(3*(Do/t)) = (4*13.5277)/(3*174.2857) = 1.0348 \text{ bars}$$

Cylindrical Shell From 50 to 60 Ext. Chart: CS-2 at 100 °C

Elastic Modulus from Chart: CS-2 at 100 °C: 199943392.000 KPa.

Results for Maximum Allowable Ext. Pressure							MAEP
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
7.000	1220.00	2400.00	174.29	1.9672	0.0002893	28.92	

$$MAEP = (4*B)/(3*(Do/t)) = (4*28.9225)/(3*174.2857) = 2.2125 \text{ bars}$$

Results for Required Thickness							Tca
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
5.178	1220.00	2400.00	235.63	1.9672	0.0001828	18.28	

$$MAEP = (4*B)/(3*(Do/t)) = (4*18.2757)/(3*235.6333) = 1.0341 \text{ bars}$$

Results for Maximum Stiffened Length							Slen
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
7.000	1220.00	4945.12	174.29	4.0534	0.0001353	13.53	

$$MAEP = (4*B)/(3*(Do/t)) = (4*13.5277)/(3*174.2857) = 1.0348 \text{ bars}$$

Cylindrical Shell From 60 to 70 Ext. Chart: CS-2 at 100 °C

Elastic Modulus from Chart: CS-2 at 100 °C: 199943392.000 KPa.

Results for Maximum Allowable Ext. Pressure							MAEP
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
7.000	1220.00	2400.00	174.29	1.9672	0.0002893	28.92	

$$MAEP = (4*B)/(3*(Do/t)) = (4*28.9225)/(3*174.2857) = 2.2125 \text{ bars}$$

 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 REBOILER (R-100)							شماره صفحه : 67 از 381
	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	
	V01	0009	CN	ME	120	MF	GCS	
	BK							

Results for Required Thickness							Tca
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
5.178	1220.00	2400.00	235.63	1.9672	0.0001828	18.28	

$$MAEP = (4*B) / (3*(Do/t)) = (4*18.2757) / (3*235.6333) = 1.0341 \text{ bars}$$

Results for Maximum Stiffened Length							Slen
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
7.000	1220.00	4945.12	174.29	4.0534	0.0001353	13.53	

$$MAEP = (4*B) / (3*(Do/t)) = (4*13.5277) / (3*174.2857) = 1.0348 \text{ bars}$$

Stiffening Ring Calcs for : Ring R1 Fr4 , SA-516 70 , Bar Ring: 100 x 15 mm.

Effective Length of Shell: 102 mm.

	Area (cm ²)	Distance (mm.)	Area*Dist
Shell:	7.116	3.5000	24.905
Ring :	15.000	57.0000	855.000
Total:	22.116		879.905

Centroid of Ring plus Shell: 40 mm.

	Inertia	Distance	A*Dist ²
Shell:	0.291	36.2864	9369.297
Ring :	125.000	-17.2136	4444.628
Total:	125.290		13813.925

Available Moment of Inertia, Ring plus Shell: 263 cm**4

Required Stress in Ring plus Shell Breq 12.66 N./mm²
Required Strain in Ring plus Shell Areq 0.0001270

Required Moment of Inertia, Ring plus Shell:

$$= (OD^2 * Slen(Tca + Aring/Slen)Areq) / 10.9$$

$$= (1220.0^2 * 3175.0(7.0 + 15.0/3175.0)0.000127) / 10.9$$

$$= 41 \text{ cm**4}$$

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 68 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

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 %
10	20	181.221	282794	135.916	286772	9.06107
20	30	250.43	961500	175.736	971139	12.5215
30	40	441.935	1696763	310.121	1713774	22.0968
40	50	441.935	1696763	310.121	1713774	22.0968
50	60	441.935	1696763	310.121	1713774	22.0968
60	70	250.43	961500	175.736	971139	12.5215
70	80	467.2	182462	453.14	182803	23.36
80	90	736.458	...	736.458	...	36.8229
Total		3211	7478547.00	2607	7553174.00	160

Weight of Details:

From	Type	Weight of Detail kg.	X Offset, Dtl. Cent. mm.	Y Offset, Dtl. Cent. mm.	Description
10	Plat	2060.48	3150	686.2	PLAT:[1 OF 1]
10	Liqd	262.758	-100	110	Liquid: 10
10	Ins1	28.4793	-125	...	Ins: 20
10	Noz1	7.58193	-223.607	...	N8 (2in)
20	Sad1	218.003	650	890	Lft Sd1
20	Liqd	856.951	425	110	Liquid: 20
20	Ins1	39.3554	425	...	Ins: 20
20	Noz1	7.58193	150	625.4	N7C (2in)
20	Noz1	3.4263	100	612.7	N12 (1in)
20	Noz1	7.58193	400	625.4	N22 (2in)
20	Noz1	11.0069	350	631.115	K9B (3in)
20	Noz1	11.0069	350	631.115	K9A (3in)
20	Noz1	9.05726	100	625.4	K10A (2in)
20	Noz1	14.7782	100	625.4	K10B (2in)
20	Noz1	9.05726	600	625.4	K11B (2in)
20	Noz1	13.3479	600	625.4	K11A (2in)
20	Wght	100	700	...	WEIR 1
30	Liqd	1512.27	750	110	Liquid: 30
30	Ins1	69.4507	750	...	Ins: 30
30	Noz1	9.05726	1350	625.4	K4 (2in)
30	Noz1	3.4263	1300	612.7	N11 (1in)
30	Noz1	374.995	550	904.8	M1 (24in)
30	Noz1	7.58193	800	625.4	N7B (2in)
30	Noz1	7.58193	515	625.4	N5 (2in)
30	Noz1	9.05726	100	625.4	K8A (2in)
30	Noz1	9.05726	100	625.4	K8B (2in)
30	Wght	100	1080	...	WEIR 2
30	Wght	200	1500	200	SMOKE BOX
30	Wght	50	515	400	GAS SPARGER
40	Liqd	1468.58	750	125	Liquid: 40
40	Ins1	69.4507	750	...	Ins.

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 69 از 381
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V01	0009	CN	ME	120	MF	GCS	BK																			

40 Ring	49.8544	1450	...	Ring R1 Fr4
40 Noz1	374.995	750	904.8	M2 (24in)
40 Noz1	22.992	750	674.536	N4 (6in)
40 Noz1	9.05726	150	625.4	K5 (2in)
50 Liqd	1468.58	750	125	Liquid: 50
50 Insl	69.4507	750	...	Ins: 40
50 Noz1	9.05726	900	625.4	K7 (2in)
50 Noz1	7.58193	1300	625.4	N7A (2in)
50 Noz1	5.36388	200	619.05	N9A (1.5in)
50 Noz1	5.36388	200	619.05	N9B (1.5in)
50 Noz1	10.4875	1100	625.4	K2A (2in)
50 Noz1	9.05726	600	625.4	K6 (2in)
50 Noz1	10.4875	1100	625.4	K2B (2in)
50 Noz1	9.05726	1200	625.4	K1 (2in)
50 Noz1	11.0069	250	631.115	K3A (3in)
50 Noz1	12.2301	250	631.115	K3B (3in)
50 Noz1	9.05726	750	625.4	K12 (2in)
50 Wght	100	1000	400	SPARGER 2
60 Sad1	218.003	300	890	New Sd1
60 Liqd	832.196	425	125	Liquid: 60
60 Insl	39.3554	425	...	Ins: 50
60 Noz1	62.0567	400	728.413	N1 (10in)
60 Wght	1000	400	600	E-100 & C-200
70 Liqd	157.925	80	125	Liquid: 70
70 Insl	6.38356	94.488	...	Ins: 60
80 Insl	20.6037	53.213	...	Ins: 70
80 Noz1	404.278	...	821.522	N3 (10in)
80 Noz1	404.278	...	821.522	Chimney Nozzle
80 Wght	800	60	320	CHIMNEY

Total Weight of Each Detail Type:

Saddles	436.0
Platforms	2060.5
Liquid	6559.3
Insulation	342.5
Stiffeners	49.9
Nozzles	1891.6
Weights	2350.0

Sum of the Detail Weights	13689.7 kg.

Weight Summation Results: (kg.)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating

Main Elements	3372.1	3372.1	3372.1	3372.1	3372.1	3372.1
Saddles	436.0	436.0	436.0	436.0	436.0	436.0
Stif. Rings	49.9	49.9	49.9	49.9	49.9	49.9
Nozzles	1891.6	1891.6	1891.6	1891.6	1891.6	1891.6
Wld Weights	1350.0	1350.0	1350.0	1350.0	1350.0	1350.0
Platforms	...	...	...	...	2060.5	2060.5 *
Insulation	...	...	...	...	342.5	342.5 *
Ope Weights	...	...	...	...	...	1000.0

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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0009		V01

Ope. Liquid	...	...	...	...	...	...	6559.3
Test Liquid	...	7474.0	...	...	...	...	...
Totals	7099.6	14573.6	7099.6	7099.6	9502.6	17061.8	

Field Installation Options:

- * Platforms installed after lifting.
- * Insulation installed after lifting.

Miscellaneous Weight Percent: 5.0 %

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	7099.6 kg.
Shop Test Wt.	- Fabricated Weight + Water (Full)	14573.6 kg.
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	7099.6 kg.
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	7099.6 kg.
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	9502.6 kg.
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	17061.8 kg.
Oper. Wt. + CA	- Corr Wt. + Operating Liquid	16427.4 kg.
Field Test Wt.	- Empty Weight + Water (Full)	16416.7 kg.

Note:

The Corroded Weight and thickness are used in the Horizontal Vessel Analysis (Ope Case) and Earthquake Load Calculations.

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

Outside Surface Areas of Elements:

From	To	Surface Area cm ²
10	20	18162.7
20	30	32578.3
30	40	57491.1
40	50	57491.1
50	60	57491.1
60	70	32578.3
70	80	11485.7
80	90	18513.4
Total		285791.812 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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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Nozzle Flange MAWP Results: (bars & °C)

Nozzle Description	Flange Rating Ope.	Flange Rating Ambient	Design Temp	Class	Grade/Group	Equiv. Press	UG-44 (b)	Max Pressure 50%	DNV
N8 (2in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
N7C (2in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
N12 (1in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
N22 (2in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
K9B (3in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
K9A (3in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
K10A (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K10B (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K11B (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K11A (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K4 (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
N11 (1in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
M1 (24in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
N7B (2in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
N5 (2in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
K8A (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K8B (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
M2 (24in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
N4 (6in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
K5 (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K7 (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
N7A (2in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
N9A (1.5in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
N9B (1.5in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
K2A (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K6 (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K2B (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K1 (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
K3A (3in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
K3B (3in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
K12 (2in)	42.51	51.10	234	300	GR 1.1	...	...	...	...
N1 (10in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
N3 (10in)	12.64	19.60	234	150	GR 1.1	...	...	...	...
Chimney Nozzle	12.64	19.60	234	150	GR 1.1	...	...	...	...
Min Rating	12.644	19.600 bars [for Core Elements]					0.000	0.000	0.000

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.

 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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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Input Values:

Wind Design Code	ASCE-7 2010
Wind Load Reduction Scale Factor	0.600
Basic Wind Speed	232 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

Wind Analysis Results

Static Gust-Effect Factor, Operating Case [G]:

$$\begin{aligned}
 &= \min(0.85, 0.925((1 + 1.7 * gQ * Izbar * Q) / (1 + 1.7 * gV * Izbar))) \\
 &= \min(0.85, 0.925((1 + 1.7 * 3.4 * 0.228 * 0.982) / (1 + 1.7 * 3.4 * 0.228))) \\
 &= \min(0.85, 0.915) \\
 &= 0.850
 \end{aligned}$$

Natural Frequency of Vessel (Operating)	33.000 Hz
Natural Frequency of Vessel (Empty)	33.000 Hz
Natural Frequency of Vessel (Test)	33.000 Hz

Force Coefficient	[Cf] 0.561
Structure Height to Diameter ratio	4.631

This is classified as a rigid structure. Static analysis performed.

Sample Calculation for the First Element

The ASCE code performs all calculations in Imperial Units only. The wind pressure is therefore computed in these units.

Value of [Alpha] and [Zg]:

Exposure Category: C from Table 26.9.1
Alpha = 9.5: Zg = 274320. mm.

Effective Height [z]:

$$\begin{aligned}
 &= \text{Centroid Height} + \text{Vessel Base Elevation} \\
 &= 1200.0 + 100.0 = 1300.0 \text{ mm.} \\
 &= 4.265 \text{ ft. Imperial Units}
 \end{aligned}$$

Velocity Pressure coefficient evaluated at height z [Kz]:

$$\begin{aligned}
 &\text{Because } z (4.265 \text{ ft.}) < 15 \text{ ft.} \\
 &= 2.01 * (15 / Zg)^{2 / Alpha}
 \end{aligned}$$

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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه											
V01	0009	CN	ME	120	MF	GCS	BK											

$$= 2.01 * (15/900.0)^{2/9.5}$$

$$= 0.849$$

Type of Hill: No Hill

Wind Directionality Factor [Kd]:

= 0.95, per Table 26.6-1

As there is No Hill Present: [Kzt]:

K1 = 0, K2 = 0, K3 = 0

Topographical Factor [Kzt]:

$$= (1 + K1 * K2 * K3)^2$$

$$= (1 + 0.0 * 0.0 * 0.0)^2$$

$$= 1.0$$

Velocity Pressure evaluated at height z, Imperial Units [qz]:

$$= \max(16, 0.00256 * Kz * Kzt * Kd * V(\text{mph})^2)$$

$$= \max(16, 0.00256 * 0.849 * 1.0 * 0.95 * 144.162^2)$$

$$= 42.9 \text{ psf } [209.487] \text{ Kgs/m}^2$$

Force on the first element [F]:

$$= qz * G * Cf * \text{WindArea}$$

$$= 42.906 * 0.85 * 0.561 * 5.638$$

$$= 115.3 \text{ lbs. } [512.7] \text{ N}$$

Element	Hgt (z) mm.	K1	K2	K3	Kz	Kzt	qz Kgs/m ²
Node 10 to 20	1300.0	0.000	0.000	0.000	0.849	1.000	209.487
Node 20 to 30	1300.0	0.000	0.000	0.000	0.849	1.000	209.487
Node 30 to 40	1300.0	0.000	0.000	0.000	0.849	1.000	209.487
Node 40 to 50	1300.0	0.000	0.000	0.000	0.849	1.000	209.487
Node 50 to 60	1300.0	0.000	0.000	0.000	0.849	1.000	209.487
Node 60 to 70	1300.0	0.000	0.000	0.000	0.849	1.000	209.487
Node 70 to 80	1300.0	0.000	0.000	0.000	0.849	1.000	209.487
Node 80 to 90	1300.0	0.000	0.000	0.000	0.849	1.000	209.487

Platform Load Calculations

ID	Wind Area cm ²	Elevation mm.	Pressure Kgs/m ²	Force N	Cf

PLAT: [1 OF 1]	31680.00	1300.00	209.49	6507.80	1.20

Wind Loads on Masses/Equipment/Piping

ID	Wind Area cm ²	Elevation mm.	Pressure Kgs/m ²	Force N

WEIR 1	0.00	1300.00	209.49	0.00
WEIR 2	0.00	1300.00	209.49	0.00

 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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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

SMOKE BOX	0.00	100.00	209.49	0.00
GAS SPARGER	0.00	100.00	209.49	0.00
SPARGER 2	0.00	100.00	209.49	0.00
E-100 & C-200	0.00	1900.00	211.68	0.00
CHIMNEY	0.00	100.00	209.49	0.00

Wind Load Calculation:

From	To	Wind Height mm.	Wind Diameter mm.	Wind Area cm ²	Wind Pressure Kgs/m ²	Element Wind Load N
10	20	1300	1680	5238.23	209.487	4212.28
20	30	1300	1680	14280	209.487	838.552
30	40	1300	1680	25200	209.487	1479.8
40	50	1300	1680	25200	209.487	1479.8
50	60	1300	1680	25200	209.487	1479.8
60	70	1300	1680	14280	209.487	838.552
70	80	1300	1656	2649.6	209.487	155.59
80	90	1300	1920	1152	209.487	67.6479

Note:

The Wind Loads calculated and printed in the Wind Load calculation report have been factored by the input scalar/load reduction factor of: 0.600.

Be sure the wind speed is in accordance with the specified wind design code.

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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

Earthquake Load Calculation:

Input Values:

Seismic Design Code		ASCE 7-2010
Seismic Load Reduction Scale Factor		0.700
Importance Factor		1.250
Table Value Fa		1.000
Table Value Fv		1.330
Short Period Acceleration value Ss		1.125
Long Period Acceleration Value Sl		0.460
Moment Reduction Factor Tau		1.000
Force Modification Factor R		3.000
Site Class		D
Component Elevation Ratio	z/h	1.000
Amplification Factor	Ap	1.000
Force Factor		0.000
Consider Vertical Acceleration		Yes
Minimum Acceleration Multiplier		0.000
User Value of Sds (used if > 0)		1.020
User Value of Sd1 (used if > 0)		0.385

Seismic Analysis Results:

$$S_{ms} = F_a * S_s = 1.0 * 1.125 = 1.125$$

$$S_{m1} = F_v * S_1 = 1.33 * 0.46 = 0.612$$

$$S_{ds} = 2/3 * S_{ms} = 2/3 * 1.125 = 0.75$$

$$S_{ds} = \text{Max}(0.8 * S_{ds}, S_{dsUser})$$

$$= \text{Max}(0.6, 1.02)$$

$$= 1.020$$

$$S_{d1} = 2/3 * S_{m1} = 2/3 * 0.612 = 0.408$$

$$S_{d1} = \text{Max}(0.8 * S_{d1}, S_{d1User})$$

$$= \text{Max}(0.326, 0.385)$$

$$= 0.385$$

Check Approximate Fundamental Period from 12.8-7 [Ta]:

$$= C_t * h_n^x \text{ where } C_t = 0.020, x = 0.75 \text{ and } h_n = \text{Structural Height (ft.)}$$

$$= 0.020 * (6.2664^{0.75})$$

$$= 0.079 \text{ seconds}$$

The Coefficient Cu from Table 12.8-1 is : 1.400

Fundamental Period (1/Frequency) [T]:

$$= (1/\text{Natural Frequency}) = (1/33.0)$$

$$= 0.030$$

Check the Value of T which is the smaller of Cu*Ta and T:

$$= \text{Minimum Value of } (1.4 * 0.079, 0.03) \text{ per 12.8.2}$$

$$= 0.030$$

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Compute the Seismic Force per equation 13.3-1, [Fp]:

$$\begin{aligned}
 &= 0.4 * A_p * S_{ds} * W * (1 + 2*(z/h)) / (R / I_e) \\
 &= 0.4 * 1.0 * 1.02 * 161087 * (1 + 2*1.0) / (3.0/1.25) \\
 &= 82154.547 \text{ N}
 \end{aligned}$$

Check the Maximum value of Fp per equation 13.3-2:

$$\begin{aligned}
 &= 1.6 * S_{ds} * I * W \\
 &= 1.6 * 1.02 * 1.25 * 161087 = 328618.19 \text{ N}
 \end{aligned}$$

Check the Minimum value of Fp per equation 13.3-3:

$$\begin{aligned}
 &= 0.3 * 1.02 * 1.25 * 161087 \\
 &= 61615.914 \text{ N}
 \end{aligned}$$

Compute the Total Base Shear V = Fp, [V]:

$$= 82154.547 \text{ N}$$

Vertical load per 12.4-4, [YEq]:

$$\begin{aligned}
 &= 0.2 * S_{ds} * W \\
 &= 0.2 * 1.02 * 161087 \\
 &= 32861.8 \text{ N}
 \end{aligned}$$

Final Base Shear, V = 57508.18 N

Final Vertical Load, YEq = 23003.28 N

Earthquake Load Calculation:

From	To	Earthquake Height mm.	Earthquake Weight N	Element Ope Load N
10	20	600	16108.7	5647.28
20	30	600	16108.7	5647.28
20	30	600	16108.7	5647.28
30	40	600	16108.7	5647.28
40	50	600	16108.7	5647.28
50	60	600	16108.7	5647.28
60	0	600	16108.7	5647.28
60	70	600	16108.7	5647.28
70	80	600	16108.7	5647.28
80	90	710	16108.7	6682.62

Note:

The Earthquake Loads calculated and printed in the Earthquake Load calculation report have been factored by the input scalar/load reduction factor of: 0.700.

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Shop/Field Installation Options :

Platform(s) installed in the Field after being lifted.
Insulation is installed in the Field after being lifted.

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

Center of Gravity of the Saddles	3200.000 mm.
Center of Gravity of the Platforms	3150.000 mm.
Center of Gravity of the Liquid	3076.286 mm.
Center of Gravity of the Insulation	3137.105 mm.
Center of Gravity of the Stiffening Rings	3850.000 mm.
Center of Gravity of the Nozzles	4191.483 mm.
Center of Gravity of the Added Weights (Operating)	5232.923 mm.
Center of Gravity of the Added Weights (Empty)	4812.866 mm.
Center of Gravity of Bare Shell New and Cold	4184.072 mm.
Center of Gravity of Bare Shell Corroded	4463.569 mm.
Vessel CG in the Operating Condition	3760.556 mm.
Vessel CG in the Fabricated (Shop/Empty) Condition	4242.833 mm.
Vessel CG in the Test Condition	3658.529 mm.

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ASME Horizontal Vessel Analysis: Stresses for the Left Saddle

(per ASME Sec. VIII Div. 2 based on the Zick method.)

Horizontal Vessel Stress Calculations : Operating Case

Input and Calculated Values:

Vessel Mean Radius	Rm	606.50	mm.
Stiffened Vessel Length per 4.15.6	L	6250.00	mm.
Distance from Saddle to Vessel tangent	a	650.00	mm.
Saddle Width	b	150.00	mm.
Saddle Bearing Angle	theta	120.00	degrees
Wear Plate Width	b1	260.00	mm.
Wear Plate Bearing Angle	theta1	145.00	degrees
Wear Plate Thickness	tr	10.0	mm.
Wear Plate Allowable Stress	Sr	137.90	N./mm ²
Inside Depth of Head	h2	303.00	mm.
Shell Allowable Stress used in Calculation		137.90	N./mm ²
Head Allowable Stress used in Calculation		137.90	N./mm ²
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	1200.00	mm.
Coefficient of Friction	mu	0.30	
Saddle Force Q, Operating Case		168312.83	N

Horizontal Vessel Analysis Results:	Actual	Allowable
	N./mm ²	N./mm ²

Long. Stress at Top of Midspan	0.48	137.90
Long. Stress at Bottom of Midspan	35.37	137.90
Long. Stress at Top of Saddles	33.98	137.90
Long. Stress at Bottom of Saddles	9.03	137.90

Tangential Shear in Shell	34.53	110.32
Circ. Stress at Horn of Saddle	56.01	172.37
Circ. Compressive Stress in Shell	7.26	137.90

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Saddle Reaction Force due to Wind Ft [Fwt]:

$$= F_{tr} (F_t / \text{Num of Saddles} + Z \text{ Force Load}) * B / E$$

$$= 3.0 (10552.0/2 + 0) * 1200.0/1073.8717$$

$$= 17687.1 \text{ N}$$

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

$$= \max (F_l, \text{Friction Load, Sum of X Forces}) * B / L_s$$

$$= \max (4229.15, 22216.98, 0) * 1200.0/5000.0005$$

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$$= 5332.1 \text{ N}$$

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:

$$= \max(F_l, \text{Friction Force, Sum of X Forces}) * B / L_s$$

$$= \max(57508.18, 22216.98, 0) * 1200.0/5000.0005$$

$$= 13802.0 \text{ N}$$

Saddle Reaction Force due to Earthquake Ft [Fst]:

$$= F_{tr}(F_t/\text{Num of Saddles} + Z \text{ Force Load}) * B / E$$

$$= 3.0(57508/2 + 0) * 1200.0/1073.8717$$

$$= 96393.9 \text{ N}$$

Load Combination Results for Q + Wind or Seismic [Q]:

$$= \text{Saddle Load} + \max(F_{wl}, F_{wt}, F_{sl}, F_{st})$$

$$= 71919 + \max(5332, 17687, 13802, 96394)$$

$$= 168312.8 \text{ N}$$

Longitudinal Wind Force [Fl]:

$$= \text{WindScalar} * \text{WindPress}(\text{Platform Area} + (\text{End Area} * \text{WindDiaMult}))$$

$$= 0.6 * 2054.32(1.584 + (1.539 * 1.2))$$

$$= 4229.371 \text{ N}$$

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	170450.56	N
Transverse Shear Load Saddle	28754.09	N
Longitudinal Shear Load Saddle	57508.18	N

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, $k = 0.1$

Saddle Dimension [E]:

$$= \min(2(\text{ShellID}/2 + t + \text{WearPadThickness}) \sin(\text{theta}/2), 2 * R_m)$$

$$= \min(2(1200.0/2 + 10.0 + 10.0) \sin(60.0/2), 2 * 606.5)$$

$$= 1073.872 \text{ mm.}$$

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0529	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	K6p = 0.0347
K7p = 0.0347			

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to $R_m / 2$.

Moment per Equation 4.15.3 [M1]:

$$= -Q * a [1 - (1 - a/L + (R_m^2 - h^2) / (2a * L)) / (1 + (4h^2) / (3L))]$$

$$= -168313 * 650.0 [1 - (1 - 650.0/6250.0 + (606.5^2 - 303.0^2) / (2 * 650.0 * 6250.0)) / (1 + (4 * 303.0) / (3 * 6250.0))]$$

$$= -13844.1 \text{ N-m}$$

Moment per Equation 4.15.4 [M2]:

$$= Q * L / 4 (1 + 2 (R_m^2 - h^2) / (L^2)) / (1 + (4h^2) / (3L)) - 4a/L$$

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$$= 168313 \cdot 6250 / 4 (1 + 2 (607^2 - 303^2) / (6250^2)) / (1 + (4 \cdot 303) / (3 \cdot 6250)) - 4 \cdot 650 / 6250$$

$$= 141166.3 \text{ N-m}$$

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

$$= P \cdot R_m / (2t) - M_2 / (\pi \cdot R_m^2 \cdot t)$$

$$= 4.138 \cdot 606.5 / (2 \cdot 7.0) - 141166.3 / (\pi \cdot 606.5^2 \cdot 7.0)$$

$$= 0.48 \text{ N./mm}^2$$

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

$$= P \cdot R_m / (2t) + M_2 / (\pi \cdot R_m^2 \cdot t)$$

$$= 4.138 \cdot 606.5 / (2 \cdot 7.0) + 141166.3 / (\pi \cdot 606.5^2 \cdot 7.0)$$

$$= 35.37 \text{ N./mm}^2$$

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

$$= P \cdot R_m / (2t) - M_1 / (K_1 \cdot \pi \cdot R_m^2 \cdot t)$$

$$= 4.138 \cdot 606.5 / (2 \cdot 7.0) - 13844.1 / (0.1066 \cdot \pi \cdot 606.5^2 \cdot 7.0)$$

$$= 33.98 \text{ N./mm}^2$$

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

$$= P \cdot R_m / (2t) + M_1 / (K_1 \cdot \pi \cdot R_m^2 \cdot t)$$

$$= 4.138 \cdot 606.5 / (2 \cdot 7.0) + 13844.1 / (0.1923 \cdot \pi \cdot 606.5^2 \cdot 7.0)$$

$$= 9.03 \text{ N./mm}^2$$

Maximum Shear Force in the Saddle (4.15.5) [T]:

$$= Q(L - 2a) / (L + (4 \cdot h^2 / 3))$$

$$= 168313 (6250.0 - 2 \cdot 650.0) / (6250.0 + (4 \cdot 303.0 / 3))$$

$$= 125210.2 \text{ N}$$

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

$$= K_2 \cdot T / (\pi \cdot R_m \cdot t)$$

$$= 1.1707 \cdot 125210.17 / (\pi \cdot 606.5 \cdot 7.0)$$

$$= 34.53 \text{ N./mm}^2$$

Decay Length (4.15.22) [x1,x2]:

$$= 0.78 \cdot \sqrt{R_m \cdot t}$$

$$= 0.78 \cdot \sqrt{606.5 \cdot 7.0}$$

$$= 50.823 \text{ mm.}$$

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:

$$= -K_5 \cdot Q \cdot k / (t \cdot (b + X_1 + X_2))$$

$$= -0.7603 \cdot 168313 \cdot 0.1 / (7.0 \cdot (150.0 + 50.82 + 50.82))$$

$$= -7.26 \text{ N./mm}^2$$

Effective reinforcing plate width (4.15.1) [B1]:

$$= \min(b + 1.56 \cdot \sqrt{R_m \cdot t}, 2a)$$

$$= \min(150.0 + 1.56 \cdot \sqrt{606.5 \cdot 7.0}, 2 \cdot 650.0)$$

$$= 251.65 \text{ mm.}$$

Wear Plate/Shell Stress ratio (4.15.29) [eta]:

$$= \min(S_r / S, 1)$$

$$= \min(137.9 / 137.9, 1)$$

$$= 1.0000$$

Circumferential Stress at Saddle Base with Wear Plate (4.15.26) [sigma6,r]:

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$$= -K5 * Q * k / (B1(t + eta * tr))$$

$$= - 0.7603 * 168313 * 0.1 / (251.646(7.0 + 1.0 * 10.0))$$

$$= -2.99 \text{ N./mm}^2$$

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.27) [sigma7,r]:

$$= -Q / (4(t + eta * tr) b1) - 3 * K7 * Q / (2(t + eta * tr)^2)$$

$$= -168313 / (4(7.0 + 1.0 * 10.0) 251.646) -$$

$$3 * 0.053 * 168313 / (2(7.0 + 1.0 * 10.0)^2)$$

$$= -56.01 \text{ N./mm}^2$$

Distance between Saddle Supports [Ls]:

$$= 5000.0 \text{ mm.}$$

Free Un-Restrained Thermal Expansion between the Saddles [Exp]:

$$= Alpha * Ls(\text{Design Temperature} - \text{Ambient Temperature})$$

$$= 0.000013 * 5000.0(234.0 - 21.1)$$

$$= 13.806 \text{ mm.}$$

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	1200.0000	mm.
Baseplate Thickness	Bpthk	15.0000	mm.
Baseplate Width	Bpwid	170.0000	mm.
Number of Ribs (inc. outside ribs)	Nribs	4	
Rib Thickness	Ribtk	15.0000	mm.
Web Thickness	Webtk	15.0000	mm.
Web Location	Webloc	Center	
Saddle Yield Stress	Sy	239.9	N./
Height of Web at Center	Hw,c	585.0	mm.
Friction Coefficient	mu	0.300	

Note: In the tables below I_o is I for the rectangle + Area * Centroid Distance²

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

	B	D	Y	A	AY	I _o
Shell	361.4	7.0	3.5	25.3	8853.1	0.157E+05
Wearplate	260.0	10.0	12.0	26.0	31200.0	0.151E+05
Web	15.0	565.0	299.5	84.8	2538262.8	0.244E+05
BasePlate	170.0	15.0	589.5	25.5	1503225.0	0.289E+05
Totals	...	...	...	161.5	4081541.2	0.841E+05

Distance to Centroid [C1]:

$$= AY / A$$

$$= 1606.906 / 161.545$$

$$= 252.657 \text{ mm.}$$

Angle [beta]:

$$= 180 - \text{Saddle Angle} / 2$$

$$= 180 - 120.0 / 2$$

$$= 120.0$$

Saddle Splitting Coefficient [K1]:

$$= (1 + \cos(\beta) - 0.5 * \sin(\beta)^2) / (\pi - \beta + \sin(\beta) \cos(\beta))$$

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$$= (1 + \cos(120.0) - 0.5 \sin(120.0)^2) / (\pi - 2.094 + \sin(120.0) \cos(120.0))$$

$$= 0.2035$$

Saddle Splitting Force [Fh]:

$$= K1 * Q$$

$$= 0.204 * 168312.828$$

$$= 34255.3086 \text{ N}$$

$$\text{Tension Stress, } St = (Fh / As) = 2.5144 \text{ N./mm}^2$$

$$\text{Allowed Stress, } Sa = 0.6 * \text{Yield Str} = 143.9676 \text{ N./mm}^2$$

Saddle Splitting Dimension [d]:

$$= B - R * \sin(\theta/2) / (\theta/2 \text{ in radians})$$

$$= 1200.0 - 603.0 * \sin(120.0/2) / 1.0472$$

$$= 701.323 \text{ mm.}$$

$$\text{Bending Moment, } M = Fh * d = 24033.7754 \text{ N-m}$$

$$\text{Bending Stress, } Sb = (M * C1 / I) = 7.2174 \text{ N./mm}^2$$

$$\text{Allowed Stress, } Sa = 2/3 * \text{Yield Str} = 159.9640 \text{ N./mm}^2$$

Minimum Thickness of Baseplate per Moss:

$$= (3 * (Q + \text{Saddle\_Wt}) * \text{BasePlateWidth} / (4 * \text{BasePlateLength} * \text{AllStress}))^{1/2}$$

$$= (3 * (168313 + 2138) * 170.0 / (4 * 1200.0 * 159.964))^{1/2}$$

$$= 10.641 \text{ mm.}$$

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:

$$= 2 * \cos(90 - \text{Saddle Angle}/2) * (\text{Inside Radius} + \text{Shell Thk} + \text{Wear Plate Thk})$$

$$= 2 * \cos(90 - 120.0/2) * (600.0 + 10.0 + 10.0)$$

$$= 1073.872 \text{ mm.}$$

Distance between Ribs [e]:

$$= \text{Web Length} / (\text{Nrings} - 1)$$

$$= 1073.8716 / (4 - 1)$$

$$= 357.957 \text{ mm.}$$

Baseplate Pressure Area [Ap]:

$$= e * \text{Bpwid} / 2$$

$$= 357.9572 * 170.0 / 2$$

$$= 304.264 \text{ cm}^2$$

Bearing Pressure [Bp]:

$$= Q / (\text{BasePlateLength} * \text{BasePlateWidth})$$

$$= 168312.828 / (1200.0 * 170.0)$$

$$= 82.506 \text{ N/cm}^2$$

Axial Load [P]:

$$= Ap * Bp$$

$$= 304.3 * 82.51$$

$$= 25103.660 \text{ N}$$

Area of the Rib and Web [Ar]:

$$= \text{Rib Area} + \text{Web Area}$$

 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	0009	V01											

$$= 20.25 + 26.847$$

$$= 47.097 \text{ cm}^2$$

Compressive Stress [Sc]:

$$= P/Ar$$

$$= 25103.7/47.0968$$

$$= 5.331 \text{ N./mm}^2$$

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
-----	-----	-----	-----	-----	-----	-----
Rib+Web	15.0	150.0	...	22.5	...	422.

Rib dimension [D]:

$$= \text{Saddle Width} - \text{Web Thickness}$$

$$= 150.0 - 15.0$$

$$= 135.000 \text{ mm.}$$

Distance to Centroid from Datum [ytot]:

$$= AY / A$$

$$= 0.0/47.097$$

$$= 0.000 \text{ mm.}$$

Distance to Centroid [C1]:

$$= \text{Saddle Width} / 2$$

$$= 150.0/2$$

$$= 75.000 \text{ mm.}$$

Radius of Gyration [r]:

$$= \sqrt{\text{Total Inertia} / \text{Total Area}}$$

$$= \sqrt{421.9/47.097}$$

$$= 29.929 \text{ mm.}$$

Length of Outer Rib [L]:

$$= \text{Saddle Height} - \cos(\text{theta}/2) (\text{radius} + \text{shlthk} + \text{wpdthk}) - \text{bpthk}$$

$$= 1200.0 - \cos(120.0/2) (600.0 + 10.0 + 10.0) - 15.0$$

$$= 875.000 \text{ mm.}$$

Intermediate Term [Cc]:

$$= \sqrt{2 * \pi^2 * \text{Elastic Modulus} / \text{Yield Stress}}$$

$$= \sqrt{2 * \pi^2 * 0.19994\text{E}+09/239.9}$$

$$= 128.255$$

Slenderness ratio [KL/r]:

$$= KL/r$$

$$= 1 * 875.0/29.929$$

$$= 29.236$$

Bending Moment [Rm]:

$$= Fl / (2 * Bplen) * e * L / 2$$

$$= 57508.2 / (2 * 1200.0) * 357.957 * 875.0/2$$

 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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$$= 3754.080 \text{ N-m}$$

Compressive Allowable, $KL/r < Cc$ ($29.2356 < 128.2549$) per AISC E2-1 [Sca]:

$$= (1 - (KL/r)^2 / (2 * Cc^2)) Fy / (5/3 + 3 * (KL/r) / (8 * Cc) - (KL/r)^3 / (8 * Cc^3))$$

$$= (1 - (29.24)^2 / (2 * 128.25^2)) 240 / (5/3 + 3 * (29.24) / (8 * 128.25) - (29.24^3) / (8 * 128.25^3))$$

$$= 133.5 \text{ N./mm}^2$$

AISC Unity Check of Outside Ribs (must be ≤ 1)

$$= Sc/Sca + (Rm * C1 / I) / Sba$$

$$= 5.33/133.5 + (3754.08 * 75.0/4218750) / 159.96$$

$$= 0.457$$

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	15.0	135.0	0.0	20.2	0.0	421.
Web	358.0	15.0	0.0	53.7	0.0	10.1
Totals	...	...	...	73.9	...	432.

Distance to Centroid from Datum [ytot]:

$$= AY / A$$

$$= 0.0/73.944$$

$$= 0.000 \text{ mm.}$$

Distance to Centroid [C1]:

$$= \text{Saddle Width} / 2$$

$$= 150.0/2$$

$$= 75.000 \text{ mm.}$$

Length of Inner Rib [L]:

$$= \text{Saddle Height} - \sqrt{ (Ro + Wpdthk)^2 - (Pitch/2)^2 } - Bpthk$$

$$= 1200.0 - \sqrt{ (620.0 + 10.0)^2 - (357.957/2)^2 } - 15.0$$

$$= 591.395 \text{ mm.}$$

Radius of Gyration [r]:

$$= \sqrt{ \text{Total Inertia} / \text{Total Area} }$$

$$= \sqrt{ 431.5/73.944 }$$

$$= 24.157 \text{ mm.}$$

Slenderness ratio [KL/r]:

$$= KL/r$$

$$= 1 * 591.395/24.157$$

$$= 24.481$$

Unit Force [Force,u]:

$$= F1 / (2 * \text{Baseplate Length})$$

$$= 57508.184 / (2 * 1200.0)$$

$$= 23.962 \text{ N/mm.}$$

Moment at base of inner Rib [Mbase,c]:

$$= \text{Unit Force} * e * L$$

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$$= 23.962 * 357.957 * 591.395$$

$$= 5074.617 \text{ N-m}$$

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:

$$= \text{Bending Moment} / \text{Section Modulus}$$

$$= 5074.617 / 57536.086$$

$$= 88.171 \text{ N./mm}^2$$

Compressive Allowable, $KL/r < Cc$ ($24.4809 < 128.2549$) per AISC E2-1 [Sca]:

$$= (1 - (Klr)^2 / (2 * Cc^2)) Fy / (5/3 + 3 * (Klr) / (8 * Cc) - (Klr^3) / (8 * Cc^3))$$

$$= (1 - (24.48)^2 / (2 * 128.25^2)) 240 /$$

$$(5/3 + 3 * (24.48) / (8 * 128.25) - (24.48^3) / (8 * 128.25^3))$$

$$= 135.6 \text{ N./mm}^2$$

AISC Unity Check of Inside Ribs (must be ≤ 1)

$$= Sc/Sca + (Mbase,c * Cl/I) / Sba$$

$$= 6.87 / 135.59 + (5074.62 * 75.0 / 431.52) / 159.96$$

$$= 0.602$$

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	4
Total Number of Bolts in Tension/Baseplate	Nbt	2
Bolt Material Specification	SA-325	
Bolt Allowable Stress	Stba	300.00 N./mm ²
Bolt Corrosion Allowance	Bca	0.0 mm.
Distance from Bolts to Edge	Edgedis	150.0 mm.
Nominal Bolt Diameter	Bnd	20.0000 mm.
Thread Series	Series	TEMA Metric
BasePlate Allowable Stress	S	95.15 N./mm ²
Area Available in a Single Bolt	BlArea	2.1705 cm ²
Saddle Load QO (Weight)	QO	74056.6 N
Saddle Load QL (Wind/Seismic contribution)	QL	13802.0 N
Maximum Transverse Force	Ft	28754.1 N
Maximum Longitudinal Force	Fl	57508.2 N
Saddle Bolted to Steel Foundation		Yes

Shear Stress in a Single Bolt, Longitudinal Direction [taub,l]:

$$= Fl / (\text{Bolt Area} * \text{Number of Bolts})$$

$$= 57508 / (2.17 * 4)$$

$$= 66.2 \text{ N./mm}^2. \text{ Must be less than } 180.0 \text{ N./mm}^2.$$

Shear Stress in a Single Bolt, Transverse Direction [taub,t]:

$$= Ft / (\text{Bolt Area} * \text{Number of Bolts})$$

$$= 28754 / (2.17 * 4)$$

$$= 33.1 \text{ N./mm}^2. \text{ Must be less than } 180.0 \text{ N./mm}^2.$$

Bolt Area Calculation per Dennis R. Moss

Bolt Area Requirement Due to Longitudinal Load [Bltarearl]:

$$= 0.0 \text{ (} QO > QL \text{ --> No Uplift in Longitudinal direction)}$$

Bolt Area due to Shear Load [Bltarears]:

$$= Fl / (\text{BoltShearAllowable} * \text{Nbolts})$$

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$$= 57508.18 / (180.0 * 4.0)$$

$$= 0.7988 \text{ cm}^2$$

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:

$$= B * Ft + \text{Sum of X Moments}$$

$$= 1200.0 * 28754.09 + 0.0$$

$$= 34518.90 \text{ N-m}$$

Eccentricity (e):

$$= Rmom / QO$$

$$= 34518.9 / 74056.61$$

$$= 465.93 \text{ mm.} > Bplen/6 \rightarrow \text{Uplift in Transverse direction}$$

$$f = Bplen / 2 - Edgedis$$

$$= 1200.0/2 - 150.01$$

$$= 449.99 \text{ mm.}$$

$$K1 = 3 (e - 0.5 * Bplen)$$

$$= 3 (465.93 - 0.5 * 1200.0)$$

$$= -402.22 \text{ mm.}$$

$$K2 = 6 * n1 * At / Bpwid * (f + e)$$

$$= 6 * 1.0 * 4.34/170.0 * (449.99 + 465.93)$$

$$= 14032.95 \text{ mm.}^2$$

$$K3 = -K2 * (0.5 * Bplen + f)$$

$$= -14032.95 * (0.5 * 1200.0 + 449.99)$$

$$= -14734426.98 \text{ mm.}^3$$

Iteratively Solving for the Effective Bearing Length:

$$Y^3 + K1 * Y^2 + K2 * Y + K3 = 0$$

$$Y^3 + -402.22 * Y^2 + 14032.95 * Y + -0.1E+08 = 0$$

$$Y = 445.07 \text{ mm.}$$

$$Num = (Bplen / 2 - Y / 3 - e)$$

$$= (1200.0/2 - 445.07/3 - 465.93)$$

$$= -14.28$$

$$Denom = (Bplen / 2 - Y / 3 + f)$$

$$= (1200.0/2 - 445.07/3 + 449.99)$$

$$= 901.63$$

Total Bolt Tension Force [Tforce]:

$$= - QO * Num / Denom$$

$$= - 74056.61 * -14.28/901.63$$

$$= 1173.25 \text{ N}$$

Bolt Area Required due to Transverse Load [Bltareart]:

$$= Tforce / (Stba * Nbt)$$

$$= 1173.25 / (300.0 * 2.0)$$

$$= 0.0196 \text{ cm}^2$$

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Required Area of a Single Bolt [Bltarear]:

$$\begin{aligned}
 &= \max[\text{Bltarearl}, \text{Bltarears}, \text{Bltareart}] \\
 &= \max[0.0, 0.7988, 0.0196] \\
 &= 0.7988 \text{ cm}^2
 \end{aligned}$$

Baseplate Thickness Calculation per D. Moss:

Bearing Pressure (fc)

$$\begin{aligned}
 &= 2(QO + Tforce) / (Y * Bpwid) \\
 &= 2(74056.61 + 1173.25) / (445.07 * 170.0) \\
 &= 19.89 \text{ bars}
 \end{aligned}$$

Distance from Baseplate Edge to the Web [ADIST]:

$$\begin{aligned}
 &= (Bplen - Weblength) / 2 \\
 &= (1200.0 - 1149.2) / 2 \\
 &= 25.4000 \text{ mm.}
 \end{aligned}$$

Overturning Moment due To Bolt Tension [Mt]:

$$\begin{aligned}
 &= Tforce * Adist \\
 &= 1173.25 * 25.4 \\
 &= 29.81 \text{ N-m}
 \end{aligned}$$

Equivalent Bearing Pressure (f1):

$$\begin{aligned}
 &= fc * (Y - Adist) / Y \\
 &= 19.89 * (445.07 - 25.4) / 445.07 \\
 &= 18.75 \text{ bars}
 \end{aligned}$$

Overturning Moment due to Bearing Pressure [Mc]:

$$\begin{aligned}
 &= (Adist^2 * Bpwid / 6) * (f1 + 2 * fc) \\
 &= (25.4^2 * 170.0 / 6) * (18.75 + 2 * 19.89) \\
 &= 107.02 \text{ N-m}
 \end{aligned}$$

Baseplate Required Thickness [Treq]:

$$\begin{aligned}
 &= (6 * \max(Mt, Mc) / (Bpwid * Sba))^{1/2} \\
 &= (6 * \max(29.81, 107.02) / (170.0 * 142.73))^{1/2} \\
 &= 5.1435 \text{ mm.}
 \end{aligned}$$

ASME Horizontal Vessel Analysis: Stresses for the Right Saddle

(per ASME Sec. VIII Div. 2 based on the Zick method.)

