

UOP RUSSELL LLC

Tulsa, Oklahoma

JOB NO: TRJ-488
 CLIENT:
 SUBJECT: 60 MMscfd RSV Cryo Plant

DATE: 11/6/17
 BY: KLS

SHELL & TUBE EXCHANGER

Duty: 1,536.00 MBtu/hr		Tag No: E-202	
Service: Gas / Product Exchanger		P.O. / S.O. No: E-10818	
Size: 12" x 312"	Type: BEM	Arrangement: 1 Parallel	Series 1
ft2/ Shell 504	Shells / Unit 1	ft2/ Unit 504	
SHELL SIDE		TUBE SIDE	
Y Grade		Inlet Gas	
Fluid Circulated	Inlet	Outlet	Inlet
Liquid lb/hr	67,633	67,633	0
Density lb/ft3	29.76	27.84	0
Molecular Weight	37.76	37.76	
Specific Heat Btu/lb-F	0.6667	0.7247	
Thermal Cond. Btu/hr-ft-F	0.0482	0.0417	
Viscosity cP	0.0848	0.0680	
Vapor lb/hr	0	0	80,797
Density lb/ft3			4.074
Molecular Weight			22.23
Specific Heat Btu/lb-F			0.6269
Thermal Cond. Btu/hr-ft-F			0.0225
Viscosity cP			0.0141
Operating Temperature F	63.2	95.9	125.0
Operating Pressure psia	1,270		935
Number of Passes			
Velocity ft/s	Allow. 2.34	Calc.	Allow. 30.20
Pressure Drop psi	5 Allow. 3.63	Calc.	5 Allow. 5.32
Fouling Resistance F-ft2-hr/Btu	0.0010		0.0010
Trans. Rate-Serv. Btu/hr-ft2-F	LMTD Corrected(F)		Heat Curve Attached Yes
CONSTRUCTION			
Code Requirements ASME Section VIII	Stamp Yes	Nat'l Board Yes	TEMA C
Max. Design Pressure \ Temp.	2035 psig @ 200 °F	1100 psig @ 150 °F	
Min. Des. Mtl. Temp. @ Press.	-20 °F @ 2035 psig	-20 °F @ 1100 psig	
Corrosion Allowance (in)	0.0625	0.0625	
Insulation Thickness (in)	1" C	None	
Tube Matl. SA-214	No. / Shell 103	OD (inch): 0.75	
Length (ft) 26.0	Pitch 0.9375 Triangular	BWG/Sch: 16 GA.	
Shell Matl. CS	OD(in) 14.00	Thickness(in)	
Channel Matl. CS	Tube Sheet Matl. CS		
Baffles Matl. SA-36	Type Horizontal - Single Seg.	Spacing & Cut 14.25	
Connections: Shell Inlet 4	Out 4	Series 900# RTJ	
Channel Inlet 6	Out 6	Series 600#	
Weight Each(lbs) Bundle & Shell 7511	Bundle Only 1895	Full of Water 8635	
Impingement Plate None			
NOTES:			
1) Add 10% to duty and flow rates for design.			
2) Wind design per ASCE 7-10, V=120 mph, Exp.C., Cat. III			
Seismic design per ASCE 7-10, Site D, I=1.25, S _s =100%, S ₁ =40%.			
3) Summer Rich Recovery case			
4) Tubeside Nozzles are Axial			
UA=51100			
REVISION	A	0	
ENGINEER/DATE	KLS 11/6/17	KLS 1/25/18	
ISSUED FOR	RFQ	Purchase	

UOP RUSSELL LLC

Tulsa, Oklahoma

JOB NO:
CLIENT:
SUBJECT: 60 MMscfd RSV Cryo Plant

DATE: 11/6/17
BY: KLS

SHELL & TUBE EXCHANGER

Duty: 1,393.00 MBtu/hr		Tag No: E-202	
Service: Gas / Product Exchanger		P.O. / S.O. No:	
Size:	Type: BEM	Arrangement: 1	Parallel 1 Series
ft2/ Shell	Shells / Unit 1	ft2/ Unit	
SHELL SIDE		TUBE SIDE	
Y Grade		Inlet Gas	
Fluid Circulated	Inlet	Outlet	Inlet
Liquid lb/hr	72,665	72,665	0
Density lb/ft3	30.11	28.51	0
Molecular Weight	39.22	39.22	
Specific Heat Btu/lb-F	0.6592	0.7051	
Thermal Cond. Btu/hr-ft-F	0.0474	0.0425	
Viscosity cP	0.0877	0.0725	
Vapor lb/hr	0	0	83,477
Density lb/ft3			4.240
Molecular Weight			22.83
Specific Heat Btu/lb-F			0.6304
Thermal Cond. Btu/hr-ft-F			0.0224
Viscosity cP			0.0142
Operating Temperature F	70.3	98.4	125.0
Operating Pressure psia	1,270		935
Number of Passes			
Velocity ft/s	Allow.	Calc.	Allow.
Pressure Drop psi	5	Allow.	5
Fouling Resistance F-ft2-hr/Btu	0.0010		0.0010
Trans. Rate-Serv. Btu/hr-ft2-F	LMTD Corrected(F)		Heat Curve Attached Yes
CONSTRUCTION			
Code Requirements	ASME Section VIII	Stamp Yes	Nat'l Board Yes
Max. Design Pressure \ Temp.	2035	psig @ 200 °F	1100 psig @ 150 °F
Min. Des. Mtl. Temp. @ Press.	-20	°F @ 2035 psig	-20 °F @ 1100 psig
Corrosion Allowance (in)	0.0625		0.0625
Insulation Thickness (in)	1" C		None
Tube Matl. SA-214	No. / Shell	OD (inch):	
Length (ft)	Pitch	BWG/Sch:	
Shell Matl. CS	OD(in)	Thickness(in)	
Channel Matl. CS	Tube Sheet Matl. CS		
Baffles Matl. SA-36	Type	Spacing & Cut	
Connections:	Shell Inlet	Out	Series 900# RTJ
	Channel Inlet	Out	Series 600#
Weight Each(lbs)	Bundle & Shell	Bundle Only	Full of Water
Impingement Plate	None		
NOTES:			
1) Add 10% to duty and flow rates for design.			
2) Wind design per ASCE 7-10, V=120 mph, Exp.C., Cat. III			
Seismic design per ASCE 7-10, Site D, I=1.25, S _s =100%, S ₁ =40%.			
3) Summer Rich Recovery 7.7 case			
4) Tubeside Nozzles are Axial			
5) Off-Design UA=51100			
REVISION	A		
ENGINEER/DATE	KLS 11/6/17		
ISSUED FOR	RFQ		

UOP RUSSELL LLC

Tulsa, Oklahoma

JOB NO:
CLIENT:
SUBJECT: 60 MMscfd Cryo Plant

DATE: 7/14/11
BY: JRG

SHELL & TUBE EXCHANGER

Duty:	1,152.00	MBtu/hr	Tag No:	E-202
Service:	Gas / Product Exchanger		P.O. / S.O. No:	
Size:	Type: BEM	Arrangement: 1	Parallel 1	Series
ft2/ Shell	Shells / Unit 1		ft2/ Unit	
	SHELL SIDE		TUBE SIDE	
Fluid Circulated	Y Grade		Inlet Gas	
	Inlet	Outlet	Inlet	Outlet
Liquid lb/hr	60,250	60,250	0	2,761
Density lb/ft3	31.42	29.78		27.88
Molecular Weight	38.26	38.26		38.25
Specific Heat Btu/lb-F	0.6330	0.6842		0.6957
Thermal Cond. Btu/hr-ft-F	0.0564	0.0500		0.0500
Viscosity cP	0.1034	0.0878		0.0850
Vapor lb/hr	0	0	65,428	62,667
Density lb/ft3			4.574	4.842
Molecular Weight			22.36	21.96
Specific Heat Btu/lb-F			0.6597	0.6918
Thermal Cond. Btu/hr-ft-F			0.0209	0.0204
Viscosity cP			0.0135	0.0132
Operating Temperature F	27.3	56.3	76.5	54.8
Operating Pressure psia		740		885
Number of Passes		One		One
Velocity ft/s	Allow.	Calc.	Allow.	Calc.
Pressure Drop psi	5	Allow.	5	Allow.
Fouling Resistance F-ft2-hr/Btu		0.0010		0.0010
Trans. Rate-Serv. Btu/hr-ft2-F		LMTD Corrected(F)		Heat Curve Attached Yes
CONSTRUCTION				
Code Requirements	ASME Section VIII	Stamp Yes	Nat'l Board Yes	TEMA C
Max. Design Pressure \ Temp.	2035	psig @ 200 °F	1100	psig @ 150 °F
Min. Des. Mtl. Temp. @ Press.	-20	°F @ 2035 psig	-20	°F @ 1100 psig
Corrosion Allowance (in)		0.0625		0.0625
Insulation Thickness (in)		1" C		None
Tube Matl. SA-214	No. / Shell	OD (inch):		
Length (ft)	Pitch	BWG/Sch:		
Shell Matl. CS	OD(in)	Thickness(in)		
Channel Matl. CS	Tube Sheet Matl. CS			
Baffles Matl. SA-36	Type	Spacing & Cut		
Connections:	Shell Inlet	Out	Series	900# RTJ
	Channel Inlet	Out	Series	600#
Weight Each(lbs)	Bundle & Shell	Bundle Only	Full of Water	
Impingement Plate	None			
NOTES:	1) Add 10% to duty and flow rates for design. 2) Wind design per ASCE 7-10, V=120 mph, Exp.C., Cat. III Seismic design per ASCE 7-10, Site D, I=1.25, S _s =100%, S ₁ =40%. 3) Duplicate of PO 247-15 4) Tubeside Nozzles are Axial UA=51080			
REVISION				
ENGINEER/DATE				
ISSUED FOR				

1				HONEYWELL INTL		Case Name: Summer Rich Recovery.hsc	
2				Bedford, MA		Unit Set: Frac Train	
3				USA		Date/Time: Wed Nov 08 16:13:18 2017	
4							
5							
6	Heat Exchanger: E-202						
7							
8							
9	RATING						
10							
11	Sizing						
12							
13	Overall Data						
14	Configuration						
15	# of Shells in Series	1	Tube Passes per Shell	2	Elevation (Base)	0.0000 ft	
16	# of Shells in Parallel	1	Exchange Orientation	Horizontal	First Tube Pass Flow Direction	Counter	
17	TEMA Type:		A		E	L	
18	Calculated Information						
19	Shell HT Coeff	---		Tube HT Coeff	---		
20	Overall U	78.70 Btu/hr-ft2-F		Overall UA	5.110e+004 Btu/F-hr *		
21	Shell DP	5.000 psi *		Tube DP	5.000 psi *		
22	Shell Vol per Shell	13.66 ft3		Tube Vol per Shell	6.816 ft3		
23	HT Area per Shell	649.3 ft2					
24	Shell Data						
25	Shell and Tube Bundle						
26	Shell Diameter	15.05	Tube Pitch	0.9843 *	Shell Fouling	0.0000	
27	(in)		(in)		(F-hr-ft2/Btu)		
28	# of Tubes per Shell	160 *	Tube Layout Angle	Triangular (30 degrees)			
29	Shell Baffles						
30	Shell Baffle Type	Single		Shell Baffle Orientation	Horizontal		
31	Baffle Cut (%Area)	20.00		Baffle Spacing	31.50 in		
32	Tube Data						
33	Dimensions						
34	OD	0.7874	ID	0.6299	Tube Thickness	7.874e-002	Tube Length
35	(in)		(in)		(in)		(ft) 19.69
36	Tube Properties						
37	Tube Fouling	0.0000	Thermal Cond.	26.00	Wall Cp	---	Wall Density
38	(F-hr-ft2/Btu)		(Btu/hr-ft-F)		(Btu/lb-F)		(lb/ft3) ---
39	Nozzle Parameters						
40							
41	Base Elevation Relative to Ground Level						0.0000 ft
42		151		215		153	
43	Diameter	(ft)	0.1640	0.1640		0.1640	
44	Elevation (Base)	(ft)	0.0000	0.0000		0.0000	
45	Elevation (Ground)	(ft)	0.0000	0.0000		0.0000	
46	Elevation (% of Height)	(%)	0.00	0.00		0.00	
47		216					
48	Diameter	(ft)	0.1640				
49	Elevation (Base)	(ft)	0.0000				
50	Elevation (Ground)	(ft)	0.0000				
51	Elevation (% of Height)	(%)	0.00				
52	CONDITIONS						
53							
54	Name	151		215		153	
55	Vapour	1.0000		0.0000		1.0000	
56	Temperature	(F)	125.0000	63.2009		94.8609	
57	Pressure	(psia)	935.0000	1270.0000		930.0000	
58	Molar Flow	(lbmole/hr)	3634.5711	1791.0986		3634.5711	
59	Mass Flow	(lb/hr)	80796.7713	67632.7271		80796.7713	
60	Std Ideal Liq Vol Flow	(barrel/day)	15538.6010	10710.0977		15538.6010	
61	Molar Enthalpy	(Btu/lbmole)	-3.439e+004	-4.760e+004		-3.481e+004	
62	Molar Entropy	(Btu/lbmole-F)	37.04	27.71		36.30	
63	Aspen Technology Inc.		Aspen HYSYS Version 8.8 (34.0.0.8909)			Page 1 of 7	

1	 HONEYWELL INTL Bedford, MA USA		Case Name: Summer Rich Recovery.hsc				
2			Unit Set: Frac Train				
3							
4			Date/Time: Wed Nov 08 16:13:18 2017				
5							
6							
7	Heat Exchanger: E-202 (continued)						
8							
9	CONDITIONS						
10							
11	Heat Flow	(MMBtu/hr)	-1.2498e+02	-8.5249e+01	-1.2652e+02	-8.3713e+01	
12	PROPERTIES						
13							
14	Name		151	215	153	216	
15	Molecular Weight		22.23	37.76	22.23	37.76	
16	Molar Density	(lbmole/ft3)	0.1833	0.7881	0.2023	0.7373	
17	Mass Density	(lb/ft3)	4.074	29.76	4.497	27.84	
18	Act. Volume Flow	(USGPM)	2473	283.3	2240	302.9	
19	Mass Enthalpy	(Btu/lb)	-1547	-1260	-1566	-1238	
20	Mass Entropy	(Btu/lb-F)	1.666	0.7339	1.633	0.7761	
21	Heat Capacity	(Btu/lbmole-F)	13.94	25.18	14.49	27.37	
22	Mass Heat Capacity	(Btu/lb-F)	0.6269	0.6667	0.6518	0.7247	
23	LHV Molar Basis (Std)	(Btu/lbmole)	4.511e+005	7.582e+005	4.511e+005	7.582e+005	
24	LHV Mass Basis (Std)	(Btu/lb)	2.029e+004	2.008e+004	2.029e+004	2.008e+004	
25	Phase Fraction [Vol. Basis]		1.000	0.0000	1.000	0.0000	
26	Phase Fraction [Mass Basis]		1.000	0.0000	1.000	0.0000	
27	Partial Pressure of CO2	(psia)	0.4870	0.0000	0.4844	0.0000	
28	Cost Based on Flow	(Cost/s)	0.0000	0.0000	0.0000	0.0000	
29	Act. Gas Flow	(ACFM)	330.5	---	299.4	---	
30	Avg. Liq. Density	(lbmole/ft3)	0.9999	0.7149	0.9999	0.7149	
31	Specific Heat	(Btu/lbmole-F)	13.94	25.18	14.49	27.37	
32	Std. Gas Flow	(MMSCFD)	33.04	16.28	33.04	16.28	
33	Std. Ideal Liq. Mass Density	(lb/ft3)	22.23	26.99	22.23	26.99	
34	Act. Liq. Flow	(USGPM)	---	283.3	---	302.9	
35	Z Factor		0.8131	0.2872	0.7725	0.2878	
36	Watson K		17.73	16.66	17.73	16.66	
37	User Property		---	---	---	---	
38	Cp/(Cp - R)		1.166	1.086	1.159	1.078	
39	Cp/Cv		1.514	1.550	1.618	1.631	
40	Heat of Vap.	(Btu/lbmole)	3686	---	3705	---	
41	Kinematic Viscosity	(cSt)	0.2155	0.1778	0.1912	0.1524	
42	Liq. Mass Density (Std. Cond)	(lb/ft3)	5.897e-002	28.59	5.897e-002	28.59	
43	Liq. Vol. Flow (Std. Cond)	(barrel/day)	5.868e+006	1.033e+004	5.960e+006	1.033e+004	
44	Liquid Fraction		0.0000	1.000	0.0000	1.000	
45	Molar Volume	(ft3/lbmole)	5.457	1.269	4.943	1.356	
46	Mass Heat of Vap.	(Btu/lb)	165.8	-373.1	166.7	-373.1	
47	Phase Fraction [Molar Basis]		1.0000	0.0000	1.0000	0.0000	
48	Surface Tension	(dyne/cm)	---	4.525	---	2.946	
49	Thermal Conductivity	(Btu/hr-ft-F)	2.251e-002	4.816e-002	2.164e-002	4.170e-002	
50	Viscosity	(cP)	1.407e-002	8.476e-002	1.377e-002	6.798e-002	
51	Cv (Semi-Ideal)	(Btu/lbmole-F)	11.95	23.19	12.50	25.38	
52	Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.5376	0.6141	0.5624	0.6721	
53	Cv	(Btu/lbmole-F)	9.206	16.25	8.953	16.78	
54	Mass Cv	(Btu/lb-F)	0.4141	0.4303	0.4028	0.4443	
55	Cv (Ent. Method)	(Btu/lbmole-F)	---	14.82	---	16.28	
56	Mass Cv (Ent. Method)	(Btu/lb-F)	---	0.3924	---	0.4312	
57	Cp/Cv (Ent. Method)		---	1.699	---	1.681	
58	Reid VP at 37.8 C	(psia)	---	407.6	---	407.6	
59	True VP at 37.8 C	(psia)	---	474.0	---	474.0	
60	Liq. Vol. Flow - Sum(Std. Cond)	(USGPM)	1.708e+005	295.0	1.708e+005	295.0	
61	Partial Pressure of H2S	(psia)	0.0000	0.0000	0.0000	0.0000	
62	Viscosity Index		---	---	---	---	
63	Aspen Technology Inc. Aspen HYSYS Version 8.8 (34.0.0.8909) Page 2 of 7						

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HONEYWELL INTL
Bedford, MA
USA

Case Name: Summer Rich Recovery.hsc

Unit Set: Frac Train

Date/Time: Wed Nov 08 16:13:18 2017

Heat Exchanger: E-202 (continued)

Shell Side - Vapour Phase

Std Gas Flow (MMSCFD)	Z Factor	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---

Shell Side - Light Liquid Phase

Mass Flow (lb/hr)	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)	Surface Tens (dyne/cm)
67632.73	29.76	0.67	0.08	0.05	4.53
67632.73	29.39	0.68	0.08	0.05	4.13
67632.73	29.01	0.69	0.08	0.05	3.75
67632.73	28.63	0.70	0.08	0.04	3.40
67632.73	28.23	0.71	0.07	0.04	3.11
67632.73	27.84	0.72	0.07	0.04	2.95

Molecular Wt	Sp Gravity	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
37.76	0.48	661.26	148.73	0.28	0.13
37.76	0.47	661.26	148.73	0.28	0.13
37.76	0.46	661.26	148.73	0.28	0.13
37.76	0.46	661.26	148.73	0.28	0.13
37.76	0.45	661.26	148.73	0.28	0.13
37.76	0.45	661.26	148.73	0.28	0.13

Shell Side - Heavy Liquid Phase

Mass Flow (lb/hr)	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)	Surface Tens (dyne/cm)
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---

Molecular Wt	Sp Gravity	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---

Shell Side - Mixed Liquid

Mass Flow (lb/hr)	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)	Surface Tens (dyne/cm)
67632.73	29.76	0.67	0.08	0.05	---
67632.73	29.39	0.68	0.08	0.05	---
67632.73	29.01	0.69	0.08	0.05	---
67632.73	28.63	0.70	0.08	0.04	---
67632.73	28.23	0.71	0.07	0.04	---
67632.73	27.84	0.72	0.07	0.04	---

Aspen Technology Inc.

Aspen HYSYS Version 8.8 (34.0.0.8909)

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1	 HONEYWELL INTL Bedford, MA USA			Case Name: Summer Rich Recovery.hsc		
2				Unit Set: Frac Train		
3				Date/Time: Wed Nov 08 16:13:18 2017		
4						
5						
6						
7	Heat Exchanger: E-202 (continued)					
8						
9						
10	Shell Side - Mixed Liquid					
11	Molecular Wt	Sp Gravity	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
12						
13	37.76	0.48	661.26	148.73	0.28	0.13
14	37.76	0.47	661.26	148.73	0.28	0.13
15	37.76	0.46	661.26	148.73	0.28	0.13
16	37.76	0.46	661.26	148.73	0.28	0.13
17	37.76	0.45	661.26	148.73	0.28	0.13
18	37.76	0.45	661.26	148.73	0.28	0.13
19						
20	Tube Side - Overall Phase					
21	Temperature (F)	Pressure (psia)	Heat Flow (MMBtu/hr)		Enthalpy (Btu/lbmole)	
22						
23	94.86	930.00	0.00		-34809.85	
24	100.72	930.99	0.30		-34726.45	
25	106.72	931.99	0.61		-34641.73	
26	112.78	932.99	0.92		-34556.80	
27	118.89	934.00	1.23		-34471.77	
28	125.00	935.00	1.54		-34387.25	
29	UA (Btu/F-hr)	Molar Vap Frac	Mass Vap Frac		Heat of Vap. (Btu/lbmole)	
30						
31	0.00	1.0000	1.0000		---	
32	9698.94	1.0000	1.0000		---	
33	19790.52	1.0000	1.0000		---	
34	30105.84	1.0000	1.0000		---	
35	40584.01	1.0000	1.0000		---	
36	51098.67	1.0000	1.0000		---	
37						
38	Tube Side - Vapour Phase					
39	Mass Flow (lb/hr)	Molecular Wt	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)
40						
41	80796.77	22.23	4.50	0.65	0.01	0.02
42	80796.77	22.23	4.41	0.65	0.01	0.02
43	80796.77	22.23	4.32	0.64	0.01	0.02
44	80796.77	22.23	4.23	0.63	0.01	0.02
45	80796.77	22.23	4.15	0.63	0.01	0.02
46	80796.77	22.23	4.07	0.63	0.01	0.02
47	Std Gas Flow (MMSCFD)	Z Factor	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
48						
49	33.61	0.77	666.29	-46.17	0.29	0.04
50	33.61	0.78	666.29	-46.17	0.29	0.04
51	33.61	0.79	666.29	-46.17	0.29	0.04
52	33.61	0.80	666.29	-46.17	0.29	0.04
53	33.61	0.81	666.29	-46.17	0.29	0.04
54	33.61	0.81	666.29	-46.17	0.29	0.04
55						
56	Tube Side - Light Liquid Phase					
57	Mass Flow (lb/hr)	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)	Surface Tens (dyne/cm)
58						
59	---	---	---	---	---	---
60	---	---	---	---	---	---
61	---	---	---	---	---	---
62	---	---	---	---	---	---
63	Aspen Technology Inc.		Aspen HYSYS Version 8.8 (34.0.0.8909)		Page 5 of 7	

1	 HONEYWELL INTL Bedford, MA USA			Case Name: Summer Rich Recovery.hsc		
2				Unit Set: Frac Train		
3				Date/Time: Wed Nov 08 16:13:18 2017		
4						
5						
6	Heat Exchanger: E-202 (continued)					
7						
8						
9	Tube Side - Light Liquid Phase					
10						
11	Mass Flow	Density	Mass Sp Heat	Viscosity	Thermal Cond	Surface Tens
12	(lb/hr)	(lb/ft3)	(Btu/lb-F)	(cP)	(Btu/hr-ft-F)	(dyne/cm)
13	---	---	---	---	---	---
14	---	---	---	---	---	---
15	Molecular Wt	Sp Gravity	Pseudo Pc	Pseudo Tc	Pseudo Zc	Pseudo Omega
16			(psia)	(F)		
17	---	---	---	---	---	---
18	---	---	---	---	---	---
19	---	---	---	---	---	---
20	---	---	---	---	---	---
21	---	---	---	---	---	---
22	---	---	---	---	---	---
23	Tube Side - Heavy Liquid Phase					
24						
25	Mass Flow	Density	Mass Sp Heat	Viscosity	Thermal Cond	Surface Tens
26	(lb/hr)	(lb/ft3)	(Btu/lb-F)	(cP)	(Btu/hr-ft-F)	(dyne/cm)
27	---	---	---	---	---	---
28	---	---	---	---	---	---
29	---	---	---	---	---	---
30	---	---	---	---	---	---
31	---	---	---	---	---	---
32	---	---	---	---	---	---
33	Molecular Wt	Sp Gravity	Pseudo Pc	Pseudo Tc	Pseudo Zc	Pseudo Omega
34			(psia)	(F)		
35	---	---	---	---	---	---
36	---	---	---	---	---	---
37	---	---	---	---	---	---
38	---	---	---	---	---	---
39	---	---	---	---	---	---
40	---	---	---	---	---	---
41	Tube Side - Mixed Liquid					
42						
43	Mass Flow	Density	Mass Sp Heat	Viscosity	Thermal Cond	Surface Tens
44	(lb/hr)	(lb/ft3)	(Btu/lb-F)	(cP)	(Btu/hr-ft-F)	(dyne/cm)
45	---	---	---	---	---	---
46	---	---	---	---	---	---
47	---	---	---	---	---	---
48	---	---	---	---	---	---
49	---	---	---	---	---	---
50	---	---	---	---	---	---
51	Molecular Wt	Sp Gravity	Pseudo Pc	Pseudo Tc	Pseudo Zc	Pseudo Omega
52			(psia)	(F)		
53	---	---	---	---	---	---
54	---	---	---	---	---	---
55	---	---	---	---	---	---
56	---	---	---	---	---	---
57	---	---	---	---	---	---
58	---	---	---	---	---	---
59	---					
60						
61						
62						
63	Aspen Technology Inc. Aspen HYSYS Version 8.8 (34.0.0.8909) Page 6 of 7					



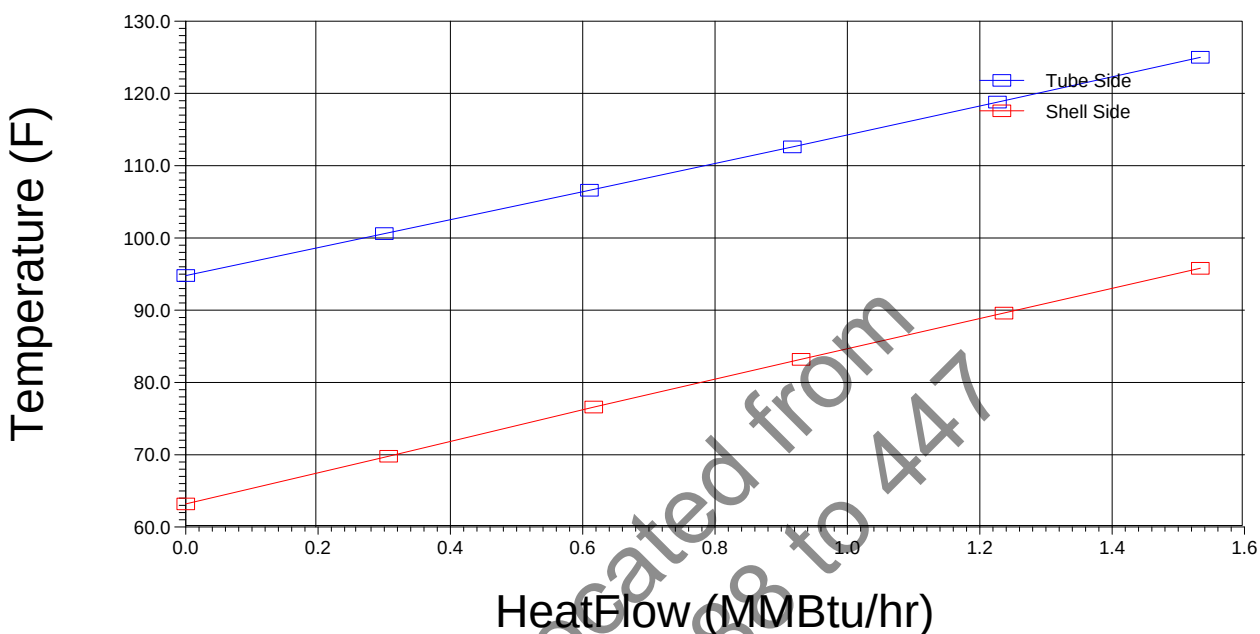
HONEYWELL INTL
Bedford, MA
USA

Case Name: Summer Rich Recovery.hsc

Unit Set: Frac Train

Date/Time: Wed Nov 08 16:13:18 2017

Heat Exchanger: E-202 (continued)



1	 HONEYWELL INTL Bedford, MA USA		Case Name: Summer Rich Recovery 7.7 GPM.hsc			
2			Unit Set: Frac Train			
3			Date/Time: Thu Nov 09 10:05:14 2017			
4						
5						
6	Heat Exchanger: E-202					
7						
8	RATING					
9						
10	Sizing					
11						
12	Overall Data					
13	Configuration					
14	# of Shells in Series	1	Tube Passes per Shell	2	Elevation (Base)	0.0000 ft
15	# of Shells in Parallel	1	Exchange Orientation	Horizontal	First Tube Pass Flow Direction	Counter
16	TEMA Type:		A		E	L
17	Calculated Information					
18	Shell HT Coeff		---		Tube HT Coeff	
19	Overall U		78.70 Btu/hr-ft ² -F		Overall UA	
20	Shell DP		5.000 psi *		Tube DP	
21	Shell Vol per Shell		13.66 ft ³		Tube Vol per Shell	
22	HT Area per Shell		649.3 ft ²			
23	Shell Data					
24	Shell and Tube Bundle					
25	Shell Diameter	15.05	Tube Pitch	0.9843 *	Shell Fouling	0.0000
26	(in)		(in)		(F-hr-ft ² /Btu)	
27	# of Tubes per Shell	160 *	Tube Layout Angle	Triangular (30 degrees)		
28	Shell Baffles					
29	Shell Baffle Type	Single	Shell Baffle Orientation	Horizontal		
30	Baffle Cut (%Area)	20.00	Baffle Spacing	31.50 in		
31	Tube Data					
32	Dimensions					
33	OD	0.7874	ID	0.6299	Tube Thickness	7.874e-002
34	(in)		(in)		(in)	
35					Tube Length	19.69
36					(ft)	
37	Tube Properties					
38	Tube Fouling	0.0000	Thermal Cond.	26.00	Wall Cp	---
39	(F-hr-ft ² /Btu)		(Btu/hr-ft-F)		(Btu/lb-F)	---
40					Wall Density	---
41					(lb/ft ³)	
42	Nozzle Parameters					
43	Base Elevation Relative to Ground Level 0.0000 ft					
44		151	215	153		
45	Diameter	(ft)	0.1640	0.1640	0.1640	
46	Elevation (Base)	(ft)	0.0000	0.0000	0.0000	
47	Elevation (Ground)	(ft)	0.0000	0.0000	0.0000	
48	Elevation (% of Height)	(%)	0.00	0.00	0.00	
49		216				
50	Diameter	(ft)	0.1640			
51	Elevation (Base)	(ft)	0.0000			
52	Elevation (Ground)	(ft)	0.0000			
53	Elevation (% of Height)	(%)	0.00			
54	CONDITIONS					
55	Name	151	215	153	216	
56	Vapour	1.0000	0.0000	1.0000	0.0000	
57	Temperature (F)	125.0000	70.2745	98.6346	98.3891	
58	Pressure (psia)	935.0000	1270.0000	930.0000	1265.0000 *	
59	Molar Flow (lbmole/hr)	3656.1718	1852.9101	3656.1718	1852.9101	
60	Mass Flow (lb/hr)	83476.5024	72665.4392	83476.5024	72665.4392	
61	Std Ideal Liq Vol Flow (barrel/day)	15743.9326	11185.9155	15743.9326	11185.9155	
62	Molar Enthalpy (Btu/lbmole)	-3.461e+004	-4.845e+004	-3.499e+004	-4.770e+004	
63	Molar Entropy (Btu/lbmole-F)	36.90	27.39	36.25	28.77	
64	Aspen Technology Inc. Aspen HYSYS Version 8.8 (34.0.0.8909) Page 1 of 7					