Input and Calculated Values:

Vessel Mean Radius	Rm	606.50	mm.
Stiffened Vessel Length per 4.15.6	L	6250.00	mm.
Distance from Saddle to Vessel tangent	a	550.00	mm.
Saddle Width	b	150.00	mm.
Saddle Bearing Angle	theta	120.00	degrees
Wear Plate Width	b1	260.00	mm.
Wear Plate Bearing Angle	theta1	145.00	degrees
Wear Plate Thickness	tr	10.0	mm.

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Wear Plate Allowable Stress	Sr	137.90	N./mm ²
Shell Allowable Stress used in Calculation		137.90	N./mm ²
Head Allowable Stress used in Calculation		136.40	N./mm ²
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	1200.00	mm.
Coefficient of Friction	mu	0.00	

Saddle Force Q, Operating Case 204290.19 N

Horizontal Vessel Analysis Results:		Actual	Allowable
		N./mm ²	N./mm ²
Long. Stress at Top of Midspan		-8.40	-164.62
Long. Stress at Top of Midspan		8.40	137.90
Long. Stress at Bottom of Midspan		44.23	137.90
Long. Stress at Top of Saddles		22.41	137.90
Long. Stress at Bottom of Saddles		15.42	137.90
Tangential Shear in Shell		46.42	110.32
Circ. Stress at Horn of Saddle		60.15	172.37
Circ. Compressive Stress in Shell		8.82	137.90

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Saddle Reaction Force due to Wind Ft [Fwt]:

$$= F_{tr} (F_t / \text{Num of Saddles} + Z \text{ Force Load}) * B / E$$

$$= 3.0 (10552.0/2 + 0) * 1200.0/1073.8717$$

$$= 17687.1 \text{ N}$$

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

$$= \max(F_l, \text{Friction Load, Sum of X Forces}) * B / L_s$$

$$= \max(4229.15, 0.0, 0) * 1200.0/5000.0005$$

$$= 1015.0 \text{ N}$$

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:

$$= \max(F_l, \text{Friction Force, Sum of X Forces}) * B / L_s$$

$$= \max(57508.18, 0.0, 0) * 1200.0/5000.0005$$

$$= 13802.0 \text{ N}$$

Saddle Reaction Force due to Earthquake Ft [Fst]:

$$= F_{tr} (F_t / \text{Num of Saddles} + Z \text{ Force Load}) * B / E$$

$$= 3.0 (57508/2 + 0) * 1200.0/1073.8717$$

$$= 96393.9 \text{ N}$$

Load Combination Results for Q + Wind or Seismic [Q]:

$$= \text{Saddle Load} + \max(F_{wl}, F_{wt}, F_{sl}, F_{st})$$

$$= 107896 + \max(1015, 17687, 13802, 96394)$$

$$= 204290.2 \text{ N}$$

Longitudinal Wind Force [Fl]:

$$= \text{WindScalar} * \text{WindPress}(\text{Platform Area} + (\text{End Area} * \text{WindDiaMult}))$$

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

$$= 0.6 * 2054.32 (1.584 + (1.539 * 1.2))$$

$$= 4229.371 \text{ N}$$

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	206427.92	N
Transverse Shear Load Saddle	28754.09	N
Longitudinal Shear Load Saddle	57508.18	N

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, $k = 0.1$

Saddle Dimension [E]:

$$= \min(2(\text{ShellID}/2 + t + \text{WearPadThickness}) \sin(\text{theta}/2), 2 * R_m)$$

$$= \min(2(1200.0/2 + 10.0 + 10.0) \sin(60.0/2), 2 * 606.5)$$

$$= 1073.872 \text{ mm.}$$

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0455	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	K6p = 0.0347
K7p = 0.0298			

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to $R_m / 2$.

Moment per Equation 4.15.3 [M1]:

$$= -Q * a [1 - (1 - a/L + (R_m^2 - h^2) / (2a * L)) / (1 + (4h^2) / (3L))]$$

$$= -204290 * 550.0 [1 - (1 - 550.0/6250.0 + (606.5^2 - 0.0^2) / (2 * 550.0 * 6250.0)) / (1 + (4 * 0.0) / (3 * 6250.0))]$$

$$= -3877.5 \text{ N-m}$$

Moment per Equation 4.15.4 [M2]:

$$= Q * L / 4 (1 + 2 (R_m^2 - h^2) / (L^2)) / (1 + (4h^2) / (3L)) - 4a/L$$

$$= 204290 * 6250 / 4 (1 + 2 (607^2 - 0^2) / (6250^2)) / (1 + (4 * 0) / (3 * 6250)) - 4 * 550 / 6250$$

$$= 212941.8 \text{ N-m}$$

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

$$= P * R_m / (2t) - M2 / (pi * R_m^2 * t)$$

$$= 4.135 * 606.5 / (2 * 7.0) - 212941.8 / (pi * 606.5^2 * 7.0)$$

$$= -8.40 \text{ N./mm}^2$$

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

$$= P * R_m / (2t) + M2 / (pi * R_m^2 * t)$$

$$= 4.135 * 606.5 / (2 * 7.0) + 212941.8 / (pi * 606.5^2 * 7.0)$$

$$= 44.23 \text{ N./mm}^2$$

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

$$= P * R_m / (2t) - M1 / (K1 * pi * R_m^2 * t)$$

$$= 4.135 * 606.5 / (2 * 7.0) - 3877.5 / (0.1066 * pi * 606.5^2 * 7.0)$$

$$= 22.41 \text{ N./mm}^2$$

 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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	پروژه		بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

$$= P * R_m / (2t) + M1 / (K1 * \pi * R_m^2 * t)$$

$$= 4.135 * 606.5 / (2 * 7.0) + 3877.5 / (0.1923 * \pi * 606.5^2 * 7.0)$$

$$= 15.42 \text{ N./mm}^2$$

Maximum Shear Force in the Saddle (4.15.5) [T]:

$$= Q(L-2a) / (L + (4 * h^2 / 3))$$

$$= 204290 (6250.0 - 2 * 550.0) / (6250.0 + (4 * 0.0 / 3))$$

$$= 168335.1 \text{ N}$$

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

$$= K2 * T / (R_m * t)$$

$$= 1.1707 * 168335.11 / (606.5 * 7.0)$$

$$= 46.42 \text{ N./mm}^2$$

Decay Length (4.15.22) [x1,x2]:

$$= 0.78 * \sqrt{R_m * t}$$

$$= 0.78 * \sqrt{606.5 * 7.0}$$

$$= 50.823 \text{ mm.}$$

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:

$$= -K5 * Q * k / (t * (b + X1 + X2))$$

$$= -0.7603 * 204290 * 0.1 / (7.0 * (150.0 + 50.82 + 50.82))$$

$$= -8.82 \text{ N./mm}^2$$

Effective reinforcing plate width (4.15.1) [B1]:

$$= \min(b + 1.56 * \sqrt{R_m * t}, 2a)$$

$$= \min(150.0 + 1.56 * \sqrt{606.5 * 7.0}, 2 * 550.0)$$

$$= 251.65 \text{ mm.}$$

Wear Plate/Shell Stress ratio (4.15.29) [eta]:

$$= \min(S_r / S, 1)$$

$$= \min(137.9 / 137.9, 1)$$

$$= 1.0000$$

Circumferential Stress at Saddle Base with Wear Plate (4.15.26) [sigma6,r]:

$$= -K5 * Q * k / (B1(t + \eta * t_r))$$

$$= -0.7603 * 204290 * 0.1 / (251.646(7.0 + 1.0 * 10.0))$$

$$= -3.63 \text{ N./mm}^2$$

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.27) [sigma7,r]:

$$= -Q / (4(t + \eta * t_r) b1) - 3 * K7 * Q / (2(t + \eta * t_r)^2)$$

$$= -204290 / (4(7.0 + 1.0 * 10.0) 251.646) -$$

$$3 * 0.045 * 204290 / (2(7.0 + 1.0 * 10.0)^2)$$

$$= -60.15 \text{ N./mm}^2$$

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	1200.0000	mm.
Baseplate Thickness	Bpthk	15.0000	mm.
Baseplate Width	Bpwid	170.0000	mm.
Number of Ribs (inc. outside ribs)	Nribs	4	
Rib Thickness	Ribtk	15.0000	mm.
Web Thickness	Webtk	15.0000	mm.
Web Location	Webloc	Center	

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Saddle Yield Stress S_y 239.9 N./
Height of Web at Center H_w, c 585.0 mm.
Friction Coefficient μ 0.000

Note: In the tables below I_o is I for the rectangle + Area * Centroid Distance²

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

	B	D	Y	A	AY	I_o
Shell	361.4	7.0	3.5	25.3	8853.1	0.157E+05
Wearplate	260.0	10.0	12.0	26.0	31200.0	0.151E+05
Web	15.0	565.0	299.5	84.8	2538262.8	0.244E+05
BasePlate	170.0	15.0	589.5	25.5	1503225.0	0.289E+05
Totals	...	...	...	161.5	4081541.2	0.841E+05

Distance to Centroid [C1]:

$$= AY / A$$

$$= 1606.906/161.545$$

$$= 252.657 \text{ mm.}$$

Angle [beta]:

$$= 180 - \text{Saddle Angle}/2$$

$$= 180 - 120.0/2$$

$$= 120.0$$

Saddle Splitting Coefficient [K1]:

$$= (1 + \cos(\beta) - 0.5 \sin^2(\beta)) / (\pi - \beta + \sin(\beta) \cos(\beta))$$

$$= (1 + \cos(120.0) - 0.5 \sin^2(120.0)) / (\pi - 2.094 + \sin(120.0) \cos(120.0))$$

$$= 0.2035$$

Saddle Splitting Force [Fh]:

$$= K1 * Q$$

$$= 0.204 * 204290.188$$

$$= 41577.4844 \text{ N}$$

Tension Stress, $St = (F_h / A_s) = 3.0518 \text{ N./mm}^2$
Allowed Stress, $Sa = 0.6 * \text{Yield Str} = 143.9676 \text{ N./mm}^2$

Saddle Splitting Dimension [d]:

$$= B - R * \sin(\theta/2) / (\theta/2 \text{ in radians})$$

$$= 1200.0 - 603.0 * \sin(120.0/2) / 1.0472$$

$$= 701.323 \text{ mm.}$$

Bending Moment, $M = F_h * d = 29171.0645 \text{ N-m}$

Bending Stress, $S_b = (M * C1 / I) = 8.7602 \text{ N./mm}^2$
Allowed Stress, $Sa = 2/3 * \text{Yield Str} = 159.9640 \text{ N./mm}^2$

Minimum Thickness of Baseplate per Moss:

$$= (3(Q + \text{Saddle\_Wt}) \text{BasePlateWidth} / (4 * \text{BasePlateLength} * \text{AllStress}))^{1/2}$$

$$= (3(204290 + 2138)170.0 / (4 * 1200.0 * 159.964))^{1/2}$$

$$= 11.710 \text{ mm.}$$

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	BK	GCS	MF	120	ME	CN	0009	V01

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:

$$\begin{aligned}
 &= 2 * \cos(90 - \text{Saddle Angle}/2) (\text{Inside Radius} + \text{Shell Thk} + \text{Wear Plate Thk}) \\
 &= 2 * \cos(90 - 120.0/2) (600.0 + 10.0 + 10.0) \\
 &= 1073.872 \text{ mm.}
 \end{aligned}$$

Distance between Ribs [e]:

$$\begin{aligned}
 &= \text{Web Length} / (\text{Nr ribs} - 1) \\
 &= 1073.8716 / (4 - 1) \\
 &= 357.957 \text{ mm.}
 \end{aligned}$$

Baseplate Pressure Area [Ap]:

$$\begin{aligned}
 &= e * \text{Bpwid} / 2 \\
 &= 357.9572 * 170.0/2 \\
 &= 304.264 \text{ cm}^2
 \end{aligned}$$

Bearing Pressure [Bp]:

$$\begin{aligned}
 &= Q / (\text{BasePlateLength} * \text{BasePlateWidth}) \\
 &= 204290.172 / (1200.0 * 170.0) \\
 &= 100.142 \text{ N/cm}^2
 \end{aligned}$$

Axial Load [P]:

$$\begin{aligned}
 &= \text{Ap} * \text{Bp} \\
 &= 304.3 * 100.14 \\
 &= 30469.643 \text{ N}
 \end{aligned}$$

Area of the Rib and Web [Ar]:

$$\begin{aligned}
 &= \text{Rib Area} + \text{Web Area} \\
 &= 20.25 + 26.847 \\
 &= 47.097 \text{ cm}^2
 \end{aligned}$$

Compressive Stress [Sc]:

$$\begin{aligned}
 &= P/\text{Ar} \\
 &= 30469.6/47.0968 \\
 &= 6.470 \text{ N./mm}^2
 \end{aligned}$$

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	I _o
-----	-----	-----	-----	-----	-----	-----
Rib+Web	15.0	150.0	...	22.5	...	422.

Rib dimension [D]:

$$\begin{aligned}
 &= \text{Saddle Width} - \text{Web Thickness} \\
 &= 150.0 - 15.0 \\
 &= 135.000 \text{ mm.}
 \end{aligned}$$

Distance to Centroid from Datum [ytot]:

$$\begin{aligned}
 &= \text{AY} / \text{A} \\
 &= 0.0/47.097 \\
 &= 0.000 \text{ mm.}
 \end{aligned}$$

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V01	0009	CN	ME	120	MF	GCS	BK											

Distance to Centroid [C1]:

$$= \text{Saddle Width} / 2$$

$$= 150.0/2$$

$$= 75.000 \text{ mm.}$$

Radius of Gyration [r]:

$$= \sqrt{\text{Total Inertia} / \text{Total Area}}$$

$$= \sqrt{421.9/47.097}$$

$$= 29.929 \text{ mm.}$$

Length of Outer Rib [L]:

$$= \text{Saddle Height} - \cos(\theta/2) (\text{radius} + \text{shlthk} + \text{wpdthk}) - \text{bpthk}$$

$$= 1200.0 - \cos(120.0/2) (600.0 + 10.0 + 10.0) - 15.0$$

$$= 875.000 \text{ mm.}$$

Intermediate Term [Cc]:

$$= \sqrt{2 * \pi^2 * \text{Elastic Modulus} / \text{Yield Stress}}$$

$$= \sqrt{2 * \pi^2 * 0.19994\text{E}+09/239.9}$$

$$= 128.255$$

Slenderness ratio [KL/r]:

$$= KL/r$$

$$= 1 * 875.0/29.929$$

$$= 29.236$$

Bending Moment [Rm]:

$$= F1 / (2 * B_{plen}) * e * L / 2$$

$$= 57508.2 / (2 * 1200.0) * 357.957 * 875.0/2$$

$$= 3754.080 \text{ N-m}$$

Compressive Allowable, $KL/r < Cc$ ($29.2356 < 128.2549$) per AISC E2-1 [Sca]:

$$= (1 - (KL/r)^2 / (2 * Cc^2)) F_y / (5/3 + 3 * (KL/r) / (8 * Cc) - (KL/r)^3 / (8 * Cc^3))$$

$$= (1 - (29.24)^2 / (2 * 128.25^2)) 240 /$$

$$(5/3 + 3 * (29.24) / (8 * 128.25) - (29.24)^3 / (8 * 128.25^3))$$

$$= 133.5 \text{ N./mm}^2$$

AISC Unity Check of Outside Ribs (must be ≤ 1)

$$= Sc/Sca + (Rm * C1 / I) / Sba$$

$$= 6.47/133.5 + (3754.08 * 75.0/4218750) / 159.96$$

$$= 0.466$$

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	15.0	135.0	0.0	20.2	0.0	421.
Web	358.0	15.0	0.0	53.7	0.0	10.1
Totals	...	...	...	73.9	...	432.

Distance to Centroid from Datum [ytot]:

$$= AY / A$$

$$= 0.0/73.944$$

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$$= 0.000 \text{ mm.}$$

Distance to Centroid [C1]:

$$= \text{Saddle Width} / 2$$

$$= 150.0/2$$

$$= 75.000 \text{ mm.}$$

Length of Inner Rib [L]:

$$= \text{Saddle Height} - \sqrt{(\text{Ro} + \text{Wpdthk})^2 - (\text{Pitch}/2)^2} - \text{Bpthk}$$

$$= 1200.0 - \sqrt{(620.0 + 10.0)^2 - (357.957/2)^2} - 15.0$$

$$= 591.395 \text{ mm.}$$

Radius of Gyration [r]:

$$= \sqrt{\text{Total Inertia} / \text{Total Area}}$$

$$= \sqrt{431.5/73.944}$$

$$= 24.157 \text{ mm.}$$

Slenderness ratio [KL/r]:

$$= \text{KL}/r$$

$$= 1 * 591.395/24.157$$

$$= 24.481$$

Unit Force [Force,u]:

$$= \text{F}_1 / (2 * \text{Baseplate Length})$$

$$= 57508.184 / (2 * 1200.0)$$

$$= 23.962 \text{ N/mm.}$$

Moment at base of inner Rib [Mbase,c]:

$$= \text{Unit Force} * e * L$$

$$= 23.962 * 357.957 * 591.395$$

$$= 5074.617 \text{ N-m}$$

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:

$$= \text{Bending Moment} / \text{Section Modulus}$$

$$= 5074.617/57536.086$$

$$= 88.171 \text{ N./mm}^2$$

Compressive Allowable, $\text{KL}/r < \text{Cc}$ ($24.4809 < 128.2549$) per AISC E2-1 [Sca]:

$$= (1 - (\text{KL}/r)^2 / (2 * \text{Cc}^2)) \text{Fy} / (5/3 + 3 * (\text{KL}/r) / (8 * \text{Cc}) - (\text{KL}/r)^3 / (8 * \text{Cc}^3))$$

$$= (1 - (24.48)^2 / (2 * 128.25^2)) 240 / (5/3 + 3 * (24.48) / (8 * 128.25) - (24.48^3) / (8 * 128.25^3))$$

$$= 135.6 \text{ N./mm}^2$$

AISC Unity Check of Inside Ribs (must be ≤ 1)

$$= \text{Sc}/\text{Sca} + (\text{Mbase,c} * \text{C1}/\text{I})/\text{Sba}$$

$$= 8.33/135.59 + (5074.62 * 75.0/431.52)/159.96$$

$$= 0.613$$

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	4	
Total Number of Bolts in Tension/Baseplate	Nbt	2	
Bolt Material Specification		SA-325	
Bolt Allowable Stress	Stba	300.00	N./mm ²
Bolt Corrosion Allowance	Bca	0.0	mm.

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	BK	GCS	MF	120	ME	CN	0009	
							V01	

Distance from Bolts to Edge	Edgedis	150.0	mm.
Nominal Bolt Diameter	Bnd	20.0000	mm.
Thread Series	Series	TEMA Metric	
BasePlate Allowable Stress	S	95.15	N./mm ²
Area Available in a Single Bolt	BltArea	2.1705	cm ²
Saddle Load QO (Weight)	QO	110034.0	N
Saddle Load QL (Wind/Seismic contribution)	QL	13802.0	N
Maximum Transverse Force	Ft	28754.1	N
Maximum Longitudinal Force	F1	57508.2	N
Saddle Bolted to Steel Foundation		Yes	

Shear Stress in a Single Bolt, Transverse Direction [taub,t]:

$$= F_t / (\text{Bolt Area} * \text{Number of Bolts})$$

$$= 28754 / (2.17 * 4)$$

$$= 33.1 \text{ N./mm}^2. \text{ Must be less than } 180.0 \text{ N./mm}^2.$$

Bolt Area Calculation per Dennis R. Moss

Bolt Area Requirement Due to Longitudinal Load [Bltarearl]:

$$= 0.0 \text{ (} QO > QL \text{ --> No Uplift in Longitudinal direction)}$$

Bolt Area due to Shear Load [Bltarears]:

$$= F_1 / (\text{BoltShearAllowable} * \text{Nbolts})$$

$$= 57508.18 / (180.0 * 4.0)$$

$$= 0.7988 \text{ cm}^2$$

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:

$$= B * F_t + \text{Sum of X Moments}$$

$$= 1200.0 * 28754.09 + 0.0$$

$$= 34518.90 \text{ N-m}$$

Eccentricity (e):

$$= R_{mom} / QO$$

$$= 34518.9 / 110033.99$$

$$= 313.58 \text{ mm.} > B_{plen}/6 \text{ --> Uplift in Transverse direction}$$

$$f = B_{plen} / 2 - Edgedis$$

$$= 1200.0/2 - 150.01$$

$$= 449.99 \text{ mm.}$$

$$K1 = 3 (e - 0.5 * B_{plen})$$

$$= 3 (313.58 - 0.5*1200.0)$$

$$= -859.25 \text{ mm.}$$

$$K2 = 6 * n1 * A_t / B_{pwid} * (f + e)$$

$$= 6 * 1.0 * 4.34/170.0 * (449.99 + 313.58)$$

$$= 11698.88 \text{ mm.}^2$$

$$K3 = -K2 * (0.5 * B_{plen} + f)$$

$$= -11698.88 * (0.5 * 1200.0 + 449.99)$$

$$= -12283681.87 \text{ mm.}^3$$

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Iteratively Solving for the Effective Bearing Length:

$$Y^3 + K1 * Y^2 + K2 * Y + K3 = 0$$

$$Y^3 + -859.25 * Y^2 + 11698.88 * Y + -0.1E+08 = 0$$

$$Y = 862.20 \text{ mm.}$$

$$\text{Num} = (\text{Bplen} / 2 - Y / 3 - e)$$

$$= (1200.0/2 - 862.2/3 - 313.58)$$

$$= -0.99$$

$$\text{Denom} = (\text{Bplen} / 2 - Y / 3 + f)$$

$$= (1200.0/2 - 862.2/3 + 449.99)$$

$$= 762.59$$

Total Bolt Tension Force [Tforce]:

$$= - QO * \text{Num} / \text{Denom}$$

$$= - 110033.99 * -0.99/762.59$$

$$= 142.14 \text{ N}$$

Bolt Area Required due to Transverse Load [Bltareart]:

$$= \text{Tforce} / (\text{Stba} * \text{Nbt})$$

$$= 142.14 / (300.0 * 2.0)$$

$$= 0.0024 \text{ cm}^2$$

Required Area of a Single Bolt [Bltarear]:

$$= \max[\text{Bltarearl}, \text{Bltarears}, \text{Bltareart}]$$

$$= \max[0.0, 0.7988, 0.0024]$$

$$= 0.7988 \text{ cm}^2$$

Baseplate Thickness Calculation per D. Moss:

Bearing Pressure (fc)

$$= 2(QO + \text{Tforce}) / (Y * \text{Bpwid})$$

$$= 2(110033.99 + 142.14) / (862.2 * 170.0)$$

$$= 15.03 \text{ bars}$$

Distance from Baseplate Edge to the Web [ADIST]:

$$= (\text{Bplen} - \text{Weblength}) / 2$$

$$= (1200.0 - 1149.2) / 2$$

$$= 25.4000 \text{ mm.}$$

Overturning Moment due To Bolt Tension [Mt]:

$$= \text{Tforce} * \text{Adist}$$

$$= 142.14 * 25.4$$

$$= 3.61 \text{ N-m}$$

Equivalent Bearing Pressure (f1):

$$= fc * (Y - \text{Adist}) / Y$$

$$= 15.03 * (862.2 - 25.4) / 862.2$$

$$= 14.59 \text{ bars}$$

Overturning Moment due to Bearing Pressure [Mc]:

$$= (\text{Adist}^2 * \text{Bpwid} / 6) * (f1 + 2 * fc)$$

$$= (25.4^2 * 170.0/6) * (14.59 + 2 * 15.03)$$

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$$= 81.66 \text{ N-m}$$

Baseplate Required Thickness [Treq]:

$$= (6 * \max(Mt, Mc) / (Bpwid * Sba))^{1/2}$$

$$= (6 * \max(3.61, 81.66 / (170.0 * 142.73))^{1/2}$$

$$= 4.4931 \text{ mm.}$$

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	BK	GCS	MF	120	ME	CN	0009		V01

ASME Horizontal Vessel Analysis: Stresses for the Left Saddle

(per ASME Sec. VIII Div. 2 based on the Zick method.)

Horizontal Vessel Stress Calculations : Test Case

Input and Calculated Values:

Vessel Mean Radius	Rm	606.50	mm.
Stiffened Vessel Length per 4.15.6	L	6250.00	mm.
Distance from Saddle to Vessel tangent	a	650.00	mm.
Saddle Width	b	150.00	mm.
Saddle Bearing Angle	theta	120.00	degrees
Wear Plate Width	b1	260.00	mm.
Wear Plate Bearing Angle	theta1	145.00	degrees
Wear Plate Thickness	tr	10.0	mm.
Wear Plate Allowable Stress	Sr	137.90	N./mm ²
Inside Depth of Head	h2	303.00	mm.
Shell Allowable Stress used in Calculation		196.74	N./mm ²
Head Allowable Stress used in Calculation		196.74	N./mm ²
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	1200.00	mm.
Coefficient of Friction	mu	0.30	
Saddle Force Q, Test Case, no Ext. Forces		74205.38	N

Horizontal Vessel Analysis Results:	Actual	Allowable
	N./mm ²	N./mm ²
-----	-----	-----
Long. Stress at Top of Midspan	15.66	196.74
Long. Stress at Bottom of Midspan	31.04	196.74
Long. Stress at Top of Saddles	30.42	196.74
Long. Stress at Bottom of Saddles	19.43	196.74
-----	-----	-----
Tangential Shear in Shell	15.22	139.65
Circ. Stress at Horn of Saddle	24.69	295.11
Circ. Compressive Stress in Shell	3.20	196.74
-----	-----	-----

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Saddle Reaction Force due to Wind Ft [Fwt]:

$$= F_{tr} (F_t / \text{Num of Saddles} + Z \text{ Force Load}) * B / E$$

$$= 3.0 (3482.2/2 + 0) * 1200.0/1073.8717$$

$$= 5836.7 \text{ N}$$

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

$$= \max (F_l, \text{Friction Load, Sum of X Forces}) * B / L_s$$

$$= \max (1395.62, 0.0, 0) * 1200.0/5000.0005$$

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$$= 334.9 \text{ N}$$

Load Combination Results for Q + Wind or Seismic [Q]:

$$= \text{Saddle Load} + \max(\text{Fwl}, \text{Fwt}, \text{Fsl}, \text{Fst})$$

$$= 68369 + \max(335, 5837, 0, 0)$$

$$= 74205.4 \text{ N}$$

Longitudinal Wind Force [F]:

$$= \text{WindScalar} * \text{WindPress}(\text{Platform Area} + (\text{End Area} * \text{WindDiaMult}))$$

$$= 0.6 * 2054.32(1.584 + (1.539 * 1.2))$$

$$= 4229.371 \text{ N}$$

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	76343.12	N
Transverse Shear Load Saddle	1741.08	N
Longitudinal Shear Load Saddle	1395.62	N

Hydrostatic Test Pressure at center of Vessel 5.389 bars

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, $k = 0.1$

Saddle Dimension [E]:

$$= \min(2(\text{ShellID}/2 + t + \text{WearPadThickness})\sin(\text{theta}/2), 2*R_m)$$

$$= \min(2(1200.0/2 + 10.0 + 10.0)\sin(60.0/2), 2*606.5)$$

$$= 1073.872 \text{ mm.}$$

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0529	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	K6p = 0.0347
K7p = 0.0347			

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to $R_m / 2$.

Moment per Equation 4.15.3 [M1]:

$$= -Q*a[1 - (1 - a/L + (R_m^2 - h^2)/(2a*L))/(1 + (4h^2)/(3L))]$$

$$= -74205*650.0[1 - (1 - 650.0/6250.0 + (606.5^2 - 303.0^2)/(2*650.0*6250.0))/(1 + (4*303.0)/(3*6250.0))]$$

$$= -6103.5 \text{ N-m}$$

Moment per Equation 4.15.4 [M2]:

$$= Q*L/4(1 + 2(R_m^2 - h^2)/(L^2))/(1 + (4h^2)/(3L)) - 4a/L$$

$$= 74205*6250/4(1 + 2(607^2 - 303^2)/(6250^2))/(1 + (4*303)/(3*6250)) - 4*650/6250$$

$$= 62237.1 \text{ N-m}$$

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

$$= P * R_m/(2t) - M2/(pi*R_m^2*t)$$

$$= 5.389 * 606.5/(2*7.0) - 62237.1/(pi*606.5^2*7.0)$$

$$= 15.66 \text{ N./mm}^2$$

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Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

$$= P * R_m / (2t) + M_2 / (\pi * R_m^2 * t)$$

$$= 5.389 * 606.5 / (2 * 7.0) + 62237.1 / (\pi * 606.5^2 * 7.0)$$

$$= 31.04 \text{ N./mm}^2$$

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

$$= P * R_m / (2t) - M_1 / (K_1 * \pi * R_m^2 * t)$$

$$= 5.389 * 606.5 / (2 * 7.0) - 6103.5 / (0.1066 * \pi * 606.5^2 * 7.0)$$

$$= 30.42 \text{ N./mm}^2$$

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

$$= P * R_m / (2t) + M_1 / (K_1 * \pi * R_m^2 * t)$$

$$= 5.389 * 606.5 / (2 * 7.0) + 6103.5 / (0.1923 * \pi * 606.5^2 * 7.0)$$

$$= 19.43 \text{ N./mm}^2$$

Maximum Shear Force in the Saddle (4.15.5) [T]:

$$= Q(L-2a) / (L + (4 * h^2 / 3))$$

$$= 74205(6250.0 - 2 * 650.0) / (6250.0 + (4 * 303.0 / 3))$$

$$= 55202.4 \text{ N}$$

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

$$= K_2 * T / (\pi * R_m * t)$$

$$= 1.1707 * 55202.38 / (\pi * 606.5 * 7.0)$$

$$= 15.22 \text{ N./mm}^2$$

Decay Length (4.15.22) [x1,x2]:

$$= 0.78 * \sqrt{R_m * t}$$

$$= 0.78 * \sqrt{606.5 * 7.0}$$

$$= 50.823 \text{ mm.}$$

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:

$$= -K_5 * Q * k / (t * (b + X_1 + X_2))$$

$$= -0.7603 * 74205 * 0.1 / (7.0 * (150.0 + 50.82 + 50.82))$$

$$= -3.20 \text{ N./mm}^2$$

Effective reinforcing plate width (4.15.1) [B1]:

$$= \min(b + 1.56 * \sqrt{R_m * t}, 2a)$$

$$= \min(150.0 + 1.56 * \sqrt{606.5 * 7.0}, 2 * 650.0)$$

$$= 251.65 \text{ mm.}$$

Wear Plate/Shell Stress ratio (4.15.29) [eta]:

$$= 1.0000 \text{ Materials are the same, test case}$$

Circumferential Stress at Saddle Base with Wear Plate (4.15.26) [sigma6,r]:

$$= -K_5 * Q * k / (B_1(t + \eta * t_r))$$

$$= -0.7603 * 74205 * 0.1 / (251.646(7.0 + 1.0 * 10.0))$$

$$= -1.32 \text{ N./mm}^2$$

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.27) [sigma7,r]:

$$= -Q / (4(t + \eta * t_r) b_1) - 3 * K_7 * Q / (2(t + \eta * t_r)^2)$$

$$= -74205 / (4(7.0 + 1.0 * 10.0) 251.646) -$$

$$3 * 0.053 * 74205 / (2(7.0 + 1.0 * 10.0)^2)$$

$$= -24.69 \text{ N./mm}^2$$

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Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	1200.0000	mm.
Baseplate Thickness	Bpthk	15.0000	mm.
Baseplate Width	Bpwid	170.0000	mm.
Number of Ribs (inc. outside ribs)	Nribs	4	
Rib Thickness	Ribtk	15.0000	mm.
Web Thickness	Webtk	15.0000	mm.
Web Location	Webloc	Center	
Saddle Yield Stress	Sy	239.9	N./
Height of Web at Center	Hw, c	585.0	mm.
Friction Coefficient	mu	0.300	

Note: In the tables below Io is I for the rectangle + Area * Centroid Distance^2

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

	B	D	Y	A	AY	Io
Shell	361.4	7.0	3.5	25.3	8853.1	0.157E+05
Wearplate	260.0	10.0	12.0	26.0	31200.0	0.151E+05
Web	15.0	565.0	299.5	84.8	2538262.8	0.244E+05
BasePlate	170.0	15.0	589.5	25.5	1503225.0	0.289E+05
Totals	...	...	...	161.5	4081541.2	0.841E+05

Distance to Centroid [C1]:

$$= AY / A$$

$$= 1606.906/161.545$$

$$= 252.657 \text{ mm.}$$

Angle [beta]:

$$= 180 - \text{Saddle Angle}/2$$

$$= 180 - 120.0/2$$

$$= 120.0$$

Saddle Splitting Coefficient [K1]:

$$= (1 + \cos(\beta) - 0.5 \cdot \sin(\beta)^2) / (\pi - \beta + \sin(\beta) \cos(\beta))$$

$$= (1 + \cos(120.0) - 0.5 \cdot \sin(120.0)^2) / (\pi - 2.094 + \sin(120.0) \cos(120.0))$$

$$= 0.2035$$

Saddle Splitting Force [Fh]:

$$= K1 \cdot Q$$

$$= 0.204 \cdot 74205.375$$

$$= 15102.4033 \text{ N}$$

$$\text{Tension Stress, } St = (Fh/As) = 1.1085 \text{ N./mm}^2$$

$$\text{Allowed Stress, } Sa = 0.6 \cdot \text{Yield Str} = 143.9676 \text{ N./mm}^2$$

Saddle Splitting Dimension [d]:

$$= B - R \cdot \sin(\theta/2) / (\theta/2 \text{ in radians})$$

$$= 1200.0 - 603.0 \cdot \sin(120.0/2) / 1.0472$$

$$= 701.323 \text{ mm.}$$

$$\text{Bending Moment, } M = Fh \cdot d = 10595.9561 \text{ N-m}$$

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$$\text{Bending Stress, } S_b = (M * C_1 / I) = 3.1820 \text{ N./mm}^2$$

$$\text{Allowed Stress, } S_a = 2/3 * \text{Yield Str} = 159.9640 \text{ N./mm}^2$$

Minimum Thickness of Baseplate per Moss:

$$= (3 (Q + \text{Saddle\_Wt}) \text{BasePlateWidth} / (4 * \text{BasePlateLength} * \text{AllStress}))^{1/2}$$

$$= (3 (74205 + 2138) 170.0 / (4 * 1200.0 * 159.964))^{1/2}$$

$$= 7.121 \text{ mm.}$$

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:

$$= 2 * \cos(90 - \text{Saddle Angle}/2) (\text{Inside Radius} + \text{Shell Thk} + \text{Wear Plate Thk})$$

$$= 2 * \cos(90 - 120.0/2) (600.0 + 10.0 + 10.0)$$

$$= 1073.872 \text{ mm.}$$

Distance between Ribs [e]:

$$= \text{Web Length} / (\text{Nr ribs} - 1)$$

$$= 1073.8716 / (4 - 1)$$

$$= 357.957 \text{ mm.}$$

Baseplate Pressure Area [Ap]:

$$= e * \text{Bpwid} / 2$$

$$= 357.9572 * 170.0/2$$

$$= 304.264 \text{ cm}^2$$

Bearing Pressure [Bp]:

$$= Q / (\text{BasePlateLength} * \text{BasePlateWidth})$$

$$= 74205.375 / (1200.0 * 170.0)$$

$$= 36.375 \text{ N/cm}^2$$

Axial Load [P]:

$$= A_p * B_p$$

$$= 304.3 * 36.38$$

$$= 11067.645 \text{ N}$$

Area of the Rib and Web [Ar]:

$$= \text{Rib Area} + \text{Web Area}$$

$$= 20.25 + 26.847$$

$$= 47.097 \text{ cm}^2$$

Compressive Stress [Sc]:

$$= P / A_r$$

$$= 11067.6 / 47.0968$$

$$= 2.350 \text{ N./mm}^2$$

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
-----	-----	-----	-----	-----	-----	-----
Rib+Web	15.0	150.0	...	22.5	...	422.

Rib dimension [D]:

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= Saddle Width - Web Thickness
= 150.0 - 15.0
= 135.000 mm.

Distance to Centroid from Datum [ytot]:

= AY / A
= 0.0/47.097
= 0.000 mm.

Distance to Centroid [C1]:

= Saddle Width / 2
= 150.0/2
= 75.000 mm.

Radius of Gyration [r]:

= sqrt(Total Inertia / Total Area)
= sqrt(421.9/47.097)
= 29.929 mm.

Length of Outer Rib [L]:

= Saddle Height - cos(theta/2) (radius + shlthk + wpdthk) - bpthk
= 1200.0 - cos(120.0/2) (600.0 + 10.0 + 10.0) - 15.0
= 875.000 mm.

Intermediate Term [Cc]:

= sqrt(2 * pi² * Elastic Modulus / Yield Stress)
= sqrt(2 * pi² * 0.19994E+09/239.9)
= 128.255

Slenderness ratio [KL/r]:

= KL/r
= 1 * 875.0/29.929
= 29.236

Bending Moment [Rm]:

= Fl / (2 * Bplen) * e * L / 2
= 1395.6 / (2 * 1200.0) * 357.957 * 875.0/2
= 91.105 N-m

Compressive Allowable, KL/r < Cc (29.2356 < 128.2549) per AISC E2-1 [Sca]:

= (1 - (KLr)² / (2 * Cc²)) Fy / (5/3 + 3 * (KLr) / (8 * Cc) - (KLr³) / (8 * Cc³))
= (1 - (29.24)² / (2 * 128.25²)) 240 /
(5/3 + 3 * (29.24) / (8 * 128.25) - (29.24³) / (8 * 128.25³))
= 133.5 N./mm²

AISC Unity Check of Outside Ribs (must be <= 1)

= Sc/Sca + (Rm * C1 / I) / Sba
= 2.35/133.5 + (91.1 * 75.0/4218750) / 159.96
= 0.028

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

B | D | Y | A | AY | Io |

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Rib	15.0		135.0		0.0		20.2		0.0		421.	
Web	358.0		15.0		0.0		53.7		0.0		10.1	
Totals	...		...		...		73.9		...		432.	

Distance to Centroid from Datum [ytot]:

$$= AY / A$$

$$= 0.0/73.944$$

$$= 0.000 \text{ mm.}$$

Distance to Centroid [C1]:

$$= \text{Saddle Width} / 2$$

$$= 150.0/2$$

$$= 75.000 \text{ mm.}$$

Length of Inner Rib [L]:

$$= \text{Saddle Height} - \sqrt{(\text{Ro} + \text{Wpdthk})^2 - (\text{Pitch}/2)^2} - \text{Bpthk}$$

$$= 1200.0 - \sqrt{(620.0 + 10.0)^2 - (357.957/2)^2} - 15.0$$

$$= 591.395 \text{ mm.}$$

Radius of Gyration [r]:

$$= \sqrt{\text{Total Inertia} / \text{Total Area}}$$

$$= \sqrt{431.5/73.944}$$

$$= 24.157 \text{ mm.}$$

Slenderness ratio [KL/r]:

$$= KL/r$$

$$= 1 * 591.395/24.157$$

$$= 24.481$$

Unit Force [Force,u]:

$$= F1 / (2 * \text{Baseplate Length})$$

$$= 1395.62/(2 * 1200.0)$$

$$= 0.582 \text{ N/mm.}$$

Moment at base of inner Rib [Mbase,c]:

$$= \text{Unit Force} * e * L$$

$$= 0.582 * 357.957 * 591.395$$

$$= 123.152 \text{ N-m}$$

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:

$$= \text{Bending Moment} / \text{Section Modulus}$$

$$= 123.152/57536.086$$

$$= 2.140 \text{ N./mm}^2$$

Compressive Allowable, $KL/r < Cc$ ($24.4809 < 128.2549$) per AISC E2-1 [Sca]:

$$= (1 - (KL/r)^2 / (2 * Cc^2)) Fy / (5/3 + 3 * (KL/r) / (8 * Cc) - (KL/r^3) / (8 * Cc^3))$$

$$= (1 - (24.48)^2 / (2 * 128.25^2)) 240 / (5/3 + 3 * (24.48) / (8 * 128.25) - (24.48^3) / (8 * 128.25^3))$$

$$= 135.6 \text{ N./mm}^2$$

AISC Unity Check of Inside Ribs (must be ≤ 1)

$$= Sc/Sca + (Mbase,c * C1/I) / Sba$$

$$= 3.03/135.59 + (123.15 * 75.0/431.52) / 159.96$$

$$= 0.036$$

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Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	4	
Total Number of Bolts in Tension/Baseplate	Nbt	2	
Bolt Material Specification		SA-325	
Bolt Allowable Stress	Stba	300.00	N./mm ²
Bolt Corrosion Allowance	Bca	0.0	mm.
Distance from Bolts to Edge	Edgedis	150.0	mm.
Nominal Bolt Diameter	Bnd	20.0000	mm.
Thread Series	Series	TEMA Metric	
BasePlate Allowable Stress	S	95.15	N./mm ²
Area Available in a Single Bolt	BlArea	2.1705	cm ²
Saddle Load QO (Weight)	QO	70506.4	N
Saddle Load QL (Wind/Seismic contribution)	QL	334.9	N
Maximum Transverse Force	Ft	1741.1	N
Maximum Longitudinal Force	Fl	1395.6	N
Saddle Bolted to Steel Foundation		Yes	

Shear Stress in a Single Bolt, Longitudinal Direction [taub,l]:

$$= Fl / (Bolt Area * Number of Bolts)$$

$$= 1396 / (2.17 * 4)$$

$$= 1.6 \text{ N./mm}^2. \text{ Must be less than } 180.0 \text{ N./mm}^2.$$

Shear Stress in a Single Bolt, Transverse Direction [taub,t]:

$$= Ft / (Bolt Area * Number of Bolts)$$

$$= 1741 / (2.17 * 4)$$

$$= 2.0 \text{ N./mm}^2. \text{ Must be less than } 180.0 \text{ N./mm}^2.$$

Bolt Area Calculation per Dennis R. Moss

Bolt Area Requirement Due to Longitudinal Load [Bltarearl]:

$$= 0.0 \text{ (} QO > QL \text{ --> No Uplift in Longitudinal direction)}$$

Bolt Area due to Shear Load [Bltarears]:

$$= Fl / (BoltShearAllowable * Nbolts)$$

$$= 1395.62 / (180.0 * 4.0)$$

$$= 0.0194 \text{ cm}^2$$

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:

$$= B * Ft + \text{Sum of X Moments}$$

$$= 1200.0 * 1741.08 + 0.0$$

$$= 2090.15 \text{ N-m}$$

Eccentricity (e):

$$= Rmom / QO$$

$$= 2090.15 / 70506.39$$

$$= 29.63 \text{ mm.} < Bplen/6 \text{ --> No Uplift in Transverse direction}$$

Bolt Area due to Transverse Load [Bltareart]:

$$= 0 \text{ (No Uplift)}$$

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Required Area of a Single Bolt [Bltarear]:

$$\begin{aligned}
 &= \max[\text{Bltarearl}, \text{Bltarears}, \text{Bltareart}] \\
 &= \max[0.0, 0.0194, 0.0] \\
 &= 0.0194 \text{ cm}^2
 \end{aligned}$$

ASME Horizontal Vessel Analysis: Stresses for the Right Saddle (per ASME Sec. VIII Div. 2 based on the Zick method.)

Input and Calculated Values:

Vessel Mean Radius	Rm	606.50	mm.
Stiffened Vessel Length per 4.15.6	L	6250.00	mm.
Distance from Saddle to Vessel tangent	a	550.00	mm.
Saddle Width	b	150.00	mm.
Saddle Bearing Angle	theta	120.00	degrees
Wear Plate Width	b1	260.00	mm.
Wear Plate Bearing Angle	theta1	145.00	degrees
Wear Plate Thickness	tr	10.0	mm.
Wear Plate Allowable Stress	Sr	137.90	N./mm ²
Shell Allowable Stress used in Calculation		196.74	N./mm ²
Head Allowable Stress used in Calculation		196.74	N./mm ²
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	1200.00	mm.
Coefficient of Friction	mu	0.00	
Saddle Force Q, Test Case, no Ext. Forces		99664.73	N
Horizontal Vessel Analysis Results:	Actual Allowable		
	N./mm ² N./mm ²		
Long. Stress at Top of Midspan	10.51	196.74	
Long. Stress at Bottom of Midspan	36.19	196.74	
Long. Stress at Top of Saddles	25.54	196.74	
Long. Stress at Bottom of Saddles	22.13	196.74	
Tangential Shear in Shell	22.65	139.65	
Circ. Stress at Horn of Saddle	29.35	295.11	
Circ. Compressive Stress in Shell	4.30	196.74	

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Saddle Reaction Force due to Wind Ft [Fwt]:

$$\begin{aligned}
 &= F_{tr} (F_t / \text{Num of Saddles} + Z \text{ Force Load}) * B / E \\
 &= 3.0 (3482.2/2 + 0) * 1200.0/1073.8717 \\
 &= 5836.7 \text{ N}
 \end{aligned}$$

Saddle Reaction Force due to Wind FI or Friction [Fwl]:

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V01	0009	CN	ME	120	MF	GCS	BK																			

$= \max(F_l, \text{Friction Load, Sum of X Forces}) * B / L_s$
 $= \max(1395.62, 0.0, 0) * 1200.0/5000.0005$
 $= 334.9 \text{ N}$

Load Combination Results for Q + Wind or Seismic [Q]:

$= \text{Saddle Load} + \max(F_{wl}, F_{wt}, F_{sl}, F_{st})$
 $= 93828 + \max(335, 5837, 0, 0)$
 $= 99664.7 \text{ N}$

Longitudinal Wind Force [F_l]:

$= \text{WindScalar} * \text{WindPress}(\text{Platform Area} + (\text{End Area} * \text{WindDiaMult}))$
 $= 0.6 * 2054.32(1.584 + (1.539 * 1.2))$
 $= 4229.371 \text{ N}$

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	101802.48	N
Transverse Shear Load Saddle	1741.08	N
Longitudinal Shear Load Saddle	1395.62	N

Hydrostatic Test Pressure at center of Vessel 5.389 bars

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, $k = 0.1$

Saddle Dimension [E]:

$= \min(2(\text{ShellID}/2 + t + \text{WearPadThickness}) \sin(\text{theta}/2), 2 * R_m)$
 $= \min(2(1200.0/2 + 10.0 + 10.0) \sin(60.0/2), 2 * 606.5)$
 $= 1073.872 \text{ mm.}$

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0455	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	K6p = 0.0347
K7p = 0.0298			

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to $R_m / 2$.

Moment per Equation 4.15.3 [M1]:

$= -Q * a [1 - (1 - a/L + (R_m^2 - h^2) / (2a * L)) / (1 + (4h^2) / (3L))]$
 $= -99665 * 550.0 [1 - (1 - 550.0/6250.0 + (606.5^2 - 0.0^2) / (2 * 550.0 * 6250.0)) / (1 + (4 * 0.0) / (3 * 6250.0))]$
 $= -1891.7 \text{ N-m}$

Moment per Equation 4.15.4 [M2]:

$= Q * L / 4 (1 + 2 (R_m^2 - h^2) / (L^2)) / (1 + (4h^2) / (3L)) - 4a/L$
 $= 99665 * 6250 / 4 (1 + 2 (607^2 - 0^2) / (6250^2)) / (1 + (4 * 0) / (3 * 6250)) - 4 * 550 / 6250$
 $= 103885.5 \text{ N-m}$

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

$= P * R_m / (2t) - M2 / (\pi i * R_m^2 t)$

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$$= 5.389 * 606.5 / (2 * 7.0) - 103885.5 / (\pi * 606.5^2 * 7.0)$$

$$= 10.51 \text{ N./mm}^2$$

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

$$= P * R_m / (2t) + M2 / (\pi * R_m^2 * t)$$

$$= 5.389 * 606.5 / (2 * 7.0) + 103885.5 / (\pi * 606.5^2 * 7.0)$$

$$= 36.19 \text{ N./mm}^2$$

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

$$= P * R_m / (2t) - M1 / (K1 * \pi * R_m^2 * t)$$

$$= 5.389 * 606.5 / (2 * 7.0) - 1891.7 / (0.1066 * \pi * 606.5^2 * 7.0)$$

$$= 25.54 \text{ N./mm}^2$$

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

$$= P * R_m / (2t) + M1 / (K1 * \pi * R_m^2 * t)$$

$$= 5.389 * 606.5 / (2 * 7.0) + 1891.7 / (0.1923 * \pi * 606.5^2 * 7.0)$$

$$= 22.13 \text{ N./mm}^2$$

Maximum Shear Force in the Saddle (4.15.5) [T]:

$$= Q(L-2a) / (L + (4 * h^2 / 3))$$

$$= 99665(6250.0 - 2 * 550.0) / (6250.0 + (4 * 0.0 / 3))$$

$$= 82123.7 \text{ N}$$

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

$$= K2 * T / (\pi * R_m * t)$$

$$= 1.1707 * 82123.73 / (\pi * 606.5 * 7.0)$$

$$= 22.65 \text{ N./mm}^2$$

Decay Length (4.15.22) [x1,x2]:

$$= 0.78 * \sqrt{R_m * t}$$

$$= 0.78 * \sqrt{606.5 * 7.0}$$

$$= 50.823 \text{ mm.}$$

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:

$$= -K5 * Q * k / (t * (b + X1 + X2))$$

$$= -0.7603 * 99665 * 0.1 / (7.0 * (150.0 + 50.82 + 50.82))$$

$$= -4.30 \text{ N./mm}^2$$

Effective reinforcing plate width (4.15.1) [B1]:

$$= \min(b + 1.56 * \sqrt{R_m * t}, 2a)$$

$$= \min(150.0 + 1.56 * \sqrt{606.5 * 7.0}, 2 * 550.0)$$

$$= 251.65 \text{ mm.}$$

Wear Plate/Shell Stress ratio (4.15.29) [eta]:

$$= 1.0000 \text{ Materials are the same, test case}$$

Circumferential Stress at Saddle Base with Wear Plate (4.15.26) [sigma6,r]:

$$= -K5 * Q * k / (B1(t + \eta * t_r))$$

$$= -0.7603 * 99665 * 0.1 / (251.646(7.0 + 1.0 * 10.0))$$

$$= -1.77 \text{ N./mm}^2$$

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.27) [sigma7,r]:

$$= -Q / (4(t + \eta * t_r) b1) - 3 * K7 * Q / (2(t + \eta * t_r)^2)$$

$$= -99665 / (4(7.0 + 1.0 * 10.0) 251.646) -$$

$$3 * 0.045 * 99665 / (2(7.0 + 1.0 * 10.0)^2)$$

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$$= -29.35 \text{ N./mm}^2$$

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	1200.0000	mm.
Baseplate Thickness	Bpthk	15.0000	mm.
Baseplate Width	Bpwid	170.0000	mm.
Number of Ribs (inc. outside ribs)	Nribs	4	
Rib Thickness	Ribtk	15.0000	mm.
Web Thickness	Webtk	15.0000	mm.
Web Location	Webloc	Center	
Saddle Yield Stress	Sy	239.9	N./
Height of Web at Center	Hw,c	585.0	mm.
Friction Coefficient	mu	0.000	

Note: In the tables below Io is I for the rectangle + Area * Centroid Distance^2

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

	B	D	Y	A	AY	Io
Shell	361.4	7.0	3.5	25.3	8853.1	0.157E+05
Wearplate	260.0	10.0	12.0	26.0	31200.0	0.151E+05
Web	15.0	565.0	299.5	84.8	2538262.8	0.244E+05
BasePlate	170.0	15.0	589.5	25.5	1503225.0	0.289E+05
Totals	...	...	...	161.5	4081541.2	0.841E+05

Distance to Centroid [C1]:

$$= AY / A$$

$$= 1606.906/161.545$$

$$= 252.657 \text{ mm.}$$

Angle [beta]:

$$= 180 - \text{Saddle Angle}/2$$

$$= 180 - 120.0/2$$

$$= 120.0$$

Saddle Splitting Coefficient [K1]:

$$= (1 + \cos(\text{beta}) - 0.5 \cdot \sin(\text{beta})^2) / (\pi - \text{beta} + \sin(\text{beta}) \cos(\text{beta}))$$

$$= (1 + \cos(120.0) - 0.5 \cdot \sin(120.0)^2) / (\pi - 2.094 + \sin(120.0) \cos(120.0))$$

$$= 0.2035$$

Saddle Splitting Force [Fh]:

$$= K1 * Q$$

$$= 0.204 * 99664.734$$

$$= 20283.9355 \text{ N}$$

$$\text{Tension Stress, St} = (Fh/As) = 1.4889 \text{ N./mm}^2$$

$$\text{Allowed Stress, Sa} = 0.6 * \text{Yield Str} = 143.9676 \text{ N./mm}^2$$

Saddle Splitting Dimension [d]:

$$= B - R * \sin(\text{theta}/2) / (\text{theta}/2 \text{ in radians})$$

$$= 1200.0 - 603.0 * \sin(120.0/2) / 1.0472$$

$$= 701.323 \text{ mm.}$$

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$$\text{Bending Moment, } M = F_h * d = 14231.3574 \text{ N-m}$$

$$\text{Bending Stress, } S_b = (M * C_1 / I) = 4.2737 \text{ N./mm}^2$$

$$\text{Allowed Stress, } S_a = 2/3 * \text{Yield Str} = 159.9640 \text{ N./mm}^2$$

Minimum Thickness of Baseplate per Moss:

$$= (3 (Q + \text{Saddle\_Wt}) \text{BasePlateWidth} / (4 * \text{BasePlateLength} * \text{AllStress}))^{1/2}$$

$$= (3 (99665 + 2138) 170.0 / (4 * 1200.0 * 159.964))^{1/2}$$

$$= 8.223 \text{ mm.}$$

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:

$$= 2 * \cos(90 - \text{Saddle Angle}/2) (\text{Inside Radius} + \text{Shell Thk} + \text{Wear Plate Thk})$$

$$= 2 * \cos(90 - 120.0/2) (600.0 + 10.0 + 10.0)$$

$$= 1073.872 \text{ mm.}$$

Distance between Ribs [e]:

$$= \text{Web Length} / (\text{Nribs} - 1)$$

$$= 1073.8716 / (4 - 1)$$

$$= 357.957 \text{ mm.}$$

Baseplate Pressure Area [Ap]:

$$= e * \text{Bpwid} / 2$$

$$= 357.9572 * 170.0/2$$

$$= 304.264 \text{ cm}^2$$

Bearing Pressure [Bp]:

$$= Q / (\text{BasePlateLength} * \text{BasePlateWidth})$$

$$= 99664.727 / (1200.0 * 170.0)$$

$$= 48.855 \text{ N/cm}^2$$

Axial Load [P]:

$$= A_p * B_p$$

$$= 304.3 * 48.86$$

$$= 14864.878 \text{ N}$$

Area of the Rib and Web [Ar]:

$$= \text{Rib Area} + \text{Web Area}$$

$$= 20.25 + 26.847$$

$$= 47.097 \text{ cm}^2$$

Compressive Stress [Sc]:

$$= P / A_r$$

$$= 14864.9 / 47.0968$$

$$= 3.157 \text{ N./mm}^2$$

 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)																									
شماره پیمان: 053 - 073 - 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>پروژه</th><th>بسته کاری</th><th>صادر کننده</th><th>تسهیلات</th><th>رشته</th><th>نوع مدرک</th><th>سریال</th><th>نسخه</th></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0009</td><td>V01</td></tr></table>	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)								پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 111 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه																			
BK	GCS	MF	120	ME	CN	0009	V01																			

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib+Web	15.0	150.0	...	22.5	...	422.

Rib dimension [D]:

= Saddle Width - Web Thickness
= 150.0 - 15.0
= 135.000 mm.

Distance to Centroid from Datum [ytot]:

= AY / A
= 0.0/47.097
= 0.000 mm.

Distance to Centroid [C1]:

= Saddle Width / 2
= 150.0/2
= 75.000 mm.

Radius of Gyration [r]:

= sqrt(Total Inertia / Total Area)
= sqrt(421.9/47.097)
= 29.929 mm.

Length of Outer Rib [L]:

= Saddle Height - cos(theta/2) (radius + shlthk + wpdthk) - bpthk
= 1200.0 - cos(120.0/2) (600.0 + 10.0 + 10.0) - 15.0
= 875.000 mm.

Intermediate Term [Cc]:

= sqrt(2 * pi² * Elastic Modulus / Yield Stress)
= sqrt(2 * pi² * 0.19994E+09/239.9)
= 128.255

Slenderness ratio [KL/r]:

= KL/r
= 1 * 875.0/29.929
= 29.236

Bending Moment [Rm]:

= Fl / (2 * Bplen) * e * L / 2
= 1395.6 / (2 * 1200.0) * 357.957 * 875.0/2
= 91.105 N-m

Compressive Allowable, KL/r < Cc (29.2356 < 128.2549) per AISC E2-1 [Sca]:

= (1 - (KL/r)² / (2*Cc²)) Fy / (5/3 + 3*(KL/r) / (8*Cc) - (KL/r)³ / (8*Cc³))
= (1 - (29.24)² / (2 * 128.25²)) 240 /
(5/3 + 3*(29.24) / (8* 128.25) - (29.24³) / (8*128.25³))
= 133.5 N./mm²

 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	0009	V01

AISC Unity Check of Outside Ribs (must be <= 1)

$$= Sc/Sca + (Rm * C1 / I) / Sba$$

$$= 3.16/133.5 + (91.1 * 75.0/4218750) / 159.96$$

$$= 0.034$$

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	15.0	135.0	0.0	20.2	0.0	421.
Web	358.0	15.0	0.0	53.7	0.0	10.1
Totals	...	...	...	73.9	...	432.

Distance to Centroid from Datum [ytot]:

$$= AY / A$$

$$= 0.0/73.944$$

$$= 0.000 \text{ mm.}$$

Distance to Centroid [C1]:

$$= \text{Saddle Width} / 2$$

$$= 150.0/2$$

$$= 75.000 \text{ mm.}$$

Length of Inner Rib [L]:

$$= \text{Saddle Height} - \sqrt{(Ro + Wpdthk)^2 - (Pitch/2)^2} - Bpthk$$

$$= 1200.0 - \sqrt{(620.0 + 10.0)^2 - (357.957/2)^2} - 15.0$$

$$= 591.395 \text{ mm.}$$

Radius of Gyration [r]:

$$= \sqrt{\text{Total Inertia} / \text{Total Area}}$$

$$= \sqrt{431.5/73.944}$$

$$= 24.157 \text{ mm.}$$

Slenderness ratio [KL/r]:

$$= KL/r$$

$$= 1 * 591.395/24.157$$

$$= 24.481$$

Unit Force [Force,u]:

$$= F1 / (2 * \text{Baseplate Length})$$

$$= 1395.62 / (2 * 1200.0)$$

$$= 0.582 \text{ N/mm.}$$

Moment at base of inner Rib [Mbase,c]:

$$= \text{Unit Force} * e * L$$

$$= 0.582 * 357.957 * 591.395$$

$$= 123.152 \text{ N-m}$$

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:

$$= \text{Bending Moment} / \text{Section Modulus}$$

$$= 123.152/57536.086$$

$$= 2.140 \text{ N./mm}^2$$

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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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Compressive Allowable, $KL/r < C_c$ ($24.4809 < 128.2549$) per AISC E2-1 [Sca]:

$$= (1 - (KL/r)^2 / (2 * C_c^2)) F_y / (5/3 + 3 * (KL/r) / (8 * C_c) - (KL/r)^3 / (8 * C_c^3))$$

$$= (1 - (24.48)^2 / (2 * 128.25^2)) 240 / (5/3 + 3 * (24.48) / (8 * 128.25) - (24.48^3) / (8 * 128.25^3))$$

$$= 135.6 \text{ N./mm}^2$$

AISC Unity Check of Inside Ribs (must be ≤ 1)

$$= S_c / S_{ca} + (M_{base,c} * C_{1/I}) / S_{ba}$$

$$= 4.07 / 135.59 + (123.15 * 75.0 / 431.52) / 159.96$$

$$= 0.043$$

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	4
Total Number of Bolts in Tension/Baseplate	Nbt	2
Bolt Material Specification		SA-325
Bolt Allowable Stress	Stba	300.00 N./mm ²
Bolt Corrosion Allowance	Bca	0.0 mm.
Distance from Bolts to Edge	Edgedis	150.0 mm.
Nominal Bolt Diameter	Bnd	20.0000 mm.
Thread Series	Series	TEMA Metric
BasePlate Allowable Stress	S	95.15 N./mm ²
Area Available in a Single Bolt	BltArea	2.1705 cm ²
Saddle Load QO (Weight)	QO	95965.8 N
Saddle Load QL (Wind/Seismic contribution)	QL	334.9 N
Maximum Transverse Force	Ft	1741.1 N
Maximum Longitudinal Force	F1	1395.6 N
Saddle Bolted to Steel Foundation		Yes

Shear Stress in a Single Bolt, Transverse Direction [taub,t]:

$$= F_t / (\text{Bolt Area} * \text{Number of Bolts})$$

$$= 1741 / (2.17 * 4)$$

$$= 2.0 \text{ N./mm}^2. \text{ Must be less than } 180.0 \text{ N./mm}^2.$$

Bolt Area Calculation per Dennis R. Moss

Bolt Area Requirement Due to Longitudinal Load [Bltarearl]:

$$= 0.0 \text{ (} QO > QL \text{ --> No Uplift in Longitudinal direction)}$$

Bolt Area due to Shear Load [Bltarears]:

$$= F_1 / (\text{BoltShearAllowable} * \text{Nbolts})$$

$$= 1395.62 / (180.0 * 4.0)$$

$$= 0.0194 \text{ cm}^2$$

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:

$$= B * F_t + \text{Sum of X Moments}$$

$$= 1200.0 * 1741.08 + 0.0$$

$$= 2090.15 \text{ N-m}$$

Eccentricity (e):

$$= R_{mom} / QO$$

$$= 2090.15 / 95965.76$$

 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	0009	V01

= 21.77 mm. < Bplen/6 --> No Uplift in Transverse direction

Bolt Area due to Transverse Load [Bltareart]:

= 0 (No Uplift)

Required Area of a Single Bolt [Bltarear]:

= max[Bltarearl, Bltarears, Bltareart]

= max[0.0, 0.0194, 0.0]

= 0.0194 cm²

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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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	BK	GCS	MF	120	ME	CN	0009	
							V01	

Input, Nozzle Desc: N8 (2in)

From: 10

Pressure for Reinforcement Calculations	P	4.178	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Elliptical Head	D	1200.00	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	10.0000	mm.
Head Internal Corrosion Allowance	c	3.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.
Distance from Head Centerline	L1	400.0000	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

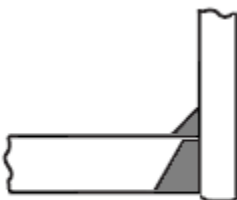
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		270.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	15.8500	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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	BK	GCS	MF	120	ME	CN	0009	V01

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: N8 (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.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]
 $= (P \cdot K_1 \cdot D) / (2 \cdot S_v \cdot E - 0.2 \cdot P)$ per UG-37 (a) (3)
 $= (4.18 \cdot 0.896 \cdot 1206.0) / (2 \cdot 137.9 \cdot 1.0 - 0.2 \cdot 4.18)$
 $= 1.6370 \text{ mm.}$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
 $= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P)$ per UG-27 (c) (1)
 $= (4.18 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.18)$
 $= 0.0871 \text{ mm.}$

Required Nozzle thickness under External Pressure per UG-28 : 0.3393 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	124.3751	mm.
Parallel to Vessel Wall, opening length	d	62.1876	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Weld Strength Reduction Factor [fr1]:

$= \min(1, S_n / S_v)$
 $= \min(1, 136.4 / 137.9)$
 $= 0.989$

Weld Strength Reduction Factor [fr2]:

 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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	V01	0009	CN	ME	120	MF	GCS	BK										

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

$$= \min(1, 136.4/137.9)$$

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.023	0.986	NA
Area in Shell	A1	3.320	2.378	NA
Area in Nozzle Wall	A2	4.734	4.641	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	9.044	8.009	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 65.97 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(62.1876 \cdot 3.1585 \cdot 1 + 2 \cdot 12.85 \cdot 3.1585 \cdot 1(1 - 0.99))$$

$$= 0.986 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 62.188(1.0 \cdot 7.0 - 1.0 \cdot 3.159) - 2 \cdot 12.85$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 3.1585) \cdot (1 - 0.989)$$

$$= 2.378 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2/\sin(\alpha3)$$

$$= (2 \cdot 17.5)(12.85 - 0.34)0.9894/\sin(69.0)$$

$$= 4.641 \text{ cm}^2$$

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]:

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $t_g = 10.0$, $t_r = 1.637$, $c = 3.0$ mm., $E^* = 1.0$
 Thickness Ratio = $t_r * (E^*) / (t_g - c) = 0.234$, Temp. Reduction = 78°C

Min Metal Temp. w/o impact per UCS-66, Curve A -8°C
 Min Metal Temp. at Required thickness (UCS 66.1) -104°C
 Min Metal Temp. w/o impact per UG-20(f) -29°C

Gov. MDMT of the nozzle to shell joint welded assembly : -104°C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18°C
 Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104°C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.18/19.60 = 0.213$

Weld Size Calculations, Description: N8 (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 9.0000$ mm.

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld $6.0000 = \text{Min per Code}$ $7.0700 = 0.7 * W_o$ mm.

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) * S_v)$$

$$= \max(0, (0.9864 - 2.3784 + 2 * 12.85 * 0.9894 * (1.0 * 7.0 - 3.1585)) * 138)$$

$$= \max(0, -5725.46) \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v$$

$$= (4.6407 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 77632.57 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.6407 + 0.0 + 0.9894 + (1.7799)) * 138$$

$$= 102174.91 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.6407 + 0.0 + 0.9894 + 0.0 + (1.7799)) * 138$$

$$= 102174.91 \text{ N}$$

 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	0009	V01

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 90.3253 * 10.0 * 0.49 * 136$$

$$= 94844. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 38.1282) * (15.85 - 3.0) * 0.7 * 136$$

$$= 146988. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 90.3253 * (10.0 - 3.0) * 0.74 * 138$$

$$= 101341. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (94844 + 146988) = 241832 \text{ N}$$

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

$$= (94844 + 0 + 101341 + 0) = 196185 \text{ N}$$

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

$$= (94844 + 101341 + 0) = 196185 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 241832 N , must exceed W = 0 N or W1 = 77632 N
 Path 2-2 = 196185 N , must exceed W = 0 N or W2 = 102174 N
 Path 3-3 = 196185 N , must exceed W = 0 N or W3 = 102174 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in the Latitudinal direction.

Reinforcement CALCULATION, Description: N8 (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 Elliptical Head, Tr [Int. Press]

$$= (P * K1 * D) / (2 * S_v * E - 0.2 * P) \text{ per UG-37(a) (3)}$$

$$= (4.18 * 0.896 * 1206.0) / (2 * 137.9 * 1.0 - 0.2 * 4.18)$$

$$= 1.6370 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

 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	0009	V01

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

$$= (4.18 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.18)$$

$$= 0.0871 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3393 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000	mm.
Parallel to Vessel Wall, opening length	d	56.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.934	0.901	NA
Area in Shell	A1	3.032	2.171	NA
Area in Nozzle Wall	A2	4.420	4.332	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.440	7.493	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]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot t_n \cdot tr \cdot F (1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5 (56.8 \cdot 3.1585 \cdot 1 + 2 \cdot 12.85 \cdot 3.1585 \cdot 1 (1 - 0.99))$$

$$= 0.901 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E1 \cdot t - F \cdot tr) - 2 \cdot t_n (E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8 (1.0 \cdot 7.0 - 1.0 \cdot 3.159) - 2 \cdot 12.85$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 3.1585) \cdot (1 - 0.989)$$

$$= 2.171 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp) (t_n - trn) fr2$$

$$= (2 \cdot 17.5) (12.85 - 0.34) 0.9894$$

$$= 4.332 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can / 0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures $t_a = 3.3393 \text{ mm.}$

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	BK	GCS	MF	120	ME	CN	0009	V01

Wall Thickness per UG16(b), $tr16b = 4.5000 \text{ mm.}$
 Wall Thickness, shell/head, internal pressure $trb1 = 4.8155 \text{ mm.}$
 Wall Thickness $tb1 = \max(trb1, tr16b) = 4.8155 \text{ mm.}$
 Wall Thickness, shell/head, external pressure $trb2 = 3.4492 \text{ mm.}$
 Wall Thickness $tb2 = \max(trb2, tr16b) = 4.5000 \text{ mm.}$
 Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.8155, 4.5)]$
 $= 4.8155 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.3393, 4.8155)$
 $= 4.8155 \text{ mm.}$

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

Weld Size Calculations, Description: N8 (2in)

Intermediate Calc. for nozzle/shell Welds $Tmin = 9.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld $6.0000 = \text{Min per Code } 7.0700 = 0.7 * Wo \text{ mm.}$

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

Weld Load [W]:

$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (0.9013 - 2.1714 + 2 * 12.85 * 0.9894 * (1.0 * 7.0 - 3.1585))138)$
 $= \max(0, -4044.92) \text{ N}$

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

Weld Load [W1]:

$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$
 $= (4.3322 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$
 $= 73377.99 \text{ N}$

Weld Load [W2]:

$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$
 $= (4.3322 + 0.0 + 0.9894 + (1.7799)) * 138$
 $= 97920.34 \text{ N}$

Weld Load [W3]:

$= (A2+A3+A4+A5+(2*tn*t*fr1))*S$
 $= (4.3322 + 0.0 + 0.9894 + 0.0 + (1.7799)) * 138$
 $= 97920.34 \text{ N}$

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شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-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>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 122 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 82.5 * 10.0 * 0.49 * 136$$

$$= 86627. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 34.825) * (15.85 - 3.0) * 0.7 * 136$$

$$= 134254. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 82.5 * (10.0 - 3.0) * 0.74 * 136$$

$$= 92562. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (86627 + 134254) = 220881 \text{ N}$$

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

$$= (86627 + 0 + 92562 + 0) = 179189 \text{ N}$$

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

$$= (86627 + 92562 + 0) = 179189 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 220881 N , must exceed W = 0 N or W1 = 73377 N
 Path 2-2 = 179188 N , must exceed W = 0 N or W2 = 97920 N
 Path 3-3 = 179188 N , must exceed W = 0 N or W3 = 97920 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 17.2963 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 178.0417 mm.

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V01	0009	CN	ME	120	MF	GCS	BK																			

Input, Nozzle Desc: N7C (2in)

From: 20

Pressure for Reinforcement Calculations	P	4.198	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		200.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

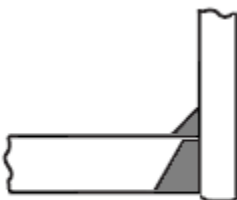
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		270.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	15.8500	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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	BK	GCS	MF	120	ME	CN	0009	V01	

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



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

Reinforcement CALCULATION, Description: N7C (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.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 1.8391 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 0.0876 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3393 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000 mm.
Parallel to Vessel Wall, opening length	d	56.8000 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)							شماره صفحه : 125 از 381
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.050	1.821	NA
Area in Shell	A1	2.917	0.350	NA
Area in Nozzle Wall	A2	4.419	4.332	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.326	5.672	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 12.85 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 12.85$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(12.85 - 0.34) \cdot 0.9894$$

$$= 4.332 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3393 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8391 mm.
Wall Thickness	tbt = max(trb1, tr16b) = 4.8391 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Wall Thickness $tb2 = \max(tb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.8391, 4.5)]$
 $= 4.8391 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.3393, 4.8391)$
 $= 4.8391 \text{ mm.}$

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

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.839$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio $= tr * (E^*) / (tg - c) = 0.263$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^{\circ}\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^{\circ}\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^{\circ}\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^{\circ}\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-29 \text{ }^{\circ}\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^{\circ}\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.20/19.60 = 0.214$

Weld Size Calculations, Description: N7C (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min}$ $7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.8208 - 0.3501 + 2 * 12.85 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$
 $= 22451.24 \text{ N}$

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

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	BK	GCS	MF	120	ME	CN	0009	
							V01	

Weld Load [W1]:

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

$$= (4.3322 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 73377.99 \text{ N}$$

Weld Load [W2]:

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

$$= (4.3322 + 0.0 + 0.9894 + (1.7799)) * 138$$

$$= 97920.34 \text{ N}$$

Weld Load [W3]:

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

$$= (4.3322 + 0.0 + 0.9894 + 0.0 + (1.7799)) * 138$$

$$= 97920.34 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 82.5 * 10.0 * 0.49 * 136$$

$$= 86627. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 34.825) * (15.85 - 3.0) * 0.7 * 136$$

$$= 134254. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 82.5 * (10.0 - 3.0) * 0.74 * 138$$

$$= 92562. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (86627 + 134254) = 220881 \text{ N}$$

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

$$= (86627 + 0 + 92562 + 0) = 179189 \text{ N}$$

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

$$= (86627 + 92562 + 0) = 179189 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 220881 N , must exceed W = 22451 N or W1 = 73377 N

Path 2-2 = 179188 N , must exceed W = 22451 N or W2 = 97920 N

Path 3-3 = 179188 N , must exceed W = 22451 N or W3 = 97920 N

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	BK	GCS	MF	120	ME	CN	0009	V01

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4197 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4197 mm.

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	BK	GCS	MF	120	ME	CN	0009		V01

Input, Nozzle Desc: N12 (1in)

From: 20

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		150.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

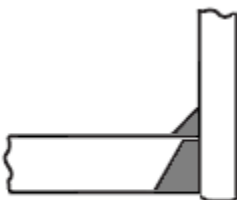
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		90.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.8000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

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: N12 (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.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= R (\exp([P / (S_n \cdot E)] - 1)) \text{ per Appendix 1-2 (a) (1)} \\
 &= 15.7 (\exp([4.1 / (136.43 \cdot 1.0)] - 1)) \\
 &= 0.0473 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.2571 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	65.0000 mm.
Parallel to Vessel Wall	Rn+tn+t	32.5000 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

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	BK	GCS	MF	120	ME	CN	0009	V01

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.568	1.008	NA
Area in Shell	A1	1.738	0.207	NA
Area in Nozzle Wall	A2	3.377	3.305	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.900	0.900	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	6.015	4.412	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(31.4 \cdot 6.3807 \cdot 1 + 2 \cdot 9.8 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.008 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 33.6(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 9.8$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.207 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(9.8 - 0.26) \cdot 0.9894$$

$$= 3.305 \text{ cm}^2$$

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

$$= (Wo^2 - \text{Area Lost}) \cdot fr2 + ((Wi - can/0.707)^2 - \text{Area Lost}) \cdot fr2$$

$$= (10.0^2 - 0.09) \cdot 0.9894 + (0.0^2 - 0.0) \cdot 0.9894$$

$$= 0.900 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.2571 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tbl = max(trb1, tr16b) = 4.7961 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.

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	BK	GCS	MF	120	ME	CN	0009		V01

Wall Thickness $tb2 = \max(tb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 6.4200 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[6.42, \max(4.7961, 4.5)]$
 $= 4.7961 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.2571, 4.7961)$
 $= 4.7961 \text{ mm.}$

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

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.796$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = $78 \text{ }^\circ\text{C}$

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^\circ\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^\circ\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^\circ\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^\circ\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-29 \text{ }^\circ\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^\circ\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.10/19.60 = 0.209$

Weld Size Calculations, Description: N12 (1in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min}$ $7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.0084 - 0.2068 + 2 * 9.8 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$
 $= 12709.29 \text{ N}$

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

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	V01	0009	CN	ME	120	MF	GCS	BK

Weld Load [W1]:

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

$$= (3.3045 + 0.0 + 0.9003 - 0.0 * 0.99) * 138$$

$$= 57979.77 \text{ N}$$

Weld Load [W2]:

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

$$= (3.3045 + 0.0 + 0.9003 + (1.3574)) * 138$$

$$= 76696.89 \text{ N}$$

Weld Load [W3]:

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

$$= (3.3045 + 0.0 + 0.9003 + 0.0 + (1.3574)) * 138$$

$$= 76696.89 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 51.0 * 10.0 * 0.49 * 136$$

$$= 53551. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 20.6) * (12.8 - 3.0) * 0.7 * 136$$

$$= 60566. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 51.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 57220. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (53551 + 60566) = 114117 \text{ N}$$

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

$$= (53551 + 0 + 57220 + 0) = 110771 \text{ N}$$

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

$$= (53551 + 57220 + 0) = 110771 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 114117 N , must exceed W = 12709 N or W1 = 57979 N

Path 2-2 = 110771 N , must exceed W = 12709 N or W2 = 76696 N

Path 3-3 = 110771 N , must exceed W = 12709 N or W3 = 76696 N

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	BK	GCS	MF	120	ME	CN	0009	
								V01

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 0.5421 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 160.5421 mm.

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شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 135 از 381
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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Input, Nozzle Desc: N22 (2in)

From: 20

Pressure for Reinforcement Calculations	P	4.198	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		450.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

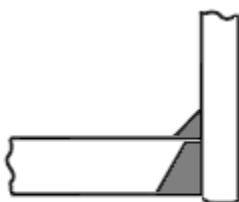
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		270.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	15.8500	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

 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 REBOILER (R-100) <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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 136 از 381
	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه										
	V01	0009	CN	ME	120	MF	GCS	BK										

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



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

Reinforcement CALCULATION, Description: N22 (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.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 1.8391 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 0.0876 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3393 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000	mm.
Parallel to Vessel Wall, opening length	d	56.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)							شماره صفحه : 137 از 381	
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0009	V01	

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.050	1.821	NA
Area in Shell	A1	2.917	0.350	NA
Area in Nozzle Wall	A2	4.419	4.332	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.326	5.672	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 12.85 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 12.85$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(12.85 - 0.34) \cdot 0.9894$$

$$= 4.332 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3393 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8391 mm.
Wall Thickness	tbt = max(trb1, tr16b) = 4.8391 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.

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Wall Thickness $tb2 = \max(trb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.8391, 4.5)]$
 $= 4.8391 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.3393, 4.8391)$
 $= 4.8391 \text{ mm.}$

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	: 12.0,	Allowable	: 136.4 N./mm ²	Passed
Expansion	: 0.0,	Allowable	: 330.9 N./mm ²	Passed
Occasional	: 0.4,	Allowable	: 181.5 N./mm ²	Passed
Shear	: 3.1,	Allowable	: 95.5 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.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.839$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.263$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)	-29 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b)	-104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.20/19.60 = 0.214$

Weld Size Calculations, Description: N22 (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min.}$	$7.0700 = 0.7 * W_o \text{ mm.}$

 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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V01	0009	CN	ME	120	MF	GCS	BK																			

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (1.8208 - 0.3501 + 2 * 12.85 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 6.3807)) 138) \\
 &= 22451.24 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (4.3322 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 73377.99 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (4.3322 + 0.0 + 0.9894 + (1.7799)) * 138 \\
 &= 97920.34 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (4.3322 + 0.0 + 0.9894 + 0.0 + (1.7799)) * 138 \\
 &= 97920.34 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 82.5 * 10.0 * 0.49 * 136 \\
 &= 86627. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 34.825) * (15.85 - 3.0) * 0.7 * 136 \\
 &= 134254. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng \\
 &= (3.1416/2.0) * 82.5 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 92562. \text{ N}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (86627 + 134254) = 220881 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (86627 + 0 + 92562 + 0) = 179189 \text{ N} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (86627 + 92562 + 0) = 179189 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned}
 \text{Path 1-1} &= 220881 \text{ N} , \text{ must exceed } W = 22451 \text{ N} \quad \text{or } W1 = 73377 \text{ N} \\
 \text{Path 2-2} &= 179188 \text{ N} , \text{ must exceed } W = 22451 \text{ N} \quad \text{or } W2 = 97920 \text{ N} \\
 \text{Path 3-3} &= 179188 \text{ N} , \text{ must exceed } W = 22451 \text{ N} \quad \text{or } W3 = 97920 \text{ N}
 \end{aligned}$$

 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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	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4197 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4197 mm.

Input Echo, WRC107/537 Item 1, Description: N22 (2in) :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	1200.000	mm.
Vessel Thickness	Tv	10.000	mm.
Design Temperature	T1	234.0	°C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	137.90	N./mm ²
Vessel Hot S.I. Allowable	Smh	137.90	N./mm ²

Note:

Using 2 * Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.

Make sure that material properties at this temperature are not time-dependent for Material: SA-516 70

Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm.
Nozzle Diameter	Dn	50.800	mm.
Nozzle Thickness	Tn	15.850	mm.
Nozzle Material		SA-105	
Nozzle UNS Number		K03504	
Nozzle Cold S.I. Allowable	SNmc	137.90	N./mm ²
Nozzle Hot S.I. Allowable	SNmh	136.43	N./mm ²
Design Internal Pressure	Dp	4.198	bars
Include Pressure Thrust	No		

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS)	P	2800.0	N
Longitudinal Shear (SUS)	Vl	2800.0	N
Circumferential Shear (SUS)	Vc	-2100.0	N
Circumferential Moment (SUS)	Mc	-280.0	N-m
Longitudinal Moment (SUS)	Ml	-360.0	N-m
Torsional Moment (SUS)	Mt	-420.0	N-m

Use Interactive Control

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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V01	0009	CN	ME	120	MF	GCS	BK											

WRC107 Version

Version March 1979

Include Pressure Stress Indices per Div. 2

No

Compute Pressure Stress per WRC-368

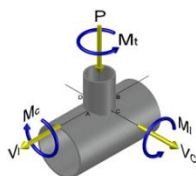
No

Local Loads applied at end of Nozzle/Attachment

No

Note:

WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:

$$\begin{aligned}
 &= \text{NozzleOD} + 2 * 1.65 * \text{sqrt}(\text{Rmean}(\text{t} - \text{ca})) \\
 &= 82.5 + 2 * 1.65 * \text{sqrt}(606.5 (10.0 - 3.0)) \\
 &= 297.520 \text{ mm.}
 \end{aligned}$$

WRC 107 Stress Calculation for SUSTAINED loads:

Radial Load	P	2800.0	N
Circumferential Shear	VC	-2100.0	N
Longitudinal Shear	VL	2800.0	N
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 = 86.64

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.060	4C	15.037	(A,B)
N(PHI) / (P/Rm)	0.060	3C	14.463	(C,D)
M(PHI) / (P)	0.060	2C1	0.100	(A,B)
M(PHI) / (P)	0.060	1C	0.139	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.060	3A	2.228	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.060	1A	0.096	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.060	3B	7.820	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.060	1B	0.049	(A,B,C,D)
N(x) / (P/Rm)	0.060	3C	14.463	(A,B)
N(x) / (P/Rm)	0.060	4C	15.037	(C,D)
M(x) / (P)	0.060	1C1	0.143	(A,B)
M(x) / (P)	0.060	2C	0.101	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.060	4A	3.056	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.060	2A	0.057	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.060	4B	2.219	(A,B,C,D)

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شماره پیمان: 053 - 073 - 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100) <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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 142 از 381
	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه										
	V01	0009	CN	ME	120	MF	GCS	BK										

M(x) / (ML/(Rm * Beta)) 0.060 2B 0.080 (A,B,C,D)

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		-9.9	-9.9	-9.9	-9.9	-9.5	-9.5	-9.5	-9.5
Circ. Bend. P		-34.4	34.4	-34.4	34.4	-47.7	47.7	-47.7	47.7
Circ. Memb. MC		0.0	0.0	0.0	0.0	4.1	4.1	-4.1	-4.1
Circ. Memb. MC		0.0	0.0	0.0	0.0	91.5	-91.5	-91.5	91.5
Circ. Memb. ML		18.4	18.4	-18.4	-18.4	0.0	0.0	0.0	0.0
Circ. Bend. ML		60.3	-60.3	-60.3	60.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.		34.3	-17.4	-123.1	66.5	38.3	-49.2	-152.8	125.6
Long. Memb. P		-9.5	-9.5	-9.5	-9.5	-9.9	-9.9	-9.9	-9.9
Long. Bend. P		-49.2	49.2	-49.2	49.2	-34.6	34.6	-34.6	34.6
Long. Memb. MC		0.0	0.0	0.0	0.0	5.6	5.6	-5.6	-5.6
Long. Bend. MC		0.0	0.0	0.0	0.0	53.8	-53.8	-53.8	53.8
Long. Memb. ML		5.2	5.2	-5.2	-5.2	0.0	0.0	0.0	0.0
Long. Bend. ML		97.2	-97.2	-97.2	97.2	0.0	0.0	0.0	0.0
Tot. Long. Str.		43.7	-52.3	-161.1	131.6	14.8	-23.5	-103.8	72.8
Shear VC		-2.3	-2.3	2.3	2.3	0.0	0.0	0.0	0.0
Shear VL		0.0	0.0	0.0	0.0	-3.1	-3.1	3.1	3.1
Shear MT		-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6
Tot. Shear		-7.9	-7.9	-3.3	-3.3	-8.7	-8.7	-2.5	-2.5
Str. Int.		48.2	54.0	161.4	131.8	41.1	51.9	152.9	125.7

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)		36.0	36.4	36.0	36.4	36.0	36.4	36.0	36.4
Circ. Pl (SUS)		8.4	8.4	-28.3	-28.3	-5.5	-5.5	-13.6	-13.6
Circ. Q (SUS)		25.9	-25.9	-94.8	94.8	43.7	-43.7	-139.2	139.2
Long. Pm (SUS)		18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Long. Pl (SUS)		-4.3	-4.3	-14.8	-14.8	-4.3	-4.3	-15.5	-15.5
Long. Q (SUS)		48.0	-48.0	-146.3	146.3	19.2	-19.2	-88.3	88.3

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	BK	GCS	MF	120	ME	CN	0009	V01

Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	-2.3	-2.3	2.3	2.3	-3.1	-3.1	3.1	3.1
Shear Q (SUS)	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6
Pm (SUS)	36.0	36.4	36.0	36.4	36.0	36.4	36.0	36.4
Pm+Pl (SUS)	44.6	45.0	8.7	9.0	31.0	31.4	22.8	23.2
Pm+Pl+Q (Total)	75.0	55.6	143.3	149.8	76.0	18.9	117.1	162.1

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	36.38	137.90	Passed
Pm+Pl (SUS)	44.99	206.85	Passed
Pm+Pl+Q (TOTAL)	162.06	413.70	Passed

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

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	BK	GCS	MF	120	ME	CN	0009	V01

Input, Nozzle Desc: K9B (3in)

From: 20

Pressure for Reinforcement Calculations	P	4.195	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	200.0000	mm.
Distance from Bottom/Left Tangent		400.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm ²
Allowable Stress At Ambient	Sna	117.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		289.14	deg
Diameter		3.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	XXS	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²

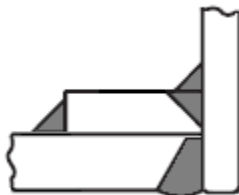
 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																	
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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Diameter of Pad along vessel surface	Dp	200.0000	mm.
Thickness of Pad	te	10.0000	mm.
Weld leg size between Pad and Shell	Wp	8.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	10.0000	mm.
Reinforcing Pad Width		55.5500	mm.

Flange Class	150
Flange Grade	GR 1.1

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K9B (3in)

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

Actual Inside Diameter Used in Calculation	2.450	in.
Actual Thickness Used in Calculation	0.525	in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 1.8377 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 34.11) / (118 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 0.1216 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3552 mm.

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

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

Parallel to Vessel Wall (Diameter Limit)	D1	144.6716	mm.
Parallel to Vessel Wall, opening length	d	72.3358	mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		17.5000	mm.

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n/S_v) \\
 &= \min(1, 117.9/137.9) \\
 &= 0.855
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n/S_v) \\
 &= \min(1, 117.9/137.9) \\
 &= 0.855
 \end{aligned}$$

Weld Strength Reduction Factor [fr4]:

$$\begin{aligned}
 &= \min(1, S_p/S_v) \\
 &= \min(1, 137.9/137.9) \\
 &= 1.000
 \end{aligned}$$

Weld Strength Reduction Factor [fr3]:

$$\begin{aligned}
 &= \min(fr2, fr4) \\
 &= \min(0.855, 1.0) \\
 &= 0.855
 \end{aligned}$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.384	2.403	NA
Area in Shell	A1	3.579	0.429	NA
Area in Nozzle Wall	A2	3.185	3.113	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.802	0.802	NA
Area in Element	A5	5.042	5.042	NA
TOTAL AREA AVAILABLE	Atot	12.609	9.386	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	70.60 Degr.

The area available without a pad is Sufficient.

The area available with the given pad is Sufficient.

Area Required [A]:

$$\begin{aligned}
 &= 0.5(d * tr * F + 2 * t_n * tr * F(1 - fr1)) \text{ per UG-37(d)} \\
 &= 0.5(72.3358 * 6.3807 * 1 + 2 * 10.335 * 6.3807 * 1(1 - 0.86)) \\
 &= 2.403 \text{ cm}^2
 \end{aligned}$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

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	BK	GCS	MF	120	ME	CN	0009	V01

$$\begin{aligned}
 &= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1) \\
 &= 72.336(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 10.335 \\
 &\quad (1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.855) \\
 &= 0.429 \text{ cm}^2
 \end{aligned}$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$\begin{aligned}
 &= (2 \cdot Tlwp) \cdot (tn - trn) \cdot fr2 / \sin(\alpha3) \\
 &= (2 \cdot 17.5) \cdot (10.34 - 0.36) \cdot 0.855 / \sin(73.6) \\
 &= 3.113 \text{ cm}^2
 \end{aligned}$$

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

Area Available in Welds [A41 + A42 + A43]:

$$\begin{aligned}
 &= (Wo^2 - Ar \text{ Lost}) \cdot Fr3 + ((Wi - can / 0.707)^2 - Ar \text{ Lost}) \cdot fr2 + Wp^2 \cdot fr4 \\
 &= (0.9375) \cdot 0.86 + (0.0) \cdot 0.86 + 0.0^2 \cdot 1.0 \\
 &= 0.802 \text{ cm}^2
 \end{aligned}$$

Area Available in Element [A5]:

$$\begin{aligned}
 &= (\min(Dp, DL) - (\text{Nozzle OD})) \cdot (\min(tp, Tlwp, te)) \cdot fr4 \\
 &= (144.6716 - 94.2496) \cdot 10.0 \cdot 1.0 \\
 &= 5.042 \text{ cm}^2
 \end{aligned}$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:B, Curve:A)

Govrn. thk, tg = 13.335, tr = 0.122, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.012, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	0 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, tg = 10.0, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.263, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 10.0, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.263, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 10.0, tr = 1.838, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.263, Temp. Reduction = 78 °C

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شماره پیمان: 053 - 073 - 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 148 از 381
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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
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Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:B, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.838, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.263, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C
Gov. MDMT of the Reinforcement Pad : -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = 4.19/19.60 = 0.214

Weld Size Calculations, Description: K9B (3in)

Intermediate Calc. for nozzle/shell Welds Tmin 10.0000 mm.
Intermediate Calc. for pad/shell Welds TminPad 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	7.0700 = 0.7 * Wo mm.
Pad Weld	3.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (2.4034 - 0.4294 + 2 * 10.335 * 0.855 * \\
 &\quad (1.0 * 7.0 - 6.3807)) 138) \\
 &= 28727.59 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (3.1126 + 5.0422 + 0.8016 - 0.0 * 0.86) * 138 \\
 &= 123497.55 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (3.1126 + 0.0 + 0.855 + (1.2371)) * 138 \\
 &= 71766.59 \text{ N}
 \end{aligned}$$

 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)																									
شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>پروژه</th><th>بسته کاری</th><th>صادر کننده</th><th>تسهیلات</th><th>رشته</th><th>نوع مدرک</th><th>سریال</th><th>نسخه</th></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0009</td><td>V01</td></tr></table>	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)								پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 149 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
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BK	GCS	MF	120	ME	CN	0009	V01																			

Weld Load [W3]:

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

$$= (3.1126 + 0.0 + 0.8016 + 5.0422 + (1.2371)) * 138$$

$$= 140555.69 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 94.2496 * 10.0 * 0.49 * 118$$

$$= 85524. \text{ N}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * D_P * W_P * 0.49 * S_{EW}$$

$$= (3.1416/2.0) * 200.0 * 8.0 * 0.49 * 138$$

$$= 169810. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 41.6464) * (13.335 - 3.0) * 0.7 * 118$$

$$= 111591. \text{ N}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg}$$

$$= (3.1416/2) * 94.2496 * 10.0 * 0.74 * 138$$

$$= 151063. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 94.2496 * (10.0 - 3.0) * 0.74 * 138$$

$$= 105744. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SPEW + SNW) = (169810 + 111591) = 281401 \text{ N}$$

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

$$= (85524 + 151063 + 105744 + 0) = 342332 \text{ N}$$

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

$$= (169810 + 105744 + 0) = 275554 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 281400 N , must exceed W = 28727 N or W1 = 123497 N

Path 2-2 = 342331 N , must exceed W = 28727 N or W2 = 71766 N

Path 3-3 = 275554 N , must exceed W = 28727 N or W3 = 140555 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)	شماره صفحه : 150 از 381																
	<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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Reinforcement CALCULATION, Description: K9B (3in)

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

Actual Inside Diameter Used in Calculation 2.450 in.
Actual Thickness Used in Calculation 0.525 in.