1	 HONEYWELL INTL Bedford, MA USA			Case Name: Summer Rich Recovery 7.7 GPM.hsc		
2				Unit Set: Frac Train		
3				Date/Time: Thu Nov 09 10:05:14 2017		
4						
5						
6						
7	Heat Exchanger: E-202 (continued)					
8						
9	CONDITIONS					
10						
11	Heat Flow	(MMBtu/hr)	-1.2653e+02	-8.9783e+01	-1.2792e+02	-8.8391e+01
12	PROPERTIES					
13						
14	Name	151	215	153	216	
15	Molecular Weight	22.83	39.22	22.83	39.22	
16	Molar Density (lbmole/ft3)	0.1857	0.7677	0.2028	0.7269	
17	Mass Density (lb/ft3)	4.240	30.11	4.630	28.51	
18	Act. Volume Flow (USGPM)	2455	300.9	2248	317.8	
19	Mass Enthalpy (Btu/lb)	-1516	-1236	-1532	-1216	
20	Mass Entropy (Btu/lb-F)	1.616	0.6984	1.587	0.7337	
21	Heat Capacity (Btu/lbmole-F)	14.39	25.85	14.93	27.65	
22	Mass Heat Capacity (Btu/lb-F)	0.6304	0.6592	0.6541	0.7051	
23	LHV Molar Basis (Std) (Btu/lbmole)	4.615e+005	7.866e+005	4.615e+005	7.866e+005	
24	LHV Mass Basis (Std) (Btu/lb)	2.021e+004	2.006e+004	2.021e+004	2.006e+004	
25	Phase Fraction [Vol. Basis]	1.000	0.0000	1.000	0.0000	
26	Phase Fraction [Mass Basis]	1.000	0.0000	1.000	0.0000	
27	Partial Pressure of CO2 (psia)	3.740e-003	0.0000	3.720e-003	0.0000	
28	Cost Based on Flow (Cost/s)	0.0000	0.0000	0.0000	0.0000	
29	Act. Gas Flow (ACFM)	328.2	---	300.5	---	
30	Avg. Liq. Density (lbmole/ft3)	0.9927	0.7081	0.9927	0.7081	
31	Specific Heat (Btu/lbmole-F)	14.39	25.85	14.93	27.65	
32	Std. Gas Flow (MMSCFD)	33.23	16.84	33.23	16.84	
33	Std. Ideal Liq. Mass Density (lb/ft3)	22.66	27.77	22.66	27.77	
34	Act. Liq. Flow (USGPM)	---	300.9	---	317.8	
35	Z Factor	0.8025	0.2909	0.7654	0.2906	
36	Watson K	17.48	16.31	17.48	16.31	
37	User Property	---	---	---	---	
38	Cp/(Cp - R)	1.160	1.083	1.153	1.077	
39	Cp/Cv	1.523	1.542	1.620	1.582	
40	Heat of Vap. (Btu/lbmole)	4080	---	4098	---	
41	Kinematic Viscosity (cSt)	0.2086	0.1818	0.1878	0.1587	
42	Liq. Mass Density (Std. Cond) (lb/ft3)	6.058e-002	29.40	6.058e-002	29.40	
43	Liq. Vol. Flow (Std. Cond) (barrel/day)	5.994e+006	1.059e+004	5.902e+006	1.059e+004	
44	Liquid Fraction	0.0000	1.000	0.0000	1.000	
45	Molar Volume (ft3/lbmole)	5.385	1.303	4.931	1.376	
46	Mass Heat of Vap. (Btu/lb)	178.7	-359.2	179.5	-359.2	
47	Phase Fraction [Molar Basis]	1.0000	0.0000	1.0000	0.0000	
48	Surface Tension (dyne/cm)	---	4.680	---	3.401	
49	Thermal Conductivity (Btu/hr-ft-F)	2.240e-002	4.744e-002	2.166e-002	4.251e-002	
50	Viscosity (cP)	1.417e-002	8.766e-002	1.393e-002	7.245e-002	
51	Cv (Semi-Ideal) (Btu/lbmole-F)	12.41	23.87	12.95	25.67	
52	Mass Cv (Semi-Ideal) (Btu/lb-F)	0.5435	0.6086	0.5671	0.6545	
53	Cv (Btu/lbmole-F)	9.449	16.77	9.218	17.48	
54	Mass Cv (Btu/lb-F)	0.4138	0.4275	0.4037	0.4457	
55	Cv (Ent. Method) (Btu/lbmole-F)	---	15.58	---	16.45	
56	Mass Cv (Ent. Method) (Btu/lb-F)	---	0.3972	---	0.4194	
57	Cp/Cv (Ent. Method)	---	1.660	---	1.681	
58	Reid VP at 37.8 C (psia)	---	368.4	---	368.4	
59	True VP at 37.8 C (psia)	---	435.2	---	435.2	
60	Liq. Vol. Flow - Sum(Std. Cond) (USGPM)	1.718e+005	308.1	1.718e+005	308.1	
61	Partial Pressure of H2S (psia)	0.0000	0.0000	0.0000	0.0000	
62	Viscosity Index	---	---	---	---	
63	Aspen Technology Inc. Aspen HYSYS Version 8.8 (34.0.0.8909) Page 2 of 7					

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HONEYWELL INTL
Bedford, MA
USA

Case Name:

Summer Rich Recovery 7.7 GPM.hsc

Unit Set:

Frac Train

Date/Time:

Thu Nov 09 10:05:14 2017

Heat Exchanger: E-202 (continued)

Shell Side - Vapour Phase

Std Gas Flow (MMSCFD)	Z Factor	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---

Shell Side - Light Liquid Phase

Mass Flow (lb/hr)	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)	Surface Tens (dyne/cm)
72665.44	30.11	0.66	0.09	0.05	4.68
72665.44	29.80	0.67	0.08	0.05	4.35
72665.44	29.48	0.68	0.08	0.04	4.04
72665.44	29.16	0.69	0.08	0.04	3.76
72665.44	28.83	0.70	0.07	0.04	3.56
72665.44	28.51	0.71	0.07	0.04	3.40

Molecular Wt	Sp Gravity	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
39.22	0.48	652.47	159.59	0.28	0.13
39.22	0.48	652.47	159.59	0.28	0.13
39.22	0.47	652.47	159.59	0.28	0.13
39.22	0.47	652.47	159.59	0.28	0.13
39.22	0.46	652.47	159.59	0.28	0.13
39.22	0.46	652.47	159.59	0.28	0.13

Shell Side - Heavy Liquid Phase

Mass Flow (lb/hr)	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)	Surface Tens (dyne/cm)
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---

Molecular Wt	Sp Gravity	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---

Shell Side - Mixed Liquid

Mass Flow (lb/hr)	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)	Surface Tens (dyne/cm)
72665.44	30.11	0.66	0.09	0.05	---
72665.44	29.80	0.67	0.08	0.05	---
72665.44	29.48	0.68	0.08	0.04	---
72665.44	29.16	0.69	0.08	0.04	---
72665.44	28.83	0.70	0.07	0.04	---
72665.44	28.51	0.71	0.07	0.04	---

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HONEYWELL INTL
Bedford, MA
USA

Case Name:

Summer Rich Recovery 7.7 GPM.hsc

Unit Set:

Frac Train

Date/Time:

Thu Nov 09 10:05:14 2017

Heat Exchanger: E-202 (continued)

Shell Side - Mixed Liquid

Molecular Wt	Sp Gravity	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
39.22	0.48	652.47	159.59	0.28	0.13
39.22	0.48	652.47	159.59	0.28	0.13
39.22	0.47	652.47	159.59	0.28	0.13
39.22	0.47	652.47	159.59	0.28	0.13
39.22	0.46	652.47	159.59	0.28	0.13
39.22	0.46	652.47	159.59	0.28	0.13

Tube Side - Overall Phase

Temperature (F)	Pressure (psia)	Heat Flow (MMBtu/hr)	Enthalpy (Btu/lbmole)
98.63	930.00	0.00	-34988.13
103.76	930.99	0.27	-34912.92
109.01	931.99	0.55	-34836.59
114.31	932.99	0.83	-34760.06
119.66	934.00	1.11	-34683.44
125.00	935.00	1.39	-34607.27
UA (Btu/F-hr)	Molar Vap Frac	Mass Vap Frac	Heat of Vap. (Btu/lbmole)
0.00	1.0000	1.0000	---
9795.57	1.0000	1.0000	---
19923.83	1.0000	1.0000	---
30229.35	1.0000	1.0000	---
40659.53	1.0000	1.0000	---
51101.08	1.0000	1.0000	---

Tube Side - Vapour Phase

Mass Flow (lb/hr)	Molecular Wt	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)
83476.50	22.83	4.63	0.65	0.01	0.02
83476.50	22.83	4.55	0.65	0.01	0.02
83476.50	22.83	4.46	0.64	0.01	0.02
83476.50	22.83	4.39	0.64	0.01	0.02
83476.50	22.83	4.31	0.63	0.01	0.02
83476.50	22.83	4.24	0.63	0.01	0.02
Std Gas Flow (MMSCFD)	Z Factor	Pseudo Pc (psia)	Pseudo Tc (F)	Pseudo Zc	Pseudo Omega
33.30	0.77	663.21	-41.39	0.29	0.05
33.30	0.77	663.21	-41.39	0.29	0.05
33.30	0.78	663.21	-41.39	0.29	0.05
33.30	0.79	663.21	-41.39	0.29	0.05
33.30	0.80	663.21	-41.39	0.29	0.05
33.30	0.80	663.21	-41.39	0.29	0.05

Tube Side - Light Liquid Phase

Mass Flow (lb/hr)	Density (lb/ft3)	Mass Sp Heat (Btu/lb-F)	Viscosity (cP)	Thermal Cond (Btu/hr-ft-F)	Surface Tens (dyne/cm)
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---

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Aspen HYSYS Version 8.8 (34.0.0.8909)

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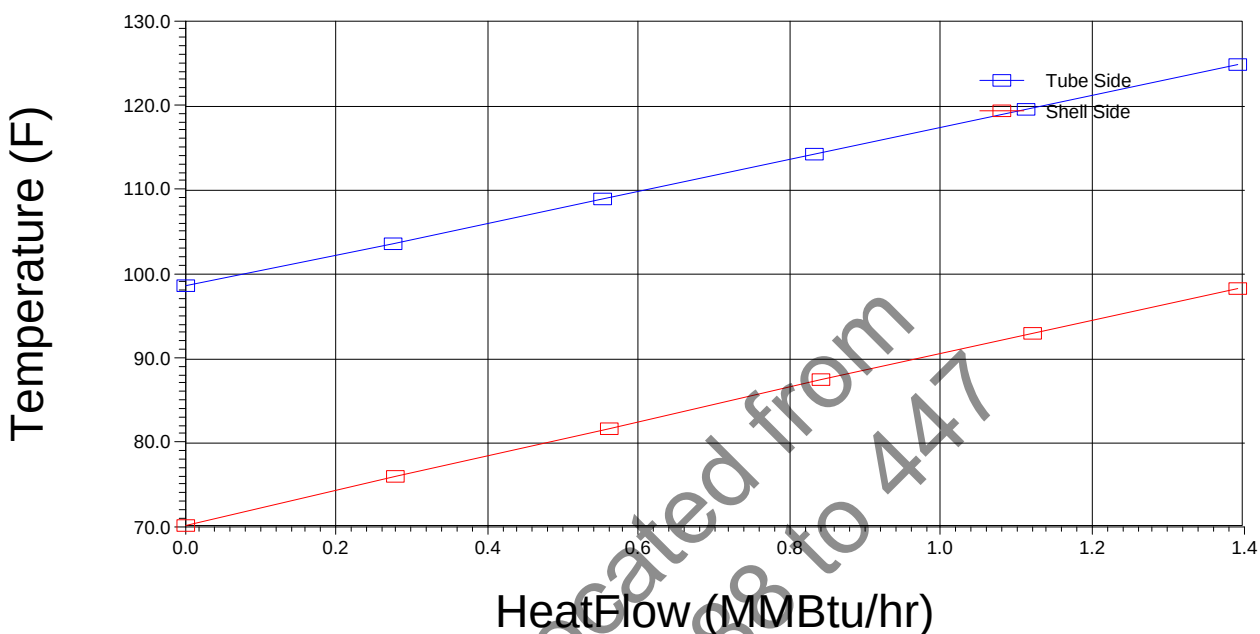
HONEYWELL INTL
Bedford, MA
USA

Case Name: Summer Rich Recovery 7.7 GPM.hsc

Unit Set: Frac Train

Date/Time: Thu Nov 09 10:05:14 2017

Heat Exchanger: E-202 (continued)



INDEX TO MANUFACTURER'S RECORD BOOK

CUSTOMER: UOP RUSSELL
PURCHASE ORDER NO.: 4500801009
UOP PROJECT NO.: J488XX
EQUIPMENT TAG NO.: E-202
SERVICE: GAS / PRODUCT EXCHANGER
STEELTEK JOB NO.: 17S-3450

CONTENTS

1. DATA SHEETS
2. CERTIFIED AS BUILT DRAWINGS
3. CERTIFIED AS BUILT CALCULATIONS
4. CODE CERTIFICATION DOCUMENTS
5. MATERIAL CERTIFICATES
6. TEST RECORDS
7. WPS / PQR'S
8. SPARE PARTS LIST
9. INSTALLATION / OPERATING / MAINTENANCE MANUAL

Steeltek, Inc / Tulsa, OK

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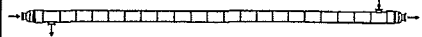
US Units

Customer	UOP RUSSELL		UOP Russell Project No.:	J488XX	
Address			Reference No.	PO#4500801009	
Plant Location			Steeltek Job No.:	17S-3450	
Service of Unit	GAS/PRODUCT EXCHANGER		Date	11-13-17	Rev 0
Size	12 x 312	inch	Type	BEM	Horizontal
Surf/Unit (Gross/Eff)	525.82 / 503.7	ft2	Shell/Unit	1	
			Item No.	E-202 CASE 1 DESIGN	
			Connected In	1	Parallel 1 Series
			Surf/Shell (Gross/Eff)	525.82 / 503.7 ft2	

PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		Y GRADE		INLET GAS	
Fluid Quantity, Total lb/hr		74396		88877	
Vapor (In/Out)				88877	
Liquid		74396			
Steam					
Water					
Noncondensables					
Temperature (In/Out) F		63.20 95.90		125.00 94.90	
Specific Gravity		0.4769 0.4461			
Viscosity cP		0.0848 0.0680		0.0141 0.0138	
Molecular Weight, Vapor					
Molecular Weight, Noncondensables					
Specific Heat Btu/lb-F		0.6667 0.7247		0.6269 0.6518	
Thermal Conductivity Btu/hr-ft-F		0.0482 0.0417		0.0225 0.0216	
Latent Heat Btu/lb					
Inlet Pressure psia		1270.0		935.00	
Velocity ft/sec		2.34		30.20	
Pressure Drop, Allow/Calc psi		5.000 3.629		5.000 5.319	
Fouling Resistance (min) ft2-hr-F/Btu		0.00100		0.00100	
Heat Exchanged 1693169 Btu/hr		MTD (Corrected) 30.0 F			
Transfer Rate, Service 111.85 Btu/ft2-hr-F		Clean 180.77 Btu/ft2-hr-F		Actual 127.94 Btu/ft2-hr-F	

CONSTRUCTION OF ONE SHELL

		Shell Side		Tube Side		
Design/Test Pressure		psig	2035 / CODE	1100 / CODE		
Design Temperature		F	200 / -20	150 / -20		
No Passes per Shell			1	1		
Corrosion Allowance		inch	0.0625	0.0625		
Connections	In	inch	1 @ 4-900#RTJ	1 @ 6-600#RF		
Size &	Out	inch	1 @ 4-900#RTJ	1 @ 6-600#RF		
Rating		Intermediate	@	@		

Tube No.	103	OD	0.7500	inch	Thk(MIN)	0.0830	inch	Length	26.000	ft	Pitch	0.9375	inch	
Tube Type	Plain	Material SA-214										Tube pattern	30	
Shell	SA-106 B	ID	12	OD	14.000	inch	Shell Cover							
Channel or Bonnet	SA-106 B							Channel Cover						
Tubesheet-Stationary	SA-516 70 N OR EQUAL							Tubesheet-Floating						
Floating Head Cover							Impingement Plate Circular plate							
Baffles-Cross	SA-36	Type	Single-Seg.	%Cut (Diam)	36.33	Spacing(c/c)	14.232	Inlet	14.232	inch				
Baffles-Long							Seal Type	None						
Supports-Tube							U-Bend	Type None						
Bypass Seal Arrangement	0	pairs seal strips					Tube-Tubesheet Joint	Expanded (2 grooves)						
Expansion Joint							Type							
Rho-V2-Inlet Nozzle	3452.9	lb/ft-sec2					Bundle Entrance	255.57	Bundle Exit	235.96	lb/ft-sec2			
Gaskets-Shell Side							Tube Side	GMGC						
- Floating Head														
Code Requirements	ASME S8 D1 / STAMP / NBR								TEMA Class		C			
Weight/Shell	7511.2	lb	Filled with Water		8634.5	lb	Bundle	1894.8	lb					

Remarks:

1. UNIT IS THERMALLY & MECHANICALLY GUARANTEED. 2. 10% ADDITIONAL DUTY AND FLOWS.
3. MEAN METAL TEMPS. (SS/TS): 80/94°F.

Note: Reported duty and flow rates include a user-specified multiplier of 1.10.

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Steeltek, Inc / Tulsa, OK

Page 1

US Units

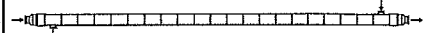
Customer	UOP RUSSELL		UOP Russell Project No.:	J488XX	
Address			Reference No.	PO#4500801009	
Plant Location			Steeltek Job No.:	17S-3450	
Service of Unit	GAS/PRODUCT EXCHANGER		Date	11-13-17	Rev 0
Size	12 x 312	inch	Type	BEM	Horizontal
Surf/Unit (Gross/Eff)	525.82 / 503.7	ft2	Shell/Unit	1	
			Connected In	1	Parallel
			Surf/Shell (Gross/Eff)	525.82 / 503.7	ft2
			Item No.	E-202 CASE 2 OFF-DESIGN	
			Series	1	

PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		Y GRADE		INLET GAS	
Fluid Quantity, Total		79932		91825	
Vapor (In/Out)				91825	
Liquid		79932			
Steam					
Water					
Noncondensables					
Temperature (In/Out)		70.30		125.00	
Specific Gravity		0.4825		0.4569	
Viscosity		0.0877		0.0142	
Molecular Weight, Vapor					
Molecular Weight, Noncondensables					
Specific Heat		0.6593		0.6304	
Thermal Conductivity		0.0474		0.0224	
Latent Heat					
Inlet Pressure		1270.0		935.00	
Velocity		2.46		25.87	
Pressure Drop, Allow/Calc		5.000		5.000	
Fouling Resistance (min)		0.00100		0.00100	
Heat Exchanged		1529398 Btu/hr		MTD (Corrected) 27.2 F	
Transfer Rate, Service		123.42 Btu/ft2-hr-F		Actual 130.13 Btu/ft2-hr-F	

CONSTRUCTION OF ONE SHELL

		Shell Side		Tube Side	
Design/Test Pressure		2035 / CODE		1100 / CODE	
Design Temperature		200 / -20		150 / -20	
No Passes per Shell		1		1	
Corrosion Allowance		0.0625		0.0625	
Connections	In	1 @ 4-900#RTJ		1 @ 6-600#RF	
	Out	1 @ 4-900#RTJ		1 @ 6-600#RF	
	Intermediate	@		@	



Tube No.	103	OD	0.7500	inch	Thk(MIN)	0.0600	inch	Length	26.000	ft	Pitch	0.9375	inch
Tube Type	Plain	Material SA-214											Tube pattern 30
Shell	SA-106 B	ID	12	OD	14.000	inch	Shell Cover						
Channel or Bonnet	SA-106 B							Channel Cover					
Tubesheet-Stationary	SA-516 70 N OR EQUAL							Tubesheet-Floating					
Floating Head Cover							Impingement Plate Circular plate						
Baffles-Cross	SA-36	Type	Single-Seg.	%Cut (Diam)	36.33	Spacing(c/c)	14.232	Inlet	14.232	inch			
Baffles-Long							Seal Type	None					
Supports-Tube							U-Bend						Type None
Bypass Seal Arrangement	0	pairs seal strips					Tube-Tubesheet Joint	Expanded (2 grooves)					
Expansion Joint							Type						
Rho-V2-Inlet Nozzle	3939.7	lb/ft-sec2					Bundle Entrance	291.60	Bundle Exit	265.98	lb/ft-sec2		
Gaskets-Shell Side							Tube Side	GMGC					
- Floating Head													
Code Requirements	ASME S8 D1 / STAMP / NBR								TEMA Class	C			
Weight/Shell	7111.9	lb	Filled with Water			8286.0	lb	Bundle	1495.4	lb			

Remarks:

1. UNIT IS THERMALLY & MECHANICALLY GUARANTEED. 2. 10% ADDITIONAL DUTY AND FLOWS.
3. MEAN METAL TEMPS. (SS/TS): 84/97°F.

Note: Reported duty and flow rates include a user-specified multiplier of 1.10.

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Page 1

US Units

Customer	UOP RUSSELL		UOP Russell Project No.:	J488XX	
Address			Reference No.	PO#4500801009	
Plant Location			Steeltek Job No.:	17S-3450	
Service of Unit	GAS/PRODUCT EXCHANGER		Date	11-28-17	Rev 0
Size	12 x 312	inch	Type	BEM	Horizontal
Surf/Unit (Gross/Eff)	525.82 / 503.7	ft2	Shell/Unit	1	
			Item No.	E-202 CASE 3 ORIG-DESIGN	
			Connected In	1	Parallel 1 Series
			Surf/Shell (Gross/Eff)	525.82 / 503.7 ft2	

PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		Y GRADE		INLET GAS	
Fluid Quantity, Total lb/hr		66275		71971	
Vapor (In/Out)					
Liquid		66275		68934	
Steam				3037.1	
Water					
Noncondensables					
Temperature (In/Out) F		27.30		54.80	
Specific Gravity		0.5035		0.4468	
Viscosity cP		0.1034		0.0135	
Molecular Weight, Vapor				0.0132 V/L 0.0850	
Molecular Weight, Noncondensables					
Specific Heat Btu/lb-F		0.6330		0.6597	
Thermal Conductivity Btu/hr-ft-F		0.0564		0.0209	
Latent Heat Btu/lb				0.0204 V/L 0.0500	
Inlet Pressure psia		740.00		885.00	
Velocity ft/sec		1.98		21.90	
Pressure Drop, Allow/Calc psi		5.000		5.000	
Fouling Resistance (min) ft2-hr-F/Btu		0.00100		0.00100	
Heat Exchanged 1266505 Btu/hr				MTD (Corrected) 24.1 F	
Transfer Rate, Service 104.28 Btu/ft2-hr-F		Clean 156.65 Btu/ft2-hr-F		Actual 115.37 Btu/ft2-hr-F	

CONSTRUCTION OF ONE SHELL

Sketch (Bundle/Nozzle Orientation)

		Shell Side		Tube Side	
Design/Test Pressure psig		2035 / CODE		1100 / CODE	
Design Temperature F		200 / -20		150 / -20	
No Passes per Shell		1		1	
Corrosion Allowance inch		0.0625		0.0625	
Connections	In	1 @ 4-900#RTJ		1 @ 6-600#RF	
	Out	1 @ 4-900#RTJ		1 @ 6-600#RF	
	Intermediate	@		@	
Size & Rating					

Tube No.	103	OD	0.7500	inch	Thk(MIN)	0.0830	inch	Length	26.000	ft	Pitch	0.9375	inch
Tube Type	Plain				Material	SA-214					Tube pattern	30	
Shell	SA-106 B	ID	12	OD	14.000	inch	Shell Cover						
Channel or Bonnet	SA-106 B				Channel Cover								
Tubesheet-Stationary	SA-516 70 N OR EQUAL				Tubesheet-Floating								
Floating Head Cover					Impingement Plate	Circular plate							
Baffles-Cross	SA-36	Type	Single-Seg.	%Cut (Diam)	36.33	Spacing(c/c)	14.232	Inlet	14.232	inch			
Baffles-Long				Seal Type	None								
Supports-Tube				U-Bend							Type	None	
Bypass Seal Arrangement	0	pairs seal strips		Tube-Tubesheet Joint	Expanded (2 grooves)								
Expansion Joint				Type									
Rho-V2-Inlet Nozzle	2595.4	lb/ft-sec2		Bundle Entrance	192.10	Bundle Exit	175.05	lb/ft-sec2					
Gaskets-Shell Side				Tube Side	GMGC								

- Floating Head													
Code Requirements	ASME S8 D1 / STAMP / NBR							TEMA Class	C				
Weight/Shell	7511.2	lb	Filled with Water	8634.5	lb	Bundle	1894.8	lb					

Remarks:

1. UNIT IS THERMALLY & MECHANICALLY GUARANTEED. 2. 10% ADDITIONAL DUTY AND FLOWS.

3. MEAN METAL TEMPS. (SS/TS): 42/53°F.

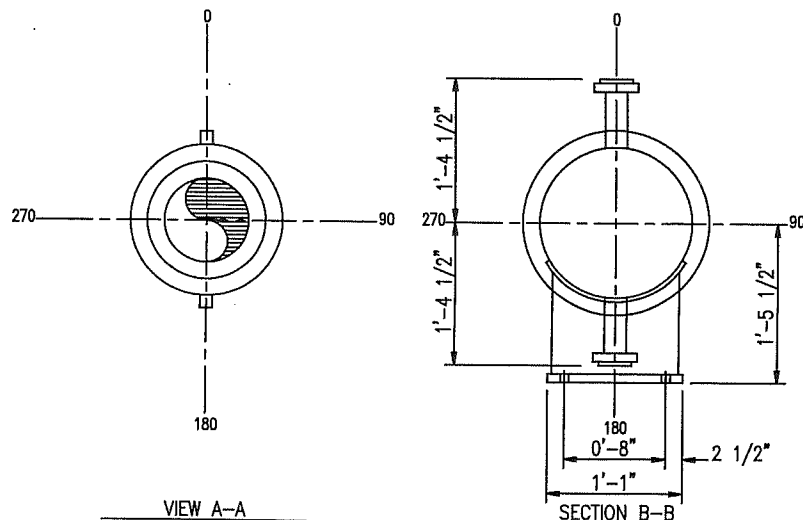
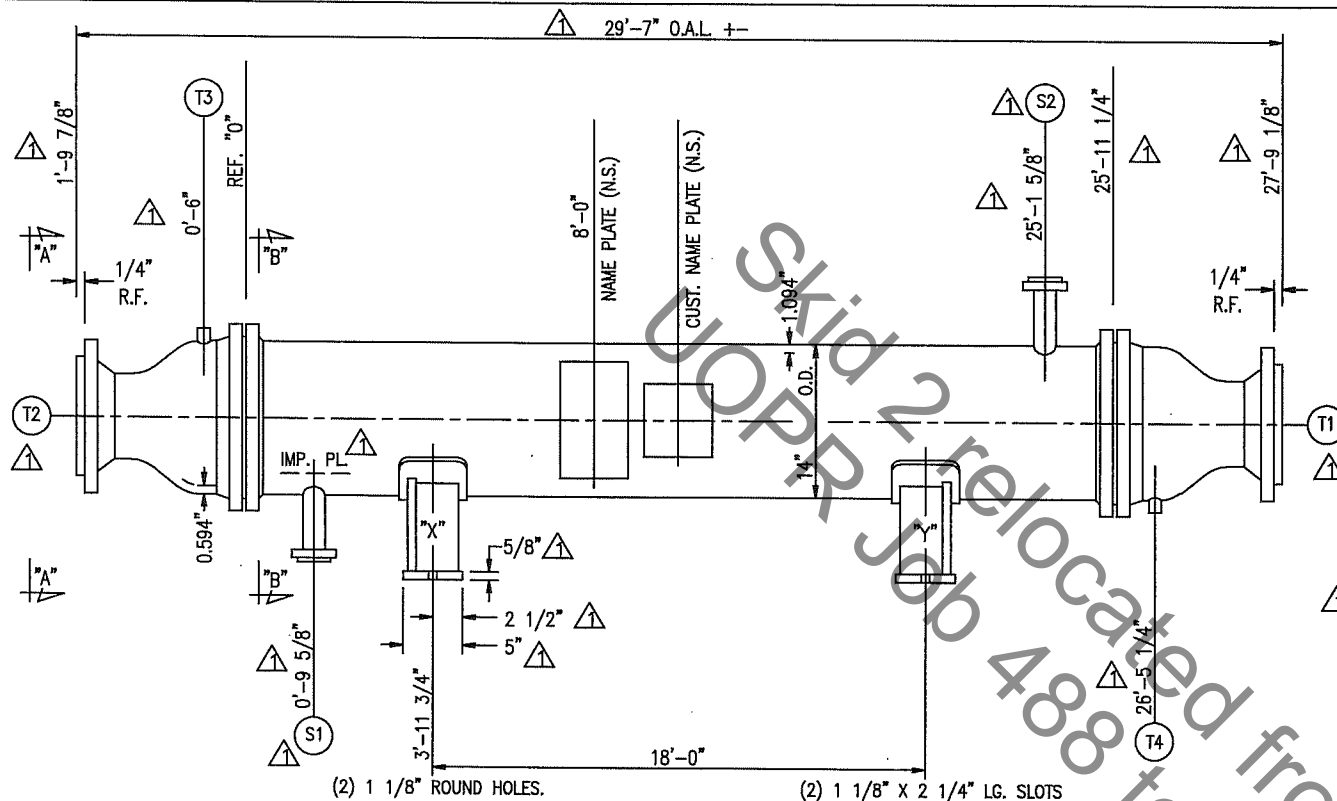
Note: Reported duty and flow rates include a user-specified multiplier of 1.10.

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CERTIFIED
AS BUILT

CERTIFIED FOR CONSTRUCTION

BY: SK DATE: 3/13/18



NOZZLE SCHEDULE				
MK	QT	DESCRIPTION	PROCESS	AUXILIARIES
S1	1	4" 900#RTJLWN	INLET	
S2	1	4" 900#RTJLWN	OUTLET	
T1	1	6" 600#RF WN	INLET	
T2	1	6" 600#RF WN	OUTLET	
T3	1	3/4" 6000#CPLG.	VENT	W/ PLUG
T4	1	3/4" 6000#CPLG.	DRAIN	W/ PLUG

DESIGN DATA	SHELL	TUBE
DESIGN PRESSURE P.S.I.G.	2035	1100
VACUUM PRESSURE P.S.I.G.	N/A	N/A
TEST PRESSURE P.S.I.G.	2646	1431
DESIGN TEMP. Deg.F.	200	150
MDMT Deg. F.	-20	-20
CORROSION ALLOWANCE	1/16"	1/16"
NUMBER OF PASSES	1	1
RADIOGRAPHY	FULL	FULL
HEAT TREAT REQUIRED	NO	NO

ESTIMATED WEIGHTS, LBS.

DRY: 7300

WET: 8500

SPECIFICATIONS

ASME CODE SECT. VIII DIV.1, 2017 EDITION (STAMP YES)

TEMA CLASS "C"

NATIONAL BOARD REGISTRATION REQUIRED

MATERIAL

CHANNEL: SA-234-WPC

SHELL: SA-333-6

TUBESHEETS: SA-350LF2CL1

BAFFLES: SA-36

TUBES: SA-214

(103) 3/4" O.D.X 0.083" (M.W.) X 26'-0"

TUBE PITCH 15/16" SURFACE 504 LG. SQ.FT.

GENERAL NOTES

ALL BOLT HOLES TO STRADDLE NATURAL CENTER LINES.

ALL BOLTING TO BE CADMIUM PLATED

GASKETS: .1250" THK. 304 S.S. GMGC

(1) SET OF SPARE GASKETS REQUIRED.

FOR PAINT DETAILS SEE DWG. "PM"

INSULATION THK. (BY OTHERS): SHELL - 2" CHANNELS - NONE

CUSTOMER: UOP RUSSELL

CUST. PROJ. NO.: J488XX

P.O. NO.: 4500801009

ITEM NO.: E-202

SERVICE: GAS/PRODUCT EXCHANGER

1 2-16 REVISED TO STD. PLANT DIMENSIONS

ASSEMBLY AND SPECIFICATIONS FOR

ONE 14-312 B E M

DWN. BY
MG

DATE
1-19-18

CKD. BY
DD

REVISIONS

NO.