Nozzle input data check completed without errors.

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

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

$$= (4.19 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.19)$$

$$= 1.8377 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.19 \cdot 34.11) / (118 \cdot 1.0 - 0.6 \cdot 4.19)$$

$$= 0.1216 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3552 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 136.4600 mm.
Parallel to Vessel Wall, opening length d 68.2300 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 mm.

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.309	2.272	NA
Area in Shell	A1	3.368	0.404	NA
Area in Nozzle Wall	A2	3.056	2.986	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.802	0.802	NA
Area in Element	A5	4.756	4.756	NA
TOTAL AREA AVAILABLE	Atot	11.981	8.948	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.

The area available with the given pad is Sufficient.

Area Required [A]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F (1 - fr1)) \text{ per UG-37 (d)}$$

$$= 0.5 (68.23 \cdot 6.3807 \cdot 1 + 2 \cdot 10.335 \cdot 6.3807 \cdot 1 (1 - 0.86))$$

$$= 2.272 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

 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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Area Available in Shell [A1]:

$$\begin{aligned}
 &= d(E1 \cdot t - F \cdot t_r) - 2 \cdot t_n(E1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 68.23(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 10.335 \\
 &\quad (1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.855) \\
 &= 0.404 \text{ cm}^2
 \end{aligned}$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$\begin{aligned}
 &= (2 \cdot T_{lwp}) \cdot (t_n - t_{rn}) \cdot f_{r2} \\
 &= (2 \cdot 17.5) \cdot (10.34 - 0.36) \cdot 0.855 \\
 &= 2.986 \text{ cm}^2
 \end{aligned}$$

Area Available in Welds [A41 + A42 + A43]:

$$\begin{aligned}
 &= (W_o^2 - A_r \text{ Lost}) \cdot F_{r3} + ((W_i - c_{an}/0.707)^2 - A_r \text{ Lost}) \cdot f_{r2} + W_p^2 \cdot f_{r4} \\
 &= (0.9375) \cdot 0.86 + (0.0) \cdot 0.86 + 0.0^2 \cdot 1.0 \\
 &= 0.802 \text{ cm}^2
 \end{aligned}$$

Area Available in Element [A5]:

$$\begin{aligned}
 &= (\min(D_p, D_L) - (\text{Nozzle OD})) \cdot (\min(t_p, T_{lwp}, t_e)) \cdot f_{r4} \\
 &= (136.46 - 88.9) \cdot 10.0 \cdot 1.0 \\
 &= 4.756 \text{ cm}^2
 \end{aligned}$$

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

Wall Thickness for Internal/External pressures	$t_a = 3.3552 \text{ mm.}$
Wall Thickness per UG16(b),	$t_{r16b} = 4.5000 \text{ mm.}$
Wall Thickness, shell/head, internal pressure	$t_{rb1} = 4.8377 \text{ mm.}$
Wall Thickness	$t_{b1} = \max(t_{rb1}, t_{r16b}) = 4.8377 \text{ mm.}$
Wall Thickness, shell/head, external pressure	$t_{rb2} = 3.4524 \text{ mm.}$
Wall Thickness	$t_{b2} = \max(t_{rb2}, t_{r16b}) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45	$t_{b3} = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$$\begin{aligned}
 &= \min[t_{b3}, \max(t_{b1}, t_{b2})] \\
 &= \min[7.8, \max(4.8377, 4.5)] \\
 &= 4.8377 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= \max(t_a, t_b) \\
 &= \max(3.3552, 4.8377) \\
 &= 4.8377 \text{ mm.}
 \end{aligned}$$

Available Nozzle Neck Thickness = 13.3350 mm. --> OK

Weld Size Calculations, Description: K9B (3in)

Intermediate Calc. for nozzle/shell Welds	T_{min}	10.0000	mm.
Intermediate Calc. for pad/shell Welds	T_{minPad}	7.0000	mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$6.0000 = \text{Min per Code}$	$7.0700 = 0.7 \cdot W_o \text{ mm.}$
Pad Weld	$3.5000 = 0.5 \cdot T_{minPad}$	$5.6560 = 0.7 \cdot W_p \text{ mm.}$

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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه										
BK	GCS	MF	120	ME	CN	0009	V01											

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (2.2724 - 0.404 + 2 * 10.335 * 0.855 * \\
 &\quad (1.0 * 7.0 - 6.3807)) 138) \\
 &= 27272.04 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (2.9865 + 4.756 + 0.8016 - 0.0 * 0.86) * 138 \\
 &= 117812.12 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (2.9865 + 0.0 + 0.855 + (1.2371)) * 138 \\
 &= 70027.48 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (2.9865 + 0.0 + 0.8016 + 4.756 + (1.2371)) * 138 \\
 &= 134870.28 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 88.9 * 10.0 * 0.49 * 118 \\
 &= 80670. \text{ N}
 \end{aligned}$$

Shear, Pad Element Weld [Spew]:

$$\begin{aligned}
 &= (\pi/2) * DP * WP * 0.49 * SEW \\
 &= (3.1416/2.0) * 200.0 * 8.0 * 0.49 * 138 \\
 &= 169810. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 39.2825) * (13.335 - 3.0) * 0.7 * 118 \\
 &= 105257. \text{ N}
 \end{aligned}$$

Tension, Pad Groove Weld [Tpgw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wgn * 0.74 * Seg \\
 &= (3.1416/2) * 88.9 * 10.0 * 0.74 * 138 \\
 &= 142489. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng \\
 &= (3.1416/2.0) * 88.9 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 99742. \text{ N}
 \end{aligned}$$

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Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SPEW} + \text{SNW}) = (169810 + 105257) = 275067 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (80670 + 142489 + 99742 + 0) = 322901 \text{ N} \\
 \text{PATH33} &= (\text{Spew} + \text{Tngw} + \text{Sinw}) \\
 &= (169810 + 99742 + 0) = 269552 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 275067 N , must exceed W = 27272 N or W1 = 117812 N
 Path 2-2 = 322900 N , must exceed W = 27272 N or W2 = 70027 N
 Path 3-3 = 269552 N , must exceed W = 27272 N or W3 = 134870 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 17.7400 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 178.3358 mm.

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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	
							V01	

Input, Nozzle Desc: K9A (3in)

From: 20

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		400.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm ²
Allowable Stress At Ambient	Sna	117.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		90.00	deg
Diameter		3.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	XXS	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²
Diameter of Pad along vessel surface	Dp	200.0000	mm.
Thickness of Pad	te	10.0000	mm.

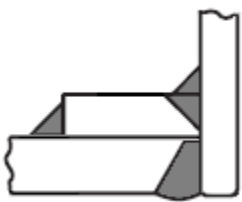
 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)							
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)							شماره صفحه : 155 از 381
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	BK	GCS	MF	120	ME	CN	0009	V01

Weld leg size between Pad and Shell Wp 8.0000 mm.
Groove weld depth between Pad and Nozzle Wgpn 10.0000 mm.
Reinforcing Pad Width 55.5500 mm.

Flange Class 150
Flange Grade GR 1.1

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: K9A (3in)

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

Actual Inside Diameter Used in Calculation 2.450 in.
Actual Thickness Used in Calculation 0.525 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

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

$$= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1)$$

$$= 1.7961 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.1 \cdot 34.11) / (118 \cdot 1.0 - 0.6 \cdot 4.1)$$

$$= 0.1189 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3552 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 136.4600 mm.
Parallel to Vessel Wall, opening length d 68.2300 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 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	0009	V01

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr2]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr4]:

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

$$= \min(1, 137.9/137.9)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.855, 1.0)$$

$$= 0.855$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.279	2.272	NA
Area in Shell	A1	3.395	0.404	NA
Area in Nozzle Wall	A2	3.057	2.986	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.802	0.802	NA
Area in Element	A5	4.756	4.756	NA
TOTAL AREA AVAILABLE	Atot	12.009	8.948	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.

The area available with the given pad is Sufficient.

Area Required [A]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot t_n \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(68.23 \cdot 6.3807 \cdot 1 + 2 \cdot 10.335 \cdot 6.3807 \cdot 1(1 - 0.86))$$

$$= 2.272 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot t_n(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 68.23(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 10.335$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.855)$$

$$= 0.404 \text{ cm}^2$$

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	BK	GCS	MF	120	ME	CN	0009	V01

Area Available in Nozzle Wall Projecting Outward [A2]:

$$= (2 * Tlwp) * (tn - trn) * fr2$$

$$= (2 * 17.5) * (10.34 - 0.36) * 0.855$$

$$= 2.986 \text{ cm}^2$$

Area Available in Welds [A41 + A42 + A43]:

$$= (Wo^2 - Ar \text{ Lost}) * Fr3 + ((Wi - can / 0.707)^2 - Ar \text{ Lost}) * fr2 + Wp^2 * fr4$$

$$= (0.9375) * 0.86 + (0.0) * 0.86 + 0.0^2 * 1.0$$

$$= 0.802 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(Dp, DL) - (\text{Nozzle OD})) * (\min(tp, Tlwp, te)) * fr4$$

$$= (136.46 - 88.9) * 10.0 * 1.0$$

$$= 4.756 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3552 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.7961 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.8000 mm.

Determine Nozzle Thickness candidate [tb]:

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

$$= \min[7.8, \max(4.7961, 4.5)]$$

$$= 4.7961 \text{ mm.}$$

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

$$= \max(ta, tb)$$

$$= \max(3.3552, 4.7961)$$

$$= 4.7961 \text{ mm.}$$

Available Nozzle Neck Thickness = 13.3350 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:B, Curve:A)

Govrn. thk, tg = 13.335, tr = 0.119, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.012, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	0 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, tg = 10.0, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.257, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C

 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 REBOILER (R-100)</th></tr><tr><th>پروژه</th><th>بسته کاری</th><th>صادر کننده</th><th>تسهیلات</th><th>رشته</th><th>نوع مدرک</th><th>سریال</th><th>نسخه</th></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0009</td><td>V01</td></tr></table>	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)								پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 158 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
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BK	GCS	MF	120	ME	CN	0009	V01																			

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 10.0, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = 78 °C

Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 10.0, tr = 1.796, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:B, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.796, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C

Gov. MDMT of the Reinforcement Pad : -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C

Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.10 / 19.60 = 0.209$

Weld Size Calculations, Description: K9A (3in)

Intermediate Calc. for nozzle/shell Welds Tmin 10.0000 mm.

Intermediate Calc. for pad/shell Welds TminPad 7.0000 mm.

Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 6.0000 = Min per Code 7.0700 = $0.7 * W_o$ mm.

Pad Weld 3.5000 = $0.5 * T_{minPad}$ 5.6560 = $0.7 * W_p$ mm.

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

Weld Load [W]:

= $\max(0, (A - A_1 + 2 * t_n * f_{r1} * (E_1 * t - t_r)) S_v)$

= $\max(0, (2.2724 - 0.404 + 2 * 10.335 * 0.855 *)$

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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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

$$(138) (1.0 * 7.0 - 6.3807) = 27272.04 \text{ N}$$

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

Weld Load [W1]:

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

$$= (2.9865 + 4.756 + 0.8016 - 0.0 * 0.86) * 138$$

$$= 117812.12 \text{ N}$$

Weld Load [W2]:

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

$$= (2.9865 + 0.0 + 0.855 + (1.2371)) * 138$$

$$= 70027.48 \text{ N}$$

Weld Load [W3]:

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

$$= (2.9865 + 0.0 + 0.8016 + 4.756 + (1.2371)) * 138$$

$$= 134870.28 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 88.9 * 10.0 * 0.49 * 118$$

$$= 80670. \text{ N}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * DP * WP * 0.49 * SEW$$

$$= (3.1416/2.0) * 200.0 * 8.0 * 0.49 * 138$$

$$= 169810. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 39.2825) * (13.335 - 3.0) * 0.7 * 118$$

$$= 105257. \text{ N}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * Seg$$

$$= (3.1416/2) * 88.9 * 10.0 * 0.74 * 138$$

$$= 142489. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 88.9 * (10.0 - 3.0) * 0.74 * 138$$

$$= 99742. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SPEW + SNW) = (169810 + 105257) = 275067 \text{ N}$$

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

$$= (80670 + 142489 + 99742 + 0) = 322901 \text{ N}$$

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

$$= (169810 + 99742 + 0) = 269552 \text{ N}$$

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V01	0009	CN	ME	120	MF	GCS	BK											

Summary of Failure Path Calculations:

Path 1-1 = 275067 N , must exceed W = 27272 N or W1 = 117812 N
 Path 2-2 = 322900 N , must exceed W = 27272 N or W2 = 70027 N
 Path 3-3 = 269552 N , must exceed W = 27272 N or W3 = 134870 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.6488 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.6488 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01

Input, Nozzle Desc: K10A (2in)

From: 20

Pressure for Reinforcement Calculations	P	4.152	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	144.0000	mm.
Distance from Bottom/Left Tangent		150.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

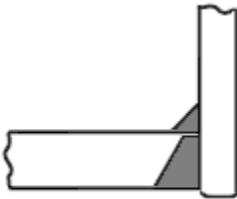
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		-13.65	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

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BK	GCS	MF	120	ME	CN	0009	V01																			

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K10A (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

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

$$= (4.15 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.15)$$

$$= 1.8190 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.15 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.15)$$

$$= 0.0866 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	117.0011	mm.
Parallel to Vessel Wall, opening length	d	58.5006	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5	Design	External	Mapnc

 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	0009	V01

Area Required	Ar		0.535		1.876		NA
Area in Shell	A1		3.545		0.361		NA
Area in Nozzle Wall	A2		4.775		4.685		NA
Area in Inward Nozzle	A3		0.000		0.000		NA
Area in Welds A41+A42+A43			0.989		0.989		NA
Area in Element	A5		0.000		0.000		NA
TOTAL AREA AVAILABLE	Atot		9.310		6.035		NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 76.15 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(58.5006 * 6.3807 * 1 + 2 * 13.6 * 6.3807 * 1(1 - 0.99))$$

$$= 1.876 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1)$$

$$= 58.501(1.0 * 7.0 - 1.0 * 6.381) - 2 * 13.6$$

$$(1.0 * 7.0 - 1.0 * 6.3807) * (1 - 0.989)$$

$$= 0.361 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 * tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 * 17.5) (13.6 - 0.34) 0.9894 / \sin(78.5)$$

$$= 4.685 \text{ cm}^2$$

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]:

$$= Wo^2 * fr2 + (Wi - can / 0.707)^2 * fr2$$

$$= 10.0^2 * 0.9894 + (0.0)^2 * 0.9894$$

$$= 0.989 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.819, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.26, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

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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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
 Design Pressure/Ambient Rating = 4.15/51.10 = 0.081

Weld Size Calculations, Description: K10A (2in)

Intermediate Calc. for nozzle/shell Welds T_{min} 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.9000 = 0.7 * t _{min} .	7.0700 = 0.7 * W _o mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A - A_1 + 2 * t_n * f_{r1} * (E_1 * t - t_r)) * S_v) \\
 &= \max(0, (1.8756 - 0.3605 + 2 * 13.6 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 6.3807)) * 138) \\
 &= 23189.23 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A_2 + A_5 + A_4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v \\
 &= (4.6846 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 78237.69 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A_2 + A_3 + A_4 + (2 * t_n * t * f_{r1})) * S_v \\
 &= (4.6846 + 0.0 + 0.9894 + (1.8838)) * 138 \\
 &= 104212.46 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A_2 + A_3 + A_4 + A_5 + (2 * t_n * t * f_{r1})) * S \\
 &= (4.6846 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138 \\
 &= 104212.46 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi / 2) * D_{lo} * W_o * 0.49 * S_{nw} \\
 &= (3.1416 / 2.0) * 86.5149 * 10.0 * 0.49 * 136 \\
 &= 90843. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - C_{an}) * 0.7 * S_n \\
 &= (3.1416 * 36.2539) * (16.6 - 3.0) * 0.7 * 136 \\
 &= 147920. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

 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	0009	V01

$$= (\pi/2) * D_{lo} * (W_{gvi} - C_{as}) * 0.74 * S_{ng}$$

$$= (3.1416/2.0) * 86.5149 * (10.0 - 3.0) * 0.74 * 138$$

$$= 97066. \text{ N}$$

Strength of Failure Paths:

$$\text{PATH11} = (\text{SONW} + \text{SNW}) = (90843 + 147920) = 238763 \text{ N}$$

$$\text{PATH22} = (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw})$$

$$= (90843 + 0 + 97066 + 0) = 187909 \text{ N}$$

$$\text{PATH33} = (\text{Sonw} + \text{Tngw} + \text{Sinw})$$

$$= (90843 + 97066 + 0) = 187909 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 238762 N , must exceed W = 23189 N or W1 = 78237 N

Path 2-2 = 187909 N , must exceed W = 23189 N or W2 = 104212 N

Path 3-3 = 187909 N , must exceed W = 23189 N or W3 = 104212 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: K10A (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 0.654 in.

Nozzle input data check completed without errors.

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

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

$$= (4.15 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.15)$$

$$= 1.8190 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.15 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.15)$$

$$= 0.0866 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 113.6000 mm.

Parallel to Vessel Wall, opening length d 56.8000 mm.

Normal to Vessel Wall (Thickness Limit), no pad Tlnp 17.5000 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	0009	V01	

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.038	1.821	NA
Area in Shell	A1	2.928	0.350	NA
Area in Nozzle Wall	A2	4.679	4.591	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.597	5.930	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(13.6 - 0.34) \cdot 0.9894$$

$$= 4.591 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3430 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8190 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.8190 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.8000 mm.

Determine Nozzle Thickness candidate [tb]:

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

$$= \min[7.8, \max(4.819, 4.5)]$$

$$= 4.8190 \text{ mm.}$$

 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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	<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>0009</td><td>V01</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01
	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

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

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

$$= \max(3.343, 4.819)$$

$$= 4.8190 \text{ mm.}$$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Weld Size Calculations, Description: K10A (2in)

Intermediate Calc. for nozzle/shell Welds T_{min} 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min}.$	$7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) S_v)$$

$$= \max(0, (1.8213 - 0.35 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$$

$$= 22586.36 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - Can / .707)^2 * f_{r2}) * S_v$$

$$= (4.5906 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76941.22 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.5906 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.5906 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416 / 2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

 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	0009		V01

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (W_{gvi-Cas}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 94245. \text{ N}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (88202 + 143620) = 231822 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (88202 + 0 + 94245 + 0) = 182447 \text{ N} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (88202 + 94245 + 0) = 182447 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned}
 \text{Path 1-1} &= 231822 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W1 = 76941 \text{ N} \\
 \text{Path 2-2} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W2 = 102915 \text{ N} \\
 \text{Path 3-3} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W3 = 102915 \text{ N}
 \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 12.0218 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 172.3178 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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	BK	GCS	MF	120	ME	CN	0009	V01

Input, Nozzle Desc: K10B (2in)

From: 20

Pressure for Reinforcement Calculations	P	4.187	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	500.0000	mm.
Distance from Bottom/Left Tangent		150.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

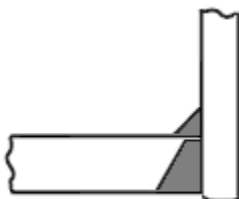
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		-55.05	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	350.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

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	BK	GCS	MF	120	ME	CN	0009	V01

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K10B (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 1.8344 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 0.0873 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.4877 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	202.6769	mm.
Parallel to Vessel Wall, opening length	d	101.3385	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5	Design	External	Mapnc

 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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	V01	0009	CN	ME	120	MF	GCS		BK

Area Required	Ar		0.932		3.242		NA
Area in Shell	A1		6.147		0.626		NA
Area in Nozzle Wall	A2		7.522		7.299		NA
Area in Inward Nozzle	A3		0.000		0.000		NA
Area in Welds A41+A42+A43			0.989		0.989		NA
Area in Element	A5		0.000		0.000		NA
TOTAL AREA AVAILABLE	Atot		14.658		8.914		NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 34.09 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(101.3385 * 6.3807 * 1 + 2 * 13.6 * 6.3807 * 1(1 - 0.99))$$

$$= 3.242 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1)$$

$$= 101.338(1.0 * 7.0 - 1.0 * 6.381) - 2 * 13.6$$

$$(1.0 * 7.0 - 1.0 * 6.3807) * (1 - 0.989)$$

$$= 0.626 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 * tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 * 17.5) (13.6 - 0.49) 0.9894 / \sin(38.5)$$

$$= 7.299 \text{ cm}^2$$

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]:

$$= Wo^2 * fr2 + (Wi - can / 0.707)^2 * fr2$$

$$= 10.0^2 * 0.9894 + (0.0)^2 * 0.9894$$

$$= 0.989 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.834, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.262, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
 Design Pressure/Ambient Rating = 4.19/51.10 = 0.082

Weld Size Calculations, Description: K10B (2in)

Intermediate Calc. for nozzle/shell Welds Tmin 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.9000 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (3.2423 - 0.6258 + 2 * 13.6 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 6.3807)) 138) \\
 &= 38375.80 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (7.2989 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 114284.82 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (7.2989 + 0.0 + 0.9894 + (1.8838)) * 138 \\
 &= 140259.59 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (7.2989 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138 \\
 &= 140259.59 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 149.8668 * 10.0 * 0.49 * 136 \\
 &= 157364. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 62.8013) * (16.6 - 3.0) * 0.7 * 136 \\
 &= 256236. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

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	BK	GCS	MF	120	ME	CN	0009	V01

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

$$= (3.1416/2.0) * 149.8668 * (10.0 - 3.0) * 0.74 * 138$$

$$= 168144. \text{ N}$$

Strength of Failure Paths:

$$\text{PATH11} = (\text{SONW} + \text{SNW}) = (157364 + 256236) = 413600 \text{ N}$$

$$\text{PATH22} = (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw})$$

$$= (157364 + 0 + 168144 + 0) = 325509 \text{ N}$$

$$\text{PATH33} = (\text{Sonw} + \text{Tngw} + \text{Sinw})$$

$$= (157364 + 168144 + 0) = 325509 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 413600 N , must exceed W = 38375 N or W1 = 114284 N

Path 2-2 = 325508 N , must exceed W = 38375 N or W2 = 140259 N

Path 3-3 = 325508 N , must exceed W = 38375 N or W3 = 140259 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: K10B (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 0.654 in.

Nozzle input data check completed without errors.

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

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

$$= (4.19 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.19)$$

$$= 1.8344 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.19 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.19)$$

$$= 0.0873 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.4877 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 113.6000 mm.

Parallel to Vessel Wall, opening length d 56.8000 mm.

Normal to Vessel Wall (Thickness Limit), no pad Tlnp 17.5000 mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

 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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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

AREA AVAILABLE, A1 to A5	Design	External	Mapnc
Area Required Ar	1.047	1.821	NA
Area in Shell A1	2.919	0.350	NA
Area in Nozzle Wall A2	4.679	4.540	NA
Area in Inward Nozzle A3	0.000	0.000	NA
Area in Welds A41+A42+A43	0.989	0.989	NA
Area in Element A5	0.000	0.000	NA
TOTAL AREA AVAILABLE Atot	8.588	5.880	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]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot t_n \cdot tr \cdot F (1 - fr_1)) \text{ per UG-37(d)}$$

$$= 0.5 (56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1 (1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E_1 \cdot t - F \cdot tr) - 2 \cdot t_n (E_1 \cdot t - F \cdot tr) \cdot (1 - fr_1)$$

$$= 56.8 (1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6 (1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot t_{lnp}) (t_n - tr_n) fr_2$$

$$= (2 \cdot 17.5) (13.6 - 0.49) \cdot 0.9894$$

$$= 4.540 \text{ cm}^2$$

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

$$= W_o^2 \cdot fr_2 + (W_i - can / 0.707)^2 \cdot fr_2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.4877 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8344 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.8344 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.8000 mm.

Determine Nozzle Thickness candidate [tb]:

$$= \min[tb_3, \max(tb_1, tb_2)]$$

$$= \min[7.8, \max(4.8344, 4.5)]$$

$$= 4.8344 \text{ mm.}$$

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

$$= \max(ta, tb)$$

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	BK	GCS	MF	120	ME	CN	0009	V01

$$= \max(3.4877, 4.8344)$$

$$= 4.8344 \text{ mm.}$$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Weld Size Calculations, Description: K10B (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min.}$	$7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) * S_v)$$

$$= \max(0, (1.8213 - 0.35 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) * 138)$$

$$= 22586.36 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v$$

$$= (4.5405 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76250.33 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.5405 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102225.10 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.5405 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102225.10 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 94245. \text{ N}$$

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V01	0009	CN	ME	120	MF	GCS	BK																			

Strength of Failure Paths:

$$\begin{aligned} \text{PATH11} &= (\text{SONW} + \text{SNW}) = (88202 + 143620) = 231822 \text{ N} \\ \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\ &= (88202 + 0 + 94245 + 0) = 182447 \text{ N} \\ \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\ &= (88202 + 94245 + 0) = 182447 \text{ N} \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned} \text{Path 1-1} &= 231822 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W1 = 76250 \text{ N} \\ \text{Path 2-2} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W2 = 102225 \text{ N} \\ \text{Path 3-3} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W3 = 102225 \text{ N} \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 74.2989 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 442.0646 mm.

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	BK	GCS	MF	120	ME	CN	0009		V01

Input, Nozzle Desc: K11B (2in)

From: 20

Pressure for Reinforcement Calculations	P	4.124	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	144.0000	mm.
Distance from Bottom/Left Tangent		650.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

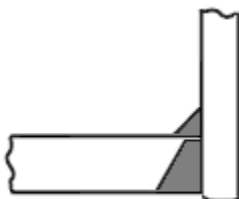
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		13.65	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

 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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The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K11B (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.12 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.12) \\
 &= 1.8066 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.12 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.12) \\
 &= 0.0860 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	117.0011	mm.
Parallel to Vessel Wall, opening length	d	58.5006	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	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	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)	شماره صفحه : 179 از 381																
	<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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.531	1.876	NA
Area in Shell	A1	3.549	0.361	NA
Area in Nozzle Wall	A2	4.775	4.685	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	9.314	6.035	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 76.15 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F (1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5 (58.5006 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1 (1 - 0.99))$$

$$= 1.876 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E1 \cdot t - F \cdot tr) - 2 \cdot tn (E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 58.501 (1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.361 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 \cdot 17.5) (13.6 - 0.34) 0.9894 / \sin(78.5)$$

$$= 4.685 \text{ cm}^2$$

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]:

$$= Wo^2 \cdot fr2 + (Wi - can / 0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

 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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Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $t_g = 10.0$, $t_r = 1.807$, $c = 3.0$ mm., $E^* = 1.0$
 Thickness Ratio = $t_r * (E^*) / (t_g - c) = 0.258$, Temp. Reduction = 78°C

Min Metal Temp. w/o impact per UCS-66, Curve A -8°C
 Min Metal Temp. at Required thickness (UCS 66.1) -104°C
 Min Metal Temp. w/o impact per UG-20(f) -29°C

Gov. MDMT of the nozzle to shell joint welded assembly : -104°C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29°C
 Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104°C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.12/51.10 = 0.081$

Weld Size Calculations, Description: K11B (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000$ mm.

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld $4.9000 = 0.7 * t_{min}$ $7.0700 = 0.7 * W_o$ mm.

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) * S_v)$$

$$= \max(0, (1.8756 - 0.3605 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) * 138)$$

$$= 23189.23 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v$$

$$= (4.6846 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 78237.69 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.6846 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 104212.46 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.6846 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 104212.46 \text{ N}$$

	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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Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 86.5149 * 10.0 * 0.49 * 136$$

$$= 90843. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 36.2539) * (16.6 - 3.0) * 0.7 * 136$$

$$= 147920. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 86.5149 * (10.0 - 3.0) * 0.74 * 138$$

$$= 97066. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (90843 + 147920) = 238763 \text{ N}$$

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

$$= (90843 + 0 + 97066 + 0) = 187909 \text{ N}$$

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

$$= (90843 + 97066 + 0) = 187909 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 238762 N , must exceed W = 23189 N or W1 = 78237 N

Path 2-2 = 187909 N , must exceed W = 23189 N or W2 = 104212 N

Path 3-3 = 187909 N , must exceed W = 23189 N or W3 = 104212 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: K11B (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 0.654 in.

Nozzle input data check completed without errors.

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

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

$$= (4.12 * 603.0) / (138 * 1.0 - 0.6 * 4.12)$$

$$= 1.8066 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.12 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.12)$$

$$= 0.0860 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000	mm.
Parallel to Vessel Wall, opening length	d	56.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.031	1.821	NA
Area in Shell	A1	2.935	0.350	NA
Area in Nozzle Wall	A2	4.680	4.591	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.604	5.930	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]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot t_n \cdot tr \cdot F (1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5 (56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1 (1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E1 \cdot t - F \cdot tr) - 2 \cdot t_n (E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8 (1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot t_{lnp}) (t_n - t_{rn}) fr2$$

$$= (2 \cdot 17.5) (13.6 - 0.34) 0.9894$$

$$= 4.591 \text{ cm}^2$$

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

$$= W_o^2 \cdot fr2 + (W_i - can / 0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures $t_a = 3.3430 \text{ mm.}$

 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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V01	0009	CN	ME	120	MF	GCS	BK											

Wall Thickness per UG16(b), $tr16b = 4.5000 \text{ mm.}$
 Wall Thickness, shell/head, internal pressure $trb1 = 4.8066 \text{ mm.}$
 Wall Thickness $tb1 = \max(trb1, tr16b) = 4.8066 \text{ mm.}$
 Wall Thickness, shell/head, external pressure $trb2 = 3.4524 \text{ mm.}$
 Wall Thickness $tb2 = \max(trb2, tr16b) = 4.5000 \text{ mm.}$
 Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.8066, 4.5)]$
 $= 4.8066 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.343, 4.8066)$
 $= 4.8066 \text{ mm.}$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Weld Size Calculations, Description: K11B (2in)

Intermediate Calc. for nozzle/shell Welds $Tmin = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld $4.9000 = 0.7 * tmin.$ $7.0700 = 0.7 * Wo \text{ mm.}$

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

Weld Load [W]:

$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.8213 - 0.35 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$
 $= 22586.36 \text{ N}$

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

Weld Load [W1]:

$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$
 $= (4.5906 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$
 $= 76941.22 \text{ N}$

Weld Load [W2]:

$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$
 $= (4.5906 + 0.0 + 0.9894 + (1.8838)) * 138$
 $= 102915.99 \text{ N}$

Weld Load [W3]:

$= (A2+A3+A4+A5+(2*tn*t*fr1))*S$
 $= (4.5906 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$
 $= 102915.99 \text{ N}$

 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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V01	0009	CN	ME	120	MF	GCS	BK											

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. N$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. N$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 136$$

$$= 94245. N$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (88202 + 143620) = 231822 N$$

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

$$= (88202 + 0 + 94245 + 0) = 182447 N$$

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

$$= (88202 + 94245 + 0) = 182447 N$$

Summary of Failure Path Calculations:

Path 1-1 = 231822 N , must exceed W = 22586 N or W1 = 76941 N

Path 2-2 = 182446 N , must exceed W = 22586 N or W2 = 102915 N

Path 3-3 = 182446 N , must exceed W = 22586 N or W3 = 102915 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 12.0218 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 172.3178 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01	

Input, Nozzle Desc: K11A (2in)

From: 20

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.

Note : User defined Limit(s) of Reinforcement specified below:

Physical Maximum for Diameter Limit	Dmax	90.0000	mm.
Distance from Cylinder/Cone Centerline	L1	500.0000	mm.
Distance from Bottom/Left Tangent		650.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		55.05	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	300.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.

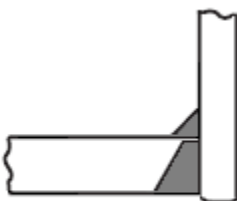
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V01	0009	CN	ME	120	MF	GCS	BK											

Flange Class
Flange Grade

300
GR 1.1

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K11A (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.0855 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.4569 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	160.5715 mm.
Parallel to Vessel Wall, opening length	d	80.2858 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 mm.

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	BK	GCS	MF	120	ME	CN	0009		V01

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.913	3.242	NA
Area in Shell	A1	3.597	0.365	NA
Area in Nozzle Wall	A2	7.523	7.316	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	12.109	8.670	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 34.09 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(101.3385 * 6.3807 * 1 + 2 * 13.6 * 6.3807 * 1(1 - 0.99))$$

$$= 3.242 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1)$$

$$= 59.233(1.0 * 7.0 - 1.0 * 6.381) - 2 * 13.6$$

$$(1.0 * 7.0 - 1.0 * 6.3807) * (1 - 0.989)$$

$$= 0.365 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 * tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 * 17.5) (13.6 - 0.46) 0.9894 / \sin(38.5)$$

$$= 7.316 \text{ cm}^2$$

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]:

$$= Wo^2 * fr2 + (Wi - can / 0.707)^2 * fr2$$

$$= 10.0^2 * 0.9894 + (0.0)^2 * 0.9894$$

$$= 0.989 \text{ cm}^2$$

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Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $t_g = 10.0$, $t_r = 1.796$, $c = 3.0$ mm., $E^* = 1.0$
 Thickness Ratio = $t_r * (E^*) / (t_g - c) = 0.257$, Temp. Reduction = 78°C

Min Metal Temp. w/o impact per UCS-66, Curve A -8°C
 Min Metal Temp. at Required thickness (UCS 66.1) -104°C
 Min Metal Temp. w/o impact per UG-20(f) -29°C

Gov. MDMT of the nozzle to shell joint welded assembly : -104°C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29°C
 Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104°C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.10/51.10 = 0.080$

Weld Size Calculations, Description: K11A (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000$ mm.

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld $4.9000 = 0.7 * t_{min}$ $7.0700 = 0.7 * W_o$ mm.

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) * S_v)$$

$$= \max(0, (3.2423 - 0.3651 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) * 138)$$

$$= 41971.50 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v$$

$$= (7.316 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 114521.38 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (7.316 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 140496.16 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (7.316 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 140496.16 \text{ N}$$

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	BK	GCS	MF	120	ME	CN	0009	V01

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 149.8668 * 10.0 * 0.49 * 136$$

$$= 157364. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 62.8013) * (16.6 - 3.0) * 0.7 * 136$$

$$= 256236. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 149.8668 * (10.0 - 3.0) * 0.74 * 138$$

$$= 168144. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (157364 + 256236) = 413600 \text{ N}$$

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

$$= (157364 + 0 + 168144 + 0) = 325509 \text{ N}$$

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

$$= (157364 + 168144 + 0) = 325509 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 413600 N , must exceed W = 41971 N or W1 = 114521 N
 Path 2-2 = 325508 N , must exceed W = 41971 N or W2 = 140496 N
 Path 3-3 = 325508 N , must exceed W = 41971 N or W3 = 140496 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: K11A (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 0.654 in.

Nozzle input data check completed without errors.

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

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

$$= (4.1 * 603.0) / (138 * 1.0 - 0.6 * 4.1)$$

$$= 1.7961 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.1 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.1)$$

$$= 0.0855 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.4569 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	90.0000	mm.
Parallel to Vessel Wall, opening length	d	45.0000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.025	1.821	NA
Area in Shell	A1	1.713	0.204	NA
Area in Nozzle Wall	A2	4.680	4.551	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.505	0.505	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	6.897	5.260	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]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot t_n \cdot tr \cdot F (1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5 (56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1 (1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E1 \cdot t - F \cdot tr) - 2 \cdot t_n (E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 33.2 (1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.204 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp) (t_n - trn) fr2$$

$$= (2 \cdot 17.5) (13.6 - 0.46) 0.9894$$

$$= 4.551 \text{ cm}^2$$

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

$$= (Wo^2 - \text{Area Lost}) \cdot fr2 + ((Wi - can / 0.707)^2 - \text{Area Lost}) \cdot fr2$$

$$= (10.0^2 - 0.49) \cdot 0.9894 + (0.0^2 - 0.0) \cdot 0.9894$$

$$= 0.505 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures $t_a = 3.4569 \text{ mm.}$

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V01	0009	CN	ME	120	MF	GCS	BK																			

Wall Thickness per UG16(b), $tr16b = 4.5000 \text{ mm.}$
 Wall Thickness, shell/head, internal pressure $trb1 = 4.7961 \text{ mm.}$
 Wall Thickness $tb1 = \max(trb1, tr16b) = 4.7961 \text{ mm.}$
 Wall Thickness, shell/head, external pressure $trb2 = 3.4524 \text{ mm.}$
 Wall Thickness $tb2 = \max(trb2, tr16b) = 4.5000 \text{ mm.}$
 Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.7961, 4.5)]$
 $= 4.7961 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.4569, 4.7961)$
 $= 4.7961 \text{ mm.}$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Weld Size Calculations, Description: K11A (2in)

Intermediate Calc. for nozzle/shell Welds $Tmin = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld $4.9000 = 0.7 * tmin.$ $7.0700 = 0.7 * Wo \text{ mm.}$

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

Weld Load [W]:

$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.8213 - 0.2038 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$
 $= 24601.74 \text{ N}$

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

Weld Load [W1]:

$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$
 $= (4.5512 + 0.0 + 0.5046 - 0.0 * 0.99) * 138$
 $= 69712.80 \text{ N}$

Weld Load [W2]:

$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$
 $= (4.5512 + 0.0 + 0.5046 + (1.8838)) * 138$
 $= 95687.57 \text{ N}$

Weld Load [W3]:

$= (A2+A3+A4+A5+(2*tn*t*fr1))*S$
 $= (4.5512 + 0.0 + 0.5046 + 0.0 + (1.8838)) * 138$
 $= 95687.57 \text{ N}$

 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>صادر کننده</td><td>بسته کاری</td><td>پروژه</td></tr><tr><td>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. N$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. N$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 136$$

$$= 94245. N$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (88202 + 143620) = 231822 N$$

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

$$= (88202 + 0 + 94245 + 0) = 182447 N$$

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

$$= (88202 + 94245 + 0) = 182447 N$$

Summary of Failure Path Calculations:

Path 1-1 = 231822 N , must exceed W = 24601 N or W1 = 69712 N

Path 2-2 = 182446 N , must exceed W = 24601 N or W2 = 95687 N

Path 3-3 = 182446 N , must exceed W = 24601 N or W3 = 95687 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 74.2989 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 392.0646 mm.

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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>0009</td><td>V01</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01
	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

Input, Nozzle Desc: K4 (2in)

From: 30

Pressure for Reinforcement Calculations	P	4.113	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3949.9995	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	250.0000	mm.
Distance from Bottom/Left Tangent		2250.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

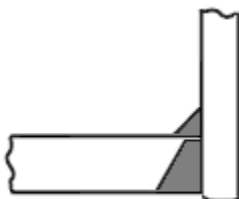
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		24.19	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

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	BK	GCS	MF	120	ME	CN	0009	V01

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K4 (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

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

$$= (4.11 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.11)$$

$$= 1.8020 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.11 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.11)$$

$$= 0.0858 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	124.7875 mm.
Parallel to Vessel Wall, opening length	d	62.3938 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5	Design	External	Mapnc

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	BK	GCS	MF	120	ME	CN	0009	V01

Area Required	Ar	0.565	2.000	NA
Area in Shell	A1	3.788	0.385	NA
Area in Nozzle Wall	A2	5.044	4.948	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	9.821	6.322	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 65.55 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5 (d * tr * F + 2 * tn * tr * F (1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5 (62.3938 * 6.3807 * 1 + 2 * 13.6 * 6.3807 * 1 (1 - 0.99))$$

$$= 2.000 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E1 * t - F * tr) - 2 * tn (E1 * t - F * tr) * (1 - fr1)$$

$$= 62.394 (1.0 * 7.0 - 1.0 * 6.381) - 2 * 13.6$$

$$(1.0 * 7.0 - 1.0 * 6.3807) * (1 - 0.989)$$

$$= 0.385 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 * tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 * 17.5) (13.6 - 0.34) 0.9894 / \sin(68.1)$$

$$= 4.948 \text{ cm}^2$$

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]:

$$= Wo^2 * fr2 + (Wi - can / 0.707)^2 * fr2$$

$$= 10.0^2 * 0.9894 + (0.0)^2 * 0.9894$$

$$= 0.989 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.802, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.257, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

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	BK	GCS	MF	120	ME	CN	0009	V01

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
 Design Pressure/Ambient Rating = 4.11/51.10 = 0.080

Weld Size Calculations, Description: K4 (2in)

Intermediate Calc. for nozzle/shell Welds Tmin 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.9000 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (2.0 - 0.3846 + 2 * 13.6 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 6.3807)) 138) \\
 &= 24569.42 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (4.9479 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 81868.14 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (4.9479 + 0.0 + 0.9894 + (1.8838)) * 138 \\
 &= 107842.91 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (4.9479 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138 \\
 &= 107842.91 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 92.2725 * 10.0 * 0.49 * 136 \\
 &= 96889. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 38.6666) * (16.6 - 3.0) * 0.7 * 136 \\
 &= 157764. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

 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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$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (W_{gvi} - C_{as}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 92.2725 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 103526. \text{ N}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (96889 + 157764) = 254652 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (96889 + 0 + 103526 + 0) = 200415 \text{ N} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (96889 + 103526 + 0) = 200415 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned}
 \text{Path 1-1} &= 254652 \text{ N}, \text{ must exceed } W = 24569 \text{ N} \quad \text{or } W1 = 81868 \text{ N} \\
 \text{Path 2-2} &= 200414 \text{ N}, \text{ must exceed } W = 24569 \text{ N} \quad \text{or } W2 = 107842 \text{ N} \\
 \text{Path 3-3} &= 200414 \text{ N}, \text{ must exceed } W = 24569 \text{ N} \quad \text{or } W3 = 107842 \text{ N}
 \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: K4 (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 0.654 in.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.11 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.11) \\
 &= 1.8020 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.11 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.11) \\
 &= 0.0858 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 113.6000 mm.
Parallel to Vessel Wall, opening length d 56.8000 mm.
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 17.5000 mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 198 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

AREA AVAILABLE, A1 to A5	Design	External	Mapnc
Area Required Ar	1.029	1.821	NA
Area in Shell A1	2.937	0.350	NA
Area in Nozzle Wall A2	4.680	4.591	NA
Area in Inward Nozzle A3	0.000	0.000	NA
Area in Welds A41+A42+A43	0.989	0.989	NA
Area in Element A5	0.000	0.000	NA
TOTAL AREA AVAILABLE Atot	8.606	5.930	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]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot t_n \cdot tr \cdot F (1 - fr_1)) \text{ per UG-37(d)}$$

$$= 0.5 (56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1 (1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E_1 \cdot t - F \cdot tr) - 2 \cdot t_n (E_1 \cdot t - F \cdot tr) \cdot (1 - fr_1)$$

$$= 56.8 (1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot t_{lnp}) (t_n - tr_n) fr_2$$

$$= (2 \cdot 17.5) (13.6 - 0.34) \cdot 0.9894$$

$$= 4.591 \text{ cm}^2$$

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

$$= W_o^2 \cdot fr_2 + (W_i - can / 0.707)^2 \cdot fr_2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3430 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8020 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.8020 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.8000 mm.

Determine Nozzle Thickness candidate [tb]:

$$= \min[tb_3, \max(tb_1, tb_2)]$$

$$= \min[7.8, \max(4.802, 4.5)]$$

$$= 4.8020 \text{ mm.}$$

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

$$= \max(ta, tb)$$

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شماره پیمان: 053 - 073 - 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>پروژه</th><th>بسته کاری</th><th>صادر کننده</th><th>تسهیلات</th><th>رشته</th><th>نوع مدرک</th><th>سریال</th><th>نسخه</th></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0009</td><td>V01</td></tr></table>	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)								پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 199 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه																			
BK	GCS	MF	120	ME	CN	0009	V01																			

$$= \max(3.343, 4.802)$$

$$= 4.8020 \text{ mm.}$$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Weld Size Calculations, Description: K4 (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min.}$	$7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) S_v)$$

$$= \max(0, (1.8213 - 0.35 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) * 138)$$

$$= 22586.36 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - Can / .707)^2 * f_{r2}) * S_v$$

$$= (4.5906 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76941.22 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.5906 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.5906 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 94245. \text{ N}$$

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Strength of Failure Paths:

$$\begin{aligned} \text{PATH11} &= (\text{SONW} + \text{SNW}) = (88202 + 143620) = 231822 \text{ N} \\ \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\ &= (88202 + 0 + 94245 + 0) = 182447 \text{ N} \\ \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\ &= (88202 + 94245 + 0) = 182447 \text{ N} \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned} \text{Path 1-1} &= 231822 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W1 = 76941 \text{ N} \\ \text{Path 2-2} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W2 = 102915 \text{ N} \\ \text{Path 3-3} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W3 = 102915 \text{ N} \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 21.2830 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 182.2645 mm.

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شماره پیمان: 053 - 073 - 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100) <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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 201 از 381
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه											
V01	0009	CN	ME	120	MF	GCS	BK											

Input, Nozzle Desc: N11 (1in)

From: 30

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3949.9995	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		2200.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

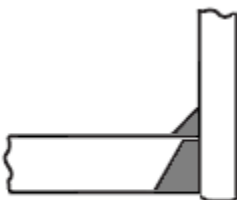
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		90.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.8000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	8.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

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: N11 (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.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= R (\exp([P / (S_n \cdot E)]) - 1) \text{ per Appendix 1-2 (a) (1)} \\
 &= 15.7 (\exp([4.1 / (136.43 \cdot 1.0)] - 1)) \\
 &= 0.0473 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.2571 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	65.0000 mm.
Parallel to Vessel Wall	Rn+tn+t	32.5000 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

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	BK	GCS	MF	120	ME	CN	0009	V01

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.568	1.008	NA
Area in Shell	A1	1.738	0.207	NA
Area in Nozzle Wall	A2	3.377	3.305	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.623	0.623	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	5.738	4.135	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(31.4 \cdot 6.3807 \cdot 1 + 2 \cdot 9.8 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.008 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 33.6(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 9.8$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.207 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(9.8 - 0.26) \cdot 0.9894$$

$$= 3.305 \text{ cm}^2$$

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

$$= (Wo^2 - \text{Area Lost}) \cdot fr2 + ((Wi - can/0.707)^2 - \text{Area Lost}) \cdot fr2$$

$$= (8.0^2 - 0.01) \cdot 0.9894 + (0.0^2 - 0.0) \cdot 0.9894$$

$$= 0.623 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.2571 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tbt = max(trb1, tr16b) = 4.7961 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01	

Wall Thickness $tb2 = \max(tb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 6.4200 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:
 $= \min[tb3, \max(tb1, tb2)]$
 $= \min[6.42, \max(4.7961, 4.5)]$
 $= 4.7961 \text{ mm.}$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
 $= \max(ta, tb)$
 $= \max(3.2571, 4.7961)$
 $= 4.7961 \text{ mm.}$

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

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.796$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = $78 \text{ }^\circ\text{C}$

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^\circ\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^\circ\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^\circ\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^\circ\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-18 \text{ }^\circ\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^\circ\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = $4.10/19.60 = 0.209$

Weld Size Calculations, Description: N11 (1in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min}$ $5.6560 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:
 $= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.0084 - 0.2068 + 2 * 9.8 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$
 $= 12709.29 \text{ N}$

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

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Weld Load [W1]:

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

$$= (3.3045 + 0.0 + 0.6233 - 0.0 * 0.99) * 138$$

$$= 54159.96 \text{ N}$$

Weld Load [W2]:

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

$$= (3.3045 + 0.0 + 0.6233 + (1.3574)) * 138$$

$$= 72877.07 \text{ N}$$

Weld Load [W3]:

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

$$= (3.3045 + 0.0 + 0.6233 + 0.0 + (1.3574)) * 138$$

$$= 72877.07 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 51.0 * 8.0 * 0.49 * 136$$

$$= 42841. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 20.6) * (12.8 - 3.0) * 0.7 * 136$$

$$= 60566. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 51.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 57220. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (42841 + 60566) = 103407 \text{ N}$$

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

$$= (42841 + 0 + 57220 + 0) = 100061 \text{ N}$$

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

$$= (42841 + 57220 + 0) = 100061 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 103406 N , must exceed W = 12709 N or W1 = 54159 N

Path 2-2 = 100061 N , must exceed W = 12709 N or W2 = 72877 N

Path 3-3 = 100061 N , must exceed W = 12709 N or W3 = 72877 N

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V01	0009	CN	ME	120	MF	GCS	BK											

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 0.5421 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 160.5421 mm.

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)							شماره صفحه : 207 از 381
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	
							V01	

Input, Nozzle Desc: M1 (24in)

From: 30

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3949.9995	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.

Note : User defined Limit(s) of Reinforcement specified below:

Physical Maximum for Diameter Limit	Dmax	920.0001	mm.
Distance from Bottom/Left Tangent		1450.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Normalized]		SA-516	70
Material UNS Number		K02700	
Material Specification/Type		Plate	
Allowable Stress at Temperature	Sn	137.90	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		OD	
Layout Angle		90.00	deg
Diameter		24.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	10.0000	mm.
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516	70

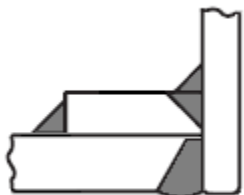
 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)																									
شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 208 از 381
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V01	0009	CN	ME	120	MF	GCS	BK																			

Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²
Diameter of Pad along vessel surface	Dp	800.0000	mm.
Thickness of Pad	te	10.0000	mm.
Weld leg size between Pad and Shell	Wp	8.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	10.0000	mm.
Reinforcing Pad Width		95.2000	mm.
This is a Manway or Access Opening.			

Flange Class 150
Flange Grade GR 1.1

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: M1 (24in)

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

Actual Outside Diameter Used in Calculation	24.000	in.
Actual Thickness Used in Calculation	0.394	in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R_o) / (S_n \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)} \\
 &= (4.1 \cdot 304.8) / (138 \cdot 1.0 + 0.4 \cdot 4.1) \\
 &= 0.9052 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 1.0868 mm.

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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه										
BK	GCS	MF	120	ME	CN	0009	V01											

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

Parallel to Vessel Wall (Diameter Limit) D1 920.0001 mm.
Parallel to Vessel Wall, opening length d 460.0000 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 mm.

Weld Strength Reduction Factor [fr1]:

= min(1, Sn/Sv)
= min(1, 137.9/137.9)
= 1.000

Weld Strength Reduction Factor [fr2]:

= min(1, Sn/Sv)
= min(1, 137.9/137.9)
= 1.000

Weld Strength Reduction Factor [fr4]:

= min(1, Sp/Sv)
= min(1, 137.9/137.9)
= 1.000

Weld Strength Reduction Factor [fr3]:

= min(fr2, fr4)
= min(1.0, 1.0)
= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	10.698	19.002	NA
Area in Shell	A1	16.881	2.009	NA
Area in Nozzle Wall	A2	2.133	2.070	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		1.577	1.577	NA
Area in Element	A5	19.040	19.040	NA
TOTAL AREA AVAILABLE	Atot	39.632	24.696	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS: Diameter Thickness
Based on given Pad Thickness: 743.0544 10.0000 mm.
Based on given Pad Diameter: 800.0001 7.0092 mm.
Based on Shell or Nozzle Thickness: 743.0544 10.0000 mm.

Area Required [A]:

= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(595.6*6.3807*1+2*7.0*6.3807*1(1-1.0))
= 19.002 cm²

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	BK	GCS	MF	120	ME	CN	0009	V01

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$\begin{aligned}
 &= d(E1 \cdot t - F \cdot t_r) - 2 \cdot t_n(E1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 324.4(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 7.0 \\
 &\quad (1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 1.0) \\
 &= 2.009 \text{ cm}^2
 \end{aligned}$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$\begin{aligned}
 &= (2 \cdot T_{lwp}) \cdot (t_n - t_{rn}) \cdot f_{r2} \\
 &= (2 \cdot 17.5) \cdot (7.0 - 1.09) \cdot 1.0 \\
 &= 2.070 \text{ cm}^2
 \end{aligned}$$

Area Available in Welds [A41 + A42 + A43]:

$$\begin{aligned}
 &= (W_o^2 - A_r \text{ Lost}) \cdot F_{r3} + ((W_i - c_{an}/0.707)^2 - A_r \text{ Lost}) \cdot f_{r2} + W_p^2 \cdot f_{r4} \\
 &= (0.9375) \cdot 1.0 + (0.0) \cdot 1.0 + 203.2^2 \cdot 1.0 \\
 &= 1.577 \text{ cm}^2
 \end{aligned}$$

Area Available in Element [A5]:

$$\begin{aligned}
 &= (\min(D_p, D_L) - (\text{Nozzle OD})) \cdot (\min(t_p, T_{lwp}, t_e)) \cdot f_{r4} \\
 &= (800.0 - 609.6) \cdot 10.0 \cdot 1.0 \\
 &= 19.040 \text{ cm}^2
 \end{aligned}$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:D, Curve:B)

Govrn. thk, $t_g = 10.0$, $t_r = 0.905$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
 Thickness Ratio = $t_r \cdot (E^*) / (t_g - c) = 0.129$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
 Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: D

Govrn. thk, $t_g = 10.0$, $t_r = 0.905$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
 Thickness Ratio = $t_r \cdot (E^*) / (t_g - c) = 0.129$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, $t_g = 10.0$, $t_r = 0.905$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
 Thickness Ratio = $t_r \cdot (E^*) / (t_g - c) = 0.129$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, $t_g = 10.0$, $t_r = 1.796$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
 Thickness Ratio = $t_r \cdot (E^*) / (t_g - c) = 0.257$, Temp. Reduction = 78 °C

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V01	0009	CN	ME	120	MF	GCS	BK																			

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)(1)(b)), Curve: D

Govrn. thk, tg = 10.0, tr = 1.796, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr \cdot (E^*) / (tg - c) = 0.257$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C
Gov. MDMT of the Reinforcement Pad : -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.10 / 19.60 = 0.209$

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

Parallel to Vessel Wall (Diameter Limit) D1 893.4000 mm.
Parallel to Vessel Wall, opening length d 446.7000 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 mm.

Reinforcement Areas for Large Nozzle (Per App 1-7(a)): (cm²)

AREA AVAILABLE, A1 to A6		No Pad	With Pad
Area Required [External Pressure]	AR	12.668	12.668
Area Available in Shell	A1	1.844	1.844
Area Available in Nozzle Wall	A2	2.070	2.070
Area Available in Inward Nozzle	A3	0.000	0.000
Area Available in Welds	A4	1.000	1.577
Area Available in Pad	A5	0.000	19.040
Area Available in Hub	A6	0.000	0.000
TOTAL AREA AVAILABLE	Atot	4.914	24.531

The area available without a pad is Insufficient.
The area available with the given pad is Sufficient.

Note: The Nozzle does not fall within the scope of the diameter requirements of App. 1-7(b). Therefore, the Membrane and Bending stress checks are not required.

Weld Size Calculations, Description: M1 (24in)

Intermediate Calc. for nozzle/shell Welds Tmin 7.0000 mm.
Intermediate Calc. for pad/shell Welds TminPad 7.0000 mm.

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	BK	GCS	MF	120	ME	CN	0009		V01

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.9000 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm.
Pad Weld	3.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (19.0017 - 2.0091 + 2 * 7.0 * 1.0 * (1.0 * 7.0 - 6.3807))138) \\
 &= 235503.12 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (2.0696 + 19.04 + 1.5775 - 0.0 * 1.0) * 138 \\
 &= 312828.88 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (2.0696 + 0.0 + 1. + (0.98)) * 138 \\
 &= 55839.54 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (2.0696 + 0.0 + 1.5775 + 19.04 + (0.98)) * 138 \\
 &= 326341.91 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 609.6 * 10.0 * 0.49 * 138 \\
 &= 646976. \text{ N}
 \end{aligned}$$

Shear, Pad Element Weld [Spew]:

$$\begin{aligned}
 &= (\pi/2) * DP * WP * 0.49 * SEW \\
 &= (3.1416/2.0) * 800.0 * 8.0 * 0.49 * 138 \\
 &= 679240. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 301.3) * (10.0 - 3.0) * 0.7 * 138 \\
 &= 639547. \text{ N}
 \end{aligned}$$

Tension, Pad Groove Weld [Tpgw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wgpn * 0.74 * Seg \\
 &= (3.1416/2) * 609.6 * 10.0 * 0.74 * 138 \\
 &= 977066. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng$$

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V01	0009	CN	ME	120	MF	GCS	BK											

$$= (3.1416/2.0) * 609.6 * (10.0 - 3.0) * 0.74 * 138$$

$$= 683946. \text{ N}$$

Strength of Failure Paths:

$$\text{PATH11} = (\text{SPEW} + \text{SNW}) = (679240 + 639547) = 1318787 \text{ N}$$

$$\text{PATH22} = (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw})$$

$$= (646976 + 977066 + 683946 + 0) = 2307988 \text{ N}$$

$$\text{PATH33} = (\text{Spew} + \text{Tngw} + \text{Sinw})$$

$$= (679240 + 683946 + 0) = 1363186 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 1318787 N , must exceed W = 235503 N or W1 = 312828 N

Path 2-2 = 2307988 N , must exceed W = 235503 N or W2 = 55839 N

Path 3-3 = 1363186 N , must exceed W = 235503 N or W3 = 326341 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 11 bars

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 83.1858 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 243.1858 mm.

Percent Elongation Calculations:

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 1.668 %

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100) <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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 214 از 381
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه											
V01	0009	CN	ME	120	MF	GCS	BK											

Input, Nozzle Desc: N7B (2in)

From: 30

Pressure for Reinforcement Calculations	P	4.198	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3949.9995	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1700.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

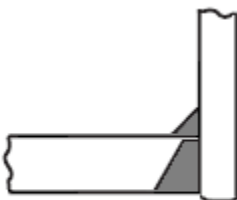
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		270.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	15.8500	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

 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 REBOILER (R-100)							شماره صفحه : 215 از 381
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	BK	GCS	MF	120	ME	CN	0009	V01

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



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

Reinforcement CALCULATION, Description: N7B (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.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 1.8391 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 0.0876 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3393 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000 mm.
Parallel to Vessel Wall, opening length	d	56.8000 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.050	1.821	NA
Area in Shell	A1	2.917	0.350	NA
Area in Nozzle Wall	A2	4.419	4.332	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.326	5.672	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 12.85 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 12.85$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(12.85 - 0.34) \cdot 0.9894$$

$$= 4.332 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3393 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8391 mm.
Wall Thickness	tbl = max(trb1, tr16b) = 4.8391 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01

Wall Thickness $tb2 = \max(tb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.8391, 4.5)]$
 $= 4.8391 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.3393, 4.8391)$
 $= 4.8391 \text{ mm.}$

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

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.839$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.263$, Temp. Reduction = $78 \text{ }^\circ\text{C}$

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^\circ\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^\circ\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^\circ\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^\circ\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-18 \text{ }^\circ\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^\circ\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.20/19.60 = 0.214$

Weld Size Calculations, Description: N7B (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min}$ $7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.8208 - 0.3501 + 2 * 12.85 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$
 $= 22451.24 \text{ N}$

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

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)	شماره صفحه : 218 از 381																
	<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>0009</td><td>V01</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01
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BK	GCS	MF	120	ME	CN	0009	V01											

Weld Load [W1]:

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

$$= (4.3322 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 73377.99 \text{ N}$$

Weld Load [W2]:

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

$$= (4.3322 + 0.0 + 0.9894 + (1.7799)) * 138$$

$$= 97920.34 \text{ N}$$

Weld Load [W3]:

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

$$= (4.3322 + 0.0 + 0.9894 + 0.0 + (1.7799)) * 138$$

$$= 97920.34 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 82.5 * 10.0 * 0.49 * 136$$

$$= 86627. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 34.825) * (15.85 - 3.0) * 0.7 * 136$$

$$= 134254. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 82.5 * (10.0 - 3.0) * 0.74 * 138$$

$$= 92562. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (86627 + 134254) = 220881 \text{ N}$$

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

$$= (86627 + 0 + 92562 + 0) = 179189 \text{ N}$$

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

$$= (86627 + 92562 + 0) = 179189 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 220881 N , must exceed W = 22451 N or W1 = 73377 N

Path 2-2 = 179188 N , must exceed W = 22451 N or W2 = 97920 N

Path 3-3 = 179188 N , must exceed W = 22451 N or W3 = 97920 N

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	V01	0009	CN	ME	120	MF	GCS	BK

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4197 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4197 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01

Input, Nozzle Desc: N5 (2in)

From: 30

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Temperature for External Pressure	Tempex	100	°C
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Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3949.9995	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1415.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

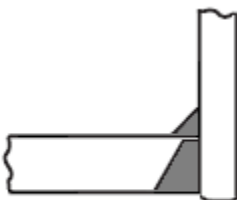
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
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Diameter Basis (for tr calc only)		ID	
Layout Angle		270.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	15.8500	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
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Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm.
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Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

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	BK	GCS	MF	120	ME	CN	0009	V01

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



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

Reinforcement CALCULATION, Description: N5 (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.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 1.8391 \text{ mm.}
 \end{aligned}$$

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$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 0.0876 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3393 mm.

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Parallel to Vessel Wall, opening length	d	56.8000 mm.
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Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.050	1.821	NA
Area in Shell	A1	2.917	0.350	NA
Area in Nozzle Wall	A2	4.419	4.332	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.326	5.672	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 12.85 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 12.85$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(12.85 - 0.34) \cdot 0.9894$$

$$= 4.332 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3393 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8391 mm.
Wall Thickness	tbt = max(trb1, tr16b) = 4.8391 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.

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شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 223 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Wall Thickness $tb2 = \max(trb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.8391, 4.5)]$
 $= 4.8391 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.3393, 4.8391)$
 $= 4.8391 \text{ mm.}$

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	: 12.0,	Allowable	: 136.4 N./mm ²	Passed
Expansion	: 0.0,	Allowable	: 330.9 N./mm ²	Passed
Occasional	: 0.4,	Allowable	: 181.5 N./mm ²	Passed
Shear	: 3.1,	Allowable	: 95.5 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.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.839$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.263$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)	-18 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b)	-104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.20/19.60 = 0.214$

Weld Size Calculations, Description: N5 (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min.}$	$7.0700 = 0.7 * W_o \text{ mm.}$

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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>0009</td><td>V01</td></tr></table>		پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01
	پروژه		بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (1.8208 - 0.3501 + 2 * 12.85 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 6.3807)) 138) \\
 &= 22451.24 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (4.3322 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 73377.99 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (4.3322 + 0.0 + 0.9894 + (1.7799)) * 138 \\
 &= 97920.34 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (4.3322 + 0.0 + 0.9894 + 0.0 + (1.7799)) * 138 \\
 &= 97920.34 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 82.5 * 10.0 * 0.49 * 136 \\
 &= 86627. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 34.825) * (15.85 - 3.0) * 0.7 * 136 \\
 &= 134254. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng \\
 &= (3.1416/2.0) * 82.5 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 92562. \text{ N}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (86627 + 134254) = 220881 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (86627 + 0 + 92562 + 0) = 179189 \text{ N} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (86627 + 92562 + 0) = 179189 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned}
 \text{Path 1-1} &= 220881 \text{ N} , \text{ must exceed } W = 22451 \text{ N} \quad \text{or } W1 = 73377 \text{ N} \\
 \text{Path 2-2} &= 179188 \text{ N} , \text{ must exceed } W = 22451 \text{ N} \quad \text{or } W2 = 97920 \text{ N} \\
 \text{Path 3-3} &= 179188 \text{ N} , \text{ must exceed } W = 22451 \text{ N} \quad \text{or } W3 = 97920 \text{ N}
 \end{aligned}$$

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Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4197 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4197 mm.

Input Echo, WRC107/537 Item 1, Description: N5 (2in) :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	1200.000	mm.
Vessel Thickness	Tv	10.000	mm.
Design Temperature	T1	234.0	°C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	137.90	N./mm ²
Vessel Hot S.I. Allowable	Smh	137.90	N./mm ²

Note:

Using 2 * Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.

Make sure that material properties at this temperature are not time-dependent for Material: SA-516 70

Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	3.0000	mm.
Nozzle Diameter	Dn	50.800	mm.
Nozzle Thickness	Tn	15.850	mm.
Nozzle Material		SA-105	
Nozzle UNS Number		K03504	
Nozzle Cold S.I. Allowable	SNmc	137.90	N./mm ²
Nozzle Hot S.I. Allowable	SNmh	136.43	N./mm ²
Design Internal Pressure	Dp	4.198	bars
Include Pressure Thrust	No		

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS)	P	2800.0	N
Longitudinal Shear (SUS)	V1	2800.0	N
Circumferential Shear (SUS)	Vc	-2100.0	N
Circumferential Moment (SUS)	Mc	-280.0	N-m
Longitudinal Moment (SUS)	M1	-360.0	N-m
Torsional Moment (SUS)	Mt	-420.0	N-m

Use Interactive Control

No

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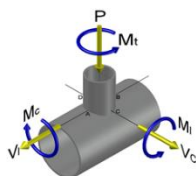
WRC107 Version

Version March 1979

Include Pressure Stress Indices per Div. 2 No
 Compute Pressure Stress per WRC-368 No
 Local Loads applied at end of Nozzle/Attachment No

Note:

WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:

$$\begin{aligned}
 &= \text{NozzleOD} + 2 * 1.65 * \text{sqrt}(\text{Rmean}(\text{t} - \text{ca})) \\
 &= 82.5 + 2 * 1.65 * \text{sqrt}(606.5 (10.0 - 3.0)) \\
 &= 297.520 \text{ mm.}
 \end{aligned}$$

WRC 107 Stress Calculation for SUSTAINED loads:

Radial Load	P	2800.0	N
Circumferential Shear	VC	-2100.0	N
Longitudinal Shear	VL	2800.0	N
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 = 86.64

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.060	4C	15.037	(A,B)
N(PHI) / (P/Rm)	0.060	3C	14.463	(C,D)
M(PHI) / (P)	0.060	2C1	0.100	(A,B)
M(PHI) / (P)	0.060	1C	0.139	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.060	3A	2.228	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.060	1A	0.096	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.060	3B	7.820	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.060	1B	0.049	(A,B,C,D)
N(x) / (P/Rm)	0.060	3C	14.463	(A,B)
N(x) / (P/Rm)	0.060	4C	15.037	(C,D)
M(x) / (P)	0.060	1C1	0.143	(A,B)
M(x) / (P)	0.060	2C	0.101	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.060	4A	3.056	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.060	2A	0.057	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.060	4B	2.219	(A,B,C,D)

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$M(x) / (ML/Rm * Beta) = 0.060 \quad 2B \quad 0.080 \quad (A, B, C, D)$

Stress Concentration Factors: $K_n = 1.00$, $K_b = 1.00$

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		-9.9	-9.9	-9.9	-9.9	-9.5	-9.5	-9.5	-9.5
Circ. Bend. P		-34.4	34.4	-34.4	34.4	-47.7	47.7	-47.7	47.7
Circ. Memb. MC		0.0	0.0	0.0	0.0	4.1	4.1	-4.1	-4.1
Circ. Memb. MC		0.0	0.0	0.0	0.0	91.5	-91.5	-91.5	91.5
Circ. Memb. ML		18.4	18.4	-18.4	-18.4	0.0	0.0	0.0	0.0
Circ. Bend. ML		60.3	-60.3	-60.3	60.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.		34.3	-17.4	-123.1	66.5	38.3	-49.2	-152.8	125.6
Long. Memb. P		-9.5	-9.5	-9.5	-9.5	-9.9	-9.9	-9.9	-9.9
Long. Bend. P		-49.2	49.2	-49.2	49.2	-34.6	34.6	-34.6	34.6
Long. Memb. MC		0.0	0.0	0.0	0.0	5.6	5.6	-5.6	-5.6
Long. Bend. MC		0.0	0.0	0.0	0.0	53.8	-53.8	-53.8	53.8
Long. Memb. ML		5.2	5.2	-5.2	-5.2	0.0	0.0	0.0	0.0
Long. Bend. ML		97.2	-97.2	-97.2	97.2	0.0	0.0	0.0	0.0
Tot. Long. Str.		43.7	-52.3	-161.1	131.6	14.8	-23.5	-103.8	72.8
Shear VC		-2.3	-2.3	2.3	2.3	0.0	0.0	0.0	0.0
Shear VL		0.0	0.0	0.0	0.0	-3.1	-3.1	3.1	3.1
Shear MT		-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6
Tot. Shear		-7.9	-7.9	-3.3	-3.3	-8.7	-8.7	-2.5	-2.5
Str. Int.		48.2	54.0	161.4	131.8	41.1	51.9	152.9	125.7

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	BK	GCS	MF	120	ME	CN	0009		V01

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)		36.0	36.4	36.0	36.4	36.0	36.4	36.0	36.4
Circ. Pl (SUS)		8.4	8.4	-28.3	-28.3	-5.5	-5.5	-13.6	-13.6
Circ. Q (SUS)		25.9	-25.9	-94.8	94.8	43.7	-43.7	-139.2	139.2
Long. Pm (SUS)		18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Long. Pl (SUS)		-4.3	-4.3	-14.8	-14.8	-4.3	-4.3	-15.5	-15.5
Long. Q (SUS)		48.0	-48.0	-146.3	146.3	19.2	-19.2	-88.3	88.3
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		-2.3	-2.3	2.3	2.3	-3.1	-3.1	3.1	3.1
Shear Q (SUS)		-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6
Pm (SUS)		36.0	36.4	36.0	36.4	36.0	36.4	36.0	36.4
Pm+Pl (SUS)		44.6	45.0	8.7	9.0	31.0	31.4	22.8	23.2
Pm+Pl+Q (Total)		75.0	55.6	143.3	149.8	76.0	18.9	117.1	162.1

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	36.38	137.90	Passed
Pm+Pl (SUS)	44.99	206.85	Passed
Pm+Pl+Q (TOTAL)	162.06	413.70	Passed

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

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شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 229 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Input, Nozzle Desc: K8A (2in)

From: 30

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3949.9995	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	555.0000	mm.
Distance from Bottom/Left Tangent		1000.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

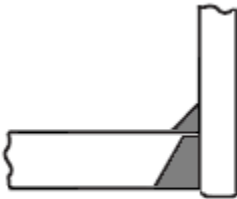
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		65.48	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

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V01	0009	CN	ME	120	MF	GCS	BK																			

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K8A (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.0855 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	294.7762	mm.
Parallel to Vessel Wall, opening length	d	147.3881	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5	Design	External	Mapnc

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	BK	GCS	MF	120	ME	CN	0009		V01

Area Required	Ar		1.326		4.711		NA
Area in Shell	A1		8.976		0.911		NA
Area in Nozzle Wall	A2		9.599		9.416		NA
Area in Inward Nozzle	A3		0.000		0.000		NA
Area in Welds A41+A42+A43			0.989		0.989		NA
Area in Element	A5		0.000		0.000		NA
TOTAL AREA AVAILABLE	Atot		19.565		11.317		NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 22.67 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(147.3881 * 6.3807 * 1 + 2 * 13.6 * 6.3807 * 1(1 - 0.99))$$

$$= 4.711 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1)$$

$$= 147.388(1.0 * 7.0 - 1.0 * 6.381) - 2 * 13.6$$

$$(1.0 * 7.0 - 1.0 * 6.3807) * (1 - 0.989)$$

$$= 0.911 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 * tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 * 17.5) (13.6 - 0.34) 0.9894 / \sin(29.2)$$

$$= 9.416 \text{ cm}^2$$

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]:

$$= Wo^2 * fr2 + (Wi - can / 0.707)^2 * fr2$$

$$= 10.0^2 * 0.9894 + (0.0)^2 * 0.9894$$

$$= 0.989 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.796, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.257, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

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	BK	GCS	MF	120	ME	CN	0009	V01

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
 Design Pressure/Ambient Rating = 4.10/51.10 = 0.080

Weld Size Calculations, Description: K8A (2in)

Intermediate Calc. for nozzle/shell Welds Tmin 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.9000 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (4.7114 - 0.911 + 2 * 13.6 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 6.3807)) 138) \\
 &= 54701.00 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (9.4163 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 143482.38 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (9.4163 + 0.0 + 0.9894 + (1.8838)) * 138 \\
 &= 169457.14 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (9.4163 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138 \\
 &= 169457.14 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 217.9684 * 10.0 * 0.49 * 136 \\
 &= 228873. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 91.3391) * (16.6 - 3.0) * 0.7 * 136 \\
 &= 372674. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

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	BK	GCS	MF	120	ME	CN	0009	V01	

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (W_{gvi} - C_{as}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 217.9684 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 244552. \text{ N}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (228873 + 372674) = 601546 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (228873 + 0 + 244552 + 0) = 473424 \text{ N} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (228873 + 244552 + 0) = 473424 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned}
 \text{Path 1-1} &= 601546 \text{ N}, \text{ must exceed } W = 54700 \text{ N} \quad \text{or } W1 = 143482 \text{ N} \\
 \text{Path 2-2} &= 473424 \text{ N}, \text{ must exceed } W = 54700 \text{ N} \quad \text{or } W2 = 169457 \text{ N} \\
 \text{Path 3-3} &= 473424 \text{ N}, \text{ must exceed } W = 54700 \text{ N} \quad \text{or } W3 = 169457 \text{ N}
 \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: K8A (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 0.654 in.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.0855 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	Dl	113.6000	mm.
Parallel to Vessel Wall, opening length	d	56.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

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Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.025	1.821	NA
Area in Shell	A1	2.941	0.350	NA
Area in Nozzle Wall	A2	4.680	4.591	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.610	5.930	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(13.6 - 0.34) \cdot 0.9894$$

$$= 4.591 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3430 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.7961 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.8000 mm.

Determine Nozzle Thickness candidate [tb]:

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

$$= \min[7.8, \max(4.7961, 4.5)]$$

$$= 4.7961 \text{ mm.}$$

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

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

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

$$= \max(3.343, 4.7961)$$

$$= 4.7961 \text{ mm.}$$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Weld Size Calculations, Description: K8A (2in)

Intermediate Calc. for nozzle/shell Welds T_{min} 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min}.$	$7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) S_v)$$

$$= \max(0, (1.8213 - 0.35 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$$

$$= 22586.36 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - Can / .707)^2 * f_{r2}) * S_v$$

$$= (4.5906 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76941.22 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.5906 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.5906 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416 / 2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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	BK	GCS	MF	120	ME	CN	0009	V01

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (W_{gvi-Cas}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 94245. \text{ N}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (88202 + 143620) = 231822 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (88202 + 0 + 94245 + 0) = 182447 \text{ N} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (88202 + 94245 + 0) = 182447 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned}
 \text{Path 1-1} &= 231822 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W1 = 76941 \text{ N} \\
 \text{Path 2-2} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W2 = 102915 \text{ N} \\
 \text{Path 3-3} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W3 = 102915 \text{ N}
 \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 168.0554 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 343.2057 mm.

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شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 237 از 381
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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Input, Nozzle Desc: K8B (2in)

From: 30

Pressure for Reinforcement Calculations	P	4.198	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3949.9995	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1000.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

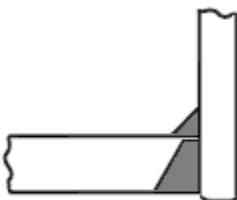
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		270.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

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



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

Reinforcement CALCULATION, Description: K8B (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 1.8391 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.2 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.2) \\
 &= 0.0876 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000 mm.
Parallel to Vessel Wall, opening length	d	56.8000 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

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	BK	GCS	MF	120	ME	CN	0009	V01

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.050	1.821	NA
Area in Shell	A1	2.916	0.350	NA
Area in Nozzle Wall	A2	4.679	4.591	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.585	5.930	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(13.6 - 0.34)0.9894$$

$$= 4.591 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3430 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8391 mm.
Wall Thickness	tbt = max(trb1, tr16b) = 4.8391 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Wall Thickness $tb2 = \max(tb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.8391, 4.5)]$
 $= 4.8391 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.343, 4.8391)$
 $= 4.8391 \text{ mm.}$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.839$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.263$, Temp. Reduction = $78 \text{ }^\circ\text{C}$

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^\circ\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^\circ\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^\circ\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^\circ\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-18 \text{ }^\circ\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^\circ\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.20/51.10 = 0.082$

Weld Size Calculations, Description: K8B (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min.}$ $7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.8213 - 0.35 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$
 $= 22586.36 \text{ N}$

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

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Weld Load [W1]:

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

$$= (4.5906 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76941.22 \text{ N}$$

Weld Load [W2]:

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

$$= (4.5906 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Weld Load [W3]:

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

$$= (4.5906 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 94245. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (88202 + 143620) = 231822 \text{ N}$$

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

$$= (88202 + 0 + 94245 + 0) = 182447 \text{ N}$$

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

$$= (88202 + 94245 + 0) = 182447 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 231822 N , must exceed W = 22586 N or W1 = 76941 N

Path 2-2 = 182446 N , must exceed W = 22586 N or W2 = 102915 N

Path 3-3 = 182446 N , must exceed W = 22586 N or W3 = 102915 N

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	BK	GCS	MF	120	ME	CN	0009	V01

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4718 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4718 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01

Input, Nozzle Desc: M2 (24in)

From: 40

Pressure for Reinforcement Calculations	P	4.135	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.

Note : User defined Limit(s) of Reinforcement specified below:

Physical Maximum for Diameter Limit	Dmax	1000.0000	mm.
Distance from Bottom/Left Tangent		3150.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Normalized]		SA-516	70
Material UNS Number		K02700	
Material Specification/Type		Plate	
Allowable Stress at Temperature	Sn	137.90	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		24.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	10.0000	mm.
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516	70

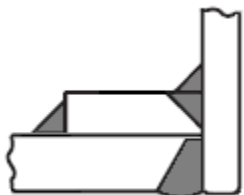
 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)							
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	BK	GCS	MF	120	ME	CN	0009	V01

Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²
Diameter of Pad along vessel surface	Dp	800.0000	mm.
Thickness of Pad	te	10.0000	mm.
Weld leg size between Pad and Shell	Wp	8.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	10.0000	mm.
Reinforcing Pad Width		95.2000	mm.
This is a Manway or Access Opening.			

Flange Class 150
Flange Grade GR 1.1

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: M2 (24in)

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

Actual Outside Diameter Used in Calculation	24.000	in.
Actual Thickness Used in Calculation	0.394	in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.13 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.13) \\
 &= 1.8115 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R_o) / (S_n \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)} \\
 &= (4.13 \cdot 304.8) / (138 \cdot 1.0 + 0.4 \cdot 4.13) \\
 &= 0.9129 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 1.0868 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	0009	V01

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

Parallel to Vessel Wall (Diameter Limit) D1 1000.0000 mm.
Parallel to Vessel Wall, opening length d 500.0000 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 mm.

Weld Strength Reduction Factor [fr1]:

= min(1, Sn/Sv)
= min(1, 137.9/137.9)
= 1.000

Weld Strength Reduction Factor [fr2]:

= min(1, Sn/Sv)
= min(1, 137.9/137.9)
= 1.000

Weld Strength Reduction Factor [fr4]:

= min(1, Sp/Sv)
= min(1, 137.9/137.9)
= 1.000

Weld Strength Reduction Factor [fr3]:

= min(fr2, fr4)
= min(1.0, 1.0)
= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	10.789	19.002	NA
Area in Shell	A1	20.982	2.505	NA
Area in Nozzle Wall	A2	2.130	2.070	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		1.577	1.577	NA
Area in Element	A5	19.040	19.040	NA
TOTAL AREA AVAILABLE	Atot	43.730	25.192	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS: Diameter Thickness
Based on given Pad Thickness: 738.0999 10.0000 mm.
Based on given Pad Diameter: 800.0001 6.7489 mm.
Based on Shell or Nozzle Thickness: 738.0999 10.0000 mm.

Area Required [A]:

= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(595.6*6.3807*1+2*7.0*6.3807*1(1-1.0))
= 19.002 cm²

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شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-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>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 246 از 381
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V01	0009	CN	ME	120	MF	GCS	BK																			

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$\begin{aligned}
 &= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1) \\
 &= 404.4(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 7.0 \\
 &\quad (1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 1.0) \\
 &= 2.505 \text{ cm}^2
 \end{aligned}$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$\begin{aligned}
 &= (2 \cdot Tlwp) \cdot (tn - trn) \cdot fr2 \\
 &= (2 \cdot 17.5) \cdot (7.0 - 1.09) \cdot 1.0 \\
 &= 2.070 \text{ cm}^2
 \end{aligned}$$

Area Available in Welds [A41 + A42 + A43]:

$$\begin{aligned}
 &= (Wo^2 - Ar \text{ Lost}) \cdot Fr3 + ((Wi - can / 0.707)^2 - Ar \text{ Lost}) \cdot fr2 + Wp^2 \cdot fr4 \\
 &= (0.9375) \cdot 1.0 + (0.0) \cdot 1.0 + 203.2^2 \cdot 1.0 \\
 &= 1.577 \text{ cm}^2
 \end{aligned}$$

Area Available in Element [A5]:

$$\begin{aligned}
 &= (\min(Dp, DL) - (\text{Nozzle OD})) \cdot (\min(tp, Tlwp, te)) \cdot fr4 \\
 &= (800.0 - 609.6) \cdot 10.0 \cdot 1.0 \\
 &= 19.040 \text{ cm}^2
 \end{aligned}$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:D, Curve:B)

Govrn. thk, tg = 10.0, tr = 0.913, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.13, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: D

Govrn. thk, tg = 10.0, tr = 0.913, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.13, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 10.0, tr = 0.913, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.13, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 10.0, tr = 1.811, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.259, Temp. Reduction = 78 °C

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	BK	GCS	MF	120	ME	CN	0009	V01

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)(1)(b)), Curve: D

Govrn. thk, tg = 10.0, tr = 1.811, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.259, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C
Gov. MDMT of the Reinforcement Pad : -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = 4.13/19.60 = 0.211

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

Parallel to Vessel Wall (Diameter Limit) D1 893.4000 mm.
Parallel to Vessel Wall, opening length d 446.7000 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 mm.

Reinforcement Areas for Large Nozzle (Per App 1-7(a)): (cm²)

AREA AVAILABLE, A1 to A6		No Pad	With Pad
Area Required [External Pressure]	AR	12.668	12.668
Area Available in Shell	A1	1.844	1.844
Area Available in Nozzle Wall	A2	2.070	2.070
Area Available in Inward Nozzle	A3	0.000	0.000
Area Available in Welds	A4	1.000	1.577
Area Available in Pad	A5	0.000	19.040
Area Available in Hub	A6	0.000	0.000
TOTAL AREA AVAILABLE	Atot	4.914	24.531

The area available without a pad is Insufficient.
The area available with the given pad is Sufficient.

Note: The Nozzle does not fall within the scope of the diameter requirements of App. 1-7(b). Therefore, the Membrane and Bending stress checks are not required.

Weld Size Calculations, Description: M2 (24in)

Intermediate Calc. for nozzle/shell Welds Tmin 7.0000 mm.
Intermediate Calc. for pad/shell Welds TminPad 7.0000 mm.

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min}$	$7.0700 = 0.7 * W_o \text{ mm.}$
Pad Weld	$3.5000 = 0.5 * T_{minPad}$	$5.6560 = 0.7 * W_p \text{ mm.}$

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A - A_1 + 2 * t_n * f_{r1} * (E_1 * t - t_r)) * S_v) \\
 &= \max(0, (19.0017 - 2.5045 + 2 * 7.0 * 1.0 * (1.0 * 7.0 - 6.3807)) * 138) \\
 &= 228671.33 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A_2 + A_5 + A_4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v \\
 &= (2.0696 + 19.04 + 1.5775 - 0.0 * 1.0) * 138 \\
 &= 312828.88 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A_2 + A_3 + A_4 + (2 * t_n * t * f_{r1})) * S_v \\
 &= (2.0696 + 0.0 + 1. + (0.98)) * 138 \\
 &= 55839.54 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A_2 + A_3 + A_4 + A_5 + (2 * t_n * t * f_{r1})) * S \\
 &= (2.0696 + 0.0 + 1.5775 + 19.04 + (0.98)) * 138 \\
 &= 326341.91 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi / 2) * D_{lo} * W_o * 0.49 * S_{nw} \\
 &= (3.1416 / 2.0) * 609.6 * 10.0 * 0.49 * 138 \\
 &= 646976. \text{ N}
 \end{aligned}$$

Shear, Pad Element Weld [Spew]:

$$\begin{aligned}
 &= (\pi / 2) * D_P * W_P * 0.49 * S_{EW} \\
 &= (3.1416 / 2.0) * 800.0 * 8.0 * 0.49 * 138 \\
 &= 679240. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - C_{an}) * 0.7 * S_n \\
 &= (3.1416 * 301.3) * (10.0 - 3.0) * 0.7 * 138 \\
 &= 639547. \text{ N}
 \end{aligned}$$

Tension, Pad Groove Weld [Tpgw]:

$$\begin{aligned}
 &= (\pi / 2) * D_{lo} * W_{gpn} * 0.74 * S_{eg} \\
 &= (3.1416 / 2) * 609.6 * 10.0 * 0.74 * 138 \\
 &= 977066. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

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

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V01	0009	CN	ME	120	MF	GCS	BK											

$$= (3.1416/2.0) * 609.6 * (10.0 - 3.0) * 0.74 * 138$$

$$= 683946. \text{ N}$$

Strength of Failure Paths:

$$\text{PATH11} = (\text{SPEW} + \text{SNW}) = (679240 + 639547) = 1318787 \text{ N}$$

$$\text{PATH22} = (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw})$$

$$= (646976 + 977066 + 683946 + 0) = 2307988 \text{ N}$$

$$\text{PATH33} = (\text{Spew} + \text{Tngw} + \text{Sinw})$$

$$= (679240 + 683946 + 0) = 1363186 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 1318787 N , must exceed W = 228671 N or W1 = 312828 N

Path 2-2 = 2307988 N , must exceed W = 228671 N or W2 = 55839 N

Path 3-3 = 1363186 N , must exceed W = 228671 N or W3 = 326341 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 11 bars

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 83.1858 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 243.1858 mm.

Percent Elongation Calculations:

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 1.668 %

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	BK	GCS	MF	120	ME	CN	0009	
							V01	

Input, Nozzle Desc: N4 (6in)

From: 40

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		3150.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm ²
Allowable Stress At Ambient	Sna	117.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		90.00	deg
Diameter		6.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	80	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	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	8.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²
Diameter of Pad along vessel surface	Dp	300.0000	mm.
Thickness of Pad	te	10.0000	mm.

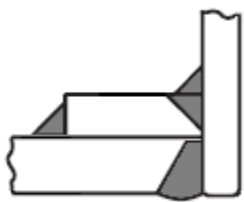
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	BK	GCS	MF	120	ME	CN	0009	V01

Weld leg size between Pad and Shell Wp 6.0000 mm.
Groove weld depth between Pad and Nozzle Wgpn 10.0000 mm.
Reinforcing Pad Width 65.8625 mm.

Flange Class 150
Flange Grade GR 1.1

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: N4 (6in)

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

Actual Inside Diameter Used in Calculation 5.869 in.
Actual Thickness Used in Calculation 0.378 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

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

$$= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1)$$

$$= 1.7961 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.1 \cdot 77.54) / (118 \cdot 1.0 - 0.6 \cdot 4.1)$$

$$= 0.2702 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.5131 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 310.1452 mm.
Parallel to Vessel Wall, opening length d 155.0726 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01

Weld Strength Reduction Factor [fr1]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr2]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr4]:

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

$$= \min(1, 137.9/137.9)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.855, 1.0)$$

$$= 0.855$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	2.820	5.008	NA
Area in Shell	A1	7.970	0.949	NA
Area in Nozzle Wall	A2	1.895	1.822	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.896	0.896	NA
Area in Element	A5	13.173	13.173	NA
TOTAL AREA AVAILABLE	Atot	23.934	16.839	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness
Based on given Pad Thickness:	181.6906	10.0000 mm.
Based on given Pad Diameter:	300.0000	1.0185 mm.
Based on Shell or Nozzle Thickness:	182.2478	9.6012 mm.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * t_n * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(155.0726 * 6.3807 * 1 + 2 * 6.6012 * 6.3807 * 1(1 - 0.86))$$

$$= 5.008 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 * t - F * tr) - 2 * t_n(E1 * t - F * tr) * (1 - fr1)$$

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

$$= 155.073 (1.0 * 7.0 - 1.0 * 6.381) - 2 * 6.601$$

$$(1.0 * 7.0 - 1.0 * 6.3807) * (1 - 0.855)$$

$$= 0.949 \text{ cm}^2$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$= (2 * Tlwp) * (tn - trn) * fr2$$

$$= (2 * 17.5) * (6.6 - 0.51) * 0.855$$

$$= 1.822 \text{ cm}^2$$

Area Available in Welds [A41 + A42 + A43]:

$$= (Wo^2 - Ar \text{ Lost}) * Fr3 + ((Wi - can / 0.707)^2 - Ar \text{ Lost}) * fr2 + Trapfr4$$

$$= (0.6375) * 0.86 + (0.0) * 0.86 + 35.1399^2 * 1.0$$

$$= 0.896 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(Dp, DL) - (\text{Nozzle OD})) * (\min(tp, Tlwp, te)) * fr4$$

$$= (300.0 - 168.275) * 10.0 * 1.0$$

$$= 13.173 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.5131 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.7961 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 9.2200 mm.

Determine Nozzle Thickness candidate [tb]:

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

$$= \min[9.22, \max(4.7961, 4.5)]$$

$$= 4.7961 \text{ mm.}$$

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

$$= \max(ta, tb)$$

$$= \max(3.5131, 4.7961)$$

$$= 4.7961 \text{ mm.}$$

Available Nozzle Neck Thickness = 9.6012 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 9.601, tr = 0.27, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.041, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, tg = 9.601, tr = 0.27, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.041, Temp. Reduction = 78 °C

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V01	0009	CN	ME	120	MF	GCS	BK											

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 9.601, tr = 0.27, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.041$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 10.0, tr = 1.796, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:B, Curve:D)

Govrn. thk, tg = 9.601, tr = 0.27, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.041$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C
Gov. MDMT of the Reinforcement Pad : -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.10/19.60 = 0.209$

Weld Size Calculations, Description: N4 (6in)

Intermediate Calc. for nozzle/shell Welds Tmin 6.6012 mm.
Intermediate Calc. for pad/shell Welds TminPad 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.6208 = 0.7 * t_{min}$	$5.6560 = 0.7 * W_o$ mm.
Pad Weld	$3.5000 = 0.5 * t_{minPad}$	$4.2420 = 0.7 * W_p$ mm.