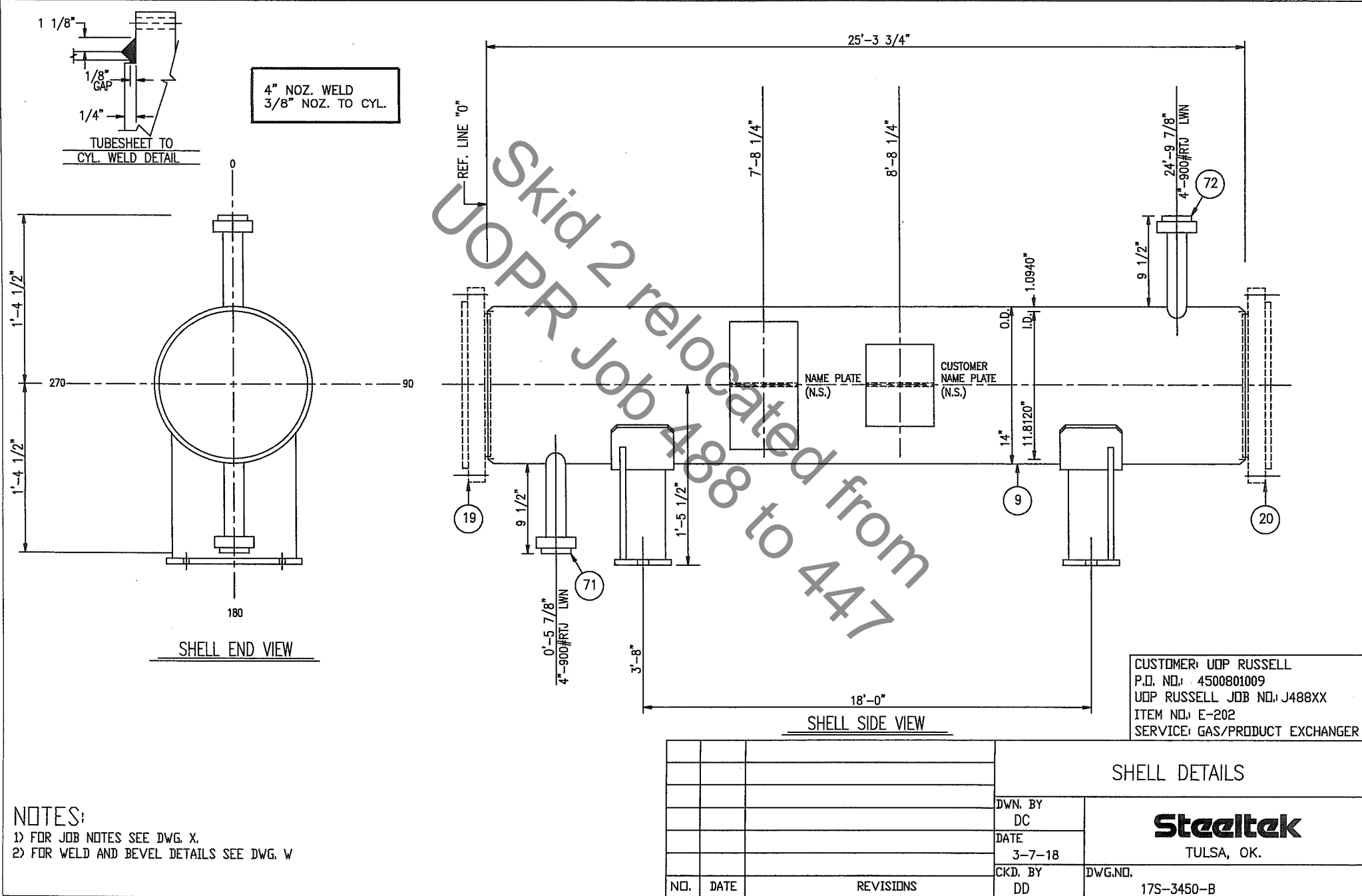
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DWG.NO.

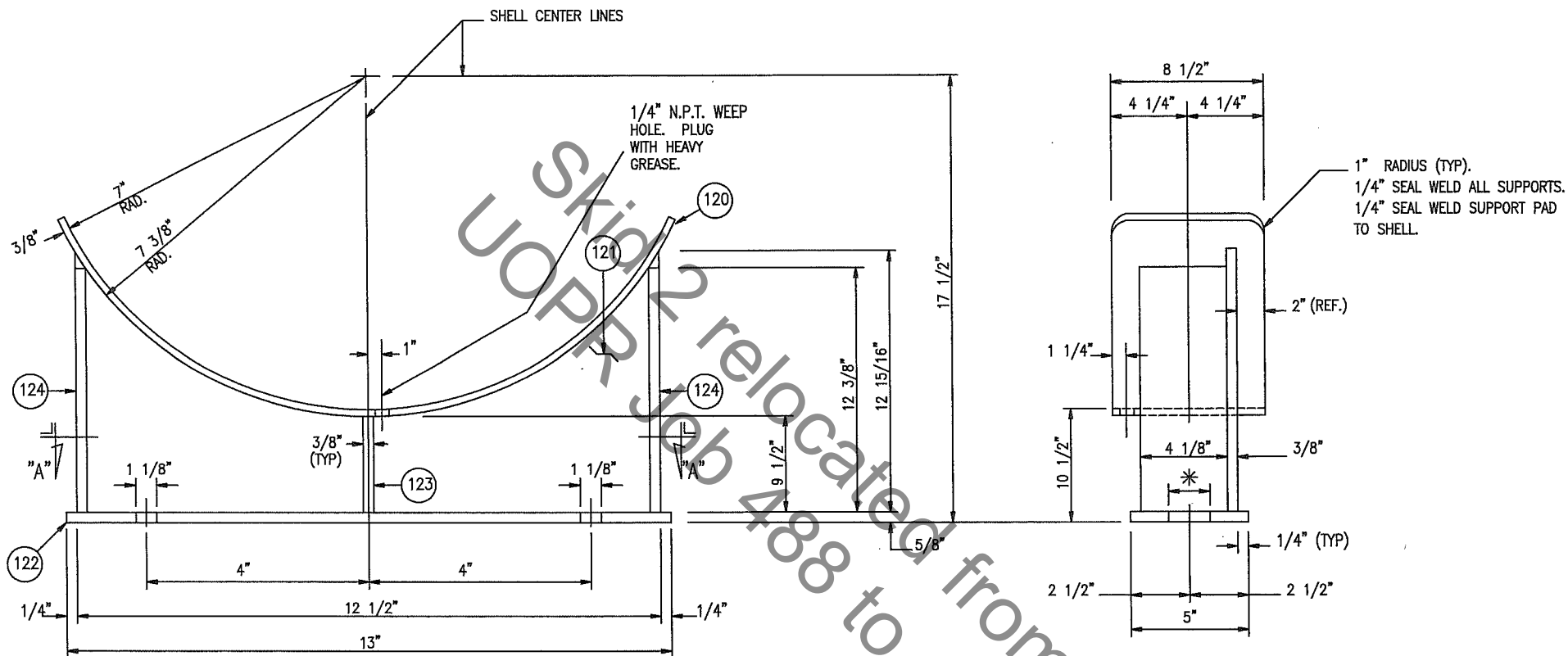
Steeltek
TULSA, OK.

17S-3450-A

CERTIFIED AS BUILT

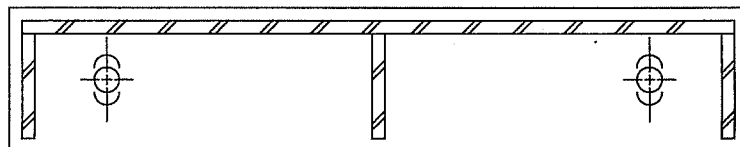


CERTIFIED AS BUILT



- * ONE REQUIRED MARKED "X" W/ (2) 1 1/8" ROUND HOLES.
ONE REQUIRED MARKED "Y" W/ (2) 1 1/8" X 2 1/4" LG. SLOTS.

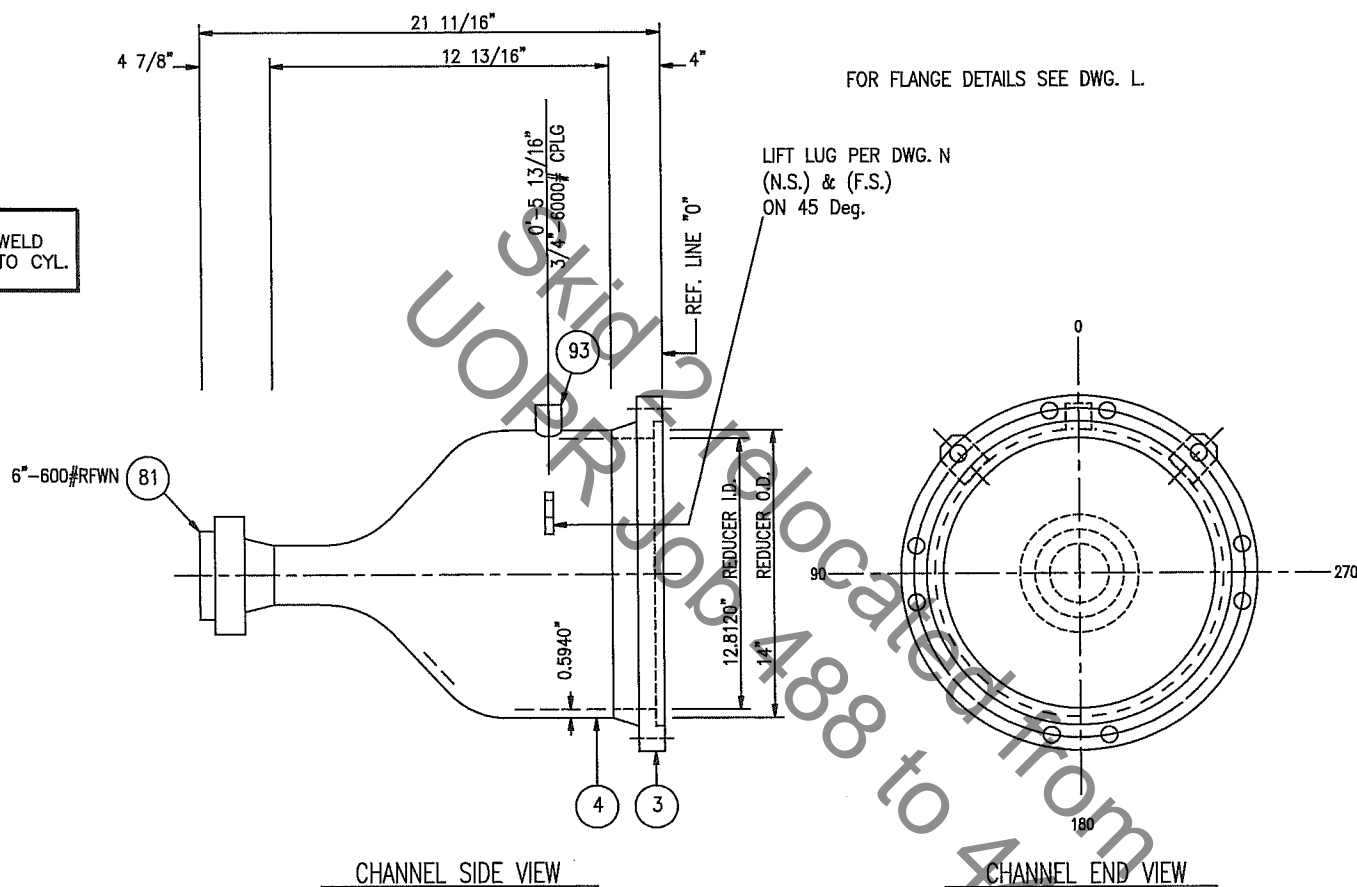
CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER



NOTES:
1) FOR JOB NOTES SEE DWG. X.

			SUPPORT DETAILS	
			DWN. BY DC	Steeltek TULSA, OK.
			DATE 3-8-18	
			CKD. BY DD	
NO.	DATE	REVISIONS	DWG. NO.	17S-3450-C

CERTIFIED AS BUILT



NOTES:

- 1) FOR JOB NOTES SEE DWG. X.
- 2) FOR WELD AND BEVEL DETAILS SEE DWG. W

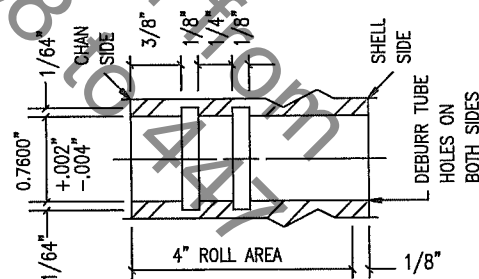
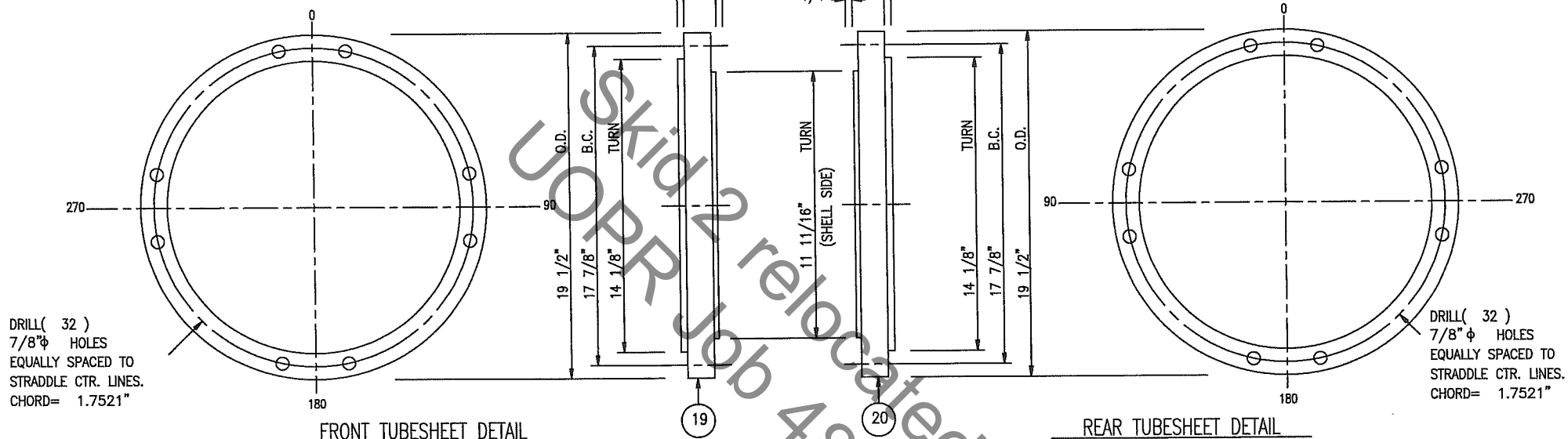
CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

FRONT CHANNEL DETAILS		
	DWN. BY	Steeltek TULSA, OK. DWG. NO. 17S-3450-D
	DC	
	DATE	
	3-8-18	
	CKD. BY	DWG. NO.
	DD	
NO.	DATE	REVISIONS

			REAR CHANNEL DETAILS	
			DWN. BY DC	 TULSA, OK.
			DATE 3-8-18	
			CKD. BY DD	
NO.	DATE	REVISIONS	DWG. NO.	17S-3450-E

CERTIFIED AS BUILT

DRILL & TAP 3/4" DEEP FOR 4- 1/2" DIA.
TIE RODS ON SHELL SIDE OF
19 TUBESHEET. DO NOT DRILL THRU!!
(SEE TUBE LAYOUT FOR LOCATIONS.)



NOTES:

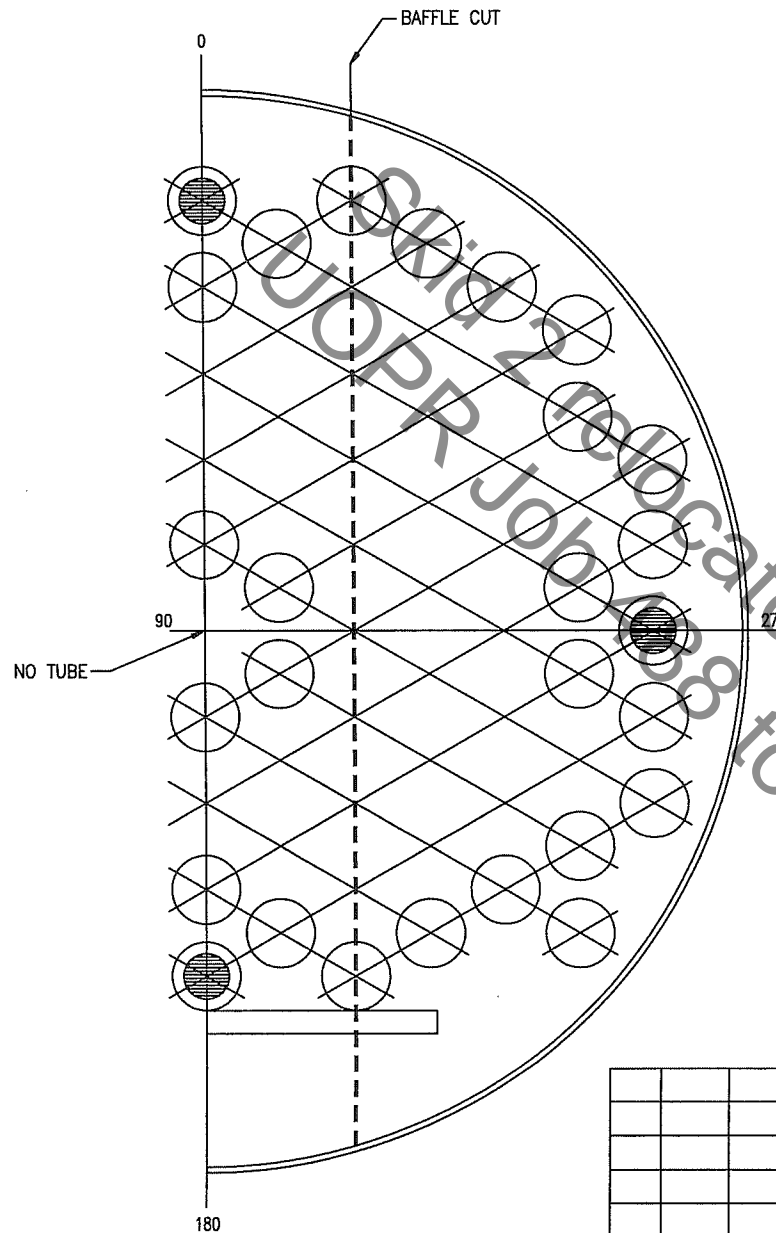
- 1) MACHINE ALL SURFACES TO 250 RMS EXCEPT GASKET FACES TO BE 125 RMS.
- 2) FOR JOB NOTES SEE DWG. X

CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

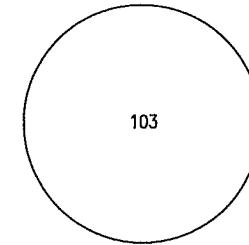
TUBESHEET DETAILS			
NO.	DATE	REVISIONS	DWN. BY MG
			DATE 8-31-17
NO.	DATE	REVISIONS	CKD. BY DD
			DWG. NO. 17S-3450-F

Steeltek
TULSA, OK.

TIE RODS.
1/2" O.D.
4 REQD. TOTAL



LAYOUT SYMMETRICAL
ABOUT VERTICAL
CENTER LINE.



TUBE DISTRIBUTION

- 1) DRILL AND REAM TUBE HOLES IN TUBESHEETS TO $.760^{+0.002}_{-.004}$ DIA. FOR 103 - 3/4" O.D. TUBES.
- 2) TUBE PITCH = 15/16" ROT. TRIANGLE.
- 3) NUMBER OF PASSES = 1
- 4) SEE DRAWING F FOR TUBE HOLE GROOVING DETAILS.
- 5) BAFFLE O.D. = 11 11/16"
- 6) O.T.L. = 11 1/4"

CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

			TUBE LAYOUT	DWN. BY DC	DATE 3- 9-18	Steeltek TULSA, OK.
			CKD. BY DD	DWG. NO.	17S-3450-G	
NO.	DATE	REVISIONS				

Diagram showing a 90° NOTCH on the BOTTOM.



1/4" THK.

10 -REQD. CUT AAA

10 -REQD. CUT BBB

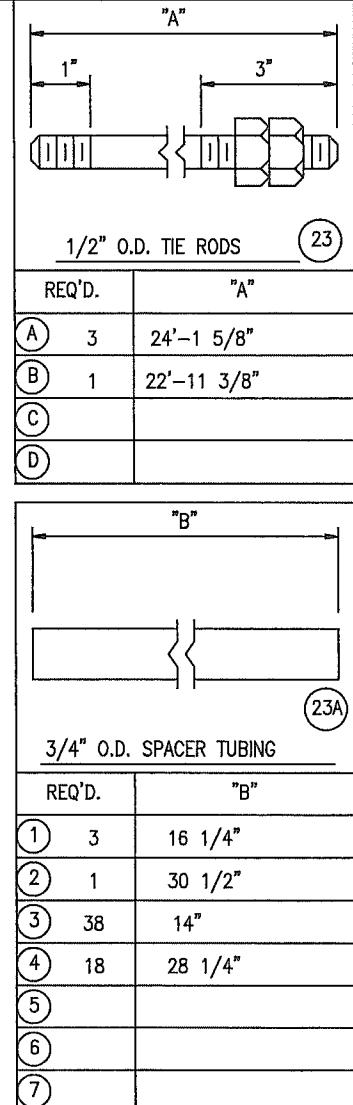
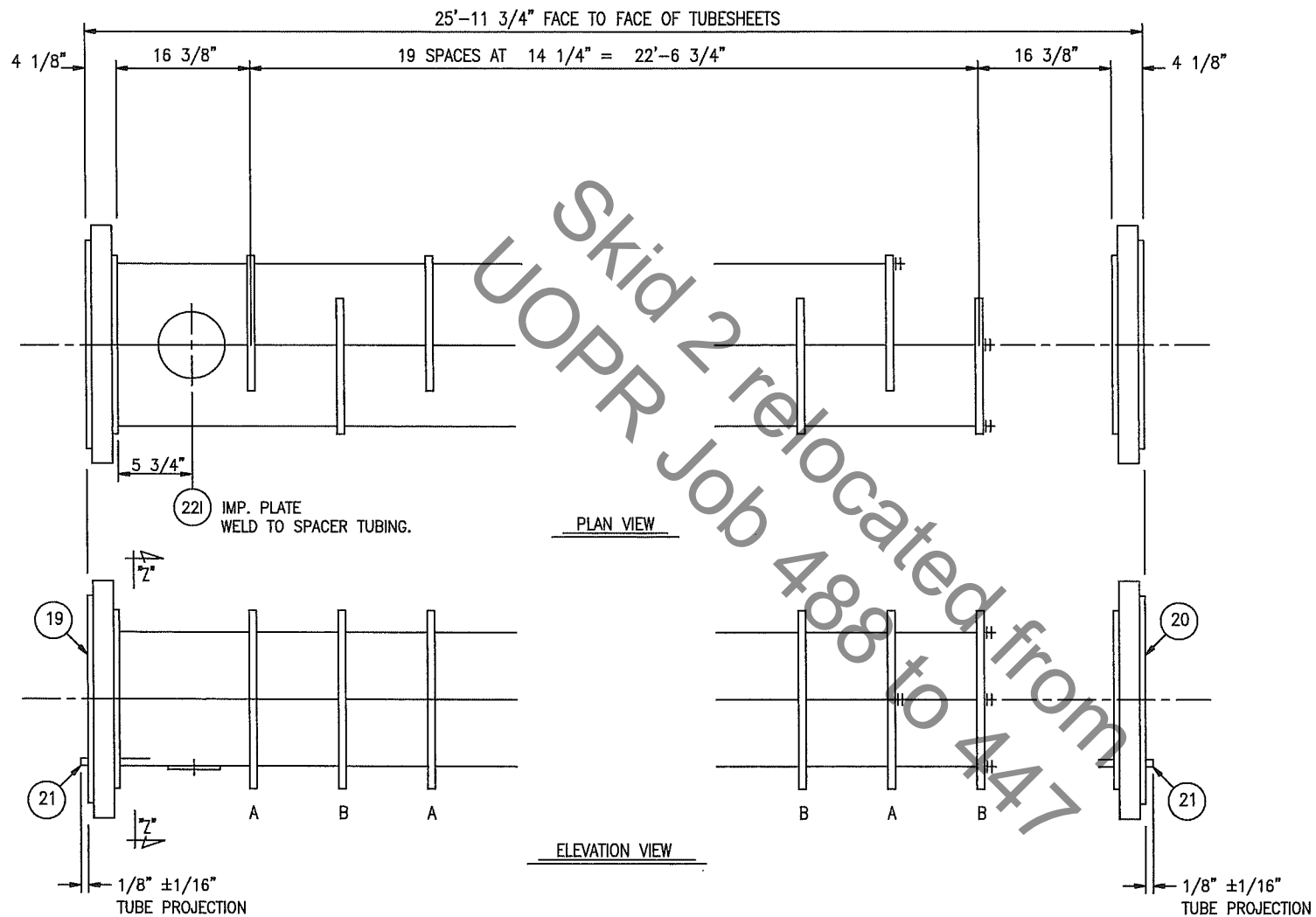
- 1) DRILL TUBE HOLES IN BAFFLES 25/32" DIA. & DEBURR.
- 2) DRILL TIE ROD HOLES 9/16" DIA.
SEE TUBE LAYOUT FOR LOCATION.
- 3) RADIUS ALL CORNERS ON BAFFLE CUTS.
- 4) CHECK SHELL I.D. BEFORE MACHINING BAFFLE O.D.
- 5) MACHINE O.D. OF BAFFLES TO 250 RMS.
- 6) FOR JOB NOTES SEE DWG. X.

BAFFLE DETAILS

Steeltek
TULSA, OK.

			BAFFLE DETAILS	
			DWN. BY DC	 TULSA, OK.
			DATE	
			3- 9-18	
			CKD. BY DD	
NO.	DATE	REVISIONS	DWG. NO.	17S-3450-H

CERTIFIED AS BUILT



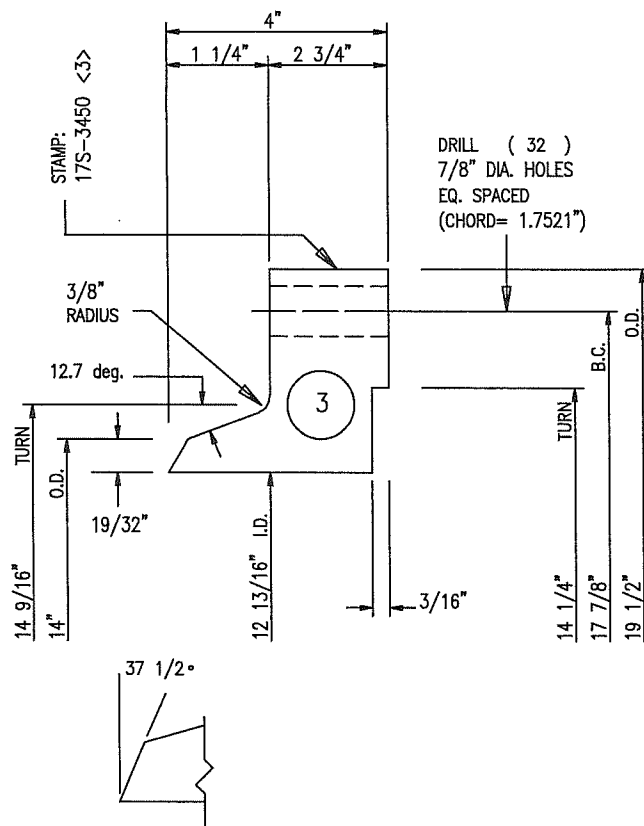
NOTES:

- 1) FOR SECTION AND VIEW DETAILS SEE DWG. H.
- 2) FOR JOB NOTES SEE DWG. X.

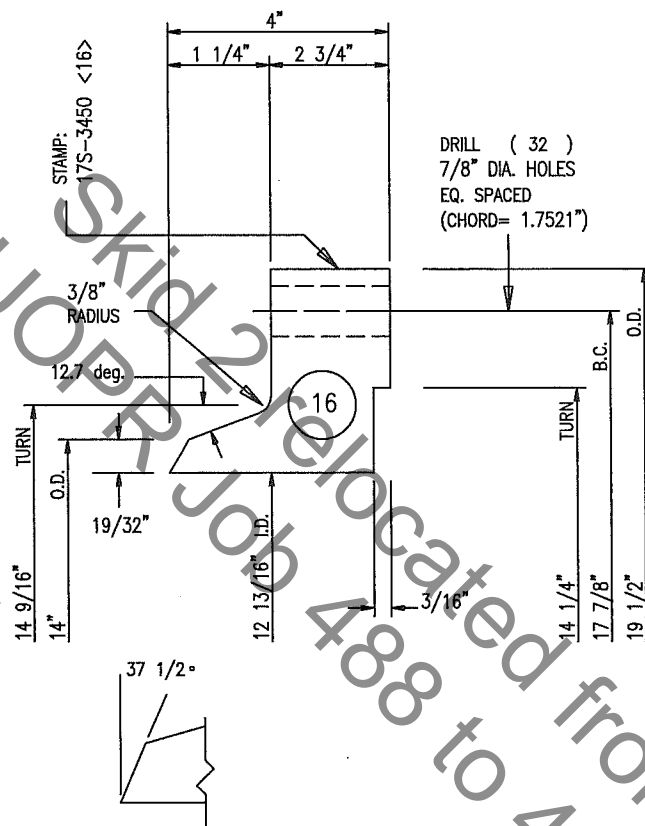
CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

BUNDLE DETAILS		
	DWN. BY	Steeltek TULSA, OK. DWG. NO. 17S-3450-J
	DC	
	DATE	
	3/9/18	
	CKD. BY	DD
	DD	
NO.	DATE	REVISIONS

CERTIFIED AS BUILT



3 GIRTH FLANGE (ONE)REQ'D.



16 GIRTH FLANGE (ONE)REQ'D.

CUSTOMER: UOP RUSSELL
P.I. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

NOTES:

- 1) MACHINE ALL SURFACES TO 250 RMS
EXCEPT GASKET SURFACES MACHINE TO 125 RMS.
- 2) ALL BOLT HOLES TO STRADDLE NATURAL CENTER LINES.
- 3) FOR JOB NOTES SEE DWG. X.

GIRTH FLANGES

DWN. BY
DC

DATE
3-8-19

CKD. BY
DD

DWG. NO.

Steeltek
TULSA, OK.

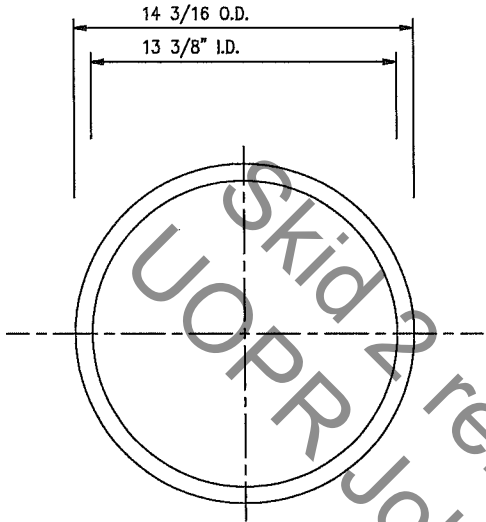
17S-3450-L

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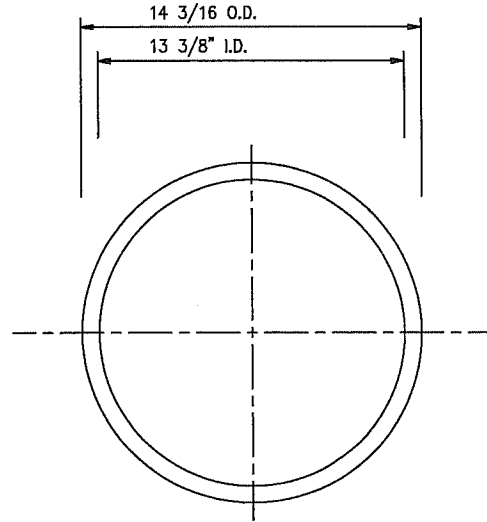
DATE

REVISIONS

CERTIFIED
AS BUILT



(1)-REQUIRED.
CHANNEL GASKET.
1/8" THK 304 SS KAMMPROFILE LP-1 WITH GRAPHOIL FACING



(1)-REQUIRED.
REAR CHANNEL GASKET.
1/8" THK 304 SS KAMMPROFILE LP-1 WITH GRAPHOIL FACING

GASKET TOLERANCES
O.D. +0" / -1/16"
I.D. +1/16" / -0"

- NOTES:
- 1) QUANTITIES SHOWN FOR ONE SET
(2)-SETS REQUIRED TOTAL.
ONE SET OF GASKETS TO BE USED IN EXCH. AND
(1) SET TO BE BOXED, MARKED WITH
P.O. & ITEM NO. & SHIPPED WITH EXCHANGER.
 - 2) FOR JOB NOTES SEE DWG. X.

CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

			GASKET DETAILS	
			DWN. BY	Steeltek TULSA, OK.
			DC	
			DATE	
			3-8-18	
			CKD. BY	DWG.NO.
			DD	17S-3450-M
NO.	DATE	REVISIONS		

6 1/2"

10 1/2"

5 1/4"

1/4" TYP.

3"

STD. NAME PLATE

FTS CAUTION TAG
SEE DWG. N1

CYL.

CENTERLINE

3/16"

Orthographic drawing of a mechanical part. The front view (left) shows a rectangular base with a semi-circular top. The total height is $4 \frac{1}{8}"$. The base width is $3 \frac{3}{4}"$. A central hole is located $1 \frac{7}{8}"$ from the top edge. The hole has a diameter of $1 \frac{7}{8}"$ and a radius of $1 \frac{7}{8}"$ RAD. The side view (right) shows the profile of the part, which is $\frac{1}{2}"$ thick.

CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

NB

CERTIFIED BY

Steeltek

TULSA, OKLA.