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) S_v)$$

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$$= \max(0, (5.0084 - 0.9485 + 2 * 6.6012 * 0.855 * (1.0 * 7.0 - 6.3807)) * 138)$$

$$= 56944.79 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - \text{Can} / .707)^2 * fr2) * Sv$$

$$= (1.8218 + 13.1725 + 0.8965 - 0.0 * 0.86) * 138$$

$$= 219115.64 \text{ N}$$

Weld Load [W2]:

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

$$= (1.8218 + 0.0 + 0.5472 + (0.7902)) * 138$$

$$= 43561.84 \text{ N}$$

Weld Load [W3]:

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

$$= (1.8218 + 0.0 + 0.8965 + 13.1725 + (0.7902)) * 138$$

$$= 230011.06 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 168.275 * 8.0 * 0.49 * 118$$

$$= 122157. \text{ N}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * DP * WP * 0.49 * SEW$$

$$= (3.1416/2.0) * 300.0 * 6.0 * 0.49 * 138$$

$$= 191036. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 80.8369) * (9.6012 - 3.0) * 0.7 * 118$$

$$= 138348. \text{ N}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg}$$

$$= (3.1416/2) * 168.275 * 10.0 * 0.74 * 138$$

$$= 269711. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 168.275 * (10.0 - 3.0) * 0.74 * 138$$

$$= 188798. \text{ N}$$

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Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SPEW} + \text{SNW}) = (191036 + 138348) = 329385 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (122157 + 269711 + 188798 + 0) = 580666 \text{ N} \\
 \text{PATH33} &= (\text{Spew} + \text{Tngw} + \text{Sinw}) \\
 &= (191036 + 188798 + 0) = 379834 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 329384 N , must exceed W = 56944 N or W1 = 219115 N
 Path 2-2 = 580665 N , must exceed W = 56944 N or W2 = 43561 N
 Path 3-3 = 379833 N , must exceed W = 56944 N or W3 = 230011 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 5.9286 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 165.9286 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01

Input, Nozzle Desc: K5 (2in)

From: 40

Pressure for Reinforcement Calculations	P	4.110	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	3950.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	250.0000	mm.
Distance from Bottom/Left Tangent		2550.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

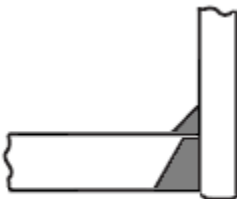
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		24.19	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

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The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K5 (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.11 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.11) \\
 &= 1.8007 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.11 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.11) \\
 &= 0.0857 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	124.7875	mm.
Parallel to Vessel Wall, opening length	d	62.3938	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5	Design	External	Mapnc

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BK	GCS	MF	120	ME	CN	0009	V01																			

Area Required	Ar		0.564		2.000		NA
Area in Shell	A1		3.788		0.385		NA
Area in Nozzle Wall	A2		5.044		4.948		NA
Area in Inward Nozzle	A3		0.000		0.000		NA
Area in Welds A41+A42+A43			0.989		0.989		NA
Area in Element	A5		0.000		0.000		NA
TOTAL AREA AVAILABLE	Atot		9.821		6.322		NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 65.55 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5 (62.3938 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1 (1 - 0.99))$$

$$= 2.000 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E1 \cdot t - F \cdot tr) - 2 \cdot tn (E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 62.394 (1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.385 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 \cdot 17.5) (13.6 - 0.34) 0.9894 / \sin(68.1)$$

$$= 4.948 \text{ cm}^2$$

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]:

$$= Wo^2 \cdot fr2 + (Wi - can / 0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.801, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.257, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

 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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ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
 Design Pressure/Ambient Rating = 4.11/51.10 = 0.080

Weld Size Calculations, Description: K5 (2in)

Intermediate Calc. for nozzle/shell Welds Tmin 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.9000 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (2.0 - 0.3846 + 2 * 13.6 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 6.3807)) 138) \\
 &= 24569.42 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (4.9479 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 81868.14 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (4.9479 + 0.0 + 0.9894 + (1.8838)) * 138 \\
 &= 107842.91 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (4.9479 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138 \\
 &= 107842.91 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 92.2725 * 10.0 * 0.49 * 136 \\
 &= 96889. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 38.6666) * (16.6 - 3.0) * 0.7 * 136 \\
 &= 157764. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

 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	0009	V01

$$= (\pi/2) * D_{lo} * (W_{gvi} - C_{as}) * 0.74 * S_{ng}$$

$$= (3.1416/2.0) * 92.2725 * (10.0 - 3.0) * 0.74 * 138$$

$$= 103526. \text{ N}$$

Strength of Failure Paths:

$$\text{PATH11} = (\text{SONW} + \text{SNW}) = (96889 + 157764) = 254652 \text{ N}$$

$$\text{PATH22} = (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw})$$

$$= (96889 + 0 + 103526 + 0) = 200415 \text{ N}$$

$$\text{PATH33} = (\text{Sonw} + \text{Tngw} + \text{Sinw})$$

$$= (96889 + 103526 + 0) = 200415 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 254652 N , must exceed W = 24569 N or W1 = 81868 N

Path 2-2 = 200414 N , must exceed W = 24569 N or W2 = 107842 N

Path 3-3 = 200414 N , must exceed W = 24569 N or W3 = 107842 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: K5 (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 0.654 in.

Nozzle input data check completed without errors.

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

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

$$= (4.11 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.11)$$

$$= 1.8007 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.11 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.11)$$

$$= 0.0857 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 113.6000 mm.

Parallel to Vessel Wall, opening length d 56.8000 mm.

Normal to Vessel Wall (Thickness Limit), no pad Tlnp 17.5000 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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Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.028	1.821	NA
Area in Shell	A1	2.938	0.350	NA
Area in Nozzle Wall	A2	4.680	4.591	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.607	5.930	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 6.3807 \cdot 1 + 2 \cdot 13.6 \cdot 6.3807 \cdot 1(1 - 0.99))$$

$$= 1.821 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 6.381) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 6.3807) \cdot (1 - 0.989)$$

$$= 0.350 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(13.6 - 0.34) \cdot 0.9894$$

$$= 4.591 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3430 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8007 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.8007 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.8000 mm.

Determine Nozzle Thickness candidate [tb]:

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

$$= \min[7.8, \max(4.8007, 4.5)]$$

$$= 4.8007 \text{ mm.}$$

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	BK	GCS	MF	120	ME	CN	0009	V01

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

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

$$= \max(3.343, 4.8007)$$

$$= 4.8007 \text{ mm.}$$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Weld Size Calculations, Description: K5 (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min.}$	$7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) S_v)$$

$$= \max(0, (1.8213 - 0.35 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 6.3807)) 138)$$

$$= 22586.36 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - Can / .707)^2 * f_{r2}) * S_v$$

$$= (4.5906 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76941.22 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.5906 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.5906 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416 / 2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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V01	0009	CN	ME	120	MF	GCS	BK											

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (W_{gvi-Cas}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 94245. \text{ N}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (88202 + 143620) = 231822 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (88202 + 0 + 94245 + 0) = 182447 \text{ N} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (88202 + 94245 + 0) = 182447 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned}
 \text{Path 1-1} &= 231822 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W1 = 76941 \text{ N} \\
 \text{Path 2-2} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W2 = 102915 \text{ N} \\
 \text{Path 3-3} &= 182446 \text{ N} , \text{ must exceed } W = 22586 \text{ N} \quad \text{or } W3 = 102915 \text{ N}
 \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 21.2830 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 182.2645 mm.

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Input, Nozzle Desc: K7 (2in)

From: 50

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		4800.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

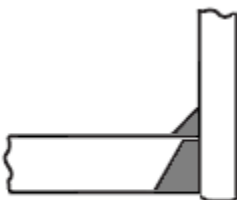
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		90.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

 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	0009	V01	

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



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

Reinforcement CALCULATION, Description: K7 (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.0855 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000	mm.
Parallel to Vessel Wall, opening length	d	56.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

 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)																									
شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-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>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 267 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.025	1.478	NA
Area in Shell	A1	2.941	1.030	NA
Area in Nozzle Wall	A2	4.680	4.591	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.610	6.610	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 5.1775 \cdot 1 + 2 \cdot 13.6 \cdot 5.1775 \cdot 1(1 - 0.99))$$

$$= 1.478 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 13.6(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 1.030 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(13.6 - 0.34) \cdot 0.9894$$

$$= 4.591 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3430 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tbt = max(trb1, tr16b) = 4.7961 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01

Wall Thickness $tb2 = \max(tb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:
 $= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.7961, 4.5)]$
 $= 4.7961 \text{ mm.}$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
 $= \max(ta, tb)$
 $= \max(3.343, 4.7961)$
 $= 4.7961 \text{ mm.}$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.796$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = $78 \text{ }^\circ\text{C}$

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^\circ\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^\circ\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^\circ\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^\circ\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-18 \text{ }^\circ\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^\circ\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = $4.10/51.10 = 0.080$

Weld Size Calculations, Description: K7 (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min.}$ $7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:
 $= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.4779 - 1.0299 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 5.1775)) 138)$
 $= 12940.23 \text{ N}$

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

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Weld Load [W1]:

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

$$= (4.5906 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76941.22 \text{ N}$$

Weld Load [W2]:

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

$$= (4.5906 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Weld Load [W3]:

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

$$= (4.5906 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 94245. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (88202 + 143620) = 231822 \text{ N}$$

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

$$= (88202 + 0 + 94245 + 0) = 182447 \text{ N}$$

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

$$= (88202 + 94245 + 0) = 182447 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 231822 N , must exceed W = 12940 N or W1 = 76941 N

Path 2-2 = 182446 N , must exceed W = 12940 N or W2 = 102915 N

Path 3-3 = 182446 N , must exceed W = 12940 N or W3 = 102915 N

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	BK	GCS	MF	120	ME	CN	0009	V01

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4718 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4718 mm.

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شماره پیمان: 053 - 073 - 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100) <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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 271 از 381
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V01	0009	CN	ME	120	MF	GCS	BK											

Input, Nozzle Desc: N7A (2in)

From: 50

Pressure for Reinforcement Calculations	P	4.195	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		5200.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

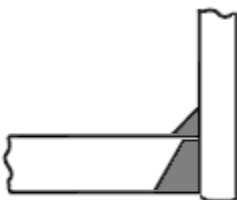
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		270.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	15.8500	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

 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>0009</td><td>V01</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01
	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

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



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

Reinforcement CALCULATION, Description: N7A (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.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 1.8378 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 0.0875 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3393 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000	mm.
Parallel to Vessel Wall, opening length	d	56.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

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	BK	GCS	MF	120	ME	CN	0009	V01	

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.049	1.477	NA
Area in Shell	A1	2.918	1.030	NA
Area in Nozzle Wall	A2	4.419	4.332	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.327	6.352	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 5.1775 \cdot 1 + 2 \cdot 12.85 \cdot 5.1775 \cdot 1(1 - 0.99))$$

$$= 1.477 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 12.85$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 1.030 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(12.85 - 0.34) \cdot 0.9894$$

$$= 4.332 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3393 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8378 mm.
Wall Thickness	tbl = max(trb1, tr16b) = 4.8378 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 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	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-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>0009</td><td>V01</td></tr></table>	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 274 از 381
پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0009	V01											

Wall Thickness $tb2 = \max(tb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.8378, 4.5)]$
 $= 4.8378 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.3393, 4.8378)$
 $= 4.8378 \text{ mm.}$

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

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.838$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.263$, Temp. Reduction = $78 \text{ }^\circ\text{C}$

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^\circ\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^\circ\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^\circ\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^\circ\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-18 \text{ }^\circ\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^\circ\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.19/19.60 = 0.214$

Weld Size Calculations, Description: N7A (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min}$ $7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.4775 - 1.0302 + 2 * 12.85 * 0.9894 * (1.0 * 7.0 - 5.1775))138)$
 $= 12557.59 \text{ N}$

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

 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 REBOILER (R-100)	شماره صفحه : 275 از 381																
	<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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Weld Load [W1]:

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

$$= (4.3322 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 73377.99 \text{ N}$$

Weld Load [W2]:

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

$$= (4.3322 + 0.0 + 0.9894 + (1.7799)) * 138$$

$$= 97920.34 \text{ N}$$

Weld Load [W3]:

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

$$= (4.3322 + 0.0 + 0.9894 + 0.0 + (1.7799)) * 138$$

$$= 97920.34 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 82.5 * 10.0 * 0.49 * 136$$

$$= 86627. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 34.825) * (15.85 - 3.0) * 0.7 * 136$$

$$= 134254. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 82.5 * (10.0 - 3.0) * 0.74 * 138$$

$$= 92562. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (86627 + 134254) = 220881 \text{ N}$$

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

$$= (86627 + 0 + 92562 + 0) = 179189 \text{ N}$$

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

$$= (86627 + 92562 + 0) = 179189 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 220881 N , must exceed W = 12557 N or W1 = 73377 N

Path 2-2 = 179188 N , must exceed W = 12557 N or W2 = 97920 N

Path 3-3 = 179188 N , must exceed W = 12557 N or W3 = 97920 N

 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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	V01	0009	CN	ME	120	MF	GCS	BK

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4197 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4197 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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	BK	GCS	MF	120	ME	CN	0009	V01

Input, Nozzle Desc: N9A (1.5in)

From: 50

Pressure for Reinforcement Calculations	P	4.192	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	200.0000	mm.
Distance from Bottom/Left Tangent		4100.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

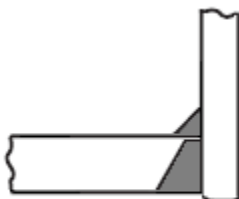
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		289.14	deg
Diameter		1.5000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	14.4500	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

 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	0009	V01

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: N9A (1.5in)

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

Actual Inside Diameter Used in Calculation	1.500 in.
Actual Thickness Used in Calculation	0.569 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 1.8364 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= R \left(\exp \left(\frac{P}{S_n \cdot E} \right) - 1 \right) \text{ per Appendix 1-2 (a) (1)} \\
 &= 22.05 \left(\exp \left(\frac{4.19}{136.43 \cdot 1.0} \right) - 1 \right) \\
 &= 0.0679 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3000 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	93.4748 mm.
Parallel to Vessel Wall, opening length	d	46.7374 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5	Design	External	Mapnc

 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	0009	V01

Area Required	Ar		0.431		1.216		NA
Area in Shell	A1		2.828		0.847		NA
Area in Nozzle Wall	A2		4.134		4.050		NA
Area in Inward Nozzle	A3		0.000		0.000		NA
Area in Welds A41+A42+A43			0.989		0.989		NA
Area in Element	A5		0.000		0.000		NA
TOTAL AREA AVAILABLE	Atot		7.951		5.886		NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 70.66 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(46.7374 * 5.1775 * 1 + 2 * 11.45 * 5.1775 * 1(1 - 0.99))$$

$$= 1.216 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1)$$

$$= 46.737(1.0 * 7.0 - 1.0 * 5.178) - 2 * 11.45$$

$$(1.0 * 7.0 - 1.0 * 5.1775) * (1 - 0.989)$$

$$= 0.847 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 * tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 * 17.5) (11.45 - 0.3) 0.9894 / \sin(72.4)$$

$$= 4.050 \text{ cm}^2$$

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]:

$$= Wo^2 * fr2 + (Wi - can / 0.707)^2 * fr2$$

$$= 10.0^2 * 0.9894 + (0.0)^2 * 0.9894$$

$$= 0.989 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.836, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.262, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 280 از 381
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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
 Design Pressure/Ambient Rating = 4.19/19.60 = 0.214

Weld Size Calculations, Description: N9A (1.5in)

Intermediate Calc. for nozzle/shell Welds Tmin 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.9000 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (1.2162 - 0.8473 + 2 * 11.45 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 5.1775)) 138) \\
 &= 10780.08 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (4.0495 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 69480.23 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (4.0495 + 0.0 + 0.9894 + (1.586)) * 138 \\
 &= 91348.70 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (4.0495 + 0.0 + 0.9894 + 0.0 + (1.586)) * 138 \\
 &= 91348.70 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 71.007 * 10.0 * 0.49 * 136 \\
 &= 74559. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 29.4361) * (14.45 - 3.0) * 0.7 * 136 \\
 &= 101116. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

 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	0009	V01

$$= (\pi/2) * D_{lo} * (W_{gvi} - C_{as}) * 0.74 * S_{ng}$$

$$= (3.1416/2.0) * 71.007 * (10.0 - 3.0) * 0.74 * 138$$

$$= 79667. \text{ N}$$

Strength of Failure Paths:

$$\text{PATH11} = (\text{SONW} + \text{SNW}) = (74559 + 101116) = 175675 \text{ N}$$

$$\text{PATH22} = (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw})$$

$$= (74559 + 0 + 79667 + 0) = 154226 \text{ N}$$

$$\text{PATH33} = (\text{Sonw} + \text{Tngw} + \text{Sinw})$$

$$= (74559 + 79667 + 0) = 154226 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 175674 N , must exceed W = 10780 N or W1 = 69480 N

Path 2-2 = 154226 N , must exceed W = 10780 N or W2 = 91348 N

Path 3-3 = 154226 N , must exceed W = 10780 N or W3 = 91348 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: N9A (1.5in)

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

Actual Inside Diameter Used in Calculation 1.500 in.

Actual Thickness Used in Calculation 0.569 in.

Nozzle input data check completed without errors.

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

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

$$= (4.19 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.19)$$

$$= 1.8364 \text{ mm.}$$

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

$$= R (\exp([P / (S_n \cdot E)] - 1)) \text{ per Appendix 1-2 (a) (1)}$$

$$= 22.05 (\exp([4.19 / (136.43 \cdot 1.0)] - 1))$$

$$= 0.0679 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3000 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 88.2000 mm.

Parallel to Vessel Wall, opening length d 44.1000 mm.

Normal to Vessel Wall (Thickness Limit), no pad Tlnp 17.5000 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 REBOILER (R-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>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 282 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.814	1.148	NA
Area in Shell	A1	2.265	0.799	NA
Area in Nozzle Wall	A2	3.941	3.861	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	7.195	5.650	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(44.1 \cdot 5.1775 \cdot 1 + 2 \cdot 11.45 \cdot 5.1775 \cdot 1(1 - 0.99))$$

$$= 1.148 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 44.1(1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 11.45(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 0.799 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(11.45 - 0.3) \cdot 0.9894$$

$$= 3.861 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3000 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8364 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.8364 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.5200 mm.

Determine Nozzle Thickness candidate [tb]:

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

$$= \min[7.52, \max(4.8364, 4.5)]$$

$$= 4.8364 \text{ mm.}$$

 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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	<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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

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

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

$$= \max(3.3, 4.8364)$$

$$= 4.8364 \text{ mm.}$$

Available Nozzle Neck Thickness = 14.4500 mm. --> OK

Weld Size Calculations, Description: N9A (1.5in)

Intermediate Calc. for nozzle/shell Welds T_{min} 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min}$	$7.0700 = 0.7 * W_o$ mm.

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

Weld Load [W]:

$$= \max(0, (A - A_1 + 2 * t_n * f_{r1} * (E_1 * t - t_r)) S_v)$$

$$= \max(0, (1.148 - 0.7993 + 2 * 11.45 * 0.9894 * (1.0 * 7.0 - 5.1775)) 138)$$

$$= 10501.40 \text{ N}$$

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

Weld Load [W1]:

$$= (A_2 + A_5 + A_4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v$$

$$= (3.861 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 66880.87 \text{ N}$$

Weld Load [W2]:

$$= (A_2 + A_3 + A_4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (3.861 + 0.0 + 0.9894 + (1.586)) * 138$$

$$= 88749.34 \text{ N}$$

Weld Load [W3]:

$$= (A_2 + A_3 + A_4 + A_5 + (2 * t_n * t * f_{r1})) * S$$

$$= (3.861 + 0.0 + 0.9894 + 0.0 + (1.586)) * 138$$

$$= 88749.34 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416 / 2.0) * 67.0 * 10.0 * 0.49 * 136$$

$$= 70352. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 27.775) * (14.45 - 3.0) * 0.7 * 136$$

$$= 95410. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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	BK	GCS	MF	120	ME	CN	0009		V01

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (W_{gvi-Cas}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 67.0 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 75171. \text{ N}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (70352 + 95410) = 165762 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (70352 + 0 + 75171 + 0) = 145523 \text{ N} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (70352 + 75171 + 0) = 145523 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned}
 \text{Path 1-1} &= 165761 \text{ N} , \text{ must exceed } W = 10501 \text{ N} \quad \text{or } W1 = 66880 \text{ N} \\
 \text{Path 2-2} &= 145523 \text{ N} , \text{ must exceed } W = 10501 \text{ N} \quad \text{or } W2 = 88749 \text{ N} \\
 \text{Path 3-3} &= 145523 \text{ N} , \text{ must exceed } W = 10501 \text{ N} \quad \text{or } W3 = 88749 \text{ N}
 \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 12.9850 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 173.5808 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01	

Input, Nozzle Desc: N9B (1.5in)

From: 50

Pressure for Reinforcement Calculations	P	4.192	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	200.0000	mm.
Distance from Bottom/Left Tangent		4100.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

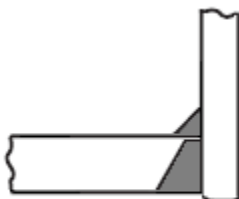
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		250.86	deg
Diameter		1.5000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	14.4500	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		150	
Flange Grade		GR 1.1	

 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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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
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V01	0009	CN	ME	120	MF	GCS	BK																			

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: N9B (1.5in)

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

Actual Inside Diameter Used in Calculation	1.500 in.
Actual Thickness Used in Calculation	0.569 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 1.8364 \text{ mm.}
 \end{aligned}$$

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

$$\begin{aligned}
 &= R \left(\exp \left(\frac{P}{S_n \cdot E} \right) - 1 \right) \text{ per Appendix 1-2 (a) (1)} \\
 &= 22.05 \left(\exp \left(\frac{4.19}{136.43 \cdot 1.0} \right) - 1 \right) \\
 &= 0.0679 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3000 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	93.4748 mm.
Parallel to Vessel Wall, opening length	d	46.7374 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 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	0009		V01

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.431	1.216	NA
Area in Shell	A1	2.828	0.847	NA
Area in Nozzle Wall	A2	4.134	4.050	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	7.951	5.886	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 70.66 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5 (46.7374 \cdot 5.1775 \cdot 1 + 2 \cdot 11.45 \cdot 5.1775 \cdot 1 (1 - 0.99))$$

$$= 1.216 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E1 \cdot t - F \cdot tr) - 2 \cdot tn (E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 46.737 (1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 11.45$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 0.847 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 \cdot 17.5) (11.45 - 0.3) 0.9894 / \sin(72.4)$$

$$= 4.050 \text{ cm}^2$$

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]:

$$= Wo^2 \cdot fr2 + (Wi - can / 0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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	BK	GCS	MF	120	ME	CN	0009	V01	

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $t_g = 10.0$, $t_r = 1.836$, $c = 3.0$ mm., $E^* = 1.0$
 Thickness Ratio = $t_r * (E^*) / (t_g - c) = 0.262$, Temp. Reduction = 78°C

Min Metal Temp. w/o impact per UCS-66, Curve A -8°C
 Min Metal Temp. at Required thickness (UCS 66.1) -104°C
 Min Metal Temp. w/o impact per UG-20(f) -29°C

Gov. MDMT of the nozzle to shell joint welded assembly : -104°C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18°C
 Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104°C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.19/19.60 = 0.214$

Weld Size Calculations, Description: N9B (1.5in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000$ mm.

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld $4.9000 = 0.7 * t_{min}$ $7.0700 = 0.7 * W_o$ mm.

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) * S_v)$$

$$= \max(0, (1.2162 - 0.8473 + 2 * 11.45 * 0.9894 * (1.0 * 7.0 - 5.1775)) * 138)$$

$$= 10780.08 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v$$

$$= (4.0495 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 69480.23 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.0495 + 0.0 + 0.9894 + (1.586)) * 138$$

$$= 91348.70 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.0495 + 0.0 + 0.9894 + 0.0 + (1.586)) * 138$$

$$= 91348.70 \text{ N}$$

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	BK	GCS	MF	120	ME	CN	0009		V01

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 71.007 * 10.0 * 0.49 * 136$$

$$= 74559. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 29.4361) * (14.45 - 3.0) * 0.7 * 136$$

$$= 101116. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 71.007 * (10.0 - 3.0) * 0.74 * 138$$

$$= 79667. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (74559 + 101116) = 175675 \text{ N}$$

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

$$= (74559 + 0 + 79667 + 0) = 154226 \text{ N}$$

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

$$= (74559 + 79667 + 0) = 154226 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 175674 N , must exceed W = 10780 N or W1 = 69480 N

Path 2-2 = 154226 N , must exceed W = 10780 N or W2 = 91348 N

Path 3-3 = 154226 N , must exceed W = 10780 N or W3 = 91348 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: N9B (1.5in)

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

Actual Inside Diameter Used in Calculation 1.500 in.

Actual Thickness Used in Calculation 0.569 in.

Nozzle input data check completed without errors.

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

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

$$= (4.19 * 603.0) / (138 * 1.0 - 0.6 * 4.19)$$

$$= 1.8364 \text{ mm.}$$

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

 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 REBOILER (R-100)							شماره صفحه : 290 از 381
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

$$= R(\exp([P/(Sn \cdot E)] - 1)) \text{ per Appendix 1-2 (a) (1)}$$

$$= 22.05(\exp([4.19/(136.43 \cdot 1.0)] - 1))$$

$$= 0.0679 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3000 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	88.2000	mm.
Parallel to Vessel Wall, opening length	d	44.1000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.814	1.148	NA
Area in Shell	A1	2.265	0.799	NA
Area in Nozzle Wall	A2	3.941	3.861	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	7.195	5.650	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(44.1 \cdot 5.1775 \cdot 1 + 2 \cdot 11.45 \cdot 5.1775 \cdot 1(1 - 0.99))$$

$$= 1.148 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 44.1(1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 11.45$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 0.799 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp) (tn - trn) fr2$$

$$= (2 \cdot 17.5) (11.45 - 0.3) 0.9894$$

$$= 3.861 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures $t_a = 3.3000 \text{ mm.}$

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 291 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Wall Thickness per UG16(b), $tr16b = 4.5000 \text{ mm.}$
 Wall Thickness, shell/head, internal pressure $trb1 = 4.8364 \text{ mm.}$
 Wall Thickness $tb1 = \max(trb1, tr16b) = 4.8364 \text{ mm.}$
 Wall Thickness, shell/head, external pressure $trb2 = 3.4524 \text{ mm.}$
 Wall Thickness $tb2 = \max(trb2, tr16b) = 4.5000 \text{ mm.}$
 Wall Thickness per table UG-45 $tb3 = 7.5200 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.52, \max(4.8364, 4.5)]$
 $= 4.8364 \text{ mm.}$

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

$= \max(ta, tb)$
 $= \max(3.3, 4.8364)$
 $= 4.8364 \text{ mm.}$

Available Nozzle Neck Thickness = 14.4500 mm. --> OK

Weld Size Calculations, Description: N9B (1.5in)

Intermediate Calc. for nozzle/shell Welds $Tmin = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld $4.9000 = 0.7 * tmin.$ $7.0700 = 0.7 * Wo \text{ mm.}$

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

Weld Load [W]:

$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.148 - 0.7993 + 2 * 11.45 * 0.9894 * (1.0 * 7.0 - 5.1775)) 138)$
 $= 10501.40 \text{ N}$

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

Weld Load [W1]:

$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$
 $= (3.861 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$
 $= 66880.87 \text{ N}$

Weld Load [W2]:

$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$
 $= (3.861 + 0.0 + 0.9894 + (1.586)) * 138$
 $= 88749.34 \text{ N}$

Weld Load [W3]:

$= (A2+A3+A4+A5+(2*tn*t*fr1))*S$
 $= (3.861 + 0.0 + 0.9894 + 0.0 + (1.586)) * 138$
 $= 88749.34 \text{ N}$

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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 67.0 * 10.0 * 0.49 * 136$$

$$= 70352. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 27.775) * (14.45 - 3.0) * 0.7 * 136$$

$$= 95410. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 67.0 * (10.0 - 3.0) * 0.74 * 136$$

$$= 75171. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (70352 + 95410) = 165762 \text{ N}$$

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

$$= (70352 + 0 + 75171 + 0) = 145523 \text{ N}$$

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

$$= (70352 + 75171 + 0) = 145523 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 165761 N , must exceed W = 10501 N or W1 = 66880 N

Path 2-2 = 145523 N , must exceed W = 10501 N or W2 = 88749 N

Path 3-3 = 145523 N , must exceed W = 10501 N or W3 = 88749 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 12.9850 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 173.5808 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)																	
شماره پیمان: 053 - 073 - 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)	شماره صفحه : 293 از 381																
	<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>0009</td><td>V01</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01
	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

Input, Nozzle Desc: K2A (2in)

From: 50

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	500.0000	mm.
Distance from Bottom/Left Tangent		5000.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

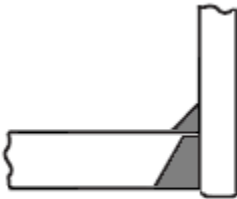
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		55.05	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه																			
BK	GCS	MF	120	ME	CN	0009	V01																			

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K2A (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.0855 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3862 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	203.1283	mm.
Parallel to Vessel Wall, opening length	d	101.5642	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5	Design	External	Mapnc

 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 REBOILER (R-100)							شماره صفحه : 295 از 381
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

Area Required	Ar		0.915		2.637		NA
Area in Shell	A1		6.180		1.846		NA
Area in Nozzle Wall	A2		7.523		7.355		NA
Area in Inward Nozzle	A3		0.000		0.000		NA
Area in Welds A41+A42+A43			0.989		0.989		NA
Area in Element	A5		0.000		0.000		NA
TOTAL AREA AVAILABLE	Atot		14.692		10.190		NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 34.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(101.5642 * 5.1775 * 1 + 2 * 13.6 * 5.1775 * 1(1 - 0.99))$$

$$= 2.637 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1)$$

$$= 101.564(1.0 * 7.0 - 1.0 * 5.178) - 2 * 13.6$$

$$(1.0 * 7.0 - 1.0 * 5.1775) * (1 - 0.989)$$

$$= 1.846 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 * tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 * 17.5) (13.6 - 0.39) 0.9894 / \sin(38.5)$$

$$= 7.355 \text{ cm}^2$$

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]:

$$= Wo^2 * fr2 + (Wi - can / 0.707)^2 * fr2$$

$$= 10.0^2 * 0.9894 + (0.0)^2 * 0.9894$$

$$= 0.989 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.796, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.257, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

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شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 296 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
 Design Pressure/Ambient Rating = 4.10/51.10 = 0.080

Weld Size Calculations, Description: K2A (2in)

Intermediate Calc. for nozzle/shell Welds Tmin 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.9000 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (2.6367 - 1.8457 + 2 * 13.6 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 5.1775)) 138) \\
 &= 17670.21 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (7.3554 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 115064.30 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (7.3554 + 0.0 + 0.9894 + (1.8838)) * 138 \\
 &= 141039.08 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (7.3554 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138 \\
 &= 141039.08 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 150.2005 * 10.0 * 0.49 * 136 \\
 &= 157715. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 62.9412) * (16.6 - 3.0) * 0.7 * 136 \\
 &= 256807. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

 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 REBOILER (R-100)	شماره صفحه : 297 از 381																
	<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>0009</td><td>V01</td></tr></table>		پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01
	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (W_{gvi} - C_{as}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 150.2005 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 168519. \text{ N}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (157715 + 256807) = 414522 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (157715 + 0 + 168519 + 0) = 326234 \text{ N} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (157715 + 168519 + 0) = 326234 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned}
 \text{Path 1-1} &= 414521 \text{ N}, \text{ must exceed } W = 17670 \text{ N} \quad \text{or } W1 = 115064 \text{ N} \\
 \text{Path 2-2} &= 326233 \text{ N}, \text{ must exceed } W = 17670 \text{ N} \quad \text{or } W2 = 141039 \text{ N} \\
 \text{Path 3-3} &= 326233 \text{ N}, \text{ must exceed } W = 17670 \text{ N} \quad \text{or } W3 = 141039 \text{ N}
 \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: K2A (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 0.654 in.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.0855 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3862 mm.

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

Parallel to Vessel Wall (Diameter Limit)	Dl	113.6000	mm.
Parallel to Vessel Wall, opening length	d	56.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

 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	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

AREA AVAILABLE, A1 to A5	Design	External	Mapnc
Area Required Ar	1.025	1.478	NA
Area in Shell A1	2.941	1.030	NA
Area in Nozzle Wall A2	4.680	4.576	NA
Area in Inward Nozzle A3	0.000	0.000	NA
Area in Welds A41+A42+A43	0.989	0.989	NA
Area in Element A5	0.000	0.000	NA
TOTAL AREA AVAILABLE Atot	8.610	6.595	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]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot t_n \cdot tr \cdot F (1 - fr_1)) \text{ per UG-37(d)}$$

$$= 0.5 (56.8 \cdot 5.1775 \cdot 1 + 2 \cdot 13.6 \cdot 5.1775 \cdot 1 (1 - 0.99))$$

$$= 1.478 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E_1 \cdot t - F \cdot tr) - 2 \cdot t_n (E_1 \cdot t - F \cdot tr) \cdot (1 - fr_1)$$

$$= 56.8 (1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 13.6 (1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 1.030 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot t_{lnp}) (t_n - tr_n) fr_2$$

$$= (2 \cdot 17.5) (13.6 - 0.39) \cdot 0.9894$$

$$= 4.576 \text{ cm}^2$$

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

$$= W_o^2 \cdot fr_2 + (W_i - can / 0.707)^2 \cdot fr_2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3862 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.7961 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.8000 mm.

Determine Nozzle Thickness candidate [tb]:

$$= \min[tb_3, \max(tb_1, tb_2)]$$

$$= \min[7.8, \max(4.7961, 4.5)]$$

$$= 4.7961 \text{ mm.}$$

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

$$= \max(ta, tb)$$

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

$$= \max(3.3862, 4.7961)$$

$$= 4.7961 \text{ mm.}$$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Weld Size Calculations, Description: K2A (2in)

Intermediate Calc. for nozzle/shell Welds Tmin 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min}$	$7.0700 = 0.7 * W_o$ mm.

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) * S_v)$$

$$= \max(0, (1.4779 - 1.0299 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 5.1775)) * 138)$$

$$= 12940.23 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - Can / .707)^2 * f_{r2}) * S_v$$

$$= (4.5757 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76735.23 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.5757 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102710.00 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.5757 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102710.00 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 94245. \text{ N}$$

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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Strength of Failure Paths:

$$\begin{aligned} \text{PATH11} &= (\text{SONW} + \text{SNW}) = (88202 + 143620) = 231822 \text{ N} \\ \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\ &= (88202 + 0 + 94245 + 0) = 182447 \text{ N} \\ \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\ &= (88202 + 94245 + 0) = 182447 \text{ N} \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned} \text{Path 1-1} &= 231822 \text{ N} , \text{ must exceed } W = 12940 \text{ N} \quad \text{or } W1 = 76735 \text{ N} \\ \text{Path 2-2} &= 182446 \text{ N} , \text{ must exceed } W = 12940 \text{ N} \quad \text{or } W2 = 102710 \text{ N} \\ \text{Path 3-3} &= 182446 \text{ N} , \text{ must exceed } W = 12940 \text{ N} \quad \text{or } W3 = 102710 \text{ N} \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 74.2989 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 292.0646 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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	V01	0009	CN	ME	120	MF	GCS	BK

Input, Nozzle Desc: K6 (2in)

From: 50

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		4500.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

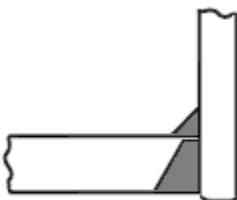
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		90.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	6.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

 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	0009	V01

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



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

Reinforcement CALCULATION, Description: K6 (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 31.4) / (136 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.0945 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	125.6000	mm.
Parallel to Vessel Wall, opening length	d	62.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

 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)																	
شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)	شماره صفحه : 303 از 381																
	<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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.132	1.632	NA
Area in Shell	A1	3.256	1.140	NA
Area in Nozzle Wall	A2	3.638	3.552	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	7.883	5.682	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(62.8 \cdot 5.1775 \cdot 1 + 2 \cdot 10.6 \cdot 5.1775 \cdot 1(1 - 0.99))$$

$$= 1.632 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 62.8(1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 10.6(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 1.140 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(10.6 - 0.34)0.9894$$

$$= 3.552 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 6.3430 mm.
Wall Thickness per UG16(b),	tr16b = 7.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tbt = max(trb1, tr16b) = 7.5000 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 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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	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0009		V01

Wall Thickness $tb2 = \max(trb2, tr16b) = 7.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 10.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:
 $= \min[tb3, \max(tb1, tb2)]$
 $= \min[10.8, \max(7.5, 7.5)]$
 $= 7.5000 \text{ mm.}$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
 $= \max(ta, tb)$
 $= \max(6.343, 7.5)$
 $= 7.5000 \text{ mm.}$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $t_g = 10.0$, $t_r = 1.796$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $t_r * (E^*) / (t_g - c) = 0.257$, Temp. Reduction = $78 \text{ }^\circ\text{C}$

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^\circ\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^\circ\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^\circ\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^\circ\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-18 \text{ }^\circ\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^\circ\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = $4.10/51.10 = 0.080$

Weld Size Calculations, Description: K6 (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min.}$ $7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:
 $= \max(0, (A-A1+2*t_n*fr1*(E1*t-t_r))S_v)$
 $= \max(0, (1.6316 - 1.1404 + 2 * 10.6 * 0.9894 * (1.0 * 7.0 - 5.1775))138)$
 $= 12043.67 \text{ N}$

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

 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>صادر کننده</td><td>بسته کاری</td><td>پروژه</td></tr><tr><td>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Weld Load [W1]:

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

$$= (3.5518 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 62616.88 \text{ N}$$

Weld Load [W2]:

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

$$= (3.5518 + 0.0 + 0.9894 + (1.4682)) * 138$$

$$= 82861.92 \text{ N}$$

Weld Load [W3]:

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

$$= (3.5518 + 0.0 + 0.9894 + 0.0 + (1.4682)) * 138$$

$$= 82861.92 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 36.7) * (16.6 - 6.0) * 0.7 * 136$$

$$= 116709. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 94245. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (88202 + 116709) = 204911 \text{ N}$$

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

$$= (88202 + 0 + 94245 + 0) = 182447 \text{ N}$$

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

$$= (88202 + 94245 + 0) = 182447 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 204911 N , must exceed W = 12043 N or W1 = 62616 N

Path 2-2 = 182446 N , must exceed W = 12043 N or W2 = 82861 N

Path 3-3 = 182446 N , must exceed W = 12043 N or W3 = 82861 N

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	BK	GCS	MF	120	ME	CN	0009	V01

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4718 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4718 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)																	
شماره پیمان: 053 - 073 - 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100) <table><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 307 از 381
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V01	0009	CN	ME	120	MF	GCS	BK											

Input, Nozzle Desc: K2B (2in)

From: 50

Pressure for Reinforcement Calculations	P	4.121	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	144.0000	mm.
Distance from Bottom/Left Tangent		5000.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

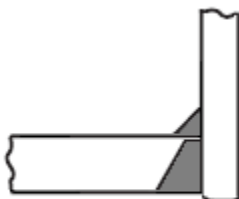
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		13.65	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

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	BK	GCS	MF	120	ME	CN	0009	V01

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K2B (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.12 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.12) \\
 &= 1.8053 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.12 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.12) \\
 &= 0.0859 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3862 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	117.0082 mm.
Parallel to Vessel Wall, opening length	d	58.5041 mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000 mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5	Design	External	Mapnc

 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	0009	V01	

Area Required	Ar		0.531		1.522		NA
Area in Shell	A1		3.550		1.061		NA
Area in Nozzle Wall	A2		4.775		4.669		NA
Area in Inward Nozzle	A3		0.000		0.000		NA
Area in Welds A41+A42+A43			0.989		0.989		NA
Area in Element	A5		0.000		0.000		NA
TOTAL AREA AVAILABLE	Atot		9.314		6.720		NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 76.14 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(58.5041 * 5.1775 * 1 + 2 * 13.6 * 5.1775 * 1(1 - 0.99))$$

$$= 1.522 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 * t - F * tr) - 2 * tn(E1 * t - F * tr) * (1 - fr1)$$

$$= 58.504(1.0 * 7.0 - 1.0 * 5.178) - 2 * 13.6$$

$$(1.0 * 7.0 - 1.0 * 5.1775) * (1 - 0.989)$$

$$= 1.061 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 * tlnp) (tn - trn) fr2 / \sin(\alpha3)$$

$$= (2 * 17.5) (13.6 - 0.39) 0.9894 / \sin(78.5)$$

$$= 4.669 \text{ cm}^2$$

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]:

$$= Wo^2 * fr2 + (Wi - can / 0.707)^2 * fr2$$

$$= 10.0^2 * 0.9894 + (0.0)^2 * 0.9894$$

$$= 0.989 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.805, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.258, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

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	BK	GCS	MF	120	ME	CN	0009	V01

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
 Design Pressure/Ambient Rating = 4.12/51.10 = 0.081

Weld Size Calculations, Description: K2B (2in)

Intermediate Calc. for nozzle/shell Welds T_{min} 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.9000 = 0.7 * t _{min} .	7.0700 = 0.7 * W _o mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) * S_v) \\
 &= \max(0, (1.522 - 1.0609 + 2 * 13.6 * 0.9894 * \\
 &\quad (1.0 * 7.0 - 5.1775) * 138) \\
 &= 13120.29 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2 + A5 + A4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v \\
 &= (4.6694 + 0.0 + 0.9894 - 0.0 * 0.99) * 138 \\
 &= 78027.48 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v \\
 &= (4.6694 + 0.0 + 0.9894 + (1.8838)) * 138 \\
 &= 104002.25 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S \\
 &= (4.6694 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138 \\
 &= 104002.25 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi / 2) * D_{lo} * W_o * 0.49 * S_{nw} \\
 &= (3.1416 / 2.0) * 86.5201 * 10.0 * 0.49 * 136 \\
 &= 90849. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - C_{an}) * 0.7 * S_n \\
 &= (3.1416 * 36.2561) * (16.6 - 3.0) * 0.7 * 136 \\
 &= 147929. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 311 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

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

$$= (3.1416/2.0) * 86.5201 * (10.0 - 3.0) * 0.74 * 138$$

$$= 97072. \text{ N}$$

Strength of Failure Paths:

$$\text{PATH11} = (\text{SONW} + \text{SNW}) = (90849 + 147929) = 238777 \text{ N}$$

$$\text{PATH22} = (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw})$$

$$= (90849 + 0 + 97072 + 0) = 187921 \text{ N}$$

$$\text{PATH33} = (\text{Sonw} + \text{Tngw} + \text{Sinw})$$

$$= (90849 + 97072 + 0) = 187921 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 238777 N , must exceed W = 13120 N or W1 = 78027 N

Path 2-2 = 187920 N , must exceed W = 13120 N or W2 = 104002 N

Path 3-3 = 187920 N , must exceed W = 13120 N or W3 = 104002 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

Reinforcement CALCULATION, Description: K2B (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 0.654 in.

Nozzle input data check completed without errors.

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

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

$$= (4.12 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.12)$$

$$= 1.8053 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.12 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.12)$$

$$= 0.0859 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3862 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 113.6000 mm.

Parallel to Vessel Wall, opening length d 56.8000 mm.

Normal to Vessel Wall (Thickness Limit), no pad Tlnp 17.5000 mm.

Results of Nozzle Reinforcement Area Calculations: (cm²)

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 312 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
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V01	0009	CN	ME	120	MF	GCS	BK																			

AREA AVAILABLE, A1 to A5	Design	External	Mapnc
Area Required Ar	1.031	1.478	NA
Area in Shell A1	2.936	1.030	NA
Area in Nozzle Wall A2	4.680	4.576	NA
Area in Inward Nozzle A3	0.000	0.000	NA
Area in Welds A41+A42+A43	0.989	0.989	NA
Area in Element A5	0.000	0.000	NA
TOTAL AREA AVAILABLE Atot	8.605	6.595	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]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot t_n \cdot tr \cdot F (1 - fr_1)) \text{ per UG-37(d)}$$

$$= 0.5 (56.8 \cdot 5.1775 \cdot 1 + 2 \cdot 13.6 \cdot 5.1775 \cdot 1 (1 - 0.99))$$

$$= 1.478 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d (E_1 \cdot t - F \cdot tr) - 2 \cdot t_n (E_1 \cdot t - F \cdot tr) \cdot (1 - fr_1)$$

$$= 56.8 (1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 13.6 (1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 1.030 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot t_{lnp}) (t_n - tr_n) fr_2$$

$$= (2 \cdot 17.5) (13.6 - 0.39) 0.9894$$

$$= 4.576 \text{ cm}^2$$

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

$$= W_o^2 \cdot fr_2 + (W_i - can / 0.707)^2 \cdot fr_2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3862 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8053 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.8053 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.8000 mm.