W
RT1

SHELL TUBE	MAWP PSI
2035	2035
1100	1100

SHELL TUBE	MDMT ° F
-20	-20
-20	-20

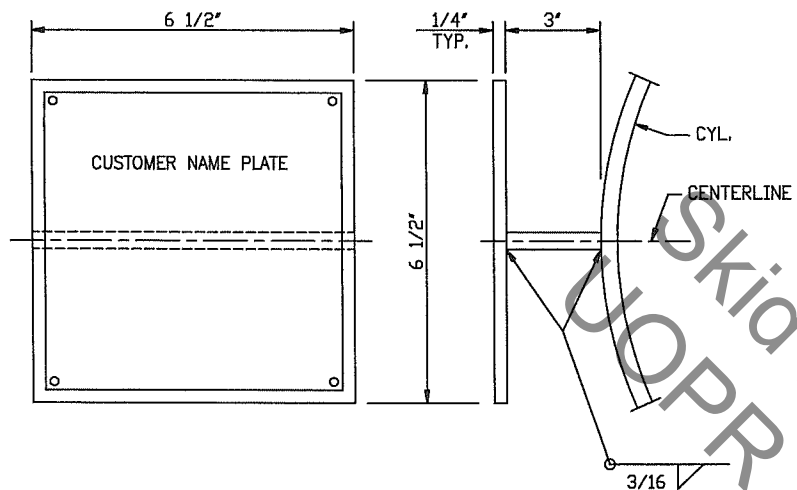
AT ° F
200
150

AT PSI
2035
1100

YEAR BUILT	2018
SERIAL NO.	17S-3450
P.D. NO.	4500801009
ITEM NO.	E-202
UOP RUSSELL PROJ. NO. : J488XX	

NATIONAL BOARD NUMBER IS REQUIRED
NUMBER WILL BE ASSIGNED AT TIME OF SHIPMENT

			NAME PLATE, BRACKET AND LIFT LUG DETAILS	
			DWN. BY DC	TULSA, OK.
			DATE 3-8-18	
			CKD. BY DD	DWG. NO. 17S-3450-N
NO.	DATE	REVISIONS		



CUSTOMER NAME PLATE BRACKET DETAIL

CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

			CUSTOMER NAME PLATE BRACKET DETAILS	
			DWN. BY DC	 TULSA, OK.
			DATE 3-8-18	
			CKD. BY DD	
NO.	DATE	REVISIONS	DWG. NO.	17S-3450-N2

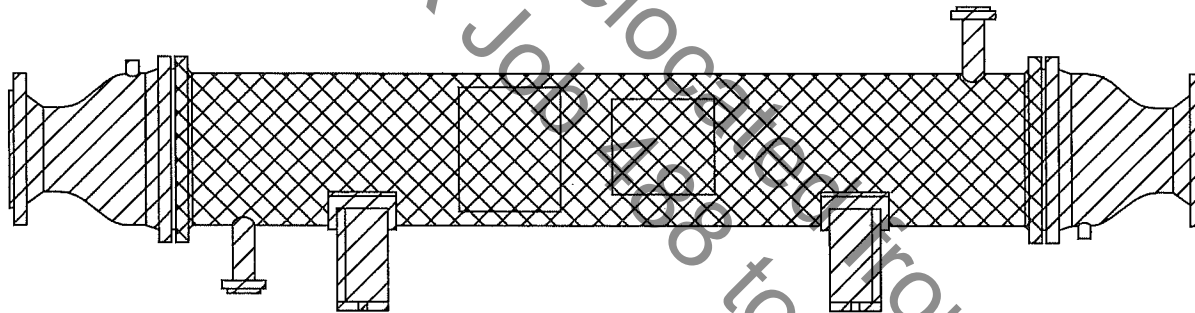
CERTIFIED AS BUILT

PAINT REQUIREMENTS SYSTEM 3

BLAST ENTIRE EXCHANGER PER SSPC-SP6 & PAINT AS FOLLOWS:

 PRIME COAT MACROPOXY 646 FAST CURE EPOXY B58-600 (4.0-6.0 MILS D.F.T.) COLOR: GRAY 4031

 PRIME COAT MACROPOXY 646 FAST CURE EPOXY B58-600 (4.0-6.0 MILS D.F.T.)
INTERMEDIATE COAT MACROPOXY 646 FAST CURE EPOXY B58-600 (4.0-6.0 MILS D.F.T.)
TOP COAT HI-SOLIDS POLYURETHANE B65 SERIES/B60V30 (3.0-4.0 MILS D.F.T.) COLOR GRAY 4031



CUSTOMER: UOP RUSSELL
P.I. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

PAINT MAP

Steeltek
TULSA, OK.

					SERVICE SHOP REQUEST EXCHANGER
			PAINT MAP		
			DWN. BY DC	Steeltek TULSA, OK.	
			DATE 3-8-18		
			CKD. BY DD		
NO.	DATE	REVISIONS		DWG. NO.	17S-3450-PM

CERTIFIED AS BUILT

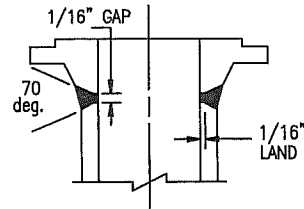
MR. NO.	QTY.	-SHIP LOOSE MATERIAL LIST-	MATERIAL
40	1	SET OF GASKETS PER DWG. M. (2 GASKETS TOTAL)	

Skid 2 relocated from
UOPR Job 488 to 447

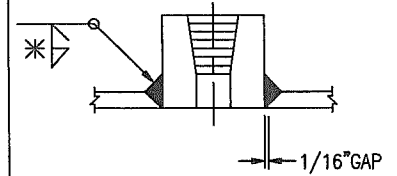
CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

SHIP LOOSE MATERIAL LIST		
	DWN. BY	Steeltek TULSA, OK.
	DC	
	DATE	
	3-8-18	
	CKD. BY	DWG. NO. 17S-3450-SL
	DD	
NO.	DATE	REVISIONS

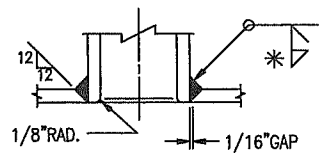
CERTIFIED AS BUILT



WELD-NECK FLANGE



PIPE CPLG.



NOZZLE W/OUT PAD

CUSTOMER: UDP RUSSELL
P.O. NO.: 4500801009
UDP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

GENERAL NOTES

- 1) FOR JOB NOTES SEE DWG. X.
- *2) ALL FILLET WELDS TO BE 3/8" UNLESS NOTED OTHERWISE.
- 3) ALL WELDING TO BE IN ACCORDANCE W/ ASME CODE (SECTION IX)

WELD & BEVEL DETAILS

DWN. BY
DC

DATE
3-8-18

CKD. BY
DD

DWG. NO.

Steeltek
TULSA, OK.

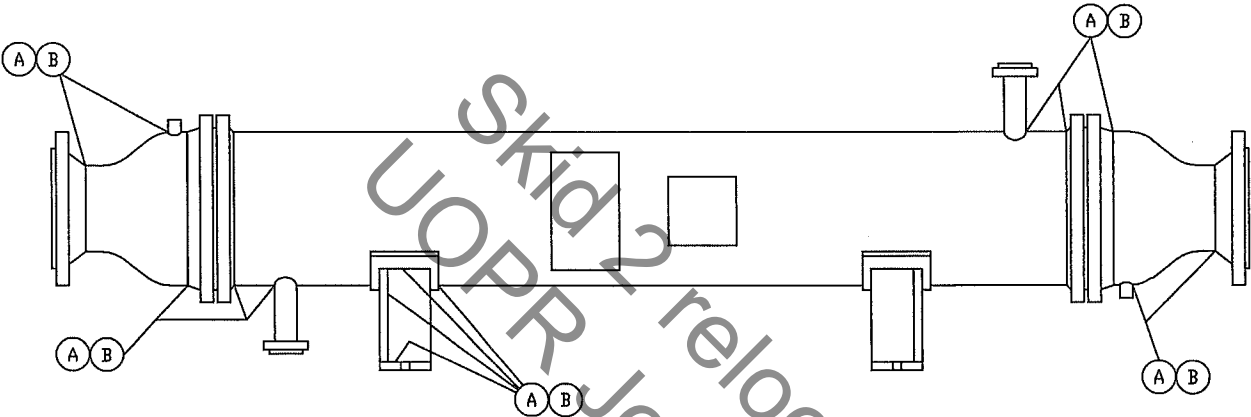
17S-3450-W

NO. DATE

REVISIONS

Skid 2 relocated from
UOPR Job 488 to 447

CERTIFIED
AS BUILT



MARK	WPS
A	ST-4
B	ST-28

CUSTOMER: UOP RUSSELL
P.I. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

			WELD MAP	
			DWN. BY DC	Steeltek TULSA, OK.
			DATE 3-9-18	
			CKD. BY DD	
NO.	DATE	REVISIONS	DWG. NO.	17S-3450-WM

CERTIFIED AS BUILT

GENERAL NOTES:

1. ALL BOLT HOLES TO STRADDLE NATURAL CENTERLINES.
2. MATCH MARKS REQUIRED AT ALL BOLTED JOINTS.
3. GRIND INSIDE WELDS FLUSH WITH SHELL I.D.
4. GRIND INSIDE WELDS SMOOTH WITH CHANNEL I.D.
5. BOLTING TO BE COATED WITH A SUITABLE THREAD LUBE.
6. HYDROTEST TO BE HELD FOR ONE HOUR (MIN).

WELDING NOTES:

1. FOR WELD PROCEDURES SEE WELD MAP DWG. WM.

RADIOGRAPHY NOTES:

1. SHELL NONE (SEAMLESS).
2. CHANNEL TO BE FULL RADIOGRAPHED.

SHIPPING PREPARATION NOTES:

1. ALL NOZZLE FLANGE GASKET SURFACES SHALL BE COATED WITH AN EASILY REMOVABLE RUST PREVENTATIVE PRIOR TO INSTALLATION OF SHIPPING COVERS.
2. NOZZLE FLANGES TO HAVE BOLTED-ON WOOD COVERS WITH RUBBER GASKETS WITH (4) BOLTS.

Skid 2 relocated from
UOPR Job 488 to 447

CUSTOMER: UOP RUSSELL
P.O. NO.: 4500801009
UOP RUSSELL JOB NO.: J488XX
ITEM NO.: E-202
SERVICE: GAS/PRODUCT EXCHANGER

			JOB NOTES	
			DWN. BY	Steeltek TULSA, OK.
			DC	
			DATE	
			3-9-18	
			CKD. BY	DWG. NO.
NO.	DATE	REVISIONS	DD	17S-3450-X

MK. NO.	QUAN.	DESCRIPTION	MATERIAL	DUE	P.O. NO.	RCV'D	PRICE
21	103	TUBES 3/4" O.D.X 0.083" (M.W.) X 26'-0" LG.	SA-214				
		FORGED RING MATERIAL					
3	1	FLG 19 1/2" O.D.X 12 13/16" I.D.X 4" THK (f)	SA-105N				
16	1	FLG 19 1/2" O.D.X 12 13/16" I.D.X 4" THK (f)	SA-105N				
		TUBESHEETS & COVERS					
19	1	TUBESHEET 19 1/2" O.D.X 4 1/8" THK (f)	SA-350LF2CL1				
20	1	TUBESHEET 19 1/2" O.D.X 4 1/8" THK (f)	SA-350LF2CL1				
		BAFFLES					
22	20	BAFFLES 12 1/16" B.O.D.X 1/4" THK	SA-36				
		CYLINDERS					
9	1	SMLS. PIPE 14" X(1.0940" Sch120)X 25'-3 3/4" LG.	SA-333-6				
4	1	CONC. REDUCER 14" (SCH60 .594") X 6" (SCH120 .562")	SA-234-WPC				
17	1	CONC. REDUCER 14" (SCH60 .594") X 6" (SCH120 .562")	SA-234-WPC				
		BEVELS					
		MK. 9: BOTH ENDS TYPE "B"					
		MK. 4: BOTH ENDS TYPE "F"					
		MK. 17: BOTH ENDS TYPE "F"					
		(f) DENOTES FINISHED DIMENSION					
		COLD FORMED HEADS TO BE HEAT TREATED AFTER FORMING.					
		ALL HOT FORMED HEADS TO BE HEAT TREATED DURING OR AFTER FORMING.					

SQUARE CUT	TYPE A
45° O.S. NO LAND	TYPE B
30° O.S. NO LAND	TYPE C
30° O.S. 1/8" LAND	TYPE D
30° I.S. 1/8" LAND	TYPE E
37 1/2° O.S. NO LAND	TYPE F
37 1/2° O.S. 1/8" LAND	TYPE G
30° W/ 1/8" LAND	TYPE H
BEVEL NOTES: O.S. = OUTSIDE / I.S. = INSIDE L.G. = LEFT SIDE END SEAM R.G. = RIGHT SIDE END SEAM L.S. = LONG SEAM A.S. = ALL SEAMS	

CERTIFIED
AS BUILT

CUSTOMER: UOP RUSSELL P.O. NO. 4500801009 UOP RUSSELL JOB NO. J488XX ITEM NO. E-202 SERVICE: GAS/PRODUCT EXCHANGER	1	2/16	REV. PER CUSTOMER	BILL OF MATERIAL	
				DWN. BY MG	Steeltek TULSA, OK.
				DATE 1/19/18	
	NO.	DATE	REVISIONS	CKD. BY DD	DWG. NO. 17S-3450-Y

Skid 2 relocated from
UOPR Job 488 to 447

AS BUILT

NO.	DATE	REVISIONS

DWG. NO.	17S-3450-Y1
----------	-------------

P.O. no: 4500801009		Job no : 18S-3450	
Date: 2/15/18 By: SK		Item no: E-202	
Customer: UOP RESSELL		HORIZONTAL	
Service : GAS/PRODUCT EXCHANGER		FIXED T.S.	
No. Shells: 1	Par. 1	Ser. 1	Surface: 525 Each 525 TotalSq.ft.
Size: 12 x 312 "		Type: B E M	
103 Tubes x 3/4" OD x 0.083" (m.w.) x 26'-0" Lg 0.9375 ROT TRI Pitch			
Tubes : SA-214			
Shell : SA-333-6			
Channel : SA-234WPB			
Tubesheets : SA-350LF2CL1			
Cross Baffles : SA-36 No. 20 Pitch 14.250 Cut 36.33 SGL SEG VERT			
Code requirements: SHELL SECT VIII STAMP YES CHANNEL SECT VIII STAMP YES			
Natl. Board #YES		Canadian Reg. #NO Tema C	
Weight Ea Dry: 5750 Lbs		Wet 7050 Lbs	
Shell		Tubes	
Design Press/Ext	2035.0 / 0.0 psig	1100.0 / 0.0 psig	
Test Pressure	2646.0 psig	1431.0 psig	
Design Temp/MDMT	200 / -20 deg.F	150 / -20 deg.F	
Corrosion Allowance	0.0625"	0.0625"	
No. of Passes	1	1	
Radiograph	FULL	FULL	
Stress Relieve	NO	NO	
Paint: See drawings			
Remarks:			
1. Shell side production impacts are not required per UCS-66.			
2. Tube side production impacts are not required per UG-20(f).			
3. All calculations are in accordance with A.S.M.E. Code, Section VIII, Div. I, 2017 Edition.			
4. Loads as required by UG-22 (a through h) have been considered and, where applicable are noted in the calculations.			
5. Nozzle wall thickness calculations per UG-45 have been considered.			
6. All design and operating conditions specified by the purchaser have been considered per UHX-12.4, UHX-13.4, or UHX-13.14, as applicable.			

11 2/10/18 REV. TO STD. PLANT DIM'S

CERTIFIED
AS BUILT

SHELL SIDE

```
=====
NOM.
SIZE      PRESS.      TEMP.      C.A.      RT      H.T.      TEMA
14.000"   2035.0psig   200deg.F   0.0625"   FULL    0deg.F    C
=====
```

ASME CODE SEC.VIII DIV.I UG-27

[CYLINDER]

====DESIGN CONDITIONS=====CYLINDER CALCULATIONS ON O.D. FORMULA=====

SHELL CYL

```
MATERIAL: SA-333-6      PRESS = 2035.0psig   TEMP = 200deg.F
O.D.      NOM. THK.      RW=0/PIPE=1   CORR.ALLOW   EFFICIENCY
14.0000"   1.0940"             1           0.0625"     1.00
ATM.STRS   DES.STRS   STRS/STRS   MAWP N-C   MAWP CORR.
17100.0psi 17100.0psi  1.000      2473.739psig 2303.522psig
```

P*(RO)

----- = 0.79519" + CORR. ALLOW. = 0.85769" + MTOL. = 0.98022"

S*E+(.4*P)

Skid 2 relocated from
UOPR Job 488 to 447

Item No: E-202
Job No : 18S-3450

By: SLC P.O. No: 4500801009
2/15/18 Page 2

CERTIFIED
AS BUILT

NOM.

SIZE	PRESS.	TEMP.	C.A.	RT	H.T.	TEMA
14.000"	1100.0psig	150deg.F	0.0625"	FULL	0deg.F	C

ASME CODE SEC.VIII DIV.I UG-27

[CYLINDER]

====DESIGN CONDITIONS=====CYLINDER CALCULATIONS ON O.D. FORMULA=====

REDUCER - LARGE END

MATERIAL: SA-234WPB		PRESS = 1100.0psig	TEMP = 150deg.F
O.D.	NOM. THK.	RW=0/PIPE=1	CORR.ALLOW EFFICIENCY
14.0000"	0.5940"	1	0.0625" 1.00
ATM.STRS	DES.STRS	STRS/STRS	MAWP N-C MAWP CORR.
17100.0psi	17100.0psi	1.000	1308.539psig 1146.965psig

P*(RO)

----- = 0.43900" + CORR. ALLOW. = 0.50150" + MTOL. = 0.57314"

S*E+(.4*P)

ASME CODE SEC.VIII DIV.I UG-27

[CYLINDER]

====DESIGN CONDITIONS=====CYLINDER CALCULATIONS ON O.D. FORMULA=====

REDUCER - SMALL END

MATERIAL: SA-234WPB		PRESS = 1100.0psig	TEMP = 150deg.F
O.D.	NOM. THK.	RW=0/PIPE=1	CORR.ALLOW EFFICIENCY
6.6250"	0.5620"	1	0.0625" 1.00
ATM.STRS	DES.STRS	STRS/STRS	MAWP N-C MAWP CORR.
17100.0psi	17100.0psi	1.000	2698.801psig 2337.040psig

P*(RO)

----- = 0.20774" + CORR. ALLOW. = 0.27024" + MTOL. = 0.30885"

S*E+(.4*P)

Item No: E-202

P.O. No: 4500801009

Job No : 18S-3450

By: SK

2/15/18

Page 3

CERTIFIED
AS BUILT

```

=====
NOM.
SIZE          PRESS.          TEMP.          C.A.          RT          H.T.          TEMA
14.000"       1100.0psig       150deg.F     0.0625"      FULL        0deg.F       C
=====
ASME CODE SEC.VIII DIV.I UG-27 [ CYLINDER ]
===DESIGN CONDITIONS=====CYLINDER CALCULATIONS ON O.D. FORMULA===
REDUCER - LARGE END
MATERIAL: SA-234WPB          PRESS = 1100.0psig  TEMP = 150deg.F
O.D.          NOM. THK.      RW=0/PIPE=1  CORR.ALLOW  EFFICIENCY
14.0000"      0.5940"          1          0.0625"      1.00
ATM.STRS      DES.STRS      STRS/STRS    MAWP N-C    MAWP CORR.
17100.0psi    17100.0psi    1.000      1308.539psig  1146.965psig

```

```

P*(RO)
----- = 0.43900" + CORR. ALLOW. = 0.50150" + MTOL. = 0.57314"
S*E+(.4*P)
*****

```

```

ASME CODE SEC.VIII DIV.I UG-27 [ CYLINDER ]
===DESIGN CONDITIONS=====CYLINDER CALCULATIONS ON O.D. FORMULA===
REDUCER - SMALL END
MATERIAL: SA-234WPB          PRESS = 1100.0psig  TEMP = 150deg.F
O.D.          NOM. THK.      RW=0/PIPE=1  CORR.ALLOW  EFFICIENCY
6.6250"      0.5620"          1          0.0625"      1.00
ATM.STRS      DES.STRS      STRS/STRS    MAWP N-C    MAWP CORR.
17100.0psi    17100.0psi    1.000      2698.801psig  2337.040psig

```

```

P*(RO)
----- = 0.20774" + CORR. ALLOW. = 0.27024" + MTOL. = 0.30885"
S*E+(.4*P)
*****

```

Skid 2 relocated from UOPR Job 488 to 447

Item No: E-202
Job No : 18S-3450

P.O. No: 4500801009
By: SK 2/15/18 Page 4

CERTIFIED
AS BUILT

NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16

NOZ NO= 1 4.00" 900 LB RTJ LWN
 [INLET] SHELL SIDE
 PRESSURE = 2035.0psig TEMP = 200.0deg.F

-----CYLINDER-----NOZZLE-----

SA-333-6	SA-105
OPER STRS= 17100.0 psi	OPER STRS= 20000.0 psi
ATM STRS = 17100.0 psi	ATM STRS = 20000.0 psi
C.A. = 0.06250"	C.A. = 0.06250"
I.D. = 12.08550"	I.D. = 4.00000"
O.D. = 14.00000"	O.D. = 6.25000"
THK. = 0.95725"	THK. = 1.12500"
T = 0.89475"	TN = 1.06250"
TR = 0.79519"	TRN = 0.22350"
ET = 0.09956"	ETN = 0.83900"

MIN STD. WT. PIPE+C.A.= 0.26987" TR+C.A.= 0.85769"
 LIMITS= 8.25000"
 fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000 F= 1.00000
 Min weld sizes:NS= 0.3536" NP= 0.0000" PS= 0.0000" IF= 0.0000"

AREA REQD. A = 3.28015in²
 EXCESS IN CYL. A1= 0.41069in²
 EXCESS IN NOZ. (OUTSIDE) A2= 3.75346in² H = 2.23688"
 AREA OF FILLETS = 0.14062in²
 AREA AVAILABLE = 4.30477in²

NOZ. NECK WELD= 0.37500" AREA= 0.14062in²

< AREA REQD-AREA AVAILABLE > = -1.02462in²

MAWP N-C= 2591.0psig LIMITED BY AR
 MAWP COR= 2321.0psig LIMITED BY AR

Skid 2 relocated from
 UOPR Job 488 to 447

Item No: E-202
 Job No : 18S-3450

By: SK P.O. No: 4500801009
 2/15/18 Page 5

CERTIFIED
 AS BUILT

NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16

NOZ NO= 2 4.00" 900 LB RTJ LWN
 [OUTLET] SHELL SIDE
 PRESSURE = 2035.0psig TEMP = 200.0deg.F

-----CYLINDER-----NOZZLE-----

SA-333-6	SA-105
OPER STRS= 17100.0 psi	OPER STRS= 20000.0 psi
ATM STRS = 17100.0 psi	ATM STRS = 20000.0 psi
C.A. = 0.06250"	C.A. = 0.06250"
I.D. = 12.08550"	I.D. = 4.00000"
O.D. = 14.00000"	O.D. = 6.25000"
THK. = 0.95725"	THK. = 1.12500"
T = 0.89475"	TN = 1.06250"
TR = 0.79519"	TRN = 0.22350"
ET = 0.09956"	ETN = 0.83900"

MIN STD. WT. PIPE+C.A.= 0.26987" TR+C.A.= 0.85769"
 LIMITS= 8.25000"
 fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000 F= 1.00000
 Min weld sizes:NS= 0.3536" NP= 0.0000" PS= 0.0000" IF= 0.0000"

AREA REQD. A = 3.28015in²
 EXCESS IN CYL. A1= 0.41069in²
 EXCESS IN NOZ. (OUTSIDE) A2= 3.75346in² H = 2.23688"
 AREA OF FILLETS = 0.14062in²
 AREA AVAILABLE = 4.30477in²

NOZ. NECK WELD= 0.37500" AREA= 0.14062in²

< AREA REQD-AREA AVAILABLE > = -1.02462in²

MAWP N-C= 2591.0psig LIMITED BY AR
 MAWP COR= 2321.0psig LIMITED BY AR

Skid 2 relocated from
 UOPR Job 488 to 447

Item No: E-202
 Job No : 18S-3450

By: SK P.O. No: 4500801009
 2/15/18 Page 6

CERTIFIED
 AS BUILT

ASME SEC.VIII DIV.1 APPENDIX 2			Front chan to tubesheet flange		
DESIGN CONDITIONS			GASKET and BOLTING CALCULATIONS		TABLE
Design Pres=	1100.0 psig	Eff.Gsk OD=	14.1250"	No.Passes=	1
Neg. Pres=	None	Eff.Gsk ID=	13.3750"	N=	0.375"
Design Temp=	150 deg.F	THK=	0.1570"	col.=	1
Flg Matl=	SA-105	Gsk Matl=	304 GMGC	y=	10100psi
Bolt Matl=	SA-193B7	Gsk Face=	FLAT FACE	w=	0.0000"
Corr Allow=	0.0625"	Wm2=	81804 #	Am =	9.5627in ²
Flange Desn Sfo	20000.0 psi	Hp =	75729 #	Ab =	9.6640in ²
Atm. Sfa	20000.0 psi	H =	163338 #	W =	240333 #
Bolting Desn Sb	25000.0 psi	Wm1=	239067 #	Wm1=	239067 #
Atm. Sa	25000.0 psi	Gasket Width Check	Nmin =	0.2769"	
CONDITION	LOAD	x	LEVER ARM	=	MOMENT
	HD =	144604 #	hD=	2.06250"	MD= 298247 in#
Operating	HG =	75729 #	hG=	2.06250"	MG= 156192 in#
	HT =	18733 #	hT=	2.26562"	MT= 42442 in#
					Mo= 496882 in#
Gasket					
Seating	HG =	240333 #	hG=	2.06250"	mo= 495688 in#
Allow.Stress-STRESS CALCULATIONS-Operating			SHAPE CONSTANTS		
1.5 Sfo&2.5 Sno Long Hub,SH	24404.8 psi	K	=	1.5072	h/ho= 0.4768
Sfo Radial Flg,SR	5171.8 psi	T	=	1.7075	F = 0.8501
Sfo Tang Flg,ST	15384.5 psi	Z	=	2.5726	V = 0.3110
Sfo .5 (SH+SR) or .5 (SH+ST)	19894.7 psi	Y	=	4.9051	f = 1.0000
J(APP.2-14)=	0.5279	U	=	5.3902	e = 0.3243in ⁻¹
Allow.Stress-STRESS CALCULATIONS-Gsk.Seating		g1/go=	1.5293	d =	12.829In ³
1.5 Sfa&2.5 Sna Long Hub,SH	24346.2 psi	ho =	2.6218"		
Sfa Radial Flg,SR	5159.3 psi	OTHER STRESS FORMULA FACTORS			
Sfa Tang Flg,ST	15347.5 psi				
Sfa .5 (SH+SR) or .5 (SH+ST)	19846.9 psi				
J(APP.2-14)=	0.5200				
O.D.	=	19.5000"	THK.	=	2.7500"
I.D.	=	12.8125"	T-Adder	=	0.0000"
GO	=	0.5938"	G1	=	0.8750"
HUB O.D.	=	14.5625"	HUB LEN	=	1.2500"
HUB ANG	=	12.6782deg	RIB LENGTH	=	0.0000"
G (MEAN)	=	13.7500"	G (CALC)	=	13.7500"
G (MIN.)	=	13.7500"	G (MAX.)	=	16.1250"
B.C.	=	17.8750"	B.S.C.F.	=	1.0000
No. BOLTS	=	32	BOLT DIAMETER	=	0.7500"
R	=	1.6562"	E	=	0.8125"
BOLT SPAC	=	1.7521"	TORQUE	=	134ft#
MIN. SPAC	=	1.7500"	TEMA MAX. SPAC	=	4.7368"
FLG TURN	=	0.1875"	FACING	=	RECESS
BPRIME	=	0.0000"	BG1	=	16.2500"
FLG RWT	=	192Lbs	FLG FWT	=	137Lbs

Item No: E-202

P.O. No: 4500801009

Job No : 18S-3450

By: SK

2/15/18

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CERTIFIED
AS BUILT

MAIN FLG IS FLANGE MARK # 3
COMP FLG IS FLANGE MARK # 7

/// INDIVIDUAL COMPONENTS ///

MAWP CORR. MAIN FLG = 1105.0 Limited by: Flange stress.
MAWP CORR. COMP FLG = 0.0
MAWP CORR. COVER = 0.0
MAWP CORR. T.S. [STD DIA] TEMA= 0.0

MAWP N-C MAIN FLG = 1111.0 Limited by: Minimum bolting area Am.
MAWP N-C COMP FLG = 0.0
MAWP N-C COVER = 0.0
MAWP N-C T.S. [STD DIA] TEMA= 0.0

/// AS MATING FLANGES (NO VACCUUM INCLUDED) ///

MAWP CORR. MAIN FLG = 0.0
MAWP CORR. COMP FLG = 0.0

MAWP N-C MAIN FLG = 0.0
MAWP N-C COMP FLG = 0.0

NOTE: TEMA TUBESHEETS NOT CONSIDERED.