Determine Nozzle Thickness candidate [tb]:

$$= \min[tb_3, \max(tb_1, tb_2)]$$

$$= \min[7.8, \max(4.8053, 4.5)]$$

$$= 4.8053 \text{ mm.}$$

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

$$= \max(ta, tb)$$

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	نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری		پروژه
	V01	0009	CN	ME	120	MF	GCS		BK

$$= \max(3.3862, 4.8053)$$

$$= 4.8053 \text{ mm.}$$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Weld Size Calculations, Description: K2B (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.9000 = 0.7 * t_{min.}$	$7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) * S_v)$$

$$= \max(0, (1.4779 - 1.0299 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 5.1775)) * 138)$$

$$= 12940.23 \text{ N}$$

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

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - Can / .707)^2 * f_{r2}) * S_v$$

$$= (4.5757 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76735.23 \text{ N}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (4.5757 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102710.00 \text{ N}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (4.5757 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102710.00 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 94245. \text{ N}$$

 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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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Strength of Failure Paths:

$$\begin{aligned} \text{PATH11} &= (\text{SONW} + \text{SNW}) = (88202 + 143620) = 231822 \text{ N} \\ \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\ &= (88202 + 0 + 94245 + 0) = 182447 \text{ N} \\ \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\ &= (88202 + 94245 + 0) = 182447 \text{ N} \end{aligned}$$

Summary of Failure Path Calculations:

$$\begin{aligned} \text{Path 1-1} &= 231822 \text{ N} , \text{ must exceed } W = 12940 \text{ N} \quad \text{or } W1 = 76735 \text{ N} \\ \text{Path 2-2} &= 182446 \text{ N} , \text{ must exceed } W = 12940 \text{ N} \quad \text{or } W2 = 102710 \text{ N} \\ \text{Path 3-3} &= 182446 \text{ N} , \text{ must exceed } W = 12940 \text{ N} \quad \text{or } W3 = 102710 \text{ N} \end{aligned}$$

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 12.0218 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 222.3178 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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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
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V01	0009	CN	ME	120	MF	GCS	BK																			

Input, Nozzle Desc: K1 (2in)

From: 50

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		5100.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

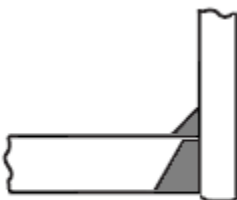
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		90.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

 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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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

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



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

Reinforcement CALCULATION, Description: K1 (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 1.7961 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.0855 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000	mm.
Parallel to Vessel Wall, opening length	d	56.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)							شماره صفحه : 317 از 381
	پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5	Design	External	Mapnc
Area Required Ar	1.025	1.478	NA
Area in Shell A1	2.941	1.030	NA
Area in Nozzle Wall A2	4.680	4.591	NA
Area in Inward Nozzle A3	0.000	0.000	NA
Area in Welds A41+A42+A43	0.989	0.989	NA
Area in Element A5	0.000	0.000	NA
TOTAL AREA AVAILABLE Atot	8.610	6.610	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 5.1775 \cdot 1 + 2 \cdot 13.6 \cdot 5.1775 \cdot 1(1 - 0.99))$$

$$= 1.478 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 13.6(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 1.030 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(13.6 - 0.34) \cdot 0.9894$$

$$= 4.591 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3430 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tbl = max(trb1, tr16b) = 4.7961 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 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 REBOILER (R-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>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 318 از 381
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Wall Thickness $tb2 = \max(trb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:
 $= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.7961, 4.5)]$
 $= 4.7961 \text{ mm.}$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
 $= \max(ta, tb)$
 $= \max(3.343, 4.7961)$
 $= 4.7961 \text{ mm.}$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.796$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = $78 \text{ }^\circ\text{C}$

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^\circ\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^\circ\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^\circ\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^\circ\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-18 \text{ }^\circ\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^\circ\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = $4.10/51.10 = 0.080$

Weld Size Calculations, Description: K1 (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min.}$ $7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:
 $= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.4779 - 1.0299 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 5.1775)) 138)$
 $= 12940.23 \text{ N}$

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

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	BK	GCS	MF	120	ME	CN	0009	V01

Weld Load [W1]:

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

$$= (4.5906 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76941.22 \text{ N}$$

Weld Load [W2]:

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

$$= (4.5906 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Weld Load [W3]:

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

$$= (4.5906 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 94245. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (88202 + 143620) = 231822 \text{ N}$$

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

$$= (88202 + 0 + 94245 + 0) = 182447 \text{ N}$$

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

$$= (88202 + 94245 + 0) = 182447 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 231822 N , must exceed W = 12940 N or W1 = 76941 N

Path 2-2 = 182446 N , must exceed W = 12940 N or W2 = 102915 N

Path 3-3 = 182446 N , must exceed W = 12940 N or W3 = 102915 N

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	V01	0009	CN	ME	120	MF	GCS	BK

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4718 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4718 mm.

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	BK	GCS	MF	120	ME	CN	0009	
							V01	

Input, Nozzle Desc: K3A (3in)

From: 50

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		4150.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm ²
Allowable Stress At Ambient	Sna	117.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		90.00	deg
Diameter		3.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	XXS	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²
Diameter of Pad along vessel surface	Dp	200.0000	mm.
Thickness of Pad	te	10.0000	mm.

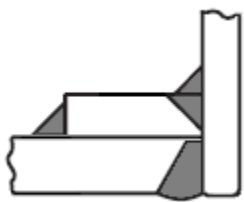
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	V01	0009	CN	ME	120	MF	GCS	BK

Weld leg size between Pad and Shell Wp 8.0000 mm.
Groove weld depth between Pad and Nozzle Wgpn 10.0000 mm.
Reinforcing Pad Width 55.5500 mm.

Flange Class 150
Flange Grade GR 1.1

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: K3A (3in)

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

Actual Inside Diameter Used in Calculation 2.450 in.
Actual Thickness Used in Calculation 0.525 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
 $= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P)$ per UG-27 (c) (1)
 $= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1)$
 $= 1.7961 \text{ mm.}$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
 $= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P)$ per UG-27 (c) (1)
 $= (4.1 \cdot 34.11) / (118 \cdot 1.0 - 0.6 \cdot 4.1)$
 $= 0.1189 \text{ mm.}$

Required Nozzle thickness under External Pressure per UG-28 : 0.3552 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 136.4600 mm.
Parallel to Vessel Wall, opening length d 68.2300 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 mm.

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	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GCS	MF	120	ME	CN	0009	V01											

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr2]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr4]:

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

$$= \min(1, 137.9/137.9)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.855, 1.0)$$

$$= 0.855$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.279	1.844	NA
Area in Shell	A1	3.395	1.189	NA
Area in Nozzle Wall	A2	3.057	2.986	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.802	0.802	NA
Area in Element	A5	4.756	4.756	NA
TOTAL AREA AVAILABLE	Atot	12.009	9.733	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.

The area available with the given pad is Sufficient.

Area Required [A]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot t_n \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(68.23 \cdot 5.1775 \cdot 1 + 2 \cdot 10.335 \cdot 5.1775 \cdot 1(1 - 0.86))$$

$$= 1.844 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot t_n(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 68.23(1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 10.335$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.855)$$

$$= 1.189 \text{ cm}^2$$

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Area Available in Nozzle Wall Projecting Outward [A2]:

$$= (2 * T_{lwp}) * (t_n - t_{rn}) * fr_2$$

$$= (2 * 17.5) * (10.34 - 0.36) * 0.855$$

$$= 2.986 \text{ cm}^2$$

Area Available in Welds [A41 + A42 + A43]:

$$= (W_o^2 - Ar \text{ Lost}) * Fr_3 + ((W_i - can / 0.707)^2 - Ar \text{ Lost}) * fr_2 + W_p^2 * fr_4$$

$$= (0.9375) * 0.86 + (0.0) * 0.86 + 0.0^2 * 1.0$$

$$= 0.802 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(D_p, DL) - (\text{Nozzle OD})) * (\min(t_p, T_{lwp}, t_e)) * fr_4$$

$$= (136.46 - 88.9) * 10.0 * 1.0$$

$$= 4.756 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	$t_a = 3.3552 \text{ mm.}$
Wall Thickness per UG16(b),	$tr_{16b} = 4.5000 \text{ mm.}$
Wall Thickness, shell/head, internal pressure	$tr_{b1} = 4.7961 \text{ mm.}$
Wall Thickness	$tb_1 = \max(tr_{b1}, tr_{16b}) = 4.7961 \text{ mm.}$
Wall Thickness, shell/head, external pressure	$tr_{b2} = 3.4524 \text{ mm.}$
Wall Thickness	$tb_2 = \max(tr_{b2}, tr_{16b}) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45	$tb_3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$$= \min[tb_3, \max(tb_1, tb_2)]$$

$$= \min[7.8, \max(4.7961, 4.5)]$$

$$= 4.7961 \text{ mm.}$$

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

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

$$= \max(3.3552, 4.7961)$$

$$= 4.7961 \text{ mm.}$$

Available Nozzle Neck Thickness = 13.3350 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:B, Curve:A)

Govrn. thk, $t_g = 13.335$, $tr = 0.119$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (t_g - c) = 0.012$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	0 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, $t_g = 10.0$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (t_g - c) = 0.257$, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C

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Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 10.0, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = 78 °C

Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 10.0, tr = 1.796, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:B, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.796, c = 3.0 mm., E* = 1.0

Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C

Gov. MDMT of the Reinforcement Pad : -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C

Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.10 / 19.60 = 0.209$

Weld Size Calculations, Description: K3A (3in)

Intermediate Calc. for nozzle/shell Welds Tmin 10.0000 mm.

Intermediate Calc. for pad/shell Welds TminPad 7.0000 mm.

Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 6.0000 = Min per Code 7.0700 = $0.7 * W_o$ mm.

Pad Weld 3.5000 = $0.5 * T_{minPad}$ 5.6560 = $0.7 * W_p$ mm.

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

Weld Load [W]:

= $\max(0, (A - A_1 + 2 * t_n * f_{r1} * (E_1 * t - t_r)) S_v)$

= $\max(0, (1.8439 - 1.1888 + 2 * 10.335 * 0.855 *)$

 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 REBOILER (R-100)							شماره صفحه : 326 از 381
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	V01	0009	CN	ME	120	MF	GCS	BK

$$(1.0 * 7.0 - 5.1775) * 138 = 13473.64 \text{ N}$$

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

Weld Load [W1]:

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

$$= (2.9865 + 4.756 + 0.8016 - 0.0 * 0.86) * 138$$

$$= 117812.12 \text{ N}$$

Weld Load [W2]:

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

$$= (2.9865 + 0.0 + 0.855 + (1.2371)) * 138$$

$$= 70027.48 \text{ N}$$

Weld Load [W3]:

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

$$= (2.9865 + 0.0 + 0.8016 + 4.756 + (1.2371)) * 138$$

$$= 134870.28 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 88.9 * 10.0 * 0.49 * 118$$

$$= 80670. \text{ N}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * DP * WP * 0.49 * SEW$$

$$= (3.1416/2.0) * 200.0 * 8.0 * 0.49 * 138$$

$$= 169810. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 39.2825) * (13.335 - 3.0) * 0.7 * 118$$

$$= 105257. \text{ N}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * Seg$$

$$= (3.1416/2) * 88.9 * 10.0 * 0.74 * 138$$

$$= 142489. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 88.9 * (10.0 - 3.0) * 0.74 * 138$$

$$= 99742. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SPEW + SNW) = (169810 + 105257) = 275067 \text{ N}$$

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

$$= (80670 + 142489 + 99742 + 0) = 322901 \text{ N}$$

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

$$= (169810 + 99742 + 0) = 269552 \text{ N}$$

 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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V01	0009	CN	ME	120	MF	GCS	BK																			

Summary of Failure Path Calculations:

Path 1-1 = 275067 N , must exceed W = 13473 N or W1 = 117812 N
 Path 2-2 = 322900 N , must exceed W = 13473 N or W2 = 70027 N
 Path 3-3 = 269552 N , must exceed W = 13473 N or W3 = 134870 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.6488 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.6488 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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	BK	GCS	MF	120	ME	CN	0009	V01

Input, Nozzle Desc: K3B (3in)

From: 50

Pressure for Reinforcement Calculations	P	4.164	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Cylinder/Cone Centerline	L1	300.0000	mm.
Distance from Bottom/Left Tangent		4150.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm ²
Allowable Stress At Ambient	Sna	117.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		-29.46	deg
Diameter		3.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	XXS	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²

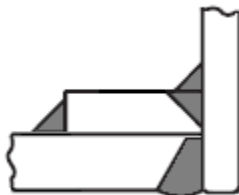
 NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض و ابنیه تحت الارض خرید بسته نم زدای گاز ایستگاه تقویت فشار گاز بینک (قرارداد BK-HD-GCS-CO-0010_08)							
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	BK	GCS	MF	120	ME	CN	0009	V01

Diameter of Pad along vessel surface	Dp	200.0000	mm.
Thickness of Pad	te	10.0000	mm.
Weld leg size between Pad and Shell	Wp	8.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	10.0000	mm.
Reinforcing Pad Width		55.5500	mm.

Flange Class	150
Flange Grade	GR 1.1

The Pressure Design option was Design Pressure + static head.

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



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

Note : Checking Nozzle 90 degrees to the Longitudinal axis.

Reinforcement CALCULATION, Description: K3B (3in)

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

Actual Inside Diameter Used in Calculation	2.450	in.
Actual Thickness Used in Calculation	0.525	in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.16 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.16) \\
 &= 1.8244 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.16 \cdot 34.11) / (118 \cdot 1.0 - 0.6 \cdot 4.16) \\
 &= 0.1208 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3989 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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V01	0009	CN	ME	120	MF	GCS	BK																			

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

Parallel to Vessel Wall (Diameter Limit)	D1	157.3089	mm.
Parallel to Vessel Wall, opening length	d	78.6544	mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		17.5000	mm.

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr2]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr4]:

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

$$= \min(1, 137.9/137.9)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.855, 1.0)$$

$$= 0.855$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.490	2.114	NA
Area in Shell	A1	3.916	1.379	NA
Area in Nozzle Wall	A2	3.415	3.322	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.802	0.802	NA
Area in Element	A5	5.483	5.483	NA
TOTAL AREA AVAILABLE	Atot	13.614	10.985	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 60.17 Degs.

The area available without a pad is Sufficient.

The area available with the given pad is Sufficient.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * t_n * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(78.6544 * 5.1775 * 1 + 2 * 10.335 * 5.1775 * 1(1 - 0.86))$$

$$= 2.114 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

 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	0009		V01

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot \tan(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 78.654(1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 10.335$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.855)$$

$$= 1.379 \text{ cm}^2$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$= (2 \cdot Tlwp) \cdot (\tan - \tan) \cdot fr2 / \sin(\alpha3)$$

$$= (2 \cdot 17.5) \cdot (10.34 - 0.4) \cdot 0.855 / \sin(63.5)$$

$$= 3.322 \text{ cm}^2$$

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

Area Available in Welds [A41 + A42 + A43]:

$$= (Wo^2 - Ar \text{ Lost}) \cdot Fr3 + ((Wi - can / 0.707)^2 - Ar \text{ Lost}) \cdot fr2 + Wp^2 \cdot fr4$$

$$= (0.9375) \cdot 0.86 + (0.0) \cdot 0.86 + 0.0^2 \cdot 1.0$$

$$= 0.802 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(Dp, DL) - (\text{Nozzle OD})) \cdot (\min(tp, Tlwp, te)) \cdot fr4$$

$$= (157.3089 - 102.4825) \cdot 10.0 \cdot 1.0$$

$$= 5.483 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:B, Curve:A)

Govrn. thk, tg = 13.335, tr = 0.121, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.012, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A 0 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, tg = 10.0, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.261, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 10.0, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.261, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 10.0, tr = 1.824, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*) / (tg - c) = 0.261, Temp. Reduction = 78 °C

	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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Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:B, Curve:D)

Govrn. thk, tg = 10.0, tr = 1.824, c = 3.0 mm., E* = 1.0
Thickness Ratio = tr * (E*)/(tg - c) = 0.261, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C
Gov. MDMT of the Reinforcement Pad : -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = 4.16/19.60 = 0.212

Weld Size Calculations, Description: K3B (3in)

Intermediate Calc. for nozzle/shell Welds Tmin 10.0000 mm.
Intermediate Calc. for pad/shell Welds TminPad 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	7.0700 = 0.7 * Wo mm.
Pad Weld	3.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm.

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (2.1138 - 1.3788 + 2 * 10.335 * 0.855 * \\
 &\quad (1.0 * 7.0 - 5.1775)) 138) \\
 &= 14575.13 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (3.3216 + 5.4826 + 0.8016 - 0.0 * 0.86) * 138 \\
 &= 132452.14 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (3.3216 + 0.0 + 0.855 + (1.2371)) * 138 \\
 &= 74647.97 \text{ N}
 \end{aligned}$$

 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)																									
شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>پروژه</th><th>بسته کاری</th><th>صادر کننده</th><th>تسهیلات</th><th>رشته</th><th>نوع مدرک</th><th>سریال</th><th>نسخه</th></tr><tr><td>BK</td><td>GCS</td><td>MF</td><td>120</td><td>ME</td><td>CN</td><td>0009</td><td>V01</td></tr></table>	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)								پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه	BK	GCS	MF	120	ME	CN	0009	V01	شماره صفحه : 333 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه																			
BK	GCS	MF	120	ME	CN	0009	V01																			

Weld Load [W3]:

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

$$= (3.3216 + 0.0 + 0.8016 + 5.4826 + (1.2371)) * 138$$

$$= 149510.30 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 102.4825 * 10.0 * 0.49 * 118$$

$$= 92995. \text{ N}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * D_P * W_P * 0.49 * S_{EW}$$

$$= (3.1416/2.0) * 200.0 * 8.0 * 0.49 * 138$$

$$= 169810. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 45.2842) * (13.335 - 3.0) * 0.7 * 118$$

$$= 121339. \text{ N}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg}$$

$$= (3.1416/2) * 102.4825 * 10.0 * 0.74 * 138$$

$$= 164259. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 102.4825 * (10.0 - 3.0) * 0.74 * 138$$

$$= 114981. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SPEW + SNW) = (169810 + 121339) = 291149 \text{ N}$$

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

$$= (92995 + 164259 + 114981 + 0) = 372235 \text{ N}$$

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

$$= (169810 + 114981 + 0) = 284791 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 291148 N , must exceed W = 14575 N or W1 = 132452 N

Path 2-2 = 372234 N , must exceed W = 14575 N or W2 = 74647 N

Path 3-3 = 284791 N , must exceed W = 14575 N or W3 = 149510 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

Note : Checking Nozzle in plane parallel to the vessel axis.

 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 REBOILER (R-100)	شماره صفحه : 334 از 381																
	<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>V01</td><td>0009</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	V01	0009	CN	ME	120	MF	GCS	BK
	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Reinforcement CALCULATION, Description: K3B (3in)

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

Actual Inside Diameter Used in Calculation 2.450 in.
Actual Thickness Used in Calculation 0.525 in.

Nozzle input data check completed without errors.

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

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

$$= (4.16 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.16)$$

$$= 1.8244 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.16 \cdot 34.11) / (118 \cdot 1.0 - 0.6 \cdot 4.16)$$

$$= 0.1208 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3989 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 136.4600 mm.
Parallel to Vessel Wall, opening length d 68.2300 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 mm.

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.299	1.844	NA
Area in Shell	A1	3.376	1.189	NA
Area in Nozzle Wall	A2	3.057	2.973	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.802	0.802	NA
Area in Element	A5	4.756	4.756	NA
TOTAL AREA AVAILABLE	Atot	11.990	9.720	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.

The area available with the given pad is Sufficient.

Area Required [A]:

$$= 0.5 (d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F (1 - fr1)) \text{ per UG-37 (d)}$$

$$= 0.5 (68.23 \cdot 5.1775 \cdot 1 + 2 \cdot 10.335 \cdot 5.1775 \cdot 1 (1 - 0.86))$$

$$= 1.844 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

 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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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه																			
BK	GCS	MF	120	ME	CN	0009	V01																			

Area Available in Shell [A1]:

$$= d (E1 \cdot t - F \cdot t_r) - 2 \cdot t_n (E1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1})$$

$$= 68.23 (1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 10.335$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.855)$$

$$= 1.189 \text{ cm}^2$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$= (2 \cdot T_{lwp}) \cdot (t_n - t_{rn}) \cdot f_{r2}$$

$$= (2 \cdot 17.5) \cdot (10.34 - 0.4) \cdot 0.855$$

$$= 2.973 \text{ cm}^2$$

Area Available in Welds [A41 + A42 + A43]:

$$= (W_o^2 - A_r \text{ Lost}) \cdot F_{r3} + ((W_i - c_{an}/0.707)^2 - A_r \text{ Lost}) \cdot f_{r2} + W_p^2 \cdot f_{r4}$$

$$= (0.9375) \cdot 0.86 + (0.0) \cdot 0.86 + 0.0^2 \cdot 1.0$$

$$= 0.802 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(D_p, D_L) - (\text{Nozzle OD})) \cdot (\min(t_p, T_{lwp}, t_e)) \cdot f_{r4}$$

$$= (136.46 - 88.9) \cdot 10.0 \cdot 1.0$$

$$= 4.756 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	$t_a = 3.3989 \text{ mm.}$
Wall Thickness per UG16(b),	$t_{r16b} = 4.5000 \text{ mm.}$
Wall Thickness, shell/head, internal pressure	$t_{rb1} = 4.8244 \text{ mm.}$
Wall Thickness	$t_{b1} = \max(t_{rb1}, t_{r16b}) = 4.8244 \text{ mm.}$
Wall Thickness, shell/head, external pressure	$t_{rb2} = 3.4524 \text{ mm.}$
Wall Thickness	$t_{b2} = \max(t_{rb2}, t_{r16b}) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45	$t_{b3} = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$$= \min[t_{b3}, \max(t_{b1}, t_{b2})]$$

$$= \min[7.8, \max(4.8244, 4.5)]$$

$$= 4.8244 \text{ mm.}$$

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

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

$$= \max(3.3989, 4.8244)$$

$$= 4.8244 \text{ mm.}$$

Available Nozzle Neck Thickness = 13.3350 mm. --> OK

Weld Size Calculations, Description: K3B (3in)

Intermediate Calc. for nozzle/shell Welds	T_{min}	10.0000	mm.
Intermediate Calc. for pad/shell Welds	T_{minPad}	7.0000	mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$6.0000 = \text{Min per Code}$	$7.0700 = 0.7 \cdot W_o \text{ mm.}$
Pad Weld	$3.5000 = 0.5 \cdot T_{minPad}$	$5.6560 = 0.7 \cdot W_p \text{ mm.}$

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

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	V01	0009	CN	ME	120	MF	GCS	BK

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (1.8439 - 1.1888 + 2 * 10.335 * 0.855 * (1.0 * 7.0 - 5.1775))138) \\
 &= 13473.64 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (2.9734 + 4.756 + 0.8016 - 0.0 * 0.86) * 138 \\
 &= 117631.63 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (2.9734 + 0.0 + 0.855 + (1.2371)) * 138 \\
 &= 69846.98 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (2.9734 + 0.0 + 0.8016 + 4.756 + (1.2371)) * 138 \\
 &= 134689.80 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 88.9 * 10.0 * 0.49 * 118 \\
 &= 80670. \text{ N}
 \end{aligned}$$

Shear, Pad Element Weld [Spew]:

$$\begin{aligned}
 &= (\pi/2) * DP * WP * 0.49 * SEW \\
 &= (3.1416/2.0) * 200.0 * 8.0 * 0.49 * 138 \\
 &= 169810. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 39.2825) * (13.335 - 3.0) * 0.7 * 118 \\
 &= 105257. \text{ N}
 \end{aligned}$$

Tension, Pad Groove Weld [Tpgw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wgpn * 0.74 * Seg \\
 &= (3.1416/2) * 88.9 * 10.0 * 0.74 * 138 \\
 &= 142489. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng \\
 &= (3.1416/2.0) * 88.9 * (10.0 - 3.0) * 0.74 * 138 \\
 &= 99742. \text{ N}
 \end{aligned}$$

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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
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Strength of Failure Paths:

$$\begin{aligned} \text{PATH11} &= (\text{SPEW} + \text{SNW}) = (169810 + 105257) = 275067 \text{ N} \\ \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\ &= (80670 + 142489 + 99742 + 0) = 322901 \text{ N} \\ \text{PATH33} &= (\text{Spew} + \text{Tngw} + \text{Sinw}) \\ &= (169810 + 99742 + 0) = 269552 \text{ N} \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 275067 N , must exceed W = 13473 N or W1 = 117631 N
 Path 2-2 = 322900 N , must exceed W = 13473 N or W2 = 69846 N
 Path 3-3 = 269552 N , must exceed W = 13473 N or W3 = 134689 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 28.3371 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 239.8528 mm.

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	BK	GCS	MF	120	ME	CN	0009	V01

Input, Nozzle Desc: K12 (2in)

From: 50

Pressure for Reinforcement Calculations	P	4.195	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2400.0000	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		4650.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

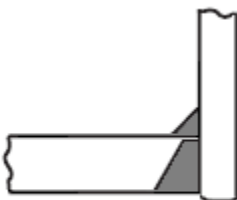
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	136.43	N./mm ²
Allowable Stress At Ambient	Sna	137.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		270.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

 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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	V01	0009	CN	ME	120	MF	GCS		BK

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



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

Reinforcement CALCULATION, Description: K12 (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	0.654 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

$$\begin{aligned}
 &= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 1.8378 \text{ mm.}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.19 \cdot 28.4) / (136 \cdot 1.0 - 0.6 \cdot 4.19) \\
 &= 0.0875 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.3430 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	113.6000	mm.
Parallel to Vessel Wall, opening length	d	56.8000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.5000	mm.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9) \\
 &= 0.989
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 136.4 / 137.9)
 \end{aligned}$$

 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	0009	V01

$$= 0.989$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.989, 1.0)$$

$$= 0.989$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	1.049	1.478	NA
Area in Shell	A1	2.917	1.030	NA
Area in Nozzle Wall	A2	4.679	4.591	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.989	0.989	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.586	6.610	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]:

$$= 0.5(d \cdot tr \cdot F + 2 \cdot tn \cdot tr \cdot F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(56.8 \cdot 5.1775 \cdot 1 + 2 \cdot 13.6 \cdot 5.1775 \cdot 1(1 - 0.99))$$

$$= 1.478 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 \cdot t - F \cdot tr) - 2 \cdot tn(E1 \cdot t - F \cdot tr) \cdot (1 - fr1)$$

$$= 56.8(1.0 \cdot 7.0 - 1.0 \cdot 5.178) - 2 \cdot 13.6$$

$$(1.0 \cdot 7.0 - 1.0 \cdot 5.1775) \cdot (1 - 0.989)$$

$$= 1.030 \text{ cm}^2$$

Area Available in Nozzle Projecting Outward [A2]:

$$= (2 \cdot tlnp)(tn - trn)fr2$$

$$= (2 \cdot 17.5)(13.6 - 0.34) \cdot 0.9894$$

$$= 4.591 \text{ cm}^2$$

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

$$= Wo^2 \cdot fr2 + (Wi - can/0.707)^2 \cdot fr2$$

$$= 10.0^2 \cdot 0.9894 + (0.0)^2 \cdot 0.9894$$

$$= 0.989 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.3430 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.8378 mm.
Wall Thickness	tbl = max(trb1, tr16b) = 4.8378 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 341 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Wall Thickness $tb2 = \max(tb2, tr16b) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45 $tb3 = 7.8000 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:
 $= \min[tb3, \max(tb1, tb2)]$
 $= \min[7.8, \max(4.8378, 4.5)]$
 $= 4.8378 \text{ mm.}$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
 $= \max(ta, tb)$
 $= \max(3.343, 4.8378)$
 $= 4.8378 \text{ mm.}$

Available Nozzle Neck Thickness = 16.6000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:A, Curve:D)

Govrn. thk, $tg = 10.0$, $tr = 1.838$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.263$, Temp. Reduction = $78 \text{ }^\circ\text{C}$

Min Metal Temp. w/o impact per UCS-66, Curve A $-8 \text{ }^\circ\text{C}$
Min Metal Temp. at Required thickness (UCS 66.1) $-104 \text{ }^\circ\text{C}$
Min Metal Temp. w/o impact per UG-20(f) $-29 \text{ }^\circ\text{C}$

Gov. MDMT of the nozzle to shell joint welded assembly : $-104 \text{ }^\circ\text{C}$

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) $-18 \text{ }^\circ\text{C}$
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) $-104 \text{ }^\circ\text{C}$

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = $4.19/51.10 = 0.082$

Weld Size Calculations, Description: K12 (2in)

Intermediate Calc. for nozzle/shell Welds $T_{min} = 7.0000 \text{ mm.}$

Results Per UW-16.1:

Required Thickness Actual Thickness
Nozzle Weld $4.9000 = 0.7 * t_{min.}$ $7.0700 = 0.7 * W_o \text{ mm.}$

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

Weld Load [W]:
 $= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$
 $= \max(0, (1.4779 - 1.0299 + 2 * 13.6 * 0.9894 * (1.0 * 7.0 - 5.1775)) 138)$
 $= 12940.23 \text{ N}$

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

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	BK	GCS	MF	120	ME	CN	0009	V01

Weld Load [W1]:

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

$$= (4.5906 + 0.0 + 0.9894 - 0.0 * 0.99) * 138$$

$$= 76941.22 \text{ N}$$

Weld Load [W2]:

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

$$= (4.5906 + 0.0 + 0.9894 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Weld Load [W3]:

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

$$= (4.5906 + 0.0 + 0.9894 + 0.0 + (1.8838)) * 138$$

$$= 102915.99 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 84.0 * 10.0 * 0.49 * 136$$

$$= 88202. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 35.2) * (16.6 - 3.0) * 0.7 * 136$$

$$= 143620. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

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

$$= (3.1416/2.0) * 84.0 * (10.0 - 3.0) * 0.74 * 138$$

$$= 94245. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SONW + SNW) = (88202 + 143620) = 231822 \text{ N}$$

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

$$= (88202 + 0 + 94245 + 0) = 182447 \text{ N}$$

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

$$= (88202 + 94245 + 0) = 182447 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 231822 N , must exceed W = 12940 N or W1 = 76941 N

Path 2-2 = 182446 N , must exceed W = 12940 N or W2 = 102915 N

Path 3-3 = 182446 N , must exceed W = 12940 N or W3 = 102915 N

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	V01	0009	CN	ME	120	MF	GCS	BK

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 16 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 1.4718 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.4718 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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V01	0009	CN	ME	120	MF	GCS	BK											

Input, Nozzle Desc: N1 (10in)

From: 60

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Inside Diameter of Cylindrical Shell	D	1200.00	mm.
Design Length of Section	L	2399.9998	mm.
Shell Finished (Minimum) Thickness	t	10.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		5800.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm ²
Allowable Stress At Ambient	Sna	117.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		90.00	deg
Diameter		10.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	40	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	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	10.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²
Diameter of Pad along vessel surface	Dp	450.0000	mm.
Thickness of Pad	te	10.0000	mm.

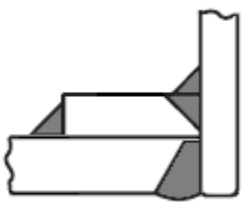
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V01	0009	CN	ME	120	MF	GCS	BK											

Weld leg size between Pad and Shell Wp 10.0000 mm.
Groove weld depth between Pad and Nozzle Wgpn 10.0000 mm.
Reinforcing Pad Width 88.4750 mm.

Flange Class 150
Flange Grade GR 1.1

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: N1 (10in)

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

Actual Inside Diameter Used in Calculation 10.111 in.
Actual Thickness Used in Calculation 0.319 in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

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

$$= (4.1 \cdot 603.0) / (138 \cdot 1.0 - 0.6 \cdot 4.1)$$

$$= 1.7961 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

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

$$= (4.1 \cdot 131.41) / (118 \cdot 1.0 - 0.6 \cdot 4.1)$$

$$= 0.4580 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.6850 mm.

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

Parallel to Vessel Wall (Diameter Limit) D1 525.6515 mm.
Parallel to Vessel Wall, opening length d 262.8257 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp 17.5000 mm.

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V01	0009	CN	ME	120	MF	GCS	BK											

Weld Strength Reduction Factor [fr1]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr2]:

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

$$= \min(1, 117.9/137.9)$$

$$= 0.855$$

Weld Strength Reduction Factor [fr4]:

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

$$= \min(1, 137.9/137.9)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.855, 1.0)$$

$$= 0.855$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	4.747	6.842	NA
Area in Shell	A1	13.600	4.763	NA
Area in Nozzle Wall	A2	1.393	1.325	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	1.802	1.802	NA
Area in Element	A5	17.695	17.695	NA
TOTAL AREA AVAILABLE	Atot	34.489	25.584	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness
Based on given Pad Thickness:	273.0500	10.0000 mm.
Based on given Pad Diameter:	450.0000	0.0000 mm.
Based on Shell or Nozzle Thickness:	273.0500	8.1121 mm.

Area Required [A]:

$$= 0.5(d * tr * F + 2 * t_n * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(262.8257 * 5.1775 * 1 + 2 * 5.1121 * 5.1775 * 1(1 - 0.86))$$

$$= 6.842 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1 * t - F * tr) - 2 * t_n(E1 * t - F * tr) * (1 - fr1)$$

 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	0009		V01

$$= 262.826 (1.0 * 7.0 - 1.0 * 5.178) - 2 * 5.112$$

$$(1.0 * 7.0 - 1.0 * 5.1775) * (1 - 0.855)$$

$$= 4.763 \text{ cm}^2$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$= (2 * Tlwp) * (tn - trn) * fr2$$

$$= (2 * 17.5) * (5.11 - 0.69) * 0.855$$

$$= 1.325 \text{ cm}^2$$

Area Available in Welds [A41 + A42 + A43]:

$$= (Wo^2 - Ar \text{ Lost}) * Fr3 + ((Wi - can / 0.707)^2 - Ar \text{ Lost}) * fr2 + Wp^2 * fr4$$

$$= (0.9375) * 0.86 + (0.0) * 0.86 + 254.0^2 * 1.0$$

$$= 1.802 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(Dp, DL) - (Nozzle \text{ OD})) * (\min(tp, Tlwp, te)) * fr4$$

$$= (450.0 - 273.05) * 10.0 * 1.0$$

$$= 17.695 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	ta = 3.6850 mm.
Wall Thickness per UG16(b),	tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 4.7961 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 4.7961 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.4524 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45	tb3 = 11.1026 mm.

Determine Nozzle Thickness candidate [tb]:

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

$$= \min[11.103, \max(4.7961, 4.5)]$$

$$= 4.7961 \text{ mm.}$$

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

$$= \max(ta, tb)$$

$$= \max(3.685, 4.7961)$$

$$= 4.7961 \text{ mm.}$$

Available Nozzle Neck Thickness = 8.1121 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	: 53.0,	Allowable	: 117.9 N./mm ²	Passed
Expansion	: 0.0,	Allowable	: 241.8 N./mm ²	Passed
Occasional	: 5.2,	Allowable	: 156.8 N./mm ²	Passed
Shear	: 8.3,	Allowable	: 82.5 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.

 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 REBOILER (R-100)	شماره صفحه : 348 از 381																
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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 8.112, tr = 0.458, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.09$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, tg = 8.112, tr = 0.458, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.09$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 8.112, tr = 0.458, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.09$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 10.0, tr = 1.796, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.257$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:B, Curve:D)

Govrn. thk, tg = 8.112, tr = 0.458, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.09$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C
Gov. MDMT of the Reinforcement Pad : -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = 4.10/19.60 = 0.209

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	BK	GCS	MF	120	ME	CN	0009	V01

Weld Size Calculations, Description: N1 (10in)

Intermediate Calc. for nozzle/shell Welds T_{min} 5.1121 mm.
Intermediate Calc. for pad/shell Welds T_{minPad} 7.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$3.5785 = 0.7 * t_{min}$	$7.0700 = 0.7 * W_o$ mm.
Pad Weld	$3.5000 = 0.5 * T_{minPad}$	$7.0700 = 0.7 * W_p$ mm.

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

Weld Load [W]:

$$= \max(0, (A - A_1 + 2 * t_n * f_{r1} * (E_1 * t - t_r)) * S_v)$$

$$= \max(0, (6.8423 - 4.7629 + 2 * 5.1121 * 0.855 * (1.0 * 7.0 - 5.1775)) * 138)$$

$$= 30869.81 \text{ N}$$

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

Weld Load [W1]:

$$= (A_2 + A_5 + A_4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v$$

$$= (1.3248 + 17.695 + 1.8016 - 0.0 * 0.86) * 138$$

$$= 287102.38 \text{ N}$$

Weld Load [W2]:

$$= (A_2 + A_3 + A_4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (1.3248 + 0.0 + 0.855 + (0.6119)) * 138$$

$$= 38494.77 \text{ N}$$

Weld Load [W3]:

$$= (A_2 + A_3 + A_4 + A_5 + (2 * t_n * t * f_{r1})) * S$$

$$= (1.3248 + 0.0 + 1.8016 + 17.695 + (0.6119)) * 138$$

$$= 295540.03 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

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

$$= (3.1416/2.0) * 273.05 * 10.0 * 0.49 * 118$$

$$= 247772. \text{ N}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * D_P * W_P * 0.49 * S_{EW}$$

$$= (3.1416/2.0) * 450.0 * 10.0 * 0.49 * 138$$

$$= 477591. \text{ N}$$

Shear, Nozzle Wall [Snw]:

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

$$= (3.1416 * 133.9689) * (8.1121 - 3.0) * 0.7 * 118$$

$$= 177561. \text{ N}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg}$$

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	BK	GCS	MF	120	ME	CN	0009	V01

$$= (3.1416/2) * 273.05 * 10.0 * 0.74 * 138$$

$$= 437644. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

$$= (\pi/2) * D_{lo} * (W_{gvi} - C_{as}) * 0.74 * S_{ng}$$

$$= (3.1416/2.0) * 273.05 * (10.0 - 3.0) * 0.74 * 138$$

$$= 306351. \text{ N}$$

Strength of Failure Paths:

$$PATH11 = (SPEW + SNW) = (477591 + 177561) = 655151 \text{ N}$$

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

$$= (247772 + 437644 + 306351 + 0) = 991767 \text{ N}$$

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

$$= (477591 + 306351 + 0) = 783941 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 655151 N , must exceed W = 30869 N or W1 = 287102 N

Path 2-2 = 991766 N , must exceed W = 30869 N or W2 = 38494 N

Path 3-3 = 783941 N , must exceed W = 30869 N or W3 = 295540 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 12 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Drop for this Nozzle is : 15.7390 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 175.7390 mm.

Input Echo, WRC107/537 Item 1, Description: N1 (10in) :

Diameter Basis for Vessel	Vbasis	ID
Cylindrical or Spherical Vessel	Cylsph	Cylindrical
Internal Corrosion Allowance	Cas	3.0000 mm.
Vessel Diameter	Dv	1200.000 mm.
Vessel Thickness	Tv	10.000 mm.
Design Temperature	T1	234.0 °C
Vessel Material		SA-516 70
Vessel UNS Number		K02700
Vessel Cold S.I. Allowable	Smc	137.90 N./mm ²
Vessel Hot S.I. Allowable	Smh	137.90 N./mm ²

Note:

Using 2 * Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.

Make sure that material properties at this temperature are not time-dependent for Material: SA-516 70

Attachment Type Type Round

Diameter Basis for Nozzle Nbasis ID

 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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Corrosion Allowance for Nozzle	Can	3.0000	mm.
Nozzle Diameter	Dn	256.826	mm.
Nozzle Thickness	Tn	8.112	mm.
Nozzle Material		SA-106 B	
Nozzle UNS Number		K03006	
Nozzle Cold S.I. Allowable	SNmc	117.90	N./mm ²
Nozzle Hot S.I. Allowable	SNmh	117.90	N./mm ²
Thickness of Reinforcing Pad	Tpad	10.000	mm.
Diameter of Reinforcing Pad	Dpad	450.000	mm.
Design Internal Pressure	Dp	4.100	bars
Include Pressure Thrust	No		

External Forces and Moments in WRC 107/537 Convention:

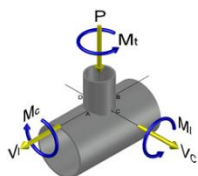
Radial Load	(SUS)	P	14000.0	N
Longitudinal Shear	(SUS)	Vl	14000.0	N
Circumferential Shear	(SUS)	Vc	-10500.0	N
Circumferential Moment	(SUS)	Mc	-7000.0	N-m
Longitudinal Moment	(SUS)	Ml	-10500.0	N-m
Torsional Moment	(SUS)	Mt	-9100.0	N-m

Use Interactive Control No
WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No
Local Loads applied at end of Nozzle/Attachment No

Note:

WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:

$$\begin{aligned}
 &= \text{NozzleOD} + 2 * 1.65 * \text{sqrt}(\text{Rmean}(\text{t} - \text{ca})) \\
 &= 273.05 + 2 * 1.65 * \text{sqrt}(606.5 (10.0 - 3.0)) \\
 &= 488.070 \text{ mm.}
 \end{aligned}$$

WRC 107 Stress Calculation for SUSstained loads:

Radial Load	P	14000.0	N
Circumferential Shear	VC	-10500.0	N
Longitudinal Shear	VL	14000.0	N
Circumferential Moment	MC	-7000.0	N-m
Longitudinal Moment	ML	-10500.0	N-m

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V01	0009	CN	ME	120	MF	GCS	BK																			

Torsional Moment MT -9100.0 N-m

Dimensionless Parameters used : Gamma = 35.97

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.195	4C	5.137	(A,B)
N(PHI) / (P/Rm)	0.195	3C	3.416	(C,D)
M(PHI) / (P)	0.195	2C1	0.039	(A,B)
M(PHI) / (P)	0.195	1C !	0.070	(C,D)
N(PHI) / (MC/ (Rm**2 * Beta))	0.195	3A	1.457	(A,B,C,D)
M(PHI) / (MC/ (Rm * Beta))	0.195	1A	0.080	(A,B,C,D)
N(PHI) / (ML/ (Rm**2 * Beta))	0.195	3B	3.709	(A,B,C,D)
M(PHI) / (ML/ (Rm * Beta))	0.195	1B	0.027	(A,B,C,D)
N(x) / (P/Rm)	0.195	3C	3.416	(A,B)
N(x) / (P/Rm)	0.195	4C	5.137	(C,D)
M(x) / (P)	0.195	1C1	0.072	(A,B)
M(x) / (P)	0.195	2C !	0.039	(C,D)
N(x) / (MC/ (Rm**2 * Beta))	0.195	4A	2.685	(A,B,C,D)
M(x) / (MC/ (Rm * Beta))	0.195	2A	0.039	(A,B,C,D)
N(x) / (ML/ (Rm**2 * Beta))	0.195	4B	1.461	(A,B,C,D)
M(x) / (ML/ (Rm * Beta))	0.195	2B	0.042	(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		-6.9	-6.9	-6.9	-6.9	-4.6	-4.6	-4.6	-4.6
Circ. Bend. P		-11.3	11.3	-11.3	11.3	-20.2	20.2	-20.2	20.2
Circ. Memb. MC		0.0	0.0	0.0	0.0	8.2	8.2	-8.2	-8.2
Circ. Memb. MC		0.0	0.0	0.0	0.0	97.0	-97.0	-97.0	97.0
Circ. Memb. ML		31.4	31.4	-31.4	-31.4	0.0	0.0	0.0	0.0
Circ. Bend. ML		50.1	-50.1	-50.1	50.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.		63.3	-14.4	-99.7	23.1	80.4	-73.2	-130.1	104.4
Long. Memb. P		-4.6	-4.6	-4.6	-4.6	-6.9	-6.9	-6.9	-6.9
Long. Bend. P		-20.9	20.9	-20.9	20.9	-11.2	11.2	-11.2	11.2
Long. Memb. MC		0.0	0.0	0.0	0.0	15.1	15.1	-15.1	-15.1
Long. Bend. MC		0.0	0.0	0.0	0.0	46.9	-46.9	-46.9	46.9
Long. Memb. ML		12.3	12.3	-12.3	-12.3	0.0	0.0	0.0	0.0
Long. Bend. ML		77.0	-77.0	-77.0	77.0	0.0	0.0	0.0	0.0

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Tot. Long. Str.	63.9	-48.4	-114.9	81.0	43.9	-27.4	-80.2	36.1
Shear VC	-1.4	-1.4	1.4	1.4	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.9	-1.9	1.9	1.9
Shear MT	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6
Tot. Shear	-6.0	-6.0	-3.1	-3.1	-6.5	-6.5	-2.6	-2.6
Str. Int.	69.6	49.4	115.5	81.1	81.6	74.1	130.2	104.5

Dimensionless Parameters used : Gamma = 86.64

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.325	4C	6.644	(A,B)
N(PHI) / (P/Rm)	0.325	3C	2.278	(C,D)
M(PHI) / (P)	0.325	2C1	0.007	(A,B)
M(PHI) / (P)	0.325	1C !	0.067	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.325	3A	1.925	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.325	1A	0.055	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.325	3B	3.838	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.325	1B	0.005	(A,B,C,D)
N(x) / (P/Rm)	0.325	3C	2.278	(A,B)
N(x) / (P/Rm)	0.325	4C	6.644	(C,D)
M(x) / (P)	0.325	1C1	0.020	(A,B)
M(x) / (P)	0.325	2C !	0.036	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.325	4A	7.630	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.325	2A	0.021	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.325	4B	2.131	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.325	2B	0.007	(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 Edge of Reinforcing Pad (N./mm²)

		Stress Intensity Values at							
Type of Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		-21.9	-21.9	-21.9	-21.9	-7.5	-7.5	-7.5	-7.5
Circ. Bend. P		-11.7	11.7	-11.7	11.7	-115.4	115.4	-115.4	115.4
Circ. Memb. MC		0.0	0.0	0.0	0.0	16.1	16.1	-16.1	-16.1
Circ. Memb. MC		0.0	0.0	0.0	0.0	238.1	-238.1	-238.1	238.1
Circ. Memb. ML		48.2	48.2	-48.2	-48.2	0.0	0.0	0.0	0.0
Circ. Bend. ML		34.2	-34.2	-34.2	34.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.		48.7	3.8	-116.0	-24.2	131.3	-114.1	-377.1	329.8

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 354 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Long. Memb. P	-7.5	-7.5	-7.5	-7.5	-21.9	-21.9	-21.9	-21.9
Long. Bend. P	-33.5	33.5	-33.5	33.5	-61.7	61.7	-61.7	61.7
Long. Memb. MC	0.0	0.0	0.0	0.0	63.9	63.9	-63.9	-63.9
Long. Bend. MC	0.0	0.0	0.0	0.0	91.6	-91.6	-91.6	91.6
Long. Memb. ML	26.8	26.8	-26.8	-26.8	0.0	0.0	0.0	0.0
Long. Bend. ML	48.3	-48.3	-48.3	48.3	0.0	0.0	0.0	0.0
Tot. Long. Str.	34.1	4.4	-116.0	47.5	71.9	12.1	-239.1	67.5
Shear VC	-2.1	-2.1	2.1	2.1	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-2.8	-2.8	2.8	2.8
Shear MT	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
Tot. Shear	-6.2	-6.2	-2.0	-2.0	-6.9	-6.9	-1.3	-1.3
Str. Int.	51.0	12.4	118.0	71.8	132.1	126.9	377.1	329.8

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)		14.3	14.8	14.3	14.8	14.3	14.8	14.3	14.8
Circ. Pl (SUS)		24.4	24.4	-38.3	-38.3	3.6	3.6	-12.8	-12.8
Circ. Q (SUS)		38.8	-38.8	-61.4	61.4	76.8	-76.8	-117.3	117.3
Long. Pm (SUS)		7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Long. Pl (SUS)		7.7	7.7	-16.9	-16.9	8.2	8.2	-22.0	-22.0
Long. Q (SUS)		56.2	-56.2	-97.9	97.9	35.7	-35.7	-58.1	58.1
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		-1.4	-1.4	1.4	1.4	-1.9	-1.9	1.9	1.9
Shear Q (SUS)		-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6
Pm (SUS)		14.3	14.8	14.3	14.8	14.3	14.8	14.3	14.8
Pm+Pl (SUS)		38.9	39.3	24.1	23.7	19.0	19.3	16.8	17.2
Pm+Pl+Q (Total)		81.2	43.3	108.1	88.3	95.7	59.5	115.9	119.3

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	BK	GCS	MF	120	ME	CN	0009	V01

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	14.75	137.90	Passed
Pm+Pl (SUS)	39.27	206.85	Passed
Pm+Pl+Q (TOTAL)	119.29	413.70	Passed

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

WRC 107/537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N./mm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		35.1	35.5	35.1	35.5	35.1	35.5	35.1	35.5
Circ. Pl (SUS)		26.3	26.3	-70.1	-70.1	8.6	8.6	-23.6	-23.6
Circ. Q (SUS)		22.4	-22.4	-45.9	45.9	122.7	-122.7	-353.4	353.4
Long. Pm (SUS)		17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6
Long. Pl (SUS)		19.2	19.2	-34.3	-34.3	42.0	42.0	-85.8	-85.8
Long. Q (SUS)		14.8	-14.8	-81.8	81.8	29.9	-29.9	-153.3	153.3
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		-2.1	-2.1	2.1	2.1	-2.8	-2.8	2.8	2.8
Shear Q (SUS)		-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
Pm (SUS)		35.1	35.5	35.1	35.5	35.1	35.5	35.1	35.5
Pm+Pl (SUS)		61.6	62.0	35.2	34.8	60.0	60.0	79.9	80.3
Pm+Pl+Q (Total)		85.0	41.4	98.7	65.1	167.0	109.1	342.0	365.3

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	35.53	137.90	Passed
Pm+Pl (SUS)	80.33	206.85	Passed
Pm+Pl+Q (TOTAL)	365.34	413.70	Passed

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

 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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	V01	0009	CN	ME	120	MF	GCS		BK

Input, Nozzle Desc: N3 (10in)

From: 80

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-105	
Shell Allowable Stress at Temperature	Sv	136.40	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Outside Diameter of Bolted Blind Flange	D	1420.00	mm.
Head Finished (Minimum) Thickness	t	60.0000	mm.
Head Internal Corrosion Allowance	c	3.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.