Skid 2 relocated from
UOPR Job 488 to 447

Item No: E-202
Job No : 18S-3450

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(FTS) Configuration b

No or EPC=Elastic-Plastic Calcs SSC=Simply Supported Calcs =SSC
 MT Tubes =SA-214 MT Tubesheets =SA-350LF2CL1
 MT Channel =SA-234WPB MT Shell =SA-333-6
 Diameter (Do) = 11.4375" Pass Lane Area (AL) = 0.000in²
 Perimeter of layout (CP) = 35.9319" Area enclosed by CP (AP) = 102.743in²
 Tubesheet thickness (h) = 4.1250" Tubesheet thickness HOLD = NO
 Tube Pitch (p) = 0.9375" Pitch type = Rot Triangle (30 Deg)
 Diameter of tube (dt) = 0.7500" Tube thickness (tt) = 0.0830"
 Exp length of tube (ltx) = 4.0000" Exp depth ratio (Rho) = 0.9844
 Groove channel side (hg) = 0.0000" Groove shell side = 0.0000"
 Channel I.D. (Dc) = 12.8120" Channel thickness (Tc) = 0.5940"
 Shell I.D. (Ds) = 11.8120" Shell thickness (Ts) = 1.0940"
 TS outside diameter (A) = 11.6870" Bolt circle (C) = 17.8750"
 G Channel side (Gc or G1) = 13.7500" G Shell side (Gs or G1) = 0.0000"
 Bolt load Chan side (Wc) = 240333.81# Bolt load Sh side (Ws) = 0.0#
 1.8*Sqrt(Dc*Tc) = 0.0000" 1.8*Sqrt(Ds*(Ts or Ts1)) = 0.0000"
 Thickness at Top TS (tr) = 3.6250" Outer Tube Circle = 11.4375"
 hr Ch Wm1 = 239067.6# hr Ch W = 240333.8#
 hr Sh Wm1 = 0.0# hr Sh W = 0.0#
 hr Ch Op= 1.8457" Ch Atm= 1.8506" Sh Op= 0.0000" Sh Atm= 0.0000"
 DE Stationary Tubesheet = 0.0" DE Floating Tubesheet = 0.0"
 Tubes welded Backside TS =NO Hole Size in Tubesheet = 0.0000"
 Radial Differential Thermal Expansion Adjacent to Tubesheet = NO

Design Press Chan (Pt) = 1100.0psig Design Press Shell (Ps) = 2035.0psig
 Design Temp Chan = 150.0deg Design Temp Shell = 200.0deg.
 Corr Chan = 0.06250" Corr Shell = 0.06250"
 Corr Chan side TS (ct) = 0.06250" Corr Shell side TS (cs) = 0.06250"
 Number Tubes (Nt) = 103.00 F-F Tubesheets (Lt) = 311.7500"
 Un-supported Tube Span (l) = 28.87500" Support Constant (k) = 1.00000
 Expansion Joint = None Exp Joint I.D. = 0.00000"
 Spring Rate Corr (Kj) = 0.# Spring Rate Un-Corr (Kjn) = 0.#
 MT Thickened Shl = Thk Thickened Shl (Ts1) = 0.00000"
 Len Thickened Shl (l11) = 0.00000" Len Thickened Shl (l11') = 0.00000"

Calculate/Conservative For Ps* and Pc* = Calculated values for Ps* and Pc*

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(FTS) Configuration b

Tube sheet Thickness (h)	=	4.0000"	F-F Inside Tubesheets (L)	=	303.6250"
F-F Tubesheets (Lt)	=	311.6250"	Exp depth ratio (Rho)	=	0.9844"
Exp length of tube (ltx)	=	3.9375"	Channel thickness (Tc)	=	0.5315"
Channel I.D. (Dc)	=	12.9370"	Shell thickness (Ts)	=	1.0315"
Shell I.D. (Ds)	=	11.9370"	Area enclosed by CP (AP)	=	102.743in ²
Perimeter of layout (CP)	=	35.9319"	Press Shell (Ps)	=	0.0psi
Press Chan (Pt)	=	1100.0psi	Corr Shell	=	0.06250"
Corr Chan	=	0.06250"	Corr Shell side TS (cs)	=	0.06250"
Corr Chan side TS (ct)	=	0.06250"			

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps =	66000p
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spssc =	65800p
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss =	64199p

Mu = 0.2000	d* = 0.6569"	P* = 0.93750"	Mu* = 0.2994	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 239067.6406#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.043672204	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 3958561.250Lb/In	Kt	= 16382.58008Lb/In	
Ks,t	= 2.345945120	j	= 1.000000000	Beta s	= 0.497022629in ⁻¹	
Kappa s	= 2857309.250#	Lambda s	= 15873967.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.266666889	
E*	= 8016612.000psi	v*	= 0.354272366	Xa	= 0.920697391	
Zd	= 2.839426756	Zv	= 0.183246866	Zm	= 0.734357238	
K	= 1.021814227	F	= 1.328340292	Phi	= 1.798934579	
Q1	= -0.123209588	Qz1	= 1.012048244	Qz2	= 0.033329681	
U	= 0.066659369	Gamma	= 0.0"	Omega s	= 4.545748234in ²	
Omega c	= 0.0in ²	Omega s*	= -4.513879776in ²	Omega c*	= 3.328054428in ²	
Delta s	= 0.000001030In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 0.0psi	Pt'	= 1450.738770psi	P Gamma	= 0.0psi	
PW	= 27.97001648psi	Prim	= 7.461773872psi	Es,w	= 1.000000000	
Pe	= -983.0082397psi	Q2	= -7489.410645#	Q3	= 0.342717826	
Fm	= 0.376580238	Es,w1	= 0.0	lt	= 0.0"	
Rt	= 0.0"	Et	= 0.0	Ct	= 0.0	
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.953646839	
Sigmat,1	= 761.8350220psi	Sigmat,2	= 1261.108765psi	Ft,max	= 1.042203307	
Sigma s,m	= 286.0211182psi	Sigma s,b	= -26416.72266psi	Sigma s	= 26702.74414psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (No)

/// Sigma per Simply Supported Calculations ///

Betas, Kappas, Lambdas, Deltas, Omegas = 0	Betac, Kappac, Lambdac, Deltac, Omegac = 0		
F = 0.049713001	Phi = 0.067324936	Q1 = 0.029858880	
Qz1 = 1.022125840	Qz2 = 0.073715679	U = 0.147431359	
Omega s* = 0.031868652in ²	Omega c* = 3.328054428in ²	Prim = 16.50329781psi	
Pe = -945.4132690psi	Q2 = -16564.42188#	Q3 = 1.101334691	
PW = 61.86163330psi	Fm = 0.750996649	Sigma = -29087 psi	
Sigma	-29087 psi	<= 1.5S	30000 psi [OK Per Simply Sup]
Tau	-3513 psi	<= .8S	16000 psi [OK]
Sigmat,max	1261 psi	< St	11400 psi [OK]
Sigma s	26702 psi	<= Spss	64199 psi [OK Per Simply Sup]
Sigmat,m	286 psi	<= SsEs,w	17100 psi [OK]
			] Step 10

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(FTS) Configuration b

Tubesheet Thickness (h)	=	4.0000"	F-F Inside Tubesheets (L)	=	303.6250"
F-F Tubesheets (Lt)	=	311.6250"	Exp depth ratio (Rho)	=	0.9844"
Exp length of tube (ltx)	=	3.9375"	Channel thickness (Tc)	=	0.5315"
Channel I.D. (Dc)	=	12.9370"	Shell thickness (Ts)	=	1.0315"
Shell I.D. (Ds)	=	11.9370"	Area enclosed by CP (AP)	=	102.743in ²
Perimeter of layout (CP)	=	35.9319"	Press Shell (Ps)	=	2035.0psi
Press Chan (Pt)	=	0.0psi	Corr Shell	=	0.06250"
Corr Chan	=	0.06250"	Corr Shell side TS (cs)	=	0.06250"
Corr Chan side TS (ct)	=	0.06250"			

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Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps = 66000p	
Temp TBS Tt= 200deg.F	St = 11400psi	Syt= 23800psi	Et = 28.6000psi	Vt=.300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc= 150deg.F	Sc = 17100psi	Syc= 32900psi	Ec = 28.8308psi	Vc=.300	Spssc= 65800p	
Temp SH Ts= 200deg.F	Ss = 17100psi	Sys= 32099psi	Es = 28.6000psi	Vs=.300	Spss= 64199p	

Mu=0.2000	d*=0.6569"	P*=0.93750"	Mu*=0.2994	hg' = 0.0"	hgs' = 0.0"	hrDE= 0.0"
W*	= 0.0#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.043672204	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 3958561.250Lb/In	Kt	= 16382.58008Lb/In	
Ks,t	= 2.345945120	j	= 1.000000000	Beta s	= 0.497022629in ⁻¹	
Kappa s	= 2857309.250#	Lambda s	= 15873967.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.266666889	
E*	= 8016612.000psi	v*	= 0.354272366	Xa	= 0.920697391	
Zd	= 2.839426756	Zv	= 0.183246866	Zm	= 0.734357238	
K	= 1.021814227	F	= 1.328340292	Phi	= 1.798934579	
Q1	= -0.123209588	Qz1	= 1.012048244	Qz2	= 0.033329681	
U	= 0.066659369	Gamma	= 0.0"	Omega s	= 4.545748234in ²	
Omega c	= 0.0in ²	Omega s*	= -4.513879776in ²	Omega c*	= 3.328054428in ²	
Delta s	= 0.000001030In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 2163.989990psi	Pt'	= 0.0psi	P Gamma	= 0.0psi	
PW	= 0.0psi	Prim	= 18.72291183psi	Es,w	= 1.000000000	
Pe	= 1516.013672psi	Q2	= -3957.563721#	Q3	= -0.282853574	
Fm	= 0.140031204	Es,w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Et	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft,min	= 0.994730353	
Sigmat,1	= -2146.801514psi	Sigmat,2	= -2209.736328psi	Ft,max	= 1.001968503	
Sigma s,m	= 4150.391602psi	Sigma s,b	= 12366.73730psi	Sigma s	= 16517.12891psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (No)

/// Sigma per Simply Supported Calculations ///

Betas, Kappas, Lambdas, Deltas, Omegas=0	Betac, Kappac, Lambdac, Deltac, Omegac=0
F = 0.049713001	Phi = 0.067324936
Qz1 = 1.022125840	Qz2 = 0.073715679
Omega s* = 0.031868652in ²	Omega c* = 3.328054428in ²
Pe = 1490.547607psi	Q2 = 61.79740906#
PW = 0.0psi	Fm = 0.223419666
Sigma = 13643 psi	Sigma = 13643 psi
Tau = 5418 psi	Org.Sigma = 8697 ps
Sigmat,max = 2209 psi	
Sigmat,min = -2209 psi	
Sigma s = 16517 psi	
Sigmat,m = 4150 psi	

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(FTS) Configuration b

Tubesheet Thickness (h)	=	4.0000"	F-F Inside Tubesheets (L)	=	303.6250"
F-F Tubesheets (Lt)	=	311.6250"	Exp depth ratio (Rho)	=	0.9844"
Exp length of tube (ltx)	=	3.9375"	Channel thickness (Tc)	=	0.5315"
Channel I.D. (Dc)	=	12.9370"	Shell thickness (Ts)	=	1.0315"
Shell I.D. (Ds)	=	11.9370"	Area enclosed by CP (AP)	=	102.743in ²
Perimeter of layout (CP)	=	35.9319"	Press Shell (Ps)	=	2035.0psi
Press Chan (Pt)	=	1100.0psi	Corr Shell	=	0.06250"
Corr Chan	=	0.06250"	Corr Shell side TS (cs)	=	0.06250"
Corr Chan side TS (ct)	=	0.06250"			

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps = 66000p	
Temp TBS Tt= 200deg.F	St = 11400psi	Syt= 23800psi	Et = 28.6000psi	Vt=.300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc= 150deg.F	Sc = 17100psi	Syc= 32900psi	Ec = 28.8308psi	Vc=.300	Spssc= 65800p	
Temp SH Ts= 200deg.F	Ss = 17100psi	Sys= 32099psi	Es = 28.6000psi	Vs=.300	Spss= 64199p	

Mu=0.2000	d*=0.6569"	P*=0.93750"	Mu*=0.2994	hg' = 0.0"	hgs' = 0.0"	hrDE= 0.0"
W*	= 239067.6406#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.043672204	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 3958561.250Lb/In	Kt	= 16382.58008Lb/In	
Ks,t	= 2.345945120	j	= 1.000000000	Beta s	= 0.497022629in ⁻¹	
Kappa s	= 2857309.250#	Lambda s	= 15873967.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.266666889	
E*	= 8016612.000psi	v*	= 0.354272366	Xa	= 0.920697391	
Zd	= 2.839426756	Zv	= 0.183246866	Zm	= 0.734357238	
K	= 1.021814227	F	= 1.328340292	Phi	= 1.798934579	
Q1	= -0.123209588	Qz1	= 1.012048244	Qz2	= 0.033329681	
U	= 0.066659369	Gamma	= 0.0"	Omega s	= 4.545748234in ²	
Omega c	= 0.0in ²	Omega s*	= -4.513879776in ²	Omega c*	= 3.328054428in ²	
Delta s	= 0.000001030In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 2163.989990psi	Pt'	= 1450.738770psi	P Gamma	= 0.0psi	
PW	= 27.97001648psi	Prim	= 26.18468475psi	Es,w	= 1.000000000	
Pe	= 533.0054321psi	Q2	= -11446.97461#	Q3	= -1.436578870	
Fm	= 0.716900289	Es,w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft,min	= 0.926620841	
Sigmat,1	= -945.1315918psi	Sigmat,2	= -1384.966797psi	Ft,max	= 1.070499778	
Sigma s,m	= 4436.412598psi	Sigma s,b	= -14049.98535psi	Sigma s	= 18486.39844psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (No)

/// Sigma per Simply Supported Calculations ///

Betas, Kappas, Lambdas, Deltas, Omegas=0			Betac, Kappac, Lambdac, Deltac, Omegac=0		
F	= 0.049713001	Phi	= 0.067324936	Q1	= 0.029858880
Qz1	= 1.022125840	Qz2	= 0.073715679	U	= 0.147431359
Omega s*	= 0.031868652in^2	Omega c*	= 3.328054428in^2	Prim	= 16.21093941psi
Pe	= 545.1342773psi	Q2	= -16502.62500#	Q3	= -1.821443319
PW	= 61.86163330psi	Fm	= 0.909334660	Sigma	= 20308 psi
Sigma	20308 psi	<= 1.5S	30000 psi	[OK Per Simply Sup]	Org.Sigma = 15654 ps
Tau	1905 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	1384 psi	< St	11400 psi	[OK	]
Sigmat,min	-1384 psi	<= Stb	7205 psi	[OK	]
Sigma s	18486 psi	<= Spss	64199 psi	[OK Per Simply Sup]	
Sigmat,m	4436 psi	<= SsEs,w	17100 psi	[OK	] Step 10

(FTS) Configuration b

Tube sheet Thickness (h)	=	4.0000"	F-F Inside Tubesheets (L)	=	303.6250"
F-F Tubesheets (Lt)	=	311.6250"	Exp depth ratio (Rho)	=	0.9844"
Exp length of tube (ltx)	=	3.9375"	Channel thickness (Tc)	=	0.5315"
Channel I.D. (Dc)	=	12.9370"	Shell thickness (Ts)	=	1.0315"
Shell I.D. (Ds)	=	11.9370"	Area enclosed by CP (AP)	=	102.743in ²
Perimeter of layout (CP)	=	35.9319"	Press Shell (Ps)	=	0.0psi
Press Chan (Pt)	=	1100.0psi	Corr Shell	=	0.06250"
Corr Chan	=	0.06250"	Corr Shell side TS (cs)	=	0.06250"
Corr Chan side TS (ct)	=	0.06250"			

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps = 66000p	
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spssc = 65800p	
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss = 64199p	
Tt, m	= 94deg.F			At, m = 6.4800In/In		
Ts, m	= 80deg.F			As, m = 6.4333In/In		

Mu = 0.2000	d* = 0.6569"	P* = 0.93750"	Mu* = 0.2994	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 240333.8125#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.043672204	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 3958561.250Lb/In	Kt	= 16382.58008Lb/In	
Ks, t	= 2.345945120	j	= 1.000000000	Beta s	= 0.497022629in ⁻¹	
Kappa s	= 2857309.250#	Lambda s	= 15873967.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.266666889	
E*	= 8016612.000psi	v*	= 0.354272366	Xa	= 0.920697391	
Zd	= 2.839426756	Zv	= 0.183246866	Zm	= 0.734357238	
K	= 1.021814227	F	= 1.328340292	Phi	= 1.798934579	
Q1	= -0.123209588	Qz1	= 1.012048244	Qz2	= 0.033329681	
U	= 0.066659369	Gamma	= 0.027686549"	Omega s	= 4.545748234in ²	
Omega c	= 0.0in ²	Omega s*	= -4.513879776in ²	Omega c*	= 3.328054428in ²	
Delta s	= 0.000001030In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 0.0psi	Pt'	= 1450.738770psi	P Gamma	= 454.7118530psi	
PW	= 28.11815453psi	Prim	= 7.461773872psi	Es, w	= 1.000000000	
Pe	= -667.0830688psi	Q2	= -7520.723145#	Q3	= 0.566247821	
Fm	= 0.486903787	Es, w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft, min	= 0.938966811	
Sigmat, 1	= -1022.287598psi	Sigmat, 2	= -571.7536621psi	Ft, max	= 1.056723714	
Sigma s, m	= 1058.394775psi	Sigma s, b	= -25089.35742psi	Sigma s	= 26147.75195psi	
Sigma c, m	= 0.0psi	Sigma c, b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	-13306 psi	<= Sps	66000 psi	[OK	]
Tau	-2384 psi	<= .8S	16000 psi	[OK	]
Sigmat, max	1022 psi	<= 2St	22800 psi	[OK	]
Sigmat, min	-1022 psi	<= Stb	7205 psi	[OK	]
Sigma s	26147 psi	<= Spss	64199 psi	[OK	]
Sigmat, m	1058 psi	<= Spss	64199 psi	[OK	] Step 10

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(FTS) Configuration b

Tube sheet Thickness (h)	=	4.0000"	F-F Inside Tubesheets (L)	=	303.6250"
F-F Tubesheets (Lt)	=	311.6250"	Exp depth ratio (Rho)	=	0.9844"
Exp length of tube (ltx)	=	3.9375"	Channel thickness (Tc)	=	0.5315"
Channel I.D. (Dc)	=	12.9370"	Shell thickness (Ts)	=	1.0315"
Shell I.D. (Ds)	=	11.9370"	Area enclosed by CP (AP)	=	102.743in ²
Perimeter of layout (CP)	=	35.9319"	Press Shell (Ps)	=	2035.0psi
Press Chan (Pt)	=	0.0psi	Corr Shell	=	0.06250"
Corr Chan	=	0.06250"	Corr Shell side TS (cs)	=	0.06250"
Corr Chan side TS (ct)	=	0.06250"			

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps =	66000p
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spss =	65800p
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss =	64199p
Tt, m	= 94deg.F			At, m =	6.4800In/In	
Ts, m	= 80deg.F			As, m =	6.4333In/In	

Mu = 0.2000	d* = 0.6569"	P* = 0.93750"	Mu* = 0.2994	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 240333.8125#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.043672204	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 3958561.250Lb/In	Kt	= 16382.58008Lb/In	
Ks, t	= 2.345945120	j	= 1.000000000	Beta s	= 0.497022629in ⁻¹	
Kappa s	= 2857309.250#	Lambda s	= 15873967.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.266666889	
E*	= 8016612.000psi	v*	= 0.354272366	Xa	= 0.920697391	
Zd	= 2.839426756	Zv	= 0.183246866	Zm	= 0.734357238	
K	= 1.021814227	F	= 1.328340292	Phi	= 1.798934579	
Q1	= -0.123209588	Qz1	= 1.012048244	Qz2	= 0.033329681	
U	= 0.066659369	Gamma	= 0.027686549"	Omega s	= 4.545748234in ²	
Omega c	= 0.0in ²	Omega s*	= -4.513879776in ²	Omega c*	= 3.328054428in ²	
Delta s	= 0.000001030In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 2163.989990psi	Pt'	= 0.0psi	P Gamma	= 454.7118530psi	
PW	= 28.11815453psi	Prim	= 18.72291183psi	Es, w	= 1.000000000	
Pe	= 1851.365601psi	Q2	= -9901.050781#	Q3	= -0.450261623	
Fm	= 0.223736167	Es, w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft, min	= 0.990691662	
Sigmat, 1	= -4017.148438psi	Sigmat, 2	= -4176.772949psi	Ft, max	= 1.005724669	
Sigma s, m	= 4970.259766psi	Sigma s, b	= -2535.446533psi	Sigma s	= 7505.706055psi	
Sigma c, m	= 0.0psi	Sigma c, b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	16969 psi	<= Sps	66000 psi	[OK]	
Tau	6617 psi	<= .8S	16000 psi	[OK]	
Sigmat, max	4176 psi	<= 2St	22800 psi	[OK]	
Sigmat, min	-4176 psi	<= Stb	7205 psi	[OK]	
Sigma s	7505 psi	<= Spss	64199 psi	[OK]	
Sigmat, m	4970 psi	<= Spss	64199 psi	[OK]	Step 10

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AS BUILT

(FTS) Configuration b

Tube sheet Thickness (h)	=	4.0000"		
F-F Tubesheets (Lt)	=	311.6250"	F-F Inside Tubesheets (L)	= 303.6250"
Exp length of tube (ltx)	=	3.9375"	Exp depth ratio (Rho)	= 0.9844"
Channel I.D. (Dc)	=	12.9370"	Channel thickness (Tc)	= 0.5315"
Shell I.D. (Ds)	=	11.9370"	Shell thickness (Ts)	= 1.0315"
Perimeter of layout (CP)	=	35.9319"	Area enclosed by CP (AP)	= 102.743in ²
Press Chan (Pt)	=	1100.0psi	Press Shell (Ps)	= 2035.0psi
Corr Chan	=	0.06250"	Corr Shell	= 0.06250"
Corr Chan side TS (ct)	=	0.06250"	Corr Shell side TS (cs)	= 0.06250"

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps = 66000p	
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spssc = 65800p	
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss = 64199p	
Tt, m	= 94deg.F			At, m = 6.4800In/In		
Ts, m	= 80deg.F			As, m = 6.4333In/In		

Mu = 0.2000	d* = 0.6569"	P* = 0.93750"	Mu* = 0.2994	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 240333.8125#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.043672204	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 3958561.250Lb/In	Kt	= 16382.58008Lb/In	
Ks, t	= 2.345945120	j	= 1.000000000	Beta s	= 0.497022629in ⁻¹	
Kappa s	= 2857309.250#	Lambda s	= 15873967.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.266666889	
E*	= 8016612.000psi	v*	= 0.354272366	Xa	= 0.920697391	
Zd	= 2.839426756	Zv	= 0.183246866	Zm	= 0.734357238	
K	= 1.021814227	F	= 1.328340292	Phi	= 1.798934579	
Q1	= -0.123209588	Qz1	= 1.012048244	Qz2	= 0.033329681	
U	= 0.066659369	Gamma	= 0.027686549"	Omega s	= 4.545748234in ²	
Omega c	= 0.0in ²	Omega s*	= -4.513879776in ²	Omega c*	= 3.328054428in ²	
Delta s	= 0.000001030In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 2163.989990psi	Pt'	= 1450.738770psi	P Gamma	= 454.7118530psi	
PW	= 28.11815453psi	Prim	= 26.18468475psi	Es, w	= 1.000000000	
Pe	= 848.9306030psi	Q2	= -11478.28711#	Q3	= -0.950070918	
Fm	= 0.473643601	Es, w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft, min	= 0.958224237	
Sigmat, 1	= -2777.993896psi	Sigmat, 2	= -3169.089111psi	Ft, max	= 1.038548946	
Sigma s, m	= 5208.786133psi	Sigma s, b	= -12722.62012psi	Sigma s	= 17931.40625psi	
Sigma c, m	= 0.0psi	Sigma c, b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	16473 psi	<= Sps	66000 psi	[OK	]
Tau	3034 psi	<= .8S	16000 psi	[OK	]
Sigmat, max	3169 psi	<= 2St	22800 psi	[OK	]
Sigmat, min	-3169 psi	<= Stb	7205 psi	[OK	]
Sigma s	17931 psi	<= Spss	64199 psi	[OK	]
Sigmat, m	5208 psi	<= Spss	64199 psi	[OK	] Step 10

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AS BUILT

(FTS) Configuration b

Tube sheet Thickness (h)	=	4.0000"		
F-F Tubesheets (Lt)	=	311.6250"	F-F Inside Tubesheets (L)	= 303.6250"
Exp length of tube (ltx)	=	3.9375"	Exp depth ratio (Rho)	= 0.9844"
Channel I.D. (Dc)	=	12.9370"	Channel thickness (Tc)	= 0.5315"
Shell I.D. (Ds)	=	11.9370"	Shell thickness (Ts)	= 1.0315"
Perimeter of layout (CP)	=	35.9319"	Area enclosed by CP (AP)	= 102.743in ²
Press Chan (Pt)	=	0.0psi	Press Shell (Ps)	= 0.0psi
Corr Chan	=	0.06250"	Corr Shell	= 0.06250"
Corr Chan side TS (ct)	=	0.06250"	Corr Shell side TS (cs)	= 0.06250"

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps = 66000p	
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spssc = 65800p	
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss = 64199p	
Tt, m	= 94deg.F			At, m = 6.4800In/In		
Ts, m	= 80deg.F			As, m = 6.4333In/In		

Mu = 0.2000	d* = 0.6569"	P* = 0.93750"	Mu* = 0.2994	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 240333.8125#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.043672204	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 3958561.250Lb/In	Kt	= 16382.58008Lb/In	
Ks, t	= 2.345945120	j	= 1.000000000	Beta s	= 0.497022629in ⁻¹	
Kappa s	= 2857309.250#	Lambda s	= 15873967.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.266666889	
E*	= 8016612.000psi	v*	= 0.354272366	Xa	= 0.920697391	
Zd	= 2.839426756	Zv	= 0.183246866	Zm	= 0.734357238	
K	= 1.021814227	F	= 1.328340292	Phi	= 1.798934579	
Q1	= -0.123209588	Qz1	= 1.012048244	Qz2	= 0.033329681	
U	= 0.066659369	Gamma	= 0.027686549"	Omega s	= 4.545748234in ²	
Omega c	= 0.0in ²	Omega s*	= -4.513879776in ²	Omega c*	= 3.328054428in ²	
Delta s	= 0.000001030In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 0.0psi	Pt'	= 0.0psi	P Gamma	= 454.7118530psi	
PW	= 28.11815453psi	Prim	= 0.0psi	Es, w	= 1.000000000	
Pe	= 335.3518982psi	Q2	= -5943.487305#	Q3	= -1.207057476	
Fm	= 0.602138281	Es, w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft, min	= 0.941530466	
Sigmat, 1	= -1810.907837psi	Sigmat, 2	= -2029.971191psi	Ft, max	= 1.055426240	
Sigma s, m	= 819.8681641psi	Sigma s, b	= -14902.18457psi	Sigma s	= 15722.05273psi	
Sigma c, m	= 0.0psi	Sigma c, b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	8272 psi	<= Sps	66000 psi	[OK	]
Tau	1198 psi	<= .8S	16000 psi	[OK	]
Sigmat, max	2029 psi	<= 2St	22800 psi	[OK	]
Sigmat, min	-2029 psi	<= Stb	7205 psi	[OK	]
Sigma s	15722 psi	<= Spss	64199 psi	[OK	]
Sigmat, m	819 psi	<= Spss	64199 psi	[OK	] Step 10

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AS BUILT

Tubesheet Thickness (h)	=	4.1250"
F-F Tubesheets (Lt)	=	311.7500"
Exp length of tube (ltx)	=	4.0000"
Channel I.D. (Dc)	=	12.8120"
Shell I.D. (Ds)	=	11.8120"
Perimeter of layout (CP)	=	35.9319"
Press Chan (Pt)	=	1100.0psi
Corr Chan	=	0.00000"
Corr Chan side TS (ct)	=	0.00000"

F-F Inside Tubesheets (L)	=	303.5000"
Exp depth ratio (Rho)	=	0.9844"
Channel thickness (Tc)	=	0.5940"
Shell thickness (Ts)	=	1.0940"
Area enclosed by CP (AP)	=	102.743in^2
Press Shell (Ps)	=	0.0psi
Corr Shell	=	0.00000"
Corr Shell side TS (cs)	=	0.00000"

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Temp		Stress		Yield		Modulus	Coef	Poisson	Prim Plus
						x10 ⁶	x10 ⁻⁶	Ratio	Stress
Temp	TS	T = 200deg.F	S = 20000psi	Sy =	33000psi	E =28.6000psi		V =.300	Sps = 66000p
Temp	TBS	Tt= 200deg.F	St = 11400psi	Syt=	23800psi	Et =28.6000psi		Vt=.300	
Temp	TBS	T = 200deg.F	St = 11400psi			Et =28.6000psi			
Temp	CH	Tc= 150deg.F	Sc = 17100psi	Syc=	32900psi	Ec =28.8308psi		Vc=.300	Spssc= 65800p
Temp	SH	Ts= 200deg.F	Ss = 17100psi	Sys=	32099psi	Es =28.6000psi		Vs=.300	Spss= 64199p

W*	= 239067.6406#	wj	= 0.0"	ao	= 5.718750000"
Rho s	= 1.032743216	Rho c	= 1.202185750	Chi s	= 0.557108343
Chi t	= 0.731465101	Ks	= 4179903.000Lb/In	Kt	= 16389.32812Lb/In
Ks,t	= 2.476098061	j	= 1.000000000	Beta s	= 0.483783633in ⁻¹
Kappa s	= 3318001.000#	Lambda s	= 16707216.00psi	Beta c	= 0.0in ⁻¹
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.400000095
E*	= 7961110.000psi	v*	= 0.355301291	Xa	= 0.901160777
Zd	= 3.088754416	Zv	= 0.183218822	Zm	= 0.734132349
K	= 1.021814227	F	= 1.402946949	Phi	= 1.901415825
Q1	= -0.131738871	Qz1	= 1.010544300	Qz2	= 0.028524671
U	= 0.057049341	Gamma	= 0.0"	Omega s	= 4.705734730in ²
Omega c	= 0.0in ²	Omega s*	= -4.687916279in ²	Omega c*	= 3.506765842in ²
Delta s	= 0.000000950In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725
Ps'	= 0.0psi	Pt'	= 1426.092041psi	P Gamma	= 0.0psi
PW	= 23.93768311psi	Prim	= 6.728958130psi	Es,w	= 1.000000000
Pe	= -985.9298096psi	Q2	= -7337.545410#	Q3	= 0.323388100
Fm	= 0.367455512	Es,w1	= 0.0	lt	= 0.0"
Rt	= 0.0"	Ft	= 0.0	Ct	= 0.0
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.958616614
Sigmat,1	= 805.9170532psi	Sigmat,2	= 1255.036377psi	Ft,max	= 1.038041115
Sigma s,m	= 264.2196960psi	Sigma s,b	= -24313.73242psi	Sigma s	= 24577.95117psi
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi

Thermal Expansion Acting on this Case (No)