Note : User defined Limit(s) of Reinforcement specified below:

Physical Maximum for Diameter Limit	Dmax	450.0000	mm.
Distance from Head Centerline	L1	320.0000	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

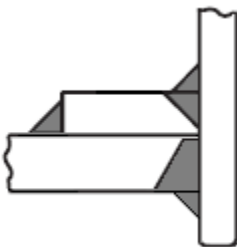
Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm ²
Allowable Stress At Ambient	Sna	117.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		320.00	deg
Diameter		10.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	20.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	26.0000	mm.
Inside Projection	h	4000.0000	mm.
Weld leg size, Inside Element to Shell	Wi	20.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²

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Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²
Diameter of Pad along vessel surface	Dp	450.0000	mm.
Thickness of Pad	te	15.0000	mm.
Weld leg size between Pad and Shell	Wp	12.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	15.0000	mm.
Reinforcing Pad Width		88.4750	mm.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



Insert/Set-in Nozzle With Pad, with Inside projection

Reinforcement CALCULATION, Description: N3 (10in)

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

Actual Inside Diameter Used in Calculation	8.781	in.
Actual Thickness Used in Calculation	0.984	in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 114.52) / (118 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.3991 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.7666 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	450.0000	mm.
Parallel to Vessel Wall, opening length	d	225.0000	mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		70.0078	mm.
Normal to Vessel Wall, Inward		47.5078	mm.

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	BK	GCS	MF	120	ME	CN	0009	V01

Weld Strength Reduction Factor [fr1]:

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

$$= \min(1, 117.9/136.4)$$

$$= 0.864$$

Weld Strength Reduction Factor [fr2]:

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

$$= \min(1, 117.9/136.4)$$

$$= 0.864$$

Weld Strength Reduction Factor [fr4]:

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

$$= \min(1, 137.9/136.4)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.864, 1.0)$$

$$= 0.864$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	50.775	50.795	NA
Area in Shell	A1	29.646	29.608	NA
Area in Nozzle Wall	A2	26.147	25.703	NA
Area in Inward Nozzle	A3	15.608	15.608	NA
Area in Welds	A41+A42+A43	5.604	5.604	NA
Area in Element	A5	26.542	26.542	NA
TOTAL AREA AVAILABLE	Atot	103.547	103.065	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degr.

The area available without a pad is Sufficient.

The area available with the given pad is Sufficient.

Area Required [A]:

$$= 0.5 * d * t + t * t_n(1-fr1) \text{ per UG-39(a) (1)}$$

$$= 0.5 * 229.0437 * 43.228 + 43.228 * 22.0031(1-0.86)$$

$$= 50.795 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1*t - F*tr) - 2 * t_n(E1*t - F*tr) * (1 - fr1)$$

$$= 220.956(1.0 * 57.0 - 1.0 * 43.228) - 2 * 22.003$$

$$(1.0 * 57.0 - 1.0 * 43.228) * (1 - 0.864)$$

$$= 29.608 \text{ cm}^2$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$= (2 * Tlwp) * (t_n - trn) * fr2$$

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	BK	GCS	MF	120	ME	CN	0009	V01

$$= (2 * 70.01) * (22.0 - 0.77) * 0.8644$$

$$= 25.703 \text{ cm}^2$$

Area Available in Inward Nozzle [A3]:

$$= 2 * t_i * \min(h, T_l, 2.5 * t_i) * f_{r2}$$

$$= 2 * 19.0031 * (47.5078) * 0.8644$$

$$= 15.608 \text{ cm}^2$$

Area Available in Welds [A41 + A42 + A43]:

$$= W_o^2 * f_{r3} + (W_i - c_{an}/0.707)^2 * f_{r2} + W_p^2 * f_{r4}$$

$$= 20.0^2 * 0.86 + (15.7573)^2 * 0.86 + 0.0^2 * 1.0$$

$$= 5.604 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(D_p, D_L) - (\text{Nozzle OD})) * (\min(t_p, T_{lwp}, t_e)) * f_{r4}$$

$$= (450.0 - 273.05) * 15.0 * 1.0$$

$$= 26.542 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	$t_a = 3.7666 \text{ mm.}$
Wall Thickness per UG16(b),	$t_{r16b} = 4.5000 \text{ mm.}$
Wall Thickness, shell/head, internal pressure	$t_{rb1} = 46.2106 \text{ mm.}$
Wall Thickness	$t_{b1} = \max(t_{rb1}, t_{r16b}) = 46.2106 \text{ mm.}$
Wall Thickness, shell/head, external pressure	$t_{rb2} = 3.4524 \text{ mm.}$
Wall Thickness	$t_{b2} = \max(t_{rb2}, t_{r16b}) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45	$t_{b3} = 11.1026 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$$= \min[t_{b3}, \max(t_{b1}, t_{b2})]$$

$$= \min[11.103, \max(46.2106, 4.5)]$$

$$= 11.1026 \text{ mm.}$$

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

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

$$= \max(3.7666, 11.1026)$$

$$= 11.1026 \text{ mm.}$$

Available Nozzle Neck Thickness = 25.0031 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, $t_g = 25.003$, $t_r = 0.399$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $t_r * (E^*) / (t_g - c) = 0.018$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-1 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, $t_g = 15.0$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$
Thickness Ratio = $t_r * (E^*) / (t_g - c) = 0.037$, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

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	BK	GCS	MF	120	ME	CN	0009	V01

Min Metal Temp. w/o impact per UCS-66, Curve B -16 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C
Min Metal Temp. w/o impact per UG-20(f) -29 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 15.0, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.037$, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve D -47 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, min(Curve:D, Curve:A)

Govrn. thk, tg = 15.0, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.037$, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve A 4 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:B, Curve:A)

Govrn. thk, tg = 25.003, tr = 0.399, c = 3.0 mm., E* = 1.0
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.018$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A 19 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C
Gov. MDMT of the Reinforcement Pad : -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.10 / 19.60 = 0.209$

Weld Size Calculations, Description: N3 (10in)

Intermediate Calc. for nozzle/shell Welds	Tmin	15.0000	mm.
Intermediate Calc. for pad/shell Welds	TminPad	15.0000	mm.
Intermediate Calc. for Inward Weld	TminIns	19.0000	mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$6.0000 = \text{Min per Code}$	$14.1400 = 0.7 * W_o$ mm.
Pad Weld	$7.5000 = 0.5 * T_{minPad}$	$8.4840 = 0.7 * W_p$ mm.
Inward Weld	$6.0000 = \text{Min per Code}$	$11.1400 = 0.7 * W_i$ -Can 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	0009	V01

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

Weld Load [W]:

$$\begin{aligned}
 &= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv) \\
 &= \max(0, (50.7953 - 29.6083 + 2 * 22.0031 * 0.8644 * \\
 &\quad (1.0 * 57.0 - 43.228))136) \\
 &= 360415.81 \text{ N}
 \end{aligned}$$

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

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv \\
 &= (25.7026 + 26.5425 + 5.6039 - 9.7753 * 0.86) * 136 \\
 &= 759720.19 \text{ N}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv \\
 &= (25.7026 + 15.6076 + 5.6039 + (21.6823)) * 136 \\
 &= 935574.56 \text{ N}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*tn*t*fr1))*S \\
 &= (25.7026 + 15.6076 + 5.6039 + 26.5425 + (21.6823)) * 136 \\
 &= 1297583.38 \text{ N}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 273.05 * 20.0 * 0.49 * 118 \\
 &= 495543. \text{ N}
 \end{aligned}$$

Shear, Inward Nozzle Weld [Sinw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416/2.0) * 273.05 * 15.7573 * 0.49 * 118 \\
 &= 390422. \text{ N}
 \end{aligned}$$

Shear, Pad Element Weld [Spew]:

$$\begin{aligned}
 &= (\pi/2) * DP * WP * 0.49 * SEW \\
 &= (3.1416/2.0) * 450.0 * 12.0 * 0.49 * 136 \\
 &= 566875. \text{ N}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 125.5234) * (25.0031 - 3.0) * 0.7 * 118 \\
 &= 716062. \text{ N}
 \end{aligned}$$

Tension, Pad Groove Weld [Tpgw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wgpn * 0.74 * Seg \\
 &= (3.1416/2) * 273.05 * 15.0 * 0.74 * 138 \\
 &= 656466. \text{ N}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

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V01	0009	CN	ME	120	MF	GCS	BK											

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

$$= (3.1416/2.0) * 273.05 * (26.0 - 3.0) * 0.74 * 136$$

$$= 995632. \text{ N}$$

Strength of Failure Paths:

$$\text{PATH11} = (\text{SPEW} + \text{SNW}) = (566875 + 716062) = 1282937 \text{ N}$$

$$\text{PATH22} = (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw})$$

$$= (495543 + 656466 + 995632 + 390422) = 2538063 \text{ N}$$

$$\text{PATH33} = (\text{Spew} + \text{Tngw} + \text{Sinw})$$

$$= (566875 + 995632 + 390422) = 1952929 \text{ N}$$

Summary of Failure Path Calculations:

Path 1-1 = 1282936 N , must exceed W = 360415 N or W1 = 759720 N
 Path 2-2 = 2538063 N , must exceed W = 360415 N or W2 = 935574 N
 Path 3-3 = 1952928 N , must exceed W = 360415 N or W3 = 1297583 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 8 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Cut Length for this Nozzle is, Drop + Ho + H + T : 4260.0000 mm.

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V01	0009	CN	ME	120	MF	GCS	BK											

Input, Nozzle Desc: Chimney Nozzle

From: 80

Pressure for Reinforcement Calculations	P	4.100	bars
Temperature for Internal Pressure	Temp	234	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-105	
Shell Allowable Stress at Temperature	Sv	136.40	N./mm ²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm ²
Outside Diameter of Bolted Blind Flange	D	1420.00	mm.
Head Finished (Minimum) Thickness	t	60.0000	mm.
Head Internal Corrosion Allowance	c	3.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.

Note : User defined Limit(s) of Reinforcement specified below:

Physical Maximum for Diameter Limit	Dmax	450.0000	mm.
Distance from Head Centerline	L1	320.0000	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

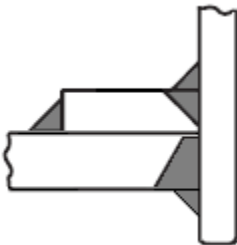
Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm ²
Allowable Stress At Ambient	Sna	117.90	N./mm ²
Diameter Basis (for tr calc only)		ID	
Layout Angle		220.00	deg
Diameter		10.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	
Flange Material		SA-105	
Flange Type		None	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	20.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	26.0000	mm.
Inside Projection	h	4000.0000	mm.
Weld leg size, Inside Element to Shell	Wi	20.0000	mm.
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm ²

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Pad Allowable Stress At Ambient	Spa	137.90	N./mm ²
Diameter of Pad along vessel surface	Dp	450.0000	mm.
Thickness of Pad	te	15.0000	mm.
Weld leg size between Pad and Shell	Wp	12.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	15.0000	mm.
Reinforcing Pad Width		88.4750	mm.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



Insert/Set-in Nozzle With Pad, with Inside projection

Reinforcement CALCULATION, Description: Chimney Nozzle

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

Actual Inside Diameter Used in Calculation	8.781	in.
Actual Thickness Used in Calculation	0.984	in.

Note:

Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$\begin{aligned}
 &= (P \cdot R) / (S_n \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (4.1 \cdot 114.52) / (118 \cdot 1.0 - 0.6 \cdot 4.1) \\
 &= 0.3991 \text{ mm.}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.7666 mm.

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

Parallel to Vessel Wall (Diameter Limit)	D1	450.0000	mm.
Parallel to Vessel Wall, opening length	d	225.0000	mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		70.0078	mm.
Normal to Vessel Wall, Inward		47.5078	mm.

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	BK	GCS	MF	120	ME	CN	0009	V01										

Weld Strength Reduction Factor [fr1]:

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

$$= \min(1, 117.9/136.4)$$

$$= 0.864$$

Weld Strength Reduction Factor [fr2]:

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

$$= \min(1, 117.9/136.4)$$

$$= 0.864$$

Weld Strength Reduction Factor [fr4]:

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

$$= \min(1, 137.9/136.4)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr3]:

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

$$= \min(0.864, 1.0)$$

$$= 0.864$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	50.775	50.795	NA
Area in Shell	A1	29.646	29.608	NA
Area in Nozzle Wall	A2	26.147	25.703	NA
Area in Inward Nozzle	A3	15.608	15.608	NA
Area in Welds A41+A42+A43		5.604	5.604	NA
Area in Element	A5	26.542	26.542	NA
TOTAL AREA AVAILABLE	Atot	103.547	103.065	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degr.

The area available without a pad is Sufficient.

The area available with the given pad is Sufficient.

Area Required [A]:

$$= 0.5 * d * t + t * t_n(1-fr1) \text{ per UG-39(a) (1)}$$

$$= 0.5 * 229.0437 * 43.228 + 43.228 * 22.0031(1-0.86)$$

$$= 50.795 \text{ cm}^2$$

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

$$= d(E1*t - F*tr) - 2 * t_n(E1*t - F*tr) * (1 - fr1)$$

$$= 220.956(1.0 * 57.0 - 1.0 * 43.228) - 2 * 22.003$$

$$(1.0 * 57.0 - 1.0 * 43.228) * (1 - 0.864)$$

$$= 29.608 \text{ cm}^2$$

Area Available in Nozzle Wall Projecting Outward [A2]:

$$= (2 * Tlwp) * (t_n - trn) * fr2$$

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V01	0009	CN	ME	120	MF	GCS	BK											

$$= (2 * 70.01) * (22.0 - 0.77) * 0.8644$$

$$= 25.703 \text{ cm}^2$$

Area Available in Inward Nozzle [A3]:

$$= 2 * t_i * \min(h, T_l, 2.5 * t_i) * f_{r2}$$

$$= 2 * 19.0031 * (47.5078) * 0.8644$$

$$= 15.608 \text{ cm}^2$$

Area Available in Welds [A41 + A42 + A43]:

$$= W_o^2 * f_{r3} + (W_i - c_{an}/0.707)^2 * f_{r2} + W_p^2 * f_{r4}$$

$$= 20.0^2 * 0.86 + (15.7573)^2 * 0.86 + 0.0^2 * 1.0$$

$$= 5.604 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(D_p, D_L) - (\text{Nozzle OD})) * (\min(t_p, T_{lwp}, t_e)) * f_{r4}$$

$$= (450.0 - 273.05) * 15.0 * 1.0$$

$$= 26.542 \text{ cm}^2$$

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

Wall Thickness for Internal/External pressures	$t_a = 3.7666 \text{ mm.}$
Wall Thickness per UG16(b),	$t_{r16b} = 4.5000 \text{ mm.}$
Wall Thickness, shell/head, internal pressure	$t_{rb1} = 46.2106 \text{ mm.}$
Wall Thickness	$t_{b1} = \max(t_{rb1}, t_{r16b}) = 46.2106 \text{ mm.}$
Wall Thickness, shell/head, external pressure	$t_{rb2} = 3.4524 \text{ mm.}$
Wall Thickness	$t_{b2} = \max(t_{rb2}, t_{r16b}) = 4.5000 \text{ mm.}$
Wall Thickness per table UG-45	$t_{b3} = 11.1026 \text{ mm.}$

Determine Nozzle Thickness candidate [tb]:

$$= \min[t_{b3}, \max(t_{b1}, t_{b2})]$$

$$= \min[11.103, \max(46.2106, 4.5)]$$

$$= 11.1026 \text{ mm.}$$

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

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

$$= \max(3.7666, 11.1026)$$

$$= 11.1026 \text{ mm.}$$

Available Nozzle Neck Thickness = 25.0031 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, $t_g = 15.0$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$

Thickness Ratio = $t_r * (E^*) / (t_g - c) = 0.037$, Temp. Reduction = 78°C

Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve B	-16°C
Min Metal Temp. at Required thickness (UCS 66.1)	-104°C
Min Metal Temp. w/o impact per UG-20(f)	-29°C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, $t_g = 15.0$, $c = 3.0 \text{ mm.}$, $E^* = 1.0$

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	BK	GCS	MF	120	ME	CN	0009		V01

Thickness Ratio = $tr * (E^*) / (tg - c) = 0.037$, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve D -47 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, min(Curve:D, Curve:A)

Govrn. thk, $tg = 15.0$, $c = 3.0$ mm., $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.037$, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

Min Metal Temp. w/o impact per UCS-66, Curve A 4 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:B, Curve:A)

Govrn. thk, $tg = 25.003$, $tr = 0.399$, $c = 3.0$ mm., $E^* = 1.0$
Thickness Ratio = $tr * (E^*) / (tg - c) = 0.018$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A 19 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C
Gov. MDMT of the Reinforcement Pad : -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $4.10 / 19.60 = 0.209$

Weld Size Calculations, Description: Chimney Nozzle

Intermediate Calc. for nozzle/shell Welds Tmin 15.0000 mm.
Intermediate Calc. for pad/shell Welds TminPad 15.0000 mm.
Intermediate Calc. for Inward Weld TminIns 19.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$6.0000 = \text{Min per Code}$	$14.1400 = 0.7 * W_o$ mm.
Pad Weld	$7.5000 = 0.5 * \text{TminPad}$	$8.4840 = 0.7 * W_p$ mm.
Inward Weld	$6.0000 = \text{Min per Code}$	$11.1400 = 0.7 * W_i$ -Can mm.

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

Weld Load [W]:

$$= \max(0, (A - A_1 + 2 * t_n * f_{r1} * (E_1 * t - t_r)) S_v)$$

$$= \max(0, (50.7953 - 29.6083 + 2 * 22.0031 * 0.8644 * (1.0 * 57.0 - 43.228)) / 136)$$

$$= 360415.81 \text{ N}$$

 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 REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 368 از 381
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

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

Weld Load [W1]:

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

$$= (25.7026 + 26.5425 + 5.6039 - 9.7753 * 0.86) * 136$$

$$= 759720.19 \text{ N}$$

Weld Load [W2]:

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

$$= (25.7026 + 15.6076 + 5.6039 + (21.6823)) * 136$$

$$= 935574.56 \text{ N}$$

Weld Load [W3]:

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

$$= (25.7026 + 15.6076 + 5.6039 + 26.5425 + (21.6823)) * 136$$

$$= 1297583.38 \text{ N}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$= (pi/2) * Dlo * Wo * 0.49 * Snw$$

$$= (3.1416/2.0) * 273.05 * 20.0 * 0.49 * 118$$

$$= 495543. \text{ N}$$

Shear, Inward Nozzle Weld [Sinw]:

$$= (pi/2) * Dlo * Wo * 0.49 * Snw$$

$$= (3.1416/2.0) * 273.05 * 15.7573 * 0.49 * 118$$

$$= 390422. \text{ N}$$

Shear, Pad Element Weld [Spew]:

$$= (pi/2) * DP * WP * 0.49 * SEW$$

$$= (3.1416/2.0) * 450.0 * 12.0 * 0.49 * 136$$

$$= 566875. \text{ N}$$

Shear, Nozzle Wall [Snw]:

$$= (pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn$$

$$= (3.1416 * 125.5234) * (25.0031 - 3.0) * 0.7 * 118$$

$$= 716062. \text{ N}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (pi/2) * Dlo * Wgn * 0.74 * Seg$$

$$= (3.1416/2) * 273.05 * 15.0 * 0.74 * 138$$

$$= 656466. \text{ N}$$

Tension, Shell Groove Weld [Tngw]:

$$= (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng$$

$$= (3.1416/2.0) * 273.05 * (26.0 - 3.0) * 0.74 * 136$$

$$= 995632. \text{ N}$$

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شماره پیمان: 053 – 073 – 9184	THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)							شماره صفحه : 369 از 381
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SPEW} + \text{SNW}) = (566875 + 716062) = 1282937 \text{ N} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (495543 + 656466 + 995632 + 390422) = 2538063 \text{ N} \\
 \text{PATH33} &= (\text{Spew} + \text{Tngw} + \text{Sinw}) \\
 &= (566875 + 995632 + 390422) = 1952929 \text{ N}
 \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 1282936 N , must exceed W = 360415 N or W1 = 759720 N
 Path 2-2 = 2538063 N , must exceed W = 360415 N or W2 = 935574 N
 Path 3-3 = 1952928 N , must exceed W = 360415 N or W3 = 1297583 N

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 8 bars

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

Nozzle is O.K. for the External Pressure 1 bars

The Cut Length for this Nozzle is, Drop + Ho + H + T : 4260.0000 mm.

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	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال		نسخه
	BK	GCS	MF	120	ME	CN	0009		V01

Lifting WRC

Input Echo, 107/537 Item 1, Description: New WRC 107/537

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	1200.000	mm.
Vessel Thickness	Tv	10.000	mm.
Design Temperature		85.00	C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	137.90	N./mm ²
Vessel Hot S.I. Allowable	Smh	137.90	N./mm ²

*Note: Using 2 * Yield for Discontinuity Stress Allowable (UG-23(e)), Sps.
Make sure that material properties at this temperature are not
time-dependent for Material: SA-516 70*

Attachment Type	Type	Rectangular	
Parameter C11	C11	20.00	mm.
Parameter C22	C22	285.00	mm.
Thickness of Reinforcing Pad	Tpad	10.000	mm.
Pad Parameter C11P	C11p	250.000	mm.
Pad Parameter C22P	C22p	385.000	mm.
Design Internal Pressure	Dp	0.000	bars
Include Pressure Thrust		No	

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS)	P	-23.3	kNf
Longitudinal Shear (SUS)	Vl	39.2	kNf
Circumferential Shear (SUS)	Vc	32.2	kNf
Circumferential Moment (SUS)	Mc	4182.0	N-m
Longitudinal Moment (SUS)	Ml	5100.0	N-m
Torsional Moment (SUS)	Mt	0.0	N-m

Use Interactive Control No
WRC107 Version Version March 1979 (B1 & B2)

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No

*Note:
WRC Bulletin 537 provides equations for the dimensionless curves
found in bulletin 107. As noted in the foreword to bulletin 537,
"537 is equivalent to WRC 107". Where 107 is printed in the
results below, "537" can be interchanged with "107".*

 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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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	-23.3	kNf
Circumferential Shear	VC	32.2	kNf
Longitudinal Shear	VL	39.2	kNf
Circumferential Moment	MC	4182.0	N-m
Longitudinal Moment	ML	5100.0	N-m
Torsional Moment	MT	0.0	N-m

Dimensionless Parameters used : Gamma = 35.97

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 B1/B2	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.098	4C	6.346	(A,B)
N(PHI) / (P/Rm)	0.098	3C	5.598	(C,D)
M(PHI) / (P)	0.053	2C1	0.148	(A,B)
M(PHI) / (P)	0.053	1C	0.189	(C,D)
N(PHI) / (MC/ (Rm**2 * Beta))	0.040	3A !	0.337	(A,B,C,D)
M(PHI) / (MC/ (Rm * Beta))	0.050	1A	0.104	(A,B,C,D)
N(PHI) / (ML/ (Rm**2 * Beta))	0.096	3B !	3.404	(A,B,C,D)
M(PHI) / (ML/ (Rm * Beta))	0.084	1B1	0.050	(A,B,C,D)
N(x) / (P/Rm)	0.077	3C	6.079	(A,B)
N(x) / (P/Rm)	0.077	4C	6.525	(C,D)
M(x) / (P)	0.081	1C1	0.152	(A,B)
M(x) / (P)	0.081	2C	0.112	(C,D)
N(x) / (MC/ (Rm**2 * Beta))	0.040	4A !	0.428	(A,B,C,D)
M(x) / (MC/ (Rm * Beta))	0.068	2A	0.059	(A,B,C,D)
N(x) / (ML/ (Rm**2 * Beta))	0.096	4B !	0.961	(A,B,C,D)
M(x) / (ML/ (Rm * Beta))	0.116	2B1	0.067	(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./mm^2)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		14.2	14.2	14.2	14.2	12.5	12.5	12.5	12.5
Circ. Bend. P		71.4	-71.4	71.4	-71.4	91.3	-91.3	91.3	-91.3
Circ. Memb. MC		0.0	0.0	0.0	0.0	-1.4	-1.4	1.4	1.4
Circ. Memb. MC		0.0	0.0	0.0	0.0	-292.6	292.6	292.6	-292.6
Circ. Memb. ML		-18.1	-18.1	18.1	18.1	0.0	0.0	0.0	0.0
Circ. Bend. ML		-103.6	103.6	103.6	-103.6	0.0	0.0	0.0	0.0
Tot. Circ. Str.		-36.0	28.2	207.3	-142.6	-190.2	212.4	397.9	-370.0

 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)																	
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پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه											
BK	GCS	MF	120	ME	CN	0009	V01											

Long. Memb. P	13.6	13.6	13.6	13.6	14.6	14.6	14.6	14.6
Long. Bend. P	73.4	-73.4	73.4	-73.4	54.3	-54.3	54.3	-54.3
Long. Memb. MC	0.0	0.0	0.0	0.0	-3.3	-3.3	3.3	3.3
Long. Bend. MC	0.0	0.0	0.0	0.0	-123.9	123.9	123.9	-123.9
Long. Memb. ML	-9.3	-9.3	9.3	9.3	0.0	0.0	0.0	0.0
Long. Bend. ML	-100.4	100.4	100.4	-100.4	0.0	0.0	0.0	0.0
Tot. Long. Str.	-22.7	31.4	196.7	-150.9	-58.4	80.9	196.2	-160.3
Shear VC	47.4	47.4	-47.4	-47.4	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-4.0	-4.0	4.0	4.0
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	47.4	47.4	-47.4	-47.4	-4.0	-4.0	4.0	4.0
Str. Int.	95.7	94.8	249.6	194.3	190.3	212.6	398.0	370.1

Dimensionless Parameters used : Gamma = 86.64

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979 B1/B2	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.313	4C	6.897	(A,B)
N(PHI) / (P/Rm)	0.313	3C	2.422	(C,D)
M(PHI) / (P)	0.241	2C1	0.013	(A,B)
M(PHI) / (P)	0.241	1C !	0.067	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.238	3A	2.625	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.252	1A	0.056	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.275	3B	4.794	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.262	1B1	0.011	(A,B,C,D)
N(x) / (P/Rm)	0.280	3C	2.929	(A,B)
N(x) / (P/Rm)	0.280	4C	7.680	(C,D)
M(x) / (P)	0.286	1C1	0.025	(A,B)
M(x) / (P)	0.286	2C !	0.036	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.238	4A	7.858	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.295	2A	0.021	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.275	4B	2.553	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.292	2B1	0.015	(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 Edge of Reinforcing Pad (N./mm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		37.9	37.9	37.9	37.9	13.3	13.3	13.3	13.3
Circ. Bend. P		37.7	-37.7	37.7	-37.7	192.0	-192.0	192.0	-192.0
Circ. Memb. MC		0.0	0.0	0.0	0.0	-11.1	-11.1	11.1	11.1

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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)																										
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Circ. Memb. MC	0.0	0.0	0.0	0.0	-188.4	188.4	188.4	-188.4
Circ. Memb. ML	-29.8	-29.8	29.8	29.8	0.0	0.0	0.0	0.0
Circ. Bend. ML	-42.3	42.3	42.3	-42.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.	3.5	12.6	147.7	-12.4	5.8	-1.5	404.8	-356.0
Long. Memb. P	16.1	16.1	16.1	16.1	42.2	42.2	42.2	42.2
Long. Bend. P	72.8	-72.8	72.8	-72.8	102.7	-102.7	102.7	-102.7
Long. Memb. MC	0.0	0.0	0.0	0.0	-42.7	-42.7	42.7	42.7
Long. Bend. MC	0.0	0.0	0.0	0.0	-61.4	61.4	61.4	-61.4
Long. Memb. ML	-18.9	-18.9	18.9	18.9	0.0	0.0	0.0	0.0
Long. Bend. ML	-54.3	54.3	54.3	-54.3	0.0	0.0	0.0	0.0
Tot. Long. Str.	15.7	-21.3	162.0	-92.1	40.8	-41.8	249.0	-79.3
Shear VC	9.2	9.2	-9.2	-9.2	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-7.3	-7.3	7.3	7.3
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	9.2	9.2	-9.2	-9.2	-7.3	-7.3	7.3	7.3
Str. Int.	22.1	38.5	166.5	93.1	42.2	43.1	405.1	356.1

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)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pl (SUS)		-3.9	-3.9	32.3	32.3	11.1	11.1	13.9	13.9
Circ. Q (SUS)		-32.1	32.1	175.0	-175.0	-201.3	201.3	384.0	-384.0
Long. Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pl (SUS)		4.3	4.3	22.9	22.9	11.3	11.3	18.0	18.0
Long. Q (SUS)		-27.0	27.0	173.8	-173.8	-69.6	69.6	178.2	-178.2
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		47.4	47.4	-47.4	-47.4	-4.0	-4.0	4.0	4.0
Shear Q (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm+Pl (SUS)		95.1	95.1	95.2	95.2	15.3	15.3	20.5	20.5
Pm+Pl+Q (Total)		95.7	94.8	249.6	194.3	190.3	212.6	398.0	370.1

 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)																									
شماره پیمان: 053 – 073 – 9184	<table><tr><th colspan="8">THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)</th></tr><tr><th>نسخه</th><th>سریال</th><th>نوع مدرک</th><th>رشته</th><th>تسهیلات</th><th>صادر کننده</th><th>بسته کاری</th><th>پروژه</th></tr><tr><td>V01</td><td>0009</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 REBOILER (R-100)								نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه	V01	0009	CN	ME	120	MF	GCS	BK	شماره صفحه : 374 از 381
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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
V01	0009	CN	ME	120	MF	GCS	BK																			

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.00	137.90	Passed
Pm+Pl (SUS)	95.18	206.85	Passed
Pm+Pl+Q (TOTAL)	398.00	413.70	Passed

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

WRC 107/537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N./mm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pl (SUS)		8.0	8.0	67.7	67.7	2.2	2.2	24.4	24.4
Circ. Q (SUS)		-4.6	4.6	80.0	-80.0	3.6	-3.6	380.4	-380.4
Long. Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pl (SUS)		-2.8	-2.8	35.0	35.0	-0.5	-0.5	84.8	84.8
Long. Q (SUS)		18.5	-18.5	127.1	-127.1	41.3	-41.3	164.1	-164.1
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		9.2	9.2	-9.2	-9.2	-7.3	-7.3	7.3	7.3
Shear Q (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm+Pl (SUS)		21.4	21.4	70.1	70.1	14.8	14.8	85.7	85.7
Pm+Pl+Q (Total)		22.1	38.5	166.5	93.1	42.2	43.1	405.1	356.1

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.00	137.90	Passed
Pm+Pl (SUS)	85.71	206.85	Passed
Pm+Pl+Q (TOTAL)	405.10	413.70	Passed

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

 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 REBOILER (R-100)							شماره صفحه : 375 از 381
	پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	
	BK	GCS	MF	120	ME	CN	0009	V01

Lifting Calculation

LIFTING LUG CALCULATION

FOR

R-100



نگهداشت و افزایش تولید میدان نفتی بینک
سطح الارض و ابنیه تحت الارض

خرید بسته نیم زدای گاز ایستگاه تقویت فشار گاز بینک
(قرارداد BK-HD-GCS-CO-0010_08)



شماره پیمان:

053 - 073 - 9184

THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)

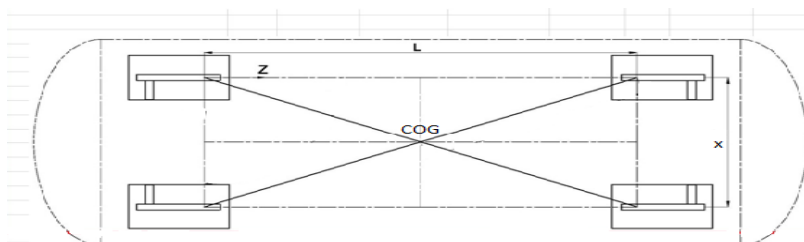
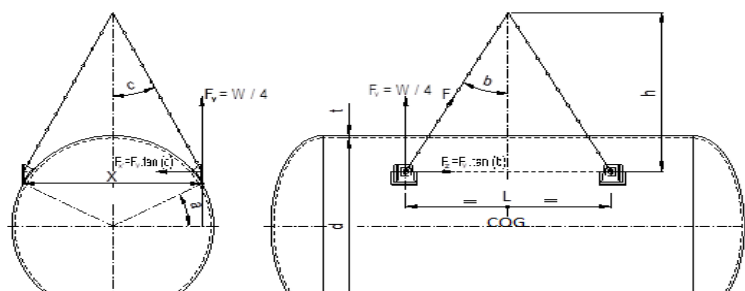
نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه
V01	0009	CN	ME	120	MF	GCS	BK

شماره صفحه : 376 از 381

INPUT DATA:	
Lifting Distance (L)-mm	5,400
W = Weight-Kg	8,000
Inside Diameter (d)-mm	1,200
Thickness (t)-mm	10
Lifting Orientation (a)-Degree	45
Lifting Angle (b)-Degree	45
Number of Lug	4
I = Impact Factor	2
Corrosion ALLOWANCE	3

RESULT:	
Lifting Distance (X)-mm:	863
Outside Radius-mm:	610
Lifting Angle (c)-Degree :	9
Lifting Height (h)-mm:	2,700
Normal Force (F_y)-Kg:	4,000
Tangential Force (F_x)-Kg:	639
Axial Force (F_z)-Kg:	4,000
Angle-Degree($180-2a$) :	90

* Corroded thickness for shell is considered in lifting calculation

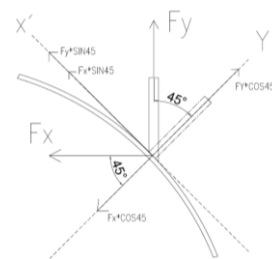


Top View

 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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V01	0009	CN	ME	120	MF	GCS	BK											

Design Data:

Material of Lug:	SA-283 C	
Errection weight :	We = 8,000	Kg
Number of Lug:	N = 4	
Impact Factor:	C = 2	
Yield Stress of Lug:	S _y = 191	N / mm ² @85°C
Max. Tensil Stress :	S _t = 379	N / mm ²
Allowable Tensil Stress:(2/7 * St)	S _a = 108.3	N / mm ²
Allowable Contact Stress:(2*Sy)	P ₀ = 382	N / mm ²
Max. Bending Stress :(0.66* Sy)	S _b = 126.1	N / mm ²
Joint Efficiency of Fillet Weld:	J.E = 0.6	(Base on Moss)
Moduls of Elasticity:	E = 19,905	Kg/mm ² @85°C
F =	55,824	N
F _x =	6,269	N
F _y =	39,224	N
F _z =	39,224	N
F _y ' = (FY-FX)COS 45	23,303	N
F _x ' = (FY+FX)SIN 45	32,168	N



(FX'=VC) AND (FY'=P) AND (FZ=VL) ARE THREE FORCES WHICH HAVE BEEN USED FOR STRESS CALCULATIONS ON SHELL WITH CODE CALC. SOFTWARE & MOMENTS EQUAL TO ($MC=FX' * L$) & ($ML = FZ * L$)

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CONVERTING SECTION OF ATTACHMENT TO RECTANGLE:

DUE TO PRESSURE VESSEL DESIGN MANUAL BY DENNIS R.MOSS FOR LOCAL STRESS CALCULATION IN CYLINDRICAL SHELLS(Chapter.7) ,IRREGULAR ATTACHMENTS CAN BE CONVERTED IN TO A RECTANGLE. SO THIS PROCEDURE HAS BEEN USED :

TC:

b:

e:

D+p

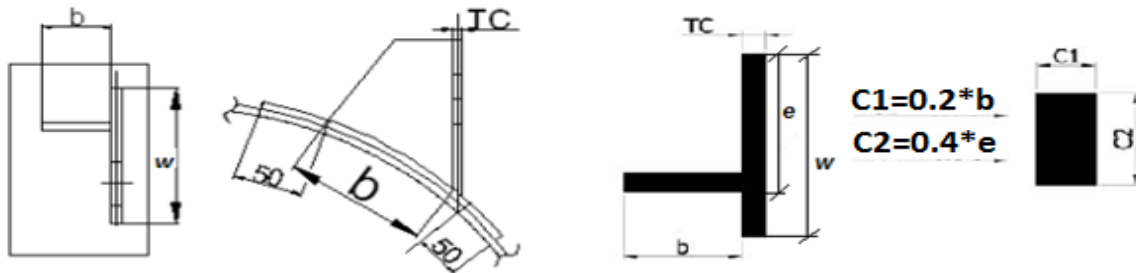
C1:

C2:

C11:

C22

20
100
150
20
60
40
120



C1 IS IN CIRCUMFERENTIAL DIRECTION AND C2 IS IN LONGITUDINAL DIRECTION



نگهداشت و افزایش تولید میدان نفتی بینک
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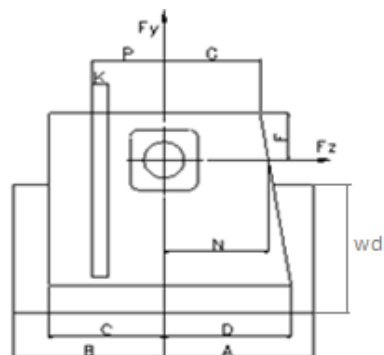
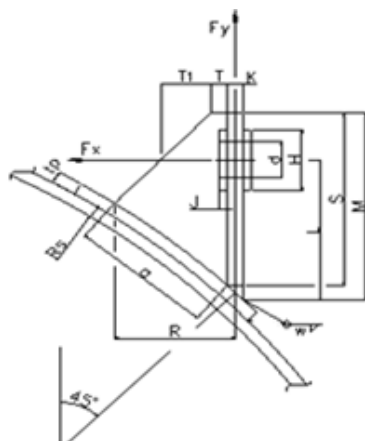
THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)

نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه
V01	0009	CN	ME	120	MF	GCS	BK

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CLIP DESIGN:

A =	175	mm	K =	10	mm
B =	210	mm	L =	130	mm
C =	160	mm	M =	220	mm
D =	125	mm	N =	100	mm
T =	20	mm	d =	80	mm
F =	90	mm	R =	80	mm
G =	80	mm	Rs =	610	mm
H =	120	mm	S =	210	mm
J =	10	mm	P =	110	mm
a =	100	mm	w =	10	mm (Weld Leg for Lug)
T1 =	50	mm	d ₁ =	60	mm (Pin Dia.)
t _p =	10	mm	wd =	110	mm





نگهداشت و افزایش تولید میدان نفتی بینک
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شماره پیمان:

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THERMAL/MECHANICAL CALCULATION BOOK FOR REBOILER (R-100)

نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه
V01	0009	CN	ME	120	MF	GCS	BK

شماره صفحه : 380 از 381

Stress Calculation:

a) Shear Stress Due to F_y :

$$S_1 = F_y / (K \times (F - d / 2) + 2 \times J \times (H / 2 - d / 2))$$

$$S_1 = 43.58 \quad \text{N/mm}^2 < 0.4 S_y \quad 76.40$$

OK

b) Tension Stress Due to F_y :

$$S_2 = F_y / (K \times (C + D - d) + 2 \times J \times (H - d) + K \times T_1)$$

$$S_2 = 11.71 \quad \text{N/mm}^2 < 0.6 S_y \quad 114.60$$

OK

c) Shear Stress Due to F_z :

$$S_3 = F_z / (K \times (N - d / 2) + 2 \times J \times (H / 2 - d / 2))$$

$$S_3 = 39.22 \quad \text{N/mm}^2 < 0.4 S_y \quad 76.40$$

OK

d) Tension Stress Due to F_z :

$$S_4 = F_z / (K \times (M - d) + 2 \times J \times (H - d))$$

$$S_4 = 17.83 \quad \text{N/mm}^2 < 0.6 S_y \quad 114.60$$

OK

e) Bending Stress Due to F_x :

$$M_z = F_x \times L \quad 814,914.92 \quad \text{N.mm}$$

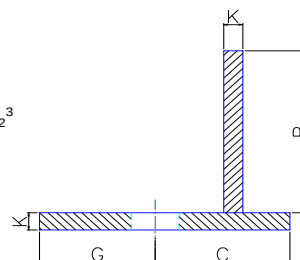
$$C_y = 52.6$$

$$I = K \times R^3 / 12 + K \times R \times d_1^2 + (C + G) \times K^3 / 12 + K \times (C + G) \times d_2^3$$

$$I = 1,063,250.7 \quad \text{mm}^4$$

$$S_5 = M_z \times C_y / I$$

$$S_5 = 40.30 \quad \text{N/mm}^2$$



f) Tension Stress Due to F_y :

$$S_6 = F_y / (K \times (C + D))$$

$$S_6 = 13.76 \quad \text{N/mm}^2$$

Combined Stress:

$$S_7 = S_5 + S_6 \quad 54.06 \quad \text{N/mm}^2$$

$$S_8 = S_5 - S_6 \quad 26.53 \quad \text{N/mm}^2$$

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	نسخه		سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه									
V01	0009	CN	ME	120	MF	GCS	BK											

$$\tau = F_z / ((C + D) \times K)$$

$$\tau = 13.8$$

$$\sigma_1 = S_7 / 2 + ((S_7 / 2)^2 + \tau^2)^{0.5}$$

$$\sigma_1 = 46.1 \quad \text{N/mm}^2 < 0.6 S_y \quad 114.60$$

OK

$$\sigma_2 = S_7 / 2 - ((S_7 / 2)^2 + \tau^2)^{0.5}$$

$$\sigma_2 = 7.9 \quad \text{N/mm}^2 < 0.6 S_y \quad 114.60$$

OK

$$\tau_{\text{Max}} = (\sigma_1 - \sigma_2) / 2$$

$$\tau_{\text{Max}} = 19.1 \quad \text{N/mm}^2 < 0.5 S_y \quad 95.50$$

OK

$$S_5 / F_a + S_6 / F_b < 1$$

$$0.48$$

OK

Hertz Stress:

$$P_0' = 0.418 \times \sqrt{(F \times EL / ((-d_1/2) \times (d/2) \times (K + 2 \times J)) / (d_1/2 - d/2))}$$

$$P_0' = 232.2 < P_0 \quad 382.0$$

OK

Weld Size Calculation:

Shear Load in Weld is Greater of Following

$$\tau_w = (6 \times F_x \times L) / (2 \times R^2)$$

$$\tau_w = 382.0 \quad \text{N/mm}^2$$

$$\tau_w = (6 \times F_z \times L) / (2 \times (C + D)^2)$$

$$\tau_w = 188.3331 \quad \text{N/mm}^2$$

$$\tau_w = (F_y) / (2 \times (C + D))$$

$$\tau_w = 68.8 \quad \text{N/mm}^2$$

$$\text{Max.} = 382.0$$

Minimum Weld Size

$$\tau_w / (0.7 \times J.E. \times S_a) = 8$$

$$\text{Weld Leg} = 10$$

OK