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/// Sigma per Simply Supported Calculations ///
```

Betas, Kappas, Lambdas, Deltas, Omegas=0 Betac, Kappac, Lambdac, Deltac, Omegac=0

F	= 0.049979810	Phi	= 0.067737713	Q1	= 0.019369191
Qz1	= 1.019673586	Qz2	= 0.065104447	U	= 0.130208895
Omega s*	= 0.017818350in^2	Omega c*	= 3.506765842in^2	Prim	= 15.35811424psi
Pe	=-951.2033081psi	Q2	=-16747.14844#	Q3	= 1.096070647
PW	= 54.63515472psi	Fm	= 0.749221802	Sigma	= -27590 psi
Sigma	-27590 psi	<= 1.5S	30000 psi	[OK Per Simply Sup]	Org.Sigma = -14025 ps
Tau	-3417 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	1255 psi	< St	11400 psi	[OK	]
Sigma s	24577 psi	<= Spss	64199 psi	[OK Per Simply Sup]	
Siqmas,m	264 psi	<=SsEs,w	17100 psi	[OK	] Step 10

(FTS) Configuration b

Tube sheet Thickness (h)	=	4.1250"	F-F Inside Tubesheets (L)	=	303.5000"
F-F Tubesheets (Lt)	=	311.7500"	Exp depth ratio (Rho)	=	0.9844"
Exp length of tube (ltx)	=	4.0000"	Channel thickness (Tc)	=	0.5940"
Channel I.D. (Dc)	=	12.8120"	Shell thickness (Ts)	=	1.0940"
Shell I.D. (Ds)	=	11.8120"	Area enclosed by CP (AP)	=	102.743in ²
Perimeter of layout (CP)	=	35.9319"	Press Shell (Ps)	=	2035.0psi
Press Chan (Pt)	=	0.0psi	Corr Shell	=	0.00000"
Corr Chan	=	0.00000"	Corr Shell side TS (cs)	=	0.00000"
Corr Chan side TS (ct)	=	0.00000"			

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AS BUILT

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps =	66000p
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spssc =	65800p
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss =	64199p

Mu = 0.2000	d* = 0.6582"	P* = 0.93750"	Mu* = 0.2979	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 0.0#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.032743216	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 4179903.000Lb/In	Kt	= 16389.32812Lb/In	
Ks,t	= 2.476098061	j	= 1.000000000	Beta s	= 0.483783633in ⁻¹	
Kappa s	= 3318001.000#	Lambda s	= 16707216.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.400000095	
E*	= 7961110.000psi	v*	= 0.355301291	Xa	= 0.901160777	
Zd	= 3.088754416	Zv	= 0.183218822	Zm	= 0.734132349	
K	= 1.021814227	F	= 1.402946949	Phi	= 1.901415825	
Q1	= -0.131738871	Qz1	= 1.010544300	Qz2	= 0.028524671	
U	= 0.057049341	Gamma	= 0.0"	Omega s	= 4.705734730in ²	
Omega c	= 0.0in ²	Omega s*	= -4.687916279in ²	Omega c*	= 3.506765842in ²	
Delta s	= 0.000000950In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 2145.720215psi	Pt'	= 0.0psi	P Gamma	= 0.0psi	
PW	= 0.0psi	Prim	= 16.64150620psi	Es,w	= 1.000000000	
Pe	= 1527.804199psi	Q2	= -3981.779785#	Q3	= -0.291120142	
Fm	= 0.145560071	Es,w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft,min	= 0.995657682	
Sigmat,1	= -2222.193848psi	Sigmat,2	= -2273.645264psi	Ft,max	= 1.001529455	
Sigma s,m	= 3852.573975psi	Sigma s,b	= 10879.87695psi	Sigma s	= 14732.45117psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (No)

/// Sigma per Simply Supported Calculations ///

Betas, Kappas, Lambdas, Deltas, Omegas = 0 Betac, Kappac, Lambdac, Deltac, Omegac = 0

F	= 0.049979810	Phi	= 0.067737713	Q1	= 0.019369191
Qz1	= 1.019673586	Qz2	= 0.065104447	U	= 0.130208895
Omega s*	= 0.017818350in ²	Omega c*	= 3.506765842in ²	Prim	= -0.144367769psi
Pe	= 1504.963257psi	Q2	= 34.54258728#	Q3	= 0.020772841
PW	= 0.0psi	Fm	= 0.217939645	Sigma	= 12698 psi
Sigma	12698 psi	<= 1.5S	30000 psi	[OK Per Simply Sup]	Org.Sigma = 8609 ps
Tau	5295 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	2273 psi	< St	11400 psi	[OK	]
Sigmat,min	-2273 psi	<= Stb	7205 psi	[OK	]
Sigma s	14732 psi	<= Spss	64199 psi	[OK Per Simply Sup]	
Sigmat,m	3852 psi	<= SsEs,w	17100 psi	[OK	] Step 10

(FTS) Configuration b

Tube sheet Thickness (h)	=	4.1250"	F-F Inside Tubesheets (L)	=	303.5000"
F-F Tubesheets (Lt)	=	311.7500"	Exp depth ratio (Rho)	=	0.9844"
Exp length of tube (ltx)	=	4.0000"	Channel thickness (Tc)	=	0.5940"
Channel I.D. (Dc)	=	12.8120"	Shell thickness (Ts)	=	1.0940"
Shell I.D. (Ds)	=	11.8120"	Area enclosed by CP (AP)	=	102.743in ²
Perimeter of layout (CP)	=	35.9319"	Press Shell (Ps)	=	2035.0psi
Press Chan (Pt)	=	1100.0psi	Corr Shell	=	0.00000"
Corr Chan	=	0.00000"	Corr Shell side TS (cs)	=	0.00000"
Corr Chan side TS (ct)	=	0.00000"			

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps = 66000p	
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spss = 65800p	
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss = 64199p	

Mu = 0.2000	d* = 0.6582"	P* = 0.93750"	Mu* = 0.2979	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 239067.6406#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.032743216	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 4179903.000Lb/In	Kt	= 16389.32812Lb/In	
Ks,t	= 2.476098061	j	= 1.000000000	Beta s	= 0.483783633in ⁻¹	
Kappa s	= 3318001.000#	Lambda s	= 16707216.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.400000095	
E*	= 7961110.000psi	v*	= 0.355301291	Xa	= 0.901160777	
Zd	= 3.088754416	Zv	= 0.183218822	Zm	= 0.734132349	
K	= 1.021814227	F	= 1.402946949	Phi	= 1.901415825	
Q1	= -0.131738871	Qz1	= 1.010544300	Qz2	= 0.028524671	
U	= 0.057049341	Gamma	= 0.0"	Omega s	= 4.705734730in ²	
Omega c	= 0.0in ²	Omega s*	= -4.687916279in ²	Omega c*	= 3.506765842in ²	
Delta s	= 0.000000950In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 2145.720215psi	Pt'	= 1426.092041psi	P Gamma	= 0.0psi	
PW	= 23.93768311psi	Prim	= 23.37046432psi	Es,w	= 1.000000000	
Pe	= 541.8744507psi	Q2	= -11319.32520#	Q3	= -1.409205675	
Fm	= 0.704602838	Es,w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft,min	= 0.933365464	
Sigmat,1	= -1013.227356psi	Sigmat,2	= -1416.276611psi	Ft,max	= 1.063053012	
Sigma s,m	= 4116.793945psi	Sigma s,b	= -13433.85449psi	Sigma s	= 17550.64844psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (No)

/// Sigma per Simply Supported Calculations ///

Betas, Kappas, Lambdas, Deltas, Omegas = 0 Betac, Kappac, Lambdac, Deltac, Omegac = 0

F	= 0.049979810	Phi	= 0.067737713	Q1	= 0.019369191
Qz1	= 1.019673586	Qz2	= 0.065104447	U	= 0.130208895
Omega s*	= 0.017818350in ²	Omega c*	= 3.506765842in ²	Prim	= 15.21374607psi
Pe	= 553.7600098psi	Q2	= -16712.60547#	Q3	= -1.826285005
PW	= 54.63515472psi	Fm	= 0.913142502	Sigma	= 19576 psi
Sigma	19576 psi	<= 1.5S	30000 psi	[OK Per Simply Sup]	Org.Sigma = 14781 ps
Tau	1878 psi	<= .8S	16000 psi	[OK	
Sigmat,max	1416 psi	< St	11400 psi	[OK	
Sigmat,min	-1416 psi	<= Stb	7205 psi	[OK	
Sigma s	17550 psi	<= Spss	64199 psi	[OK Per Simply Sup]	
Sigmatas,m	4116 psi	<= SsEs,w	17100 psi	[OK	] Step 10

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 AS BUILT

(FTS) Configuration b

Tube sheet Thickness (h)	=	4.1250"		
F-F Tubesheets (Lt)	=	311.7500"	F-F Inside Tubesheets (L)	= 303.5000"
Exp length of tube (ltx)	=	4.0000"	Exp depth ratio (Rho)	= 0.9844"
Channel I.D. (Dc)	=	12.8120"	Channel thickness (Tc)	= 0.5940"
Shell I.D. (Ds)	=	11.8120"	Shell thickness (Ts)	= 1.0940"
Perimeter of layout (CP)	=	35.9319"	Area enclosed by CP (AP)	= 102.743in ²
Press Chan (Pt)	=	1100.0psi	Press Shell (Ps)	= 0.0psi
Corr Chan	=	0.00000"	Corr Shell	= 0.00000"
Corr Chan side TS (ct)	=	0.00000"	Corr Shell side TS (cs)	= 0.00000"

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps = 66000p	
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spssc = 65800p	
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss = 64199p	
Tt, m	= 94deg.F			At, m = 6.4800In/In		
Ts, m	= 80deg.F			As, m = 6.4333In/In		

Mu = 0.2000	d* = 0.6582"	P* = 0.93750"	Mu* = 0.2979	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 240333.8125#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.032743216	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 4179903.000Lb/In	Kt	= 16389.32812Lb/In	
Ks, t	= 2.476098061	j	= 1.000000000	Beta s	= 0.483783633in ⁻¹	
Kappa s	= 3318001.000#	Lambda s	= 16707216.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.400000095	
E*	= 7961110.000psi	v*	= 0.355301291	Xa	= 0.901160777	
Zd	= 3.088754416	Zv	= 0.183218822	Zm	= 0.734132349	
K	= 1.021814227	F	= 1.402946949	Phi	= 1.901415825	
Q1	= -0.131738871	Qz1	= 1.010544300	Qz2	= 0.028524671	
U	= 0.057049341	Gamma	= 0.027675150"	Omega s	= 4.705734730in ²	
Omega c	= 0.0in ²	Omega s*	= -4.687916279in ²	Omega c*	= 3.506765842in ²	
Delta s	= 0.000000950In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 0.0psi	Pt'	= 1426.092041psi	P Gamma	= 454.7118835psi	
PW	= 24.06446457psi	Prim	= 6.728958130psi	Es, w	= 1.000000000	
Pe	= -664.5661621psi	Q2	= -7367.880371#	Q3	= 0.546264887	
Fm	= 0.477574289	Es, w1	= 0.0	lt	= 28.875000000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft, min	= 0.945182204	
Sigmat, 1	= -1012.151794psi	Sigmat, 2	= -606.8937988psi	Ft, max	= 1.051506400	
Sigma s, m	= 1008.591614psi	Sigma s, b	= -23143.22656psi	Sigma s	= 24151.81836psi	
Sigma c, m	= 0.0psi	Sigma c, b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	-12287 psi	<= Sps	66000 psi	[OK]	
Tau	-2303 psi	<= .8S	16000 psi	[OK]	
Sigmat, max	1012 psi	<= 2St	22800 psi	[OK]	
Sigmat, min	-1012 psi	<= Stb	7205 psi	[OK]	
Sigma s	24151 psi	<= Spss	64199 psi	[OK]	
Sigmat, m	1008 psi	<= Spss	64199 psi	[OK]	] Step 10

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(FTS) Configuration b

Tubesheet Thickness (h)	=	4.1250"	F-F Inside Tubesheets (L)	=	303.5000"
F-F Tubesheets (Lt)	=	311.7500"	Exp depth ratio (Rho)	=	0.9844"
Exp length of tube (ltx)	=	4.0000"	Channel thickness (Tc)	=	0.5940"
Channel I.D. (Dc)	=	12.8120"	Shell thickness (Ts)	=	1.0940"
Shell I.D. (Ds)	=	11.8120"	Area enclosed by CP (AP)	=	102.743in ²
Perimeter of layout (CP)	=	35.9319"	Press Shell (Ps)	=	2035.0psi
Press Chan (Pt)	=	0.0psi	Corr Shell	=	0.00000"
Corr Chan	=	0.00000"	Corr Shell side TS (cs)	=	0.00000"
Corr Chan side TS (ct)	=	0.00000"			

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps = 66000p	
Temp TBS Tt= 200deg.F	St = 11400psi	Syt= 23800psi	Et = 28.6000psi	Vt=.300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc= 150deg.F	Sc = 17100psi	Syc= 32900psi	Ec = 28.8308psi	Vc=.300	Spssc= 65800p	
Temp SH Ts= 200deg.F	Ss = 17100psi	Sys= 32099psi	Es = 28.6000psi	Vs=.300	Spss= 64199p	
Tt,m = 94deg.F				At,m= 6.4800In/In		
Ts,m = 80deg.F				As,m= 6.4333In/In		

Mu=0.2000	d*=0.6582"	P*=0.93750"	Mu*=0.2979	hg' = 0.0"	hgs' = 0.0"	hrDE= 0.0"
W*	= 240333.8125#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.032743216	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 4179903.000Lb/In	Kt	= 16389.32812Lb/In	
Ks,t	= 2.476098061	j	= 1.000000000	Beta s	= 0.483783633in ⁻¹	
Kappa s	= 3318001.000#	Lambda s	= 16707216.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.400000095	
E*	= 7961110.000psi	v*	= 0.355301291	Xa	= 0.901160777	
Zd	= 3.088754416	Zv	= 0.183218822	Zm	= 0.734132349	
K	= 1.021814227	F	= 1.402946949	Phi	= 1.901415825	
Q1	= -0.131738871	Qz1	= 1.010544300	Qz2	= 0.028524671	
U	= 0.057049341	Gamma	= 0.027675150"	Omega s	= 4.705734730in ²	
Omega c	= 0.0in ²	Omega s*	= -4.687916279in ²	Omega c*	= 3.506765842in ²	
Delta s	= 0.000000950In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 2145.720215psi	Pt'	= 0.0psi	P Gamma	= 454.7118835psi	
PW	= 24.06446457psi	Prim	= 16.64150620psi	Es,w	= 1.000000000	
Pe	= 1866.080933psi	Q2	= -9739.635742#	Q3	= -0.450922072	
Fm	= 0.225461036	Es,w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft,min	= 0.991260767	
Sigmat,1	= -4106.851562psi	Sigmat,2	= -4257.003418psi	Ft,max	= 1.005290151	
Sigma s,m	= 4636.121582psi	Sigma s,b	= -2877.802979psi	Sigma s	= 7513.924805psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	16288 psi	<= Sps	66000 psi	[OK	]
Tau	6467 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	4257 psi	<= 2St	22800 psi	[OK	]
Sigmat,min	-4257 psi	<= Stb	7205 psi	[OK	]
Sigma s	7513 psi	<= Spss	64199 psi	[OK	]
Sigmat,m	4636 psi	<= Spss	64199 psi	[OK	] Step 10

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(FTS) Configuration b

Tubesheet Thickness (h)	=	4.1250"		
F-F Tubesheets (Lt)	=	311.7500"	F-F Inside Tubesheets (L)	= 303.5000"
Exp length of tube (ltx)	=	4.0000"	Exp depth ratio (Rho)	= 0.9844"
Channel I.D. (Dc)	=	12.8120"	Channel thickness (Tc)	= 0.5940"
Shell I.D. (Ds)	=	11.8120"	Shell thickness (Ts)	= 1.0940"
Perimeter of layout (CP)	=	35.9319"	Area enclosed by CP (AP)	= 102.743in ²
Press Chan (Pt)	=	1100.0psi	Press Shell (Ps)	= 2035.0psi
Corr Chan	=	0.00000"	Corr Shell	= 0.00000"
Corr Chan side TS (ct)	=	0.00000"	Corr Shell side TS (cs)	= 0.00000"

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps = 66000p	
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spssc = 65800p	
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss = 64199p	
Tt, m	= 94deg.F			At, m = 6.4800In/In		
Ts, m	= 80deg.F			As, m = 6.4333In/In		

Mu = 0.2000	d* = 0.6582"	P* = 0.93750"	Mu* = 0.2979	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 240333.8125#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.032743216	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 4179903.000Lb/In	Kt	= 16389.32812Lb/In	
Ks, t	= 2.476098061	j	= 1.000000000	Beta s	= 0.483783633in ⁻¹	
Kappa s	= 3318001.000#	Lambda s	= 16707216.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.400000095	
E*	= 7961110.000psi	v*	= 0.355301291	Xa	= 0.901160777	
Zd	= 3.088754416	Zv	= 0.183218822	Zm	= 0.734132349	
K	= 1.021814227	F	= 1.402946949	Phi	= 1.901415825	
Q1	= -0.131738871	Qz1	= 1.010544300	Qz2	= 0.028524671	
U	= 0.057049341	Gamma	= 0.027675150"	Omega s	= 4.705734730in ²	
Omega c	= 0.0in ²	Omega s*	= -4.687916279in ²	Omega c*	= 3.506765842in ²	
Delta s	= 0.000000950In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 2145.720215psi	Pt'	= 1426.092041psi	P Gamma	= 454.7118835psi	
PW	= 24.06446457psi	Prim	= 23.37046432psi	Es, w	= 1.000000000	
Pe	= 863.2380981psi	Q2	= -11349.66016#	Q3	= -0.935783267	
Fm	= 0.467891634	Es, w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft, min	= 0.961967587	
Sigmat, 1	= -2875.157959psi	Sigmat, 2	= -3234.345703psi	Ft, max	= 1.034516335	
Sigma s, m	= 4861.166016psi	Sigma s, b	= -12263.35059psi	Sigma s	= 17124.51562psi	
Sigma c, m	= 0.0psi	Sigma c, b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	15637 psi	<= Sps	66000 psi	[OK	]
Tau	2991 psi	<= .8S	16000 psi	[OK	]
Sigmat, max	3234 psi	<= 2St	22800 psi	[OK	]
Sigmat, min	-3234 psi	<= Stb	7205 psi	[OK	]
Sigma s	17124 psi	<= Spss	64199 psi	[OK	]
Sigmat, m	4861 psi	<= Spss	64199 psi	[OK	] Step 10

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(FTS) Configuration b

Tube sheet Thickness (h)	=	4.1250"		
F-F Tubesheets (Lt)	=	311.7500"	F-F Inside Tubesheets (L)	= 303.5000"
Exp length of tube (ltx)	=	4.0000"	Exp depth ratio (Rho)	= 0.9844"
Channel I.D. (Dc)	=	12.8120"	Channel thickness (Tc)	= 0.5940"
Shell I.D. (Ds)	=	11.8120"	Shell thickness (Ts)	= 1.0940"
Perimeter of layout (CP)	=	35.9319"	Area enclosed by CP (AP)	= 102.743in ²
Press Chan (Pt)	=	0.0psi	Press Shell (Ps)	= 0.0psi
Corr Chan	=	0.00000"	Corr Shell	= 0.00000"
Corr Chan side TS (ct)	=	0.00000"	Corr Shell side TS (cs)	= 0.00000"

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 200deg.F	S = 20000psi	Sy = 33000psi	E = 28.6000psi	V = .300	Sps =	66000p
Temp TBS Tt = 200deg.F	St = 11400psi	Syt = 23800psi	Et = 28.6000psi	Vt = .300		
Temp TBS T = 200deg.F	St = 11400psi		Et = 28.6000psi			
Temp CH Tc = 150deg.F	Sc = 17100psi	Syc = 32900psi	Ec = 28.8308psi	Vc = .300	Spssc =	65800p
Temp SH Ts = 200deg.F	Ss = 17100psi	Sys = 32099psi	Es = 28.6000psi	Vs = .300	Spss =	64199p
Tt, m	= 94deg.F			At, m =	6.4800In/In	
Ts, m	= 80deg.F			As, m =	6.4333In/In	

Mu = 0.2000	d* = 0.6582"	P* = 0.93750"	Mu* = 0.2979	hg' = 0.0"	hgs' = 0.0"	hrDE = 0.0"
W*	= 240333.8125#	wj	= 0.0"	ao	= 5.718750000"	
Rho s	= 1.032743216	Rho c	= 1.202185750	Chi s	= 0.557108343	
Chi t	= 0.731465101	Ks	= 4179903.000Lb/In	Kt	= 16389.32812Lb/In	
Ks, t	= 2.476098061	j	= 1.000000000	Beta s	= 0.483783633in ⁻¹	
Kappa s	= 3318001.000#	Lambda s	= 16707216.00psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 4.400000095	
E*	= 7961110.000psi	v*	= 0.355301291	Xa	= 0.901160777	
Zd	= 3.088754416	Zv	= 0.183218822	Zm	= 0.734132349	
K	= 1.021814227	F	= 1.402946949	Phi	= 1.901415825	
Q1	= -0.131738871	Qz1	= 1.010544300	Qz2	= 0.028524671	
U	= 0.057049341	Gamma	= 0.027675150"	Omega s	= 4.705734730in ²	
Omega c	= 0.0in ²	Omega s*	= -4.687916279in ²	Omega c*	= 3.506765842in ²	
Delta s	= 0.000000950In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.360655725	
Ps'	= 0.0psi	Pt'	= 0.0psi	P Gamma	= 454.7118835psi	
PW	= 24.06446457psi	Prim	= 0.0psi	Es, w	= 1.000000000	
Pe	= 338.2766724psi	Q2	= -5757.855957#	Q3	= -1.172656894	
Fm	= 0.586328447	Es, w1	= 0.0	lt	= 28.87500000"	
Rt	= 0.237638906"	Ft	= 121.5078812	Ct	= 154.0137177	
Fs	= 2.000000000	Stb	= 7205.795410psi	Ft, min	= 0.947656691	
Sigmat, 1	= -1838.587524psi	Sigmat, 2	= -2034.809082psi	Ft, max	= 1.048794508	
Sigma s, m	= 783.5474243psi	Sigma s, b	= -13757.67969psi	Sigma s	= 14541.22754psi	
Sigma c, m	= 0.0psi	Sigma c, b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	7678 psi	<= Sps	66000 psi	[OK]	
Tau	1172 psi	<= .8S	16000 psi	[OK]	
Sigmat, max	2034 psi	<= 2St	22800 psi	[OK]	
Sigmat, min	-2034 psi	<= Stb	7205 psi	[OK]	
Sigma s	14541 psi	<= Spss	64199 psi	[OK]	
Sigmat, m	783 psi	<= Spss	64199 psi	[OK]	] Step 10

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***** TUBE CALCULATIONS *****

Tube size.....=	0.75000"	Straight or U-Tube.=	Straight Tube
Internal Press....=	1100.00000psig	External press.....=	2035.00000psig
Temperature used.=	200.00000deg.	Tube Matl MT# 61...=	SA-214
Stress Oper.....=	11400.00000psi	Stress Atm.....=	11400.00000psi
Yield.....=	23800.00000psi	Inside Radius.....=	0.29200"
Joint Eff.....=	1.00000	Mill tol...= 0.00% =	0.00000"
Wall Thk. t.....=	0.08300"	Tube gauge.....=	
Mean Rad., R.....=	0.00000"	Tube Length.....=	312.00000"
Corrosion ID.....=	0.00000"	Corrosion OD.....=	0.00000"
Thinning factor..=	1.00000		
tr = PR/SE - .6P =	0.02991"	(tr*TF)+MT+CA.....=	0.02991"
MAWP Internal H/C=	2768.28540psig	MAWP Internal N/C..=	2768.28540psig
MAWP External H/C=	2159.90234psig	MAWP External N/C..=	2159.90234psig

Skid 2 relocated from
UOPR Job 488 to 447

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---- SHELL NOZZLES -----DESIGN PRESS= 2035.0 DESIGN TEMP= 200.0
NOZ# 1 4.0- 900# MT# FLG= 70 GROUP=1.1 @70deg.=2220.00 @TEMP=2035.00
NOZ# 2 4.0- 900# MT# FLG= 70 GROUP=1.1 @70deg.=2220.00 @TEMP=2035.00

---- FRONT CHANNEL NOZZLES -----DESIGN PRESS= 1100.0 DESIGN TEMP= 150.0
NOZ#11 6.0- 600# MT# FLG= 70 GROUP=1.1 @70deg.=1480.00 @TEMP=1420.00

---- REAR CHANNEL/COVER NOZZLES ----DESIGN PRESS= 1100.0 DESIGN TEMP= 150.0
NOZ#17 6.0- 600# MT# FLG= 70 GROUP=1.1 @70deg.=1480.00 @TEMP=1420.00

Skid 2 relocated from
UOPR Job 488 to 447

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Input Echo, Horizontal Vessel Item 3450, Description: Bottom Supports

Design Internal Pressure	2035.00	psig
Design Temperature	200.00	F
Corrosion Allowance for Vessel	0.0625	in.
Shell Material	SA-333 6	
Shell Material UNS Number	K03006	
Shell Operating Allowable Stress	17100.00	psi
Shell Ambient Allowable Stress	17100.00	psi
Head Material	SA-105	
Head Material UNS Number	K03504	
Head Operating Allowable Stress	20000.00	psi
Head Ambient Allowable Stress	20000.00	psi
Density of Shell and Head Material	0.2800	lb./in ³
Density of Stored Liquid	53.0000	lb./ft ³
Liquid Height in Vessel	11.8120	in.
Extra Weight	2496.000	lb.
Saddle Reaction Force Factor	3.00	ft
Distance from Center of Vessel to Support B	17.50	in.
Baseplate Length	13.0000	in.
Baseplate Thickness	0.5000	in.
Baseplate Width	5.0000	in.
Number of Ribs (inc. outside ribs)	3	
Rib Thickness	0.3750	in.
Web Thickness	0.3750	in.
Web Location	Side	
Height of Center Web	9.6250	in.
Design Temperature of Base Structure	100.00	F
Saddle\Baseplate\Rib\Web Material	SA-516 70	
Saddle\Baseplate\Rib\Web Material UNS Number	K02700	
Operating Allowable Stress	20000.00	psi
Ambient Allowable Stress	20000.00	psi
Force Coefficient (Shape factor)	0.600	Cf
Extra Area	0.0000	in ²
Design Wind Code	ASCE 7-10	
Importance Factor	1.150	
Wind Velocity	120.000	mile/hr
Exposure Category	C	
Height above Grade	17.500	ft.
Type of Hill	None	
User Entered Seismic Zone Coefficient	0.2040	
Diameter Basis for Vessel	OD	
Shell Diameter	14.000	in.
Shell Length Tangent to Tangent	29.560	ft.
Thickness of Shell	1.0940	in.
Shell Joint Efficiency	1.0000	

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Head Type	Flat	
Head Thickness	4.6250	in.
Head Joint Efficiency	1.0000	
Distance from Saddle to Vessel Tangent	69.000	in.
Saddle Width	4.500	in.
Saddle Bearing Angle	116.0000	degrees
Wear Pad Thickness	0.3750	in.
Wear Pad Extension above Horn of Saddle	2.0000	in.
Wear Pad Width	8.500	in.

Stiffening Ring Present N

Results for Horizontal Vessel Number 3450, Description: Bottom Supports

Wind Load Results per ASCE-7 10

Alpha factor from Table C6-2	: 9.5
Zg from Table C6-2	: 900.00 ft.
Velocity Pressure Exposure Coeff. Kz (C3)	: 0.8769
Gust Effect Factor (Rigid) G per Eq. 6-4	: 0.8500
Directionality Factor, Kd (table 6-4)	: 0.95 (Round Structures)
Wind velocity Pressure qz at mid from Eq 6-15	: 35.316 psf
Wind velocity Pressure, P = qz * G	: 30.018 psf

Vessel Stress Summary

Shell Allowable Stress used in Calculation	17100.00	psi
Shell Compressive Yield used in Calculation	32100.00	psi
Head Allowable Stress used in Calculation	20000.00	psi
Volume of Vessel	22.97	ft.**3
Weight of Vessel, Empty	7300.27	lb.
Weight of Vessel, Full	8515.65	lb.

	Actual	Allowable
Long. Stress at Top of Saddles	14784.60	17100.00 psi
Long. Stress at Bottom of Saddles	-3823.62	-17800.00 psi
Long. Stress at Top of Midspan	4102.11	17100.00 psi
Long. Stress at Bottom of Midspan	6858.88	17100.00 psi
Tangential Shear in Shell	991.89	13680.00 psi
Circ. Stress at Horn of Saddle	-873.46	-25650.00 psi
Circ. Stress at Tip of Wear Plate	-570.04	-25650.00 psi
Circ. Compressive Stress in Shell	-523.43	-16050.00 psi

Wind(ASCE #7) and Seismic Results :

Transverse Wind Load Component, Ftw:

$F_{tw} = (AFT * C_f * QZ * C_{nv_Fac}) * 0.5$

$F_{tw} = (7643.370 * 0.600 * 30.0182 * 0.00694) * 0.5$

$F_{tw} = 478.001 \text{ lb.}$

Longitudinal Wind Load Component, Flw:

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$Flw = (AFL * QZ * Cnv_fac)$
 $Flw = (346.361 * 30.0182 * 0.00694)$
 $Flw = 72.202 \text{ lb.}$

Transverse Earthquake Load Component, Fte:

$Fte = (Cs * Wo) * 0.5$
 $Fte = (0.2040 * 8515.65) * 0.5$
 $Fte = 868.596 \text{ lb.}$

Longitudinal Earthquake Load Component, Fle:

$Fle = Cs * Wo$
 $Fle = 0.2040 * 8515.65$
 $Fle = 1737.192 \text{ lb.}$

Saddle Reaction Force due to Transverse Forces, Qr:

$Qr = ftr * \text{Max}(Ftw, Fte) * B / E$
 $Qr = 3.0 * \text{Max}(478.00, 868.60) * 17.5000 / 11.9787$
 $Qr = 3806.872 \text{ lb.}$

Saddle Reaction Force due to Longitudinal forces, Ql:

$Ql = \text{Max}(Flw, Fle, Flf, Flu) * B / Ls$
 $Ql = \text{Max}(72.20, 1737.19, 0.00, 0.00) * 17.5000 / 216.7200$
 $Ql = 140.277 \text{ lb.}$

Load Combination Results for Q + Wind or Seismic or Friction or User

$Q = Wo/2 + \text{Max}(Qr, Ql)$
 $Q = 4257.82 + \text{Max}(3806.87, 140.28)$
 $Q = 8064.696 \text{ lb.}$

Summary of Loads on this Saddle Support:

Vertical Load on this Saddle	8064.70 lb.
Transverse Shear Load on this Saddle	868.60 lb.
Longitudinal Shear Load on this Saddle	1737.19 lb.

Formulae and substitutions for ZICK Analysis
Shell and Head Required Thickness and MAWP :

Shell:

Thickness Due to Internal Pressure:
 $= (P * (D/2 - CAE)) / (S * E + 0.4 * P)$ per Appendix 1-1 (a) (1)
 $= (2035.36 * (14.0000/2 - 0.000)) / (17100.00 * 1.00 + 0.4 * 2035.36)$
 $= 0.7953 + 0.0625 = 0.8578 \text{ in.}$

Max. All. Working Pressure at Given Thickness (MAWP):

Less Operating Hydrostatic Head Pressure of 0.36 psig
 $= (S * E * (T - CA - CAE)) / ((D/2 - CAE) - 0.4 * (T - CA - CAE))$ per Appendix 1-1 (a) (1)
 $= (17100.00 * 1.00 * (1.0315)) / (14.0000/2 - 0.000 - 0.4 * 1.0315)$
 $= 2677.63 - 0.36 = 2677.27 \text{ psig}$

Maximum Allowable Pressure, New and Cold (MAPNC):

$= (SA * E * T) / (D/2 - 0.4 * T)$ per Appendix 1-1 (a) (1)
 $= (17100.00 * 1.00 * 1.0940) / (14.0000/2 - 0.4 * 1.0940)$
 $= 2850.70 \text{ psig}$

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Actual stress at given pressure and thickness (Sact):

$$\begin{aligned} &= (P * ((D/2 - CAE) - 0.4 * (T - CA - CAE))) / (E * (T - CA - CAE)) \\ &= (2035.36 * ((14.0000/2 - 0.000) - 0.4 * (1.0315))) / (1.00 * (1.0315)) \\ &= 12998.30 \text{ psi} \end{aligned}$$

Flat Head:

Thickness Due to Internal Pressure:

$$\begin{aligned} &= (D) * \text{SQRT}(Z * CF * P / (S * E)) \text{ per UG-34 (c) (3)} \\ &= (14.0000) * \text{SQRT}(1.00 * 0.30 * 2035.36 / (20000.00 * 1.00)) \\ &= 2.4462 + 0.0625 = 2.5087 \text{ in.} \end{aligned}$$

Max. All. Working Pressure at Given Thickness (MAWP):

Less Operating Hydrostatic Head Pressure of 0.36 psig

$$\begin{aligned} &= ((T - CA - CAE) / D)^2 * ((S * E) / (CF * Z)) \text{ per UG-34 (c) (3)} \\ &= ((4.5625) / 14.0000)^2 * ((20000.00 * 1.00) / (0.30 * 1.00)) \\ &= 7080.41 - 0.36 = 7080.05 \text{ psig} \end{aligned}$$

Maximum Allowable Pressure, New and Cold (MAPNC):

$$\begin{aligned} &= (T / D)^2 * ((S * E) / (CF * Z)) \text{ per UG-34 (c) (3)} \\ &= (4.6250 / 14.0000)^2 * ((20000.00 * 1.00) / (0.30 * 1.00)) \\ &= 7275.72 \text{ psig} \end{aligned}$$

Actual stress at given pressure and thickness (Sact):

$$\begin{aligned} &= (Z * CF * P) / (((T - CA - CAE) / D)^2 * E) \\ &= (1.00 * 0.30 * 2035.36) / (((4.5625) / 14.0000)^2 * 1.00) \\ &= 5749.28 \text{ psi} \end{aligned}$$

Longitudinal Bending (+-) at Midspan

$$\begin{aligned} &= (3 * Q * L * K.2 / (PI * R^2 * (T - CA))) \\ &= (3 * 8064 * 29.56 * 0.2225) / \\ &\quad (PI * 5.9685 * 5.9685 * (1.0940 - 0.0625)) \\ &= 1378.38 \text{ psi} \end{aligned}$$

Compute the area ratio [K]:

$$\begin{aligned} &= PI * (\sin(\Delta) / \Delta - \cos(\Delta)) / (\Delta + \sin(\Delta) * \cos(\Delta) - \\ &\quad (\Delta + \sin(\Delta) * \cos(\Delta) - 2 * \sin(\Delta) * \sin(\Delta) / \Delta)) \\ &= PI * (\sin(1.367) / 1.367 - \cos(1.367)) / (1.367 + \sin(1.367) * \cos(1.367) - 2 * \sin(1.367) * \sin(1.367) / 1.367) \\ &= 9.9598 \end{aligned}$$

Compute the moment fraction [X]:

$$\begin{aligned} &= (1 - (1 - A/L + (R^2 - H^2) / (2 * A * L)) / (1 + (4 * H) / (3 * L))) \\ &= (1 - (1 - 5.750 / 29.560 + (0.497^2 - 0.000^2) / (2 * 5.750 * 29.560))) / \\ &\quad (1 + (4 * 0.000) / (3 * 29.560)) \\ &= 0.1938 \end{aligned}$$

Intermediate Product [K.1]:

$$\begin{aligned} &= K * X * 4 * A / L \\ &= 9.960 * 0.194 * 4 * 5.750 / 29.560 = 1.5018 \end{aligned}$$

Longitudinal Bending (+-) at Saddle

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$$\begin{aligned}
&= (3 * Q * L * K.1 / (PI * R^2 * (T - CA))) \\
&= (3 * 8064 * 29.56 * 1.5018) / \\
&\quad (PI * 5.9685 * 5.9685 * (1.0940 - 0.0625))) \\
&= 9304.11 \text{ psi}
\end{aligned}$$

Longitudinal Pressure Stress

$$\begin{aligned}
&= DP * ((SID/2+CA) - 0.4 * (T-CA)) / (2.0 * (T-CA)) \\
&= 2035.0 * ((11.81 / 2 + 0.0625 - 0.4 * (1.094 - 0.0625)) / \\
&\quad (2.0 * (1.094 - 0.0625))) \\
&= 5480.49 \text{ psi}
\end{aligned}$$

Note: The Longitudinal Stress from Zick Analysis is combined with the Longitudinal Pressure Stress to get the total stress.

Tangential Shear in Shell near Saddle

$$\begin{aligned}
&= Q * K.4 * ((L-H-2A) / (L+H)) / (R * (T-CA)) \\
&= 8064 * 1.2394 * ((29.56 - 0.00 - 2 * 5.75) / \\
&\quad (29.56 + 0.00)) / (5.9685 * (1.0940 - 0.0625)) \\
&= 991.89 \text{ psi}
\end{aligned}$$

Circumferential Stress at Tip of the Wear Plate (L >= 8R)

$$\begin{aligned}
&= -Q / (4 * (T-CA) * (SADWTH + 1.56 * SQRT(R * (T-CA)))) - 3.0 * Q * K13 / \\
&\quad (2 * (T-CA)^2) \\
&= -8064 / (4 * 1.0315 * (4.50 + 1.56 * SQRT(5.9685 * 1.0315))) \\
&\quad - 3 * 8064 * 0.0296 / (2 * 1.0315^2) \\
&= -570.04 \text{ psi}
\end{aligned}$$

Note: Wear Plate thk. could Not be considered in this formula because,

Saddle-Tangent Distance A (69.0) is > R/2 (3.0 in.)

Circumferential Stress at Horn of Saddle (L >= 8R)

$$\begin{aligned}
&= -Q / (4 * TEM * (SADWTH + 1.56 * SQRT(R * (T-CA)))) - 3.0 * Q * K.7 / (2 * TEB) \\
&= -8064 / (4 * 1.0315 * (4.50 + 1.56 * SQRT(5.9685 * 1.0315))) \\
&\quad - 3 * 8064 * 0.0563 / (2 * 1.0640) \\
&= -873.46 \text{ psi}
\end{aligned}$$

Circumferential Compression at Bottom of Shell

$$\begin{aligned}
&= (Q * (K.9 / (TEM * WPDWTH))) \\
&= (8064 * (0.7759 / (1.4065 * 8.500))) \\
&= -523.43 \text{ psi}
\end{aligned}$$

RESULTS for VESSEL RIBS, WEB and BASE

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Ay^2	Io
Shell	0.5157	12.7604	6.5812	3.3942	1.1314
Wearplate	1.2190	3.1875	3.8856	4.7365	0.0374
Web	5.2657	2.8944	15.2414	80.2573	14.3697
BasePlate	9.3750	2.5000	23.4375	219.7266	0.0521
Totals	16.3755	21.3423	49.1456	308.1146	15.5906

$$\text{Value } C1 = \text{Sumof}(Ay) / \text{Sumof}(A) = 2.3027 \text{ in.}$$

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$$\begin{aligned} \text{Value } I &= \text{Sumof}(Ay^2) + \text{Sumof}(Io) - C1 * \text{Sumof}(Ay) = 210.5361 \text{ in}^4 \\ \text{Value } As &= \text{Sumof}(A) - A_{shell} = 8.5819 \text{ in}^2 \end{aligned}$$

$$K1 = (1 + \cos(b) - .5 * \sin(b)^2) / (\pi - b + \sin(b) * \cos(b)) = 0.1963$$

$$Fh = K1 * Q = 0.1963 * 8064.696 = 1582.983 \text{ lb.}$$

$$\begin{aligned} \text{Tension Str., } St &= (Fh / As) = 184.4552 \text{ psi} \\ \text{Allowed Str., } Sa &= .6 * \text{Yield Stress} = 22800.0000 \text{ psi} \end{aligned}$$

$$\begin{aligned} d &= B - R * \sin(\theta) / \theta = 10.5934 \text{ in.} \\ \text{Bending Moment, } M &= Fh * d = 1397.4288 \text{ ft.lb.} \end{aligned}$$

$$\begin{aligned} \text{Bending Stress, } S_{bnd} &= (M * C1 / I) = 183.4118 \text{ psi} \\ \text{Allowed Str., } Sa &= .66 * \text{Yield Str.} = 25080.0020 \text{ psi} \end{aligned}$$

Minimum Thickness of Baseplate

$$\begin{aligned} &= (3 * Q * \text{BasePlateWidth} / (2 * \text{BasePlateLength} * \\ &\quad \text{AllStress}))^{1/2} \\ &= (3 * 8064 * 5.00 / (2 * 13.000 * 25080.002))^{1/2} \\ &= 0.431 \text{ in.} \end{aligned}$$

Calculation of Axial Load, Intermediate Values and Compressive Stress:

$$\begin{aligned} \text{Effective Baseplate Length (e)} &= (\text{Bplen} - \text{Clearance}) / (\text{Nrbs} - 1) \\ &= (13.0000 - 1.0) / (3 - 1) = 6.0000 \text{ in.} \end{aligned}$$

$$\begin{aligned} \text{Baseplate Pressure Area (Ap)} &= e * \text{Bpwid} / 2 \\ &= 6.0000 * 5.0000 / 2 = 15.0000 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Axial Load (P)} &= Ap * Bp \\ &= 15.00 * 124.07 = 1861.08 \text{ lb.} \end{aligned}$$

$$\begin{aligned} \text{Area of the Rib and Web (Ar)} &= (\text{Bpwid} - \text{Clearance} - \text{Webtk}) * \text{Ribtk} + e/2 * \text{Webtk} \\ &= (5.000 - 1.0 - 0.375) * 0.375 + 6.0000 / 2 * 0.375 \\ &= 2.484 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Compressive Stress (Sc)} &= P / Ar \\ &= 1861.08 / 2.4844 = 749.1155 \text{ psi} \end{aligned}$$

Check of Outside Ribs

Inertia of Saddle, Outer Ribs - Axial Direction

	Y	A	AY	Ay ²	Io
Rib	2.1875	1.4531	3.1787	1.1068	2.3989
Web	0.1875	1.1250	0.2109	1.4296	0.0264
Values	1.3148	2.5781	3.3896	2.5364	2.4253

$$\begin{aligned} KL/R &< Cc \quad (8.4093 < 123.2882) \text{ per AISC E2-1 9th Edition} \\ Sca &= (1 - (Klr)^2 / (2 * Cc^2)) * Fy / (5/3 + 3 * (Klr) / (8 * Cc) - (Klr^3) / (8 * Cc^3)) \end{aligned}$$

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$$Sca = (1 - (8.41)^2 / (2 * 123.29^2)) * 38000 /$$

$$(5/3 + 3 * (8.41) / (8 * 123.29) - (8.41^3) / (8 * 123.29^3))$$

$$Sca = 22403.67 \text{ psi}$$

AISC Unity Check on Outside Ribs (must be ≤ 1.0)

$$\text{Check} = Sc/Sca + (Rm/Z)/Sba$$

$$\text{Check} = 749.12 / 22403.67 + (2382.10 / 1.848) / 25080.00$$

$$\text{Check} = 0.08$$

Check of Inside Ribs

Inertia of Saddle, Inner Ribs - Axial Direction

	Y	A	AY	Ay ²	Io
Rib	2.1875	1.3594	2.9736	2.1130	2.0000
Web	0.1875	2.2500	0.4219	1.2766	0.0264
Values	0.9407	3.6094	3.3955	3.3896	2.0264

$KL/R < Cc$ (6.7092 < 123.2882) per AISC E2-1 9th Edition

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

$$Sca = (1 - (6.71)^2 / (2 * 123.29^2)) * 38000 /$$

$$(5/3 + 3 * (6.71) / (8 * 123.29) - (6.71^3) / (8 * 123.29^3))$$

$$Sca = 22491.13 \text{ psi}$$

AISC Unity Check on Inside Ribs (must be ≤ 1.0)

$$\text{Check} = Sc/Sca + (Rm/Z)/Sba$$

$$\text{Check} = 1031.25 / 22491.13 + (3294.72 / 2.708) / 25080.00$$

$$\text{Check} = 0.09$$

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FORM U-1 MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by STEELTEK, INC. 4141 SOUTH JACKSON TULSA OKLAHOMA 74107 USA
(Name and address of Manufacturer)
2. Manufactured for UOP LLC c/o Honeywell International ; P.O. Box 981762 ; El Paso, TX 79998-1762
(Name and address of Purchaser)
3. Location of installation Unknown
(Name and address)
4. Type Horizontal Heat Exchanger 17S-3450
(Horizontal, vertical, or sphere) (Tank, separator, jkt. vessel, heat exch., etc.) (Manufacturer's serial number)
- NONE 17S-3450-A 3282 2018
(CRN) (Drawing number) (National Board number) (Year built)
5. ASME Code, Section VIII, Div. 1 2017 Edition NONE NONE
[Edition and Addenda, if applicable (date)] (Code Case number) [Special service per UG-120(d)]

Items 6-11 incl. to be completed for single wall vessels, jackets of jacketed vessels, shell of heat exchangers, or chamber of multichamber vessels.

6. Shell: (a) Number of course(s) 1 (b) Overall length 25' - 3-3/4"

Course(s)			Material		Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B & C)			Heat Treatment	
No.	Diameter	Length	Spec./Grade or Type		Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
1	11.812"ID	25'-3.750"	SA-333-6		1.094"	.0625"	S	None	1.0	1	Full	1.0	NONE	NONE
-	-	-	-		-	-	-	-	-	-	-	-	-	-
-	-	-	-		-	-	-	-	-	-	-	-	-	-

Body Flanges on Shells													
No.	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Location	Bolting				
									Num & Size	Bolting Material	Washer (OD, ID, thk)	Washer Material	
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-

7. Heads: (a) NONE (b) NONE
(Material spec. number, grade or type)(H.T. - time and temp.) (Material spec. number, grade or type)(H.T. - time and temp.)

	Location (Top, Bottom, Ends)	Thickness		Radius		Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure		Category A		
		Min.	Corr.	Crown	Knuckle					Convex	Concave	Type	Full, Spot, None	Eff.
(a)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(b)	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Body Flanges on Heads													
	Location	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Bolting				
									Num & Size	Bolting Material	Washer (OD, ID, thk)	Washer Material	
(a)	-	-	-	-	-	-	-	-	-	-	-	-	-
(b)	-	-	-	-	-	-	-	-	-	-	-	-	-

8. Type of jacket NONE Jacket closure NONE
(Describe as ogee and weld, bar, etc.)

If bar, give dimensions; If bolted, describe or sketch NONE

9. MAWP 2035 PSI NONE at max. temp. 200 F. NONE Min. design metal temp. -20 F. at 2035 PSI
(Internal) (External) (Internal) (External)

10. Impact test NO ; IMPACT EXEMPT PER UCS-66 at test temperature of NONE
[Indicate yes or no and the component(s) impact tested]

11. Hydro., pneu., or comb. test pressure 2646 PSI Proof test NO

Items 12 and 13 to be completed for tube sections.

12. Tubesheet SA-350LF2,CL.1 Sh.=11.687"/Ch.=14.125" 4.125" .125" Welded
[Stationary (material spec. no.)] [Diameter (subject to press.)] (Nominal thickness) (Corr. allow.) [Attachment (welded or bolted)]

- SA-350LF2,CL.1 Sh.=11.687"/Ch.=14.125" 4.125" .125" Welded
[Floating (material spec. no.)] (Diameter) (Nominal thickness) (Corr. allow.) (Attachment)

13. Tubes SA-214 .750" .083"MW 103 Straight
(material spec. no., grade or type) (O. D.) (Nominal thickness) (Number) [Type (straight or U)]



FORM U-1

Page 2 of 3

Manufactured by STEELTEK, INC. 4141 SOUTH JACKSON TULSA OKLAHOMA 74107 USAManufacturer's Serial No. 17S-3450CRN NONENational Board No. 3282

Items 14-18 incl. to be completed for inner chambers of jacketed vessels or channels of heat exchangers.

14. Shell: (a) No. of course(s) 2 (b) Overall length 2' - 1-5/8"

Course(s)			Material		Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B & C)			Heat Treatment	
No.	Diameter	Length	Spec./Grade or Type		Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
2	*Ln22	1'-.812"	SA-234-WPC		.594"	.0625"	S	None	1.0	1	Full	1.0	NONE	NONE
-	-	-	-		-	-	-	-	-	-	-	-	-	-
-	-	-	-		-	-	-	-	-	-	-	-	-	-

Body Flanges on Shells													
No.	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Location	Bolting				
									Num & Size	Bolting Material	Washer (OD, ID, thk)	Washer Material	
1	RING	12.8"	14.2"	2.750"	.5937"	SA105N	WELDED	CH.	(32) 3/4"	***Ln22	NONE	NONE	
1	RING	12.8"	14.2"	2.750"	.5937"	SA-105N	WELDED	CH.	(32) 3/4"	**Ln22	NONE	NONE	
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-

15. Heads: (a) NONE (b) NONE
(Material spec. number, grade or type)(H.T. - time and temp.) (Material spec. number, grade or type)(H.T. - time and temp.)

	Location (Top, Bottom, Ends)	Thickness		Radius		Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure		Category A		
		Min.	Corr.	Crown	Knuckle					Convex	Concave	Type	Full, Spot, None	Eff.
(a)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(b)	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Body Flanges on Heads													
	Location	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Bolting				
									Num & Size	Bolting Material	Washer (OD, ID, thk)	Washer Material	
(a)	-	-	-	-	-	-	-	-	-	-	-	-	-
(b)	-	-	-	-	-	-	-	-	-	-	-	-	-

16. MAWP 1100 PSI NONE at max. temp. 150 F. NONE Min. design metal temp. -20 F. at 1100 PSI.
(Internal) (External) (Internal) (External)17. Impact test NO ; IMPACT EXEMPT PER UG-20(f) AND BOLTING PER UCS-66(e) at test temperature of NONE.
[Indicate yes or no and the component(s) impact tested]18. Hydro., pneu., or comb. test pressure 1431 PSI Proof test NO

19. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Type	Material		Nozzle Thickness		Reinforcement Material	Attachment Details		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
SH. IN / OUT	1/1	4"-900#	rfjwn	SA105N	NONE	1.130"	.125"	N/A	E	N/A	N/A
CH. IN / OUT	1/1	6"-600#	FLG	SA105N	***Ln22	.562"	.125"	NONE	E	1	N/A
CH. VENT / DRAIN	1/1	3/4"-6000#	CPLG	SA-105	N/A	.500"	.125"	NONE	E	N/A	N/A
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-

20. Supports: Skirt NO Lugs - Legs NONE Others 2) SADDLES Attached SHELL - WELDED
(Yes or no) (Number) (Number) (Describe) (Where and how)

21. Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report (list the name of part, item number, Manufacturer's name, and identifying number):

NONE22. Remarks LN. 19 - SAFETY VALVES BY OTHERS *Ln. 14 - Channels are 14" (Sch. 60 .594") X 6" (Sch. .120" .562") Conc. Reducer.TYPE : BEM SIZE : 14-312 **Ln - Bolting Mat'l = SA-193-B7 Caduim Plated.PO NO. : 4500801009 ITEM ON. : E-202 ***Ln. 19 - Flg. Mat'l = SA-234WPC.SERVICE : GAS / PRODUCT EXCHANGER

FORM U-1

Page 3 of 3

Manufactured by STEELTEK, INC. 4141 SOUTH JACKSON TULSA OKLAHOMA 74107 USAManufacturer's Serial No. 17S-3450CRN NONENational Board No. 3282

CERTIFICATE OF SHOP COMPLIANCE

We certify that the statements in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1.

U Certificate of Authorization Number 25,595 Expires 05/16/2021Date 7-6-18 Name STEELTEK, INC.

(Manufacturer)

Signed

Carmen Moffitt
(Representative)

CERTIFICATE OF SHOP INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by

The Hartford Steam Boiler Inspection and Insurance Company of CThave inspected the pressure vessel described in this Manufacturer's Data Report on 5/18/2018, and

state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the Inspector nor his/her employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date 7/6/2018 Signed[Signature]
(Authorized Inspector)Commissions NB 11448

(National Board Authorized Inspector Commission number)

CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE

We certify that the statements in this report are correct and that the field assembly construction of all parts of this vessel conforms with the requirements of ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. U Certificate of Authorization Number 25,595 Expires 05/16/2018.

Date _____ Name STEELTEK, INC.

(Assembler)

Signed

(Representative)

CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by

of _____, have compared the statements in this Manufacturer's Data Report with the described pressure vessel and state that parts referred to as data items _____, not included in the certificate of shop inspection, have been inspected by me and to the best of my knowledge and belief, the Manufacturer has constructed and assembled this pressure vessel in accordance with the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. The described vessel was inspected and subjected to a hydrostatic test of _____. By signing this certificate neither the Inspector nor his/her employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____ Signed

(Authorized Inspector)

Commissions _____

(National Board Authorized Inspector Commission number)

3282

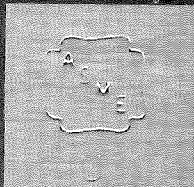
3282

3

CERTIFIED BY

Steeltek

TULSA, OKLA.



W
RT

SHELL

TUBE

MAWP PSI

2035

AT °F

200

150

MDMT °F

-20

AT PSI

2035

SHELL

TUBE

-20

1100

YEAR BUILT 2018

SERIAL NO. 17-3450

P.O. NO. 4600801009

ITEM NO. F-202

JOE RUSSELL 400-4488XX

STEELTEK

4141 SOUTH JACKSON
TULSA, OKLAHOMA 74107

INSPECTION AND TEST PLAN

STEELTEK JOB NUMBER: 17S-3450

P. O. NUMBER: 4500801009

REV. 0, 3/8/2018

CUSTOMER: UOP RUSSELL

ITEM NUMBER: E-202

INSPECTION CODES: V = VERIFIED W = WITNESSED (CUSTOMER NOTIFICATION REQUIRED) P = PERFORMED R = REVIEWED H = HOLD POINT

INSPECTION POINT	SPECIFICATION / CODE REFERENCE	ACCEPTANCE CRITERIA	STEELTEK INSP. CODE	3rd PARTY INITIAL / INSP. CODE		
MATERIAL ORIGIN	DWG. 17S-3450-Y	DWG. 17S-3450-Y	PRV	V		
MILL TEST REPORTS	ASME SECT. II	ASME SECT. VIII, DIV. 1	9-11-17	V		
MATERIAL TRACEABILITY	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1	V	V		
WELD AND NDE PROCEDURE REVIEW	WELD MAP & ASME SECT. IX	ASME SECT. IX	V, P	V, P		
WELDER QUALIFICATIONS	ASME SECT. IX	ASME SECT. IX	V	V		
ORIENTATION & FITUP CHECKED	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1	V	V, W		
FLANGE FINISH & RATING	DWG. 17S-3450-Y1 AND CUSTOMER SPECS.	DWG. 17S-3450-Y1 AND CUST. SPECS.	PRV	V		
FLANGES CHECKED	DWG. 17S-3450-L AND 17S-3450-X	DWG. 17S-3450-X	4-26-18	V		
PROJECTION CHECKED	DWG. 17S-3450-A	TEMA	V	V		
WELDER OPERATOR	ASME SECT. IX AND VIII, DIV. 1	ASME SECT. IX	V	V, W		
WELDING ELECTRODES	APPLICABLE WPS	ASME SECT. VIII, DIV. 1, WPS	V	V		
VERIFY CORRECT WELDING PREHEAT	APPLICABLE WPS	WPS	V	V		
VERIFY CORRECT WELDING PROCEDURE	APPLICABLE WPS	WPS, DWG. 17S-3450-WM	V	V		
VISUAL INSPECTION OF WELDS	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1	V, P	V, W, P		
PLUG SHELL FOR DIAMETER	DWG. 17S-3450-X	DWG. 17S-3450-X	PRV	V		
NDE OPERATOR QUALIFICATIONS	ASME SECT. V	ASME SECT. V	5-2-18	V		
MT BACKGOUNDED ROOT PASSES	DWG. 17S-3450-X	ASME SECT. V	V, P	V		
REPAD AIR/SOAP SUDS TEST	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1	V	V		
MT	DWG. 17S-3450-X	ASME SECT. V	V, P	V		
UT	DWG. 17S-3450-X	ASME SECT. V	V, P	V		
RT	DWG. 17S-3450-X, ASME SECT. V	ASME SECT. VIII, DIV. 1	PRV	V		
PT	DWG. 17S-3450-X, ASME SECT. V	ASME SECT. VIII, DIV. 1	5-18-18	V		
INTERNAL INSPECTION	ASME SECT. VIII, DIV. 1 & DWG. 17S-3450-X	ASME SECT. VIII, DIV. 1	V	W, P		
BUNDLE INSERTION	DWG. 17S-3450-X	DWG. 17S-3450-X	V	W		
FINAL VISUAL / DIMENSIONAL INSPECTION	TEMA, DWG. 17S-3450-A	TEMA, DWG. 17S-3450-A	W, P	W		
HYDROSTATIC TEST	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1	W	W		
NAME PLATE STAMPING	DWG. 17S-3450-N	ASME SECT. VIII, DIV. 1, TEMA	V, P	V		
NAME PLATE RUBBING			V, P	V		
PAINT	DWG. 17S-3450-A	DWG. 17S-3450-A	PRV	V		
MARKING / TAGGING	DWG. 17S-3450-X	DWG. 17S-3450-X	5-2-18	V		
SHIPPING PREPARATION	DWG. 17S-3450-X	DWG. 17S-3450-X	V	W		
MANUFACTURER'S DATA REPORT	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1	V, P	W		
COMPLETED DATA PACKAGE	ASME SECT. VIII, DIV. 1 & P. O. DOCUMENTS	ASME SECT. VIII, DIV. 1	V, P	W		
FINAL INSPECTION RELEASE				W		

Gulf States Tube, LLC

34066 SUNSET LANE
BROOKSHIRE, TEXAS 77423

MANUFACTURER CERTIFICATE OF COMPLIANCE IN ACCORDANCE WITH EN10204 3.1

ORDER NUMBER	CUSTOMER ORDER NUMBER	ITEM(S)	DATE	OFC	COM	DI	WI	NET SLS	GR SLS	ACCOUNT NUMBER	REV	MTR ID	MO PAGE
3779	2217-T-17		12/20/2017								00	2753	1 of 1

S O L D T O	TUBES, INC. TULSA 900 E. PECAN SAND SPRINGS , OK 74063-	S H I P T O	TUBES, INC. TULSA 900 E. PECAN SAND SPRINGS , OK 74063-
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ROUTING

CUSTOMER TRUCK - MTR WITH SHIPMENT - PROTECT FROM WEATHER

ANALYSIS	SHAPE	PRODUCT	EC	HEAT TREATMENT	REQUESTED
PER SPEC WELDED	ROUND	COLD ROLLED		FULL ANNEAL	1/31/2018
	SPECIFICATION	CMST		DESCRIPTION	PROMISED (WEEK ENDING)
	ASME SA214 / ASTM A214-96 (2012)	C1010M		WELDED CARBON STEEL TUBES	2/2/2018

SPECIAL INSTRUCTIONS:

EDDY CURRENT TESTED OVER ENTIRE LENGTH IN ACCORDANCE
WITH ASME SA450 / ASTM A450 (IN LIEU OF HYDROTEST) - OIL COATED

TAG : 2217T-17

ITEM	QUANTITY	FOOTAGE	O.D.	WALL	WSPEC	LENGTH	WT / FT	WEIGHT	ITEM STATUS - QTY SHIPPED
1	300 PCS	9,625 '	0.750"	0.083"	M/W	CUT 32'-1"	0.6526#/ft.	6,280#	COMPLETE 300 PCS
2	500 PCS	18,042 '	0.750"	0.083"	M/W	CUT 36'-1"	0.6526#/ft.	11,775#	COMPLETE 500 PCS
3	300 PCS	12,025 '	0.750"	0.083"	M/W	CUT 40'-1"	0.6526#/ft.	7,850#	COMPLETE 300 PCS
4	500 PCS	21,042 '	0.750"	0.083"	M/W	CUT 42'-1"	0.6526#/ft.	13,730#	COMPLETE 500 PCS
5	300 PCS	13,225 '	0.750"	0.083"	M/W	CUT 44'-1"	0.6526#/ft.	8,630#	COMPLETE 300 PCS
6	250 PCS	12,521 '	0.750"	0.083"	M/W	CUT 50'-1"	0.6526#/ft.	8,170#	COMPLETE 250 PCS
7	600 PCS	31,250 '	0.750"	0.083"	M/W	CUT 52'-1"	0.6526#/ft.	20,395#	COMPLETE 600 PCS
8	600 PCS	32,450 '	0.750"	0.083"	M/W	CUT 54'-1"	0.6526#/ft.	21,175#	COMPLETE 600 PCS

HEAT NO.	C	Mn	P	S	CEq	REMARKS	ORIGIN	HEAT NO.	HARDNESS	TEST RESULTS
177925	0.09	0.33	0.011	0.009	0.145	Al Killed	2	177925	57 / 61 RB	FLATTEN
A712740	0.06	0.36	0.014	0.005	0.120	Al Killed	1	A712740	58 / 62 RB	FLANGE
										OK
										OK
										REV. FLATTEN
										EDDY CURRENT
										OK
										OK
										OTHER :
										NOTE : MEETS 0.085" M/W

TUBES, INC.
1-877-537-8880

THESE MILL TEST REPORTS APPLY TO:

YOUR P.O. NO.

JOB NUMBER

94762-3450
175-3450

I CERTIFY THAT THE MATERIAL HEREIN DESCRIBED HAS BEEN MANUFACTURED IN
ACCORDANCE WITH THE ORDERED SPECIFICATION AND THAT THIS TEST
INFORMATION IS CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY.

MANUFACTURED IN THE USA

Henry Pavlicek

TECHNICAL ANALYST

1/26/2018

DATE

OFI

OKLAHOMA FORGE, INC.

Certification of Analysis and Tests

INVOICE NUMBER

118-03777

Date: 2/14/18

Toll Free (866)909-5553

e:Mail ~ sales@oklahomaforge.com

5259 S. 49TH West Ave

Local(918)446-5553 FAX (918)446-4150

Web Site ~ www.oklahomaforge.com

Tulsa, OK 74107

Sold To	Your Purchase Order	Sales Order
STEELTEK, INC. 4141 SOUTH JACKSON TULSA, OK 74107 USA	Number 94763-3450 By CHRISTY ROWE Dated 1/26/2018	Number 118-79888 Shipped Via DELIVERY Ship Date 2/14/2018

Item#	PART DESCRIPTION				Quantity
	Your Part Number	Shop Order Number	Shape	Dimensions	
		Supplier	Heat Number	Material Specifications	
	Chemical Analysis				
	Physical Properties			Charpy Impact (Ft.Lbs.)	

1	17S-3450-3/16	118-79888-01	RING	19.500"OD x 12.813"ID x 4.125"TH	2
	NUCOR	179421	A/SA105-13 NORMALIZED		

C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other
.17	1.20	.006	.0010	.26	.07	.07	.18	.02	.02	.0050	.026		.41	SN-.007;TI-.002
Yield Lb/SqIn	Tensile Strength Lb/SqIn	Elong%in 2In	Red of Area%	Brinell	Rckwl C	Bend Test	Grain Size	Type	Temp	Average	#1	#2	#3	
47,000	77,000	33	72	149			FINE	CVN	-50F	65	80	71	43	

2	17S-3450-19/20	118-79888-02	DISC	19.500"OD x 4.000"TH	2
	NUCOR	173528	A/SA350-15 LF2 CL1 NORMALIZED		

C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other
.17	1.20	.009	.0039	.19	.10	.13	.23	.04	.02	.005	.026		.43	SN-.01;TI-.001
Yield Lb/SqIn	Tensile Strength Lb/SqIn	Elong%in 2In	Red of Area%	Brinell	Rckwl C	Bend Test	Grain Size	Type	Temp	Average	#1	#2	#3	
49,000	77,000	33	72	149			FINE	CVN	-50F	67	62	68	71	

RECEIVED
FEB 14 2018
BY: *[Signature]*

Notes:

17S-3450
LN-3,16 FLG
LN-19,20 Tubesheet
OK *[Signature]*

Page 1

I CERTIFY THAT THERE IS A TRUE COPY OF THE ORIGINAL TEST SHEET NOW ON FILE AT THE OFFICE OF OKLAHOMA FORGE, INC. AND THAT THIS MATERIAL WAS MELTED AND MANUFACTURED IN THE USA.

Ryan Umbarger

Anneal by heating to 1550 degrees F for one hour/inch of thinnest section. Slow cool furnace to 1200 degrees F then air cool by opening door.
Normalize by heating to 1675 degrees F, Hold at 1675 degrees F for one hour/inch of thinnest section and air cool.
Solution Anneal by heating to 1900-2050 degrees F and Water Quenching. BS EN 10204 3.1B.

F040-4/2014

Manufacturer: ArcelorMittal Tubular Products Roman S.A. STEFAN CEL MARE ST. 15A/I ROMAN, NEAMT COUNTY, ROMANIA		MILL TEST CERTIFICATE according to EN 10204/3.1/2004		Page 1/2 D 1444/2 31.05.2014		 ArcelorMittal			
Buyer: ARCELORMITTAL INTERNATIONAL AMERICA, LLC 1 SOUTH DEARBORN STREET, 13TH FLOOR CHICAGO, IL 60603-9888 USA		SEAMLESS STEEL PIPES		Total weight: 5.932 tons 13 078 lbs		Total Length: 26.40 meters 86.61 feet		Pieces 3	Bundles -
Buyer's AMI ORDER: 1008666-4 reference PO NUMBER: 3271951 Contract 50001428		Standard: ASTM A 333 A 333M-2013; Specification PROIECT Dyno Nobel: DYNQ-F441-PP1608A; Specificien with deviation per our TO:AMR/23.12.2013: KBR P22-3PS-LS-ON-M&L; KBR P22-10M: PI-3TS-BASE-L S-BQ-M&U; P -> S-E -ON-M&L AS FB 16.25-2012							
		Dimensions: 355.60 x 27.79 mm 14.000 x 1.094 inch		Schedule: 120		Length: 7.00 - 9.00 m 22.97 - 29.53 feet			
Item 24		Item Client 46/PPAACAAZBIMAFZ		Hydro Test: Bar PSI MPa Time(sec) 190 2800 19.0 5		Steel Grade: 6			

Chemical Analysis(%)

Heat	Bulletin No.	Product Req.	Max Min	C	Mn	Si	S	P	Cr	Ni	Cu	Mo	V	
				0.30	1.06	-	0.025	0.025	0.50	0.40	0.46	0.12	0.080	0.020
49933		Heat analysis		-	0.29	0.10	-	-	-	-	-	-	-	-
49933	14-339	Product analysis		0.15	1.01	0.28	0.003	0.011	0.05	0.09	0.10	0.02	0.007	0.000
49933	14-339	Product analysis		0.15	1.03	0.30	0.005	0.009	0.02	0.06	0.14	0.01	0.002	0.002
49933	14-339	Product analysis		0.15	1.03	0.30	0.005	0.009	0.02	0.06	0.14	0.01	0.002	0.002

Tensile Test

Heat	Orientation	Length		Width/Diameter		Thickness		Section		Mechanical test Bulletin No.	YS MPa	YS (PSI:1000)	LTS MPa	UTS (PSI:1000)	% elongation	15/UTS max
		mm	inch	mm	inch	mm	inch	mm ²	inch ²							
49933	Transversal Round	50.8	2	12.45	0.490	0.00	0.000	121.7	4.791	14-385B	321.00	46.6	504.00	73.1	32.50	0.64
49933	Transversal Round	50.8	2	12.46	0.491	0.00	0.000	121.9	4.799	14-385B	325.00	47.1	503.00	73.0	34.70	0.65

Impact Test

Heat	Impact Test Bulletin No.	Orientation	Size (mm)	Temp. (°C)	Req. kV (min. J)	KV values (J)			Req. Avg. (min. J)	Avg. fracture energy (J)	KCU min.-J cm ² T: C			Shear Area min. %			Average Γ \ mm		
49933	14-896	Longitudinal	10x10x55	-45	14.0	108	100	79	18.0	96	-	-	-	90	90	90	1.36	1.25	1.04

We state on our sole responsibility that the delivered products are in conformity with the order requirements.

Quality Control Representative
 Eng. Icsanu Cristian

Exemplu 175-3450

RECEIVED
 FEB 22 2018
 BY: *[Signature]*

175-3450
 LN-9 PIPE
 OK cm

SA333-GR6 14.000" x 1.094" x 28'6" - 29'6" RANDOM LENGTH

APP SO 308027-1-1 Your PO 133-S-18
 H# 49933

Manufacturer: ArcelorMittal Tubular Products Roman S.A. STEFAN CEL MARE ST. 15A/I ROMAN, NEAMT COUNTY, ROMANIA		MILL TEST CERTIFICATE according to EN 10204/3.1/2004		Page 2/2 D 14442 31.05.2014		 ArcelorMittal	
Buyer: ARCELORMITTAL INTERNATIONAL AMERICA, LLC 1 SOUTH DEARBORN STREET, 13TH FLOOR CHICAGO, IL 60603-9888 USA		SEAMLESS STEEL PIPES		Total weight: 5.932 tons 13 078 lbs	Total Length: 26.40 meters 86.61 feet	Pieces 3	Bundles -
Buyer's AMI ORDER: 10086664 reference PO NUMBER: 3271951 Contract 50001428		Standard: ASTM A 333 A 333M-2013; Specific client. PROJECT Dyno Nobel: DYNO-F441-PP1008A; Specific client with deviation as per our TO.AMR/23.12.2013; KBR P22-2P5-US-ON-M&U; KBR P22-10M; PI-3TS-BASE-US-BO-M&U; PI-4TS-EL-ON-M&U; ASME B 16.25-2012		Dimensions: 355.60 x 27.79 mm 14.000 x 1.094 inch		Schedule: 120	
Item 24		Item Client 46/PPAACAAZBIMAFZ		Hydro Test: Bnr 190	PSI 2800	MPa 19.0	Time(sec) 5
				Steel Grade: 6			

Technological/Microstructure Test

Heat	Flattening Test Bulletin No.	Flattening Test
49933	14-105	OK
49933	14-105	OK

Heat

Heat	Pieces	Length (m)	Weight (kg)
49933	3	-	-

Remarks: Manufacturing process – hot rolling.

Steel is fully killed and produced by electric furnace. Arcelor Mittal Hunedoara S A – Piata Iancu de Hunedoara, nr.1 – Hunedoara.

Heat treatment: normalizing at temperature 900-930°C, time soaking 60-65 min.

Visual inspection and dimensional check without objection.

Hydrostatic test hold for 5 sec. no leakage noticed.

We state on our sole responsibility that the delivered products are in conformity with the order requirements.

Quality Control Representative
 Eng. Iesanu Cristian

Formular 124 rev. 0

SA333-GR6 14,000" x 1.094" x 28" - 29'3" RANDOM LENGTH

APP SO 308027-1-1 Your PO 133-S-18
 H# 49933

RECEIVED
 FEB 22 2018
 BY: *OK*

175-3450
 LN-9 PIPE
OK

To: STEELTEK

10/06/2017 From: MATTSO SUPPLY COMPANY



GIBSON PRODUCTS, INC.

Material Test Report

5691 SURREY SQUARE STREET
HOUSTON, TX 77017
Phone: 713-941-4890
Fax: 713-941-8593

Page: 1 of 1

SOLD TO: MATTSO SUPPLY
P.O. BOX 2925
TULSA, OK 74101

SHIP TO:

DATE	SALES ORDER #	CUST P.O.#	TAG NUMBER	
08/23/2017	263999	08475-12	O17-08475	
ITEM #	QTY	ITEM DESCRIPTION	HEAT CODE	HEAT NUMBER
1	2	14" S160.X 6" S120 CONC REDUCER ASME SA234 WPC	RA58	241170
				STARTING MATERIAL
				ASME SA350 - 2014 ED. LF2 CL. 1

CHEMICAL ANALYSIS

C	Si	Mn	P	S	Cr	Ni	Mo	Cu	V	Cb	C.Eqv
.167	.28	1.23	.015	.001	.17	.08	.04	.14	.005	.001	.43

PHYSICAL PROPERTIES

TENSILE (PSI)	YIELD (PSI)	ELONG 2" or 4D	REDUCTION OF AREA %	HARDNESS
75854	45687	31.8	69	148 - 151 BHN

IMPACT TESTING

TYPE	TEMP	SMPL#1	#2	#3	AVG	%SHEAR	LAT EXP
CHARPY1	-50°F	91 FT. LBS	100 FT. LBS	106 FT. LBS	99 FT. LBS	87-90-91	49-54-58 MLE

HEAT TREATMENT: NORMALIZED AT 1670°F FOR 480 MINUTES AND COOLED IN AIR, COUNTRY OF ORIGIN (MELT): ITALY

WE CERTIFY THAT THE MATERIAL FURNISHED ON THIS ORDER COMPLIES WITH THE SPECIFICATIONS AS STATED, IAW GIBSON PRODUCTS Q.A. PROGRAM AND QUALITY MANUAL, COMPLYING WITH ISO 9001 AND PRESSURE EQUIPMENT DIRECTIVE (PED) REQUIREMENTS. THE ISSUE YEAR & ADDENDA FOR THE ABOVE DESCRIBED MATERIAL IS THE SAME AS THE STARTING MATERIAL UNLESS OTHERWISE NOTED.

NO CONFLICT MINERALS WERE USED

Virgil Kellogg

QUALITY ASSURANCE

DS

RECEIVED
OCT 12 2017
OK175-3450
LN-4,17 Conc.
Reducer
OK

Material Test Report

FVC
an AFGlobal Company

Heat Code: C889AN

Forged Vessel Connections

An AFGlobal Company

13770 Industrial Rd. Houston, TX 77015

Sales: (713) 393-4200

ISO 9001:2008 Certified

MattSCO Supply Co. 00011508	PO: 00435-12.1	Sales Order: 164731	Line: 1
1111 N. 161st Avenue	Item Code: LWN040900114B002A1	Qty Shipped: 2	
Tulsa, OK 74116	Item Desc: LWN RTJ A105N 4"900X11.5		
	Mill Heat: A112238		
Spec: ASTM A105/A105M-(14)/ASME SA 105/SA 105M-(15) Section II Part A - Normalized			

Element	(%wt)	Ladle	Product	EPCRA	CAS#	Element	(%wt)	Ladle	Product	EPCRA	CAS#
C	Carbon	0.19				V	Vanadium	0.03			
Mn	Manganese	1.12		1e	7439-96-5	Cr	Chromium	0.002			
P	Phosphorous	0.007				B	Boron	0.0000			
S	Sulphur	0.002				Ti	Titanium	0.002		1e	7440-02-0
Si	Silicon	0.26				Ca	Calcium	0.0012			
Cu	Copper	0.14		1e	7440-50-8	C.E.		0.41			
Ni	Nickel	0.05		1e	7440-02-0	CuNiCrMoV		0.316			
Cr	Chromium	0.08		1e	7440-47-3	CrMo		0.10			
Mo	Molybdenum	0.02									

Mechanical Testing		Heat Treat	
Test Lab	AFG 53717	Norm. Temp. (F)	1675
Test Bar Size	SACRIFICIAL PIECE	Norm. (Hrs)	5
HBW	149 - 149	Norm. Cooling Type	AIR
Elg (%)	34.0	Norm. Location	FVC 18351
RA (%)	63.0		
Tensile Specimen Size (in)	.494	Other	
Tensile (ksi)	73.2	VD	Y
Yield (ksi)	47.1	EF	Y
Gauge Length (in)	2	Fully Killed	Y

The recording of false, fictitious, or fraudulent statement or entries on this document may be punishable as a felony under federal statute.

EPCRA Supplier Notification: This product may contain one or more toxic chemicals subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act (Title III of the Superfund Amendments and Reauthorization Act of 1986) and 40 C.F.R. Part 372. Potentially reportable chemicals are indicated with a checkmark in the "EPCRA" column and a Chemical Abstract Services (CAS) registry number is provided for each such chemical in addition to the percent by weight of the chemical present in this product. It is your responsibility alone to determine whether your facility is required to submit a Toxic Release Inventory Report under EPCRA Section 313.

Certification No.: 1317082

Certification Date: 2/23/2018

Issued By: Nancy Loos

This report is issued in compliance with the requirements of EN10204 3.1 / ISO 10474 3.1.b

175-3450
LN 71, 72 RTJ LWN
OK am

Material Test Report

Heat Code: C889AN

Forged Vessel Connections

An AFGlobal Company

13770 Industrial Rd. Houston, TX 77015

Sales: (713) 393-4200

ISO 9001:2008 Certified

MattSCO Supply Co. 00011508	PO: 00435-12.1	Sales Order: 164731	Line: 1
1111 N. 161st Avenue	Item Code: LWN 40900114B002A1	Qty Shipped: 2	
Tulsa, OK 74116	Item Desc: LWN RTJ A105N 4"900X11.5		
	Mill Heat: A112238		
Spec: ASTM A105/A105M-(14)/ASME SA 105/SA 105M-(15) Section II Part A - Normalized			

TAG: 018-00435.3

Product compliant with NACE MR0175/ISO 15156-2:2015, Annex A (A.2.1.2, A2.1.3).
 Product compliant with NACE MR0103/ISO 17945:2015, Section 13.1.1 and 13.1.3.

- * No Weld repair performed.
- * Ladle Chemical Analysis results are reported from the raw material suppliers MTR.
- * Tensile taken from a round specimen. Measurement of elongation after fracture.
- * Yield strength was determined using the .2% offset method, unless otherwise specified.
- * All material supplied under this order is certified to be free of mercury contamination and no mercury bearing equipment was used in manufacturing, fabrication or testing.
- * When reported on MTR: Tensile Testing Per ASTM E8; Brinell Hardness Per ASTM E10; Charpy Testing Per ASTM E23
- * AF Global manufactures materials according to a certified Quality Management System conforming to ISO 9001:2008 and PED 2014/68/EU, Annex 1, Section 4.3

Unless otherwise noted on PO, Dimensions of all standard pipe flanges and flange fittings (NPS 1/2 to NPS 24) per ASME B16.5-2013, large diameter steel flanges (NPS 26 to 60) per ASME B16.47-2011, Orifice flanges per ASME B16.36-2015.

* FVC FLANGE DIMENSIONS & BOLTING COMPLY - ASME B16.5
 SELF-REINFORCING NOZZLES COMPLY WITH SPECIFICATION OF SECTION VIII DIV. 1 OR DIV. 2 PER CUSTOMER DESIGN/FVC DESIGN.

RECEIVED
 MAR 01 2018
 BY: OK CM

The recording of false, fictitious, or fraudulent statement or entries on this document may be punishable as a felony under federal statute.

EPCRA Supplier Notification: This product may contain one or more toxic chemicals subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act (Title III of the Superfund Amendments and Reauthorization Act of 1986) and 40 C.F.R. Part 372. Potentially reportable chemicals are indicated with a checkmark in the "EPCRA" column and a Chemical Abstract Services (CAS) registry number is provided for each such chemical in addition to the percent by weight of the chemical present in this product. It is your responsibility alone to determine whether your facility is required to submit a Toxic Release Inventory Report under EPCRA Section 313.

Certification No.: 1317082

Certification Date: 2/23/2018

Issued By: Nancy Loos

This report is issued in compliance with the requirements of EN10204 3.1/ISO 10474 3.1.b

Rina Sane - Metallurgical Lab Manager

Page 2 of 2

175-3450
 LN-7172 RTJLWN
 OK CM

boltex mfg. co., l.p.4901 Oates Road Houston TX 77013
(713)675-9433 Fax: (713)672-6527

ORDER NUMBER 0143231

PO NUMBER 461-S-17

ORDER DATE 12/14/16

MATERIAL TEST REPORT

S O L D	MATTSO SUPPLY COMPANY 1111 N. 161ST EAST AVE TULSA OK 74116	S H I P	MATTSO SUPPLY COMPANY 1111 N 161ST EAST AVE TULSA OK 74116
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ITEMS

Ln#	Qty	Description	Matl Spec	Heat Code	Mill Heat Number
077	20	4" 600 RF WN SCH 160	SA105-N-14	P553	CM3053831
078	20	4" 600 RF WN XH	SA105-N-14	P700	CM3066699
079	27	6" 600 RF WN SCH 120	SA105-N-14	N916	CM3066140
079	3	6" 600 RF WN SCH 120	SA105-N-14	E674	SM256019
079	1	6" 600 RF WN SCH 120	SA105-N-14	J347	CM3008879
080	26	6" 600 RF WN SCH 160	SA105-N-14	N603	WR14394
082	20	8" 600 RF WN XH	SA105-N-14	N903	CM3065667

CHEMICAL PROPERTIES

Heat Code	C	Si	Mn	P	S	Cr	Al	Cu	Ni	Mo	V	Nb	Sn	N	CE
P553	0.200	0.260	1.010	0.015	0.025	0.140	0.003	0.250	0.090	0.031	0.002	0.002	0.013	0.000	0.426
P700	0.190	0.220	1.030	0.012	0.017	0.070	0.000	0.210	0.066	0.016	0.001	0.001	0.011	0.000	0.397
N916	0.200	0.220	0.990	0.013	0.020	0.070	0.001	0.250	0.060	0.015	0.002	0.002	0.007	0.000	0.403
E674	0.190	0.260	0.940	0.009	0.026	0.130	0.000	0.240	0.090	0.025	0.002	0.002	0.000	0.000	0.400
J347	0.230	0.230	0.950	0.009	0.019	0.070	0.000	0.190	0.080	0.020	0.004	0.000	0.000	0.000	0.425
N603	0.150	0.270	1.210	0.012	0.004	0.100	0.024	0.250	0.120	0.040	0.078	0.002	0.010	0.005	0.420
N903	0.190	0.230	0.990	0.011	0.012	0.070	0.001	0.190	0.070	0.014	0.002	0.001	0.008	0.000	0.390

PHYSICAL PROPERTIES

HEAT CODE	TENSL	YIELD	%ELONG	%R.A.	HBW	CHARPY	FT-LBS	LAT EXPSN	SHR FRACT	TEST TEMP
P553	79800	49500	37.20	65.80	163/163					
P700	78800	48400	36.20	65.12	163/163					
N916	80400	49800	32.00	66.77	163/163					
E674	78300	44400	34.00	56.61	163					
J347	75100	44900	32.10	59.64	159					
N603	78500	53400	30.10	46.50	159/159					
N903	78600	47100	36.20	64.66	159/163					

NOTES

HEAT CODE	NOTE
P553	NORMALIZED, TEMP/1650F, TIME @ TEMP/1 HR PER INCH, AIR COOL
P700	NORMALIZED, TEMP/1650F, TIME @ TEMP/1 HR PER INCH, AIR COOL
N916	NORMALIZED, TEMP/1650F, TIME @ TEMP/1 HR PER INCH, AIR COOL
E674	NORMALIZED, TEMP/1650F, TIME @ TEMP/1 HR PER INCH, AIR COOL
J347	NORMALIZED, TEMP/1650F, TIME @ TEMP/1 HR PER INCH, AIR COOL
N603	NORMALIZED, TEMP/1650F, TIME @ TEMP/1 HR PER INCH, AIR COOL
N903	NORMALIZED, TEMP/1650F, TIME @ TEMP/1 HR PER INCH, AIR COOL

All products bearing the "BOLTEX" name or logo "b" with the heat number prefix listed on the legend below have been manufactured at our Houston, TX facilities from steel melted and forged in the U.S.A. All other products have been manufactured at our Houston, TX facilities.

AR = Arkansas

CM or SI = Commercial Metals Corp.

GER = Gerdau Steel

NU = Nucor Steel

RE = Republic Steel

TI = Timken Steel

WR = Warren Steel

We certify our flanges are capable of passing a hydrostatic test compatible with their rating and all test results and process information contained herein are correct and true as contained in company records. All flanges meet NACE MRO-175 and/or MRO-103 Latest Revision.

Our quality system has been registered by DNV-GL to ISO 9001, Certificate No.: 142240-2013-AQ-RvA. Test results comply with EN 10204-3.1. Our flanges satisfy the material requirements for PED 97/23/EC Annex 1-4.3.

Notwithstanding the absence of a signature, the organization submitting either a printed certificate or an EDI transmitted certificates is responsible for content or the report. (ASTM/A 961-04a Section 19.4)

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Quality Assurance Manager

175-3450

LN. see above

OK

OCT 12 2017

17Apr17 9:43

TEST CERTIFICATE

4-20-17
No: 1 116748

KREHER STEEL COMPANY, LLC.
1550 NORTH 25TH AVENUE
MELROSE PARK, IL 60160
Tel: 708-345-8180 Fax: 708-345-8293

P/O No 3271
Rel
S/O No 1 296802-001
B/L No 1 241825-003 Shp 17Apr17
Inv No Inv

Sold To: (7811)
PRODUCTION MANUFACTURING CO., INC.
5909 EAST 13TH STREET
TULSA OK 74112

Ship To: (1)
PRODUCTION MANUFACTURING CO., INC.
5909 EAST 13TH STREET
TULSA OK 74112

Tel: 918-836-3585 Fax: 918-835-9681

CERTIFICATE of ANALYSIS and TESTS

Cert. No: 1 116748
17Apr17

Part No
TURN & POLISH ROUNDS A105
1.7500 X 16' R/L

ASTM A105-10 (CHEM ONLY)

ASME SA105

HEAT NUMBER 145074

Cu .18 , V .038 AND Cb/Nb .003

LOT NUMBER WEIGHT 23,232

TENSILE 83,900

YIELD 60,700

ELONGATION 22 %

REDUCTION OF AREA 41 %

HARDNESS 165 - AT SURFACE

MADE IN THE USA

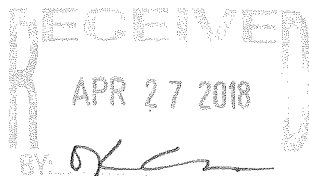
Heat Number
145074

*** Chemical Analysis ***

C=0.2100 Mn=0.9400 P=0.0070 S=0.0270 Si=0.2200 Cu=0.1800
Ni=0.0630 Cr=0.1340 Mo=0.0180 Al=0.0030 Cb=0.0030 V=0.0380
B=<.0004> Ti=<.0006> N=<.0105> Ca=<.0025>

I hereby certify that this data is correct as
contained in the records of this company.
I hereby certify that no mercury came in contact
with or no weld repair was done to this product
while in our possession.

[Signature]



178-3450
LN-93 coupling
OK
PRODUCTION MFG, TULSA, OKLA
CUSTOMER STEELTEK
P.O.# 94767-3450
ITEM 3/4"-6000" X 4" TPE COUPLER
HEAT CODE 14/K

08Apr13 14: 4

TEST CERTIFICATE

No: 1 108719

KREHER STEEL COMPANY, LLC.

1550 NORTH 25TH AVENUE

METROSE PARK, IL 60160

Tel: 708-345-8180 Fax: 708-345-8293

P/O No 2756

Rel

S/O No 1 246564-001

B/L No 1 200120-002

Inv No

4-11-13

Shp 08Apr13
Inv

Sold To: (7811)
PRODUCTION MANUFACTURING CO., INC.
5909 EAST 13TH STREET
TULSA OK 74112

Ship To: (1)
PRODUCTION MANUFACTURING CO., INC.
5909 EAST 13TH STREET
TULSA OK 74112

Tel: 918-836-3585 Fax: 918-835-9681

CERTIFICATE of ANALYSIS and TESTS

Cert. No: 1 108719
08Apr13

Part No
TURN & POLISH ROUNDS SA105
1.1250 X 16'R/L

ASTM A105-10
ASME SA105
HEAT NUMBER 121780
Cu .15 , V .036 AND Cb/Nb .001
LOT NUMBER 52809 WEIGHT 11412
TENSILE 83800
YIELD 63100
ELONGATION 25 %
REDUCTION OF AREA 48 %
HARDNESS 169 -169 AT SURFACE
MADE IN THE USA

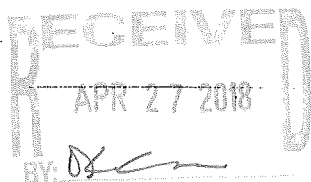
Heat Number
121780

*** Chemical Analysis ***

C=0.2000 Mn=0.9400 P=0.0090 S=0.0280 Si=0.2200 Cu=0.1500
Ni=0.0710 Cr=0.0920 Mo=0.0180 Al=0.0030 Cb=0.0010 V=0.0360
Sn=<.007> B=<.0003> Ti=<.0002> N=<.0082> Ca=<.0023> GR=<7>

I hereby certify that this data is correct as
contained in the records of this company.
I hereby certify that no mercury came in contact
with or no weld repair was done to this product
while in our possession.

G. Papp



175-3450
LN. 93 plug
OK

PRODUCTION MFG, TULSA, OKLA.
CUSTOMER STEELTEK
P.O. # 94767-3450
ITEM 3/4" X 3" RA BAR PLG
HEAT CODE 10 K

10Apr15 9:47

TEST CERTIFICATE

No: 1 113676

KREHER STEEL COMPANY, LLC.
1550 NORTH 25TH AVENUE
MELROSE PARK, IL 60160
Tel: 708-345-8180 Fax: 708-345-8293

P/O No 3220
Rel
S/O No 1 276881-001
B/L No 1 222882-002 Shp 10Apr15
Inv No Inv

4-14-15

Sold To: (7811)
PRODUCTION MANUFACTURING CO., INC.
5909 EAST 13TH STREET
TULSA OK 74112

Ship To: (1)
PRODUCTION MANUFACTURING CO., INC.
5909 EAST 13TH STREET
TULSA OK 74112

1 3/4 Ø SA105 14K

Tel: 918-836-3585 Fax: 918-835-9681

CERTIFICATE of ANALYSIS and TESTS

Cert. No: 1 113676
10Apr15

Part No
TURN & POLISH ROUNDS SA105
1.7500 X 16'R/L

0

ASTM A105-
ASME SA105
HEAT NUMBER 144424
Cu 0.18, V .038 AND Cb/Nb .001
LOT NUMBER WEIGHT 23,544
TENSILE 82,200
YIELD 57,200
ELONGATION 27 %
REDUCTION OF AREA 58 %
HARDNESS 165 - AT SURFACE
MADE IN THE USA

Heat Number
144424

*** Chemical Analysis ***

C=0.2000 Mn=0.9400 P=0.0060 S=0.0260 Si=0.2100 Cu=0.1800
Ni=0.0610 Cr=0.1180 Mo=0.0170 Al=0.0020 Cb=0.0010 V=0.0380
Sn=<.009> Ti=<.0006> N=<.0082> Ca=<.0009> GR=<8>

I hereby certify that this data is correct as
contained in the records of this company.
I hereby certify that no mercury came in contact
with or no weld repair was done to this product
while in our possession.

Playman

PRODUCTION MFG, TULSA, OKLA

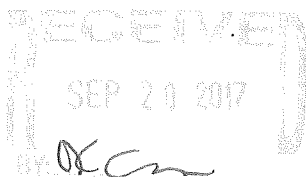
CUSTOMER STEELTEK

P.O.# 94761-3450

ITEM 3/4"-6000" X 2" TOE coupling

HEAT CODE 14K

175-3450
LN. 93 coupling
OKCm



08Apr13 14: 4

T E S T

C E R T I F I C A T E

No: 1 108719

KREHER STEEL COMPANY, LLC.
1550 NORTH 25TH AVENUE

P/O No 2756

4-11-13

MELROSE PARK, IL 60160

Rel

Tel: 708-345-8180 Fax: 708-345-8293

S/O No 1 246564-001

B/L No 1 200120-002

Shp 08Apr13

Inv No

Inv

Sold To: (7811)
PRODUCTION MANUFACTURING CO., INC.
5909 EAST 13TH STREET
TULSA OK 74112Ship To: (1)
PRODUCTION MANUFACTURING CO., INC.
5909 EAST 13TH STREET
TULSA OK 74112

Tel: 918-836-3585 Fax: 918-835-9681

CERTIFICATE of ANALYSIS and TESTSCert. No: 1 108719
08Apr13Part No
TURN & POLISH ROUNDS SA105
1.1250 X 16'R/LASTM A105-10
ASME SA105
HEAT NUMBER 121780
Cu .15 , V .036 AND Cb/Nb .001
LOT NUMBER 52809 WEIGHT 11412
TENSILE 83800
YIELD 63100
ELONGATION 25 %
REDUCTION OF AREA 48 %
HARDNESS 169 -169 AT SURFACE
MADE IN THE USAHeat Number
121780

*** Chemical Analysis ***

C=0.2000 Mn=0.9400 P=0.0090 S=0.0280 Si=0.2200 Cu=0.1500
Ni=0.0710 Cr=0.0920 Mo=0.0180 Al=0.0030 Cb=0.0010 V=0.0360
Sn=<.007> B=<.0003> Ti=<.0002> N=<.0082> Ca=<.0023> GR=<7>I hereby certify that this data is correct as
contained in the records of this company.
I hereby certify that no mercury came in contact
with or no weld repair was done to this product
while in our possession.175-3450
LJ-93 plug
OK
PRODUCTION MFG, TULSA, OKLA.
CUSTOMER STEELTEK
P.O.# 94761-3450
ITEM 3/4" x 3" Rd Bar plug
HEAT CODE 10 K



ALLOY & STAINLESS FASTENERS

11625 CHARLES ROAD
HOUSTON, TX 77041
ADMIN 713-466-3460
SALES 713-466-3031
SALES 713-466-9591 FAX

* C E R T I F I C A T E *
* O F T E S T *

To: MAINTENANCE TOOL & SUPPLY
DBA: MTS THREADED PRODUCTS CO.
1902 MESTINA STEET
CORPUS CHRISTI, TX 78408

Customer P/O # 29054

Our Order # 671435

Line	Qty	UOM	Description	LOT	
6	300	FT	3/4-10 x 12 FT. *DOMESTIC* THREADED ROD ASTM A193 GR.B7 ASTM SPEC DATE: 15 TEMPERING TEMP: 1340 DEG F QUENCHED & TEMPERED MERCURY FREE/NO WELD REPAIR COUNTRY OF MELT: USA	118591G	
				CADMIUM PLATED CUT TO 3/4-10 X 8 3/4"	
Heat No. 10397160		TENSILE (PSI) 141200	YIELD (PSI) 129200	CARBON .43	MANGANESE .87
ELONGATION 17.9		RED. OF AREA 57	HARDNESS (HB) 286	PHOSPHORUS .008	SULFUR .024
MACRO ETCH S2-R2-C2				CHROMIUM .91	MOLY. .21
					SILICON .28

We certify that the material or the fasteners, or both, were manufactured, sampled, tested, and inspected in accordance with the specification listed above and any supplementary requirements or other requirements designated in the purchase/sales order and was found to meet those requirements.

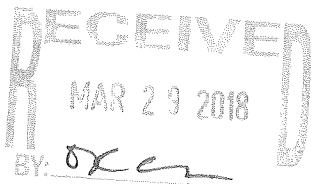
PO # 94766-3450
MK # 41

17.5-3450
LN-41 studs
OK cm

ALLOY & STAINLESS FASTENERS

By: Susan Rodriguez

Susan E. Rodriguez
Certification Custodian





ALLOY & STAINLESS FASTENERS

11625 CHARLES ROAD
HOUSTON, TX 77041
ADMIN 713-466-3460
SALES 713-466-3031
SALES 713-466-9591 FAX

* C E R T I F I C A T E *
* O F T E S T *

To: MAINTENANCE TOOL & SUPPLY
DBA: MTS THREADED PRODUCTS CO.
1902 MESTINA STEET
CORPUS CHRISTI, TX 78408

Customer P/O # 29054

Our Order # 671435

Line	Qty	UOM	Description	LOT	
6	300	FT	3/4-10 x 12 FT. *DOMESTIC* THREADED ROD ASTM A193 GR.B7 ASTM SPEC DATE: 15 TEMPERING TEMP: 1340 DEG F QUENCHED & TEMPERED MERCURY FREE/NO WELD REPAIR COUNTRY OF MELT: USA	118591G	
				CADMIUM PLATED CUT TO 3/4-10 X 8 3/4"	
Heat No. 10397160		TENSILE (PSI) 141200	YIELD (PSI) 129200	CARBON .43	MANGANESE .87
ELONGATION 17.9		RED. OF AREA 57	HARDNESS (HB) 286	PHOSPHORUS .008	SULFUR .024
MACRO ETCH S2-R2-C2				CHROMIUM .91	MOLY. .21
					SILICON .28

We certify that the material or the fasteners, or both, were manufactured, sampled, tested, and inspected in accordance with the specification listed above and any supplementary requirements or other requirements designated in the purchase/sales order and was found to meet those requirements.

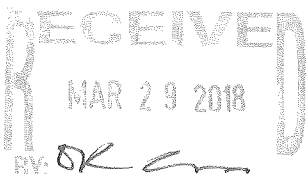
PO # 94766-3450
MK # 42

17\$-3450
LN-42 studs
OK

ALLOY & STAINLESS FASTENERS

By: Susan Rodriguez

Susan E. Rodriguez
Certification Custodian



INSPECTION CERTIFICATE

QS 9000 / ISO 9001



MANUFACTURE OF NUTS & AUTO PARTS

SAMJIN JEONGGONG CO.,LTD

630, YEONAM DONG, BUK-GU, ULSAN, KOREA

TEL : (052)701-5000, FAX : (052)701-5004

CERTIFICATE No	140227-01	DESCRIPTION	GR 2H HVY HEX NUTS	COUNTRY OF ORIGIN	KOREA
BUYER	FASTENER LINK	QUANTITY	196,800PCS	MATERIAL	AISI1045
INVOICE No	INT3-0214	TESTING SAMPLE Q'TY	5POS	HEAT No	JU1952-01
P.O. No	S1445/DL	DATE OF ISSUE	27-Feb-14	MFG DATE	27-Jan-14
SPECIFICATION	ASTM A194-09				

1. CHEMICAL COMPOSITION REQUIREMENTS

SIZE	C	Si	Mn	P	S	Ni	Cr	Cu
(mm)	x100			x1000		x100		
25.0	45	22	69	13	17	6	13	11

2. MECHANICAL REQUIREMENTS

1) MATERIAL	SIZE	Tensile stress	Yield point	Elongation	Reduction of area
		Kgf/mm ²		(%)	
Requirement					

2)PRODUCTS	SIZE	Sample No	Proof Load (KN)	Hardness Test		Tempering Temperature
				Sample nuts after heat-treatment 540°C/24h	Completed nuts	
	3/4-10	1	Pass(263)	HRB 91	HRC 30	510°C
		2	Pass(261)	HRB 91	HRC 31	
		3	Pass(262)	HRB 90	HRC 31	
		4	Pass(264)	HRB 92	HRC 32	
		5	Pass(263)	HRB 91	HRC 30	
Requirement		min 260	HRB min 89	HRC 24-35	min 455°C	

REMARK	1. Hardness tested q'ty	19,680Pcs	CADMIUM PLATED
	2. Macroetch test	OK	

PO # 94766-3450
MK # 43

See Bong Oh

Chief of Quality Control Dept

We hereby verify that the outcomes test, conducted in accordance ASTM A194 GR 2H specifications, true and correct in every aspects and details.

MAR 29 2018

BY: *OK cm*

175-3450
LN-43 nuts
OK cm



HIGHLAND THREADS

11700 GLOGER, HOUSTON, TX 77039

Phone: 800-847-5713 / 281-986-5100 / Fax: 281-986-5151

Material Test Report

MTR #: 31869

Page: 1 of 1

SOLD TO: TRI STATE SALES
745 JOHN BURROWS DR
CLAREMORE,, OK 74017

SHIP TO: TRI STATE SALES
745 JOHN BURROWS DRIVE
CLAREMORE, OK 74017

20677-3

DATE	SALES ORDER #	CUST P.O.#	TAG NUMBER	SPECIFICATION
10/23/2017	1452144	20677		ASTM A193 B7 THRU 2 1/2"

LINE #	QTY	ITEM #	ITEM DESCRIPTION	LOT NUMBER	MILL HEAT
2	48		7/8-9 X 8 1/2 ASTM A193 B7.. ALL THREAD STUDS CAD YELL	CCLU	3066802

CHEMICAL ANALYSIS						
C	Mn	P	S	Si	Cr	Mo
0.41	0.95	0.014	0.019	0.27	1.09	0.226

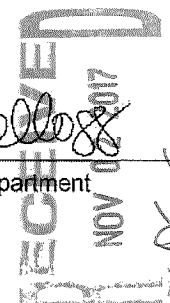
PHYSICAL PROPERTIES				
Elongation %	Reduction of Area %	Tensile PSI	Yield PSI	Hardness Brinell
23.41	60.15	146,110	137,650	306

SUPPLEMENTAL INFORMATION

MIN. TEMPERING TEMP: 1100 DEG. F. ASTM A193-14 ASTM E381: S1/R1/C1 COUNTRY OF
ORIGIN: USA QUENCHED AND TEMPERED MATERIAL

MANUFACTURED, SAMPLED, TESTED, AND INSPECTED IN ACCORDANCE WITH THE
REQUIREMENTS OF THE REFERENCED SPECIFICATION

Stacey Kellogg
Quality Assurance Department





11700 GLOGER, HOUSTON, TX 77039

Phone: 800-847-5713 / 281-986-5100 / Fax: 281-986-5151

Material Test Report

MTR # : 31871

Page : 1 of 1

SOLD TO: TRI STATE SALES
745 JOHN BURROWS DR
CLAREMORE, OK 74017

SHIP TO: TRI STATE SALES
745 JOHN BURROWS DRIVE
CLAREMORE, OK 74017

20677-4

DATE	SALES ORDER #	CUST P.O.#	TAG NUMBER	SPECIFICATION
10/23/2017	1452144	20677		ASTM A194 GR 2H HVY HX NUTS 7/8-9

LINE #	QTY	ITEM #	ITEM DESCRIPTION	LOT NUMBER	MILL HEAT
4	96		7/8-9 ASTM A194 GRADE 2H HEAVY HEX NUTS CAD YELLOW PLA	BTKT	JU1642

CHEMICAL ANALYSIS				
C	Mn	P	S	Si
0.43	0.67	0.014	0.015	0.19

PHYSICAL PROPERTIES		
Hardness Brinell	24 HR Hard BHN	Proof Load LbF
328	97	80.850

SUPPLEMENTAL INFORMATION

MIN TEMPERING TEMP 850 DEG F MACRO ETCH: E381 S1/R2/C2 SPEC DATE: ASTM
A194-13

MANUFACTURED, SAMPLED, TESTED, AND INSPECTED IN ACCORDANCE WITH THE
REQUIREMENTS OF THE REFERENCED SPECIFICATION

Q.#	TAG NUMBER	SPEC
DESCRIPTION		ASTM
ASTM A194 GRADE 2H HEAVY HEX NUTS		LOT N
LOW PL		BTKT
CHEMICAL ANALYSIS		
PHYSICAL PROPERTIES		
SUPPLEMENTAL INFORMATION		
2/C2 SPEC DATE: ASTM		
ACCORDANCE WITH THE		

1. $2x^2 + 3x - 5$
 2. $4x^2 - 7x + 1$
 3. $5x^2 + 2x - 8$
 4. $3x^2 - 9x + 6$
 5. $6x^2 + 4x - 1$
 6. $7x^2 - 2x + 3$
 7. $8x^2 + 5x - 4$
 8. $9x^2 - 6x + 2$
 9. $10x^2 + 7x - 9$
 10. $11x^2 - 8x + 5$
 11. $12x^2 + 9x - 10$
 12. $13x^2 - 10x + 7$
 13. $14x^2 + 11x - 12$
 14. $15x^2 - 12x + 9$
 15. $16x^2 + 13x - 14$
 16. $17x^2 - 14x + 11$
 17. $18x^2 + 15x - 16$
 18. $19x^2 - 16x + 13$
 19. $20x^2 + 17x - 18$
 20. $21x^2 - 18x + 15$
 21. $22x^2 + 19x - 20$
 22. $23x^2 - 20x + 17$
 23. $24x^2 + 21x - 22$
 24. $25x^2 - 22x + 19$
 25. $26x^2 + 23x - 24$
 26. $27x^2 - 24x + 21$
 27. $28x^2 + 25x - 26$
 28. $29x^2 - 26x + 23$
 29. $30x^2 + 27x - 28$
 30. $31x^2 - 28x + 25$
 31. $32x^2 + 29x - 30$
 32. $33x^2 - 30x + 27$
 33. $34x^2 + 31x - 32$
 34. $35x^2 - 32x + 29$
 35. $36x^2 + 33x - 34$
 36. $37x^2 - 34x + 31$
 37. $38x^2 + 35x - 36$
 38. $39x^2 - 36x + 33$
 39. $40x^2 + 37x - 38$
 40. $41x^2 - 38x + 35$
 41. $42x^2 + 39x - 40$
 42. $43x^2 - 40x + 37$
 43. $44x^2 + 41x - 42$
 44. $45x^2 - 42x + 39$
 45. $46x^2 + 43x - 44$
 46. $47x^2 - 44x + 41$
 47. $48x^2 + 45x - 46$
 48. $49x^2 - 46x + 43$
 49. $50x^2 + 47x - 48$
 50. $51x^2 - 48x + 45$
 51. $52x^2 + 49x - 50$
 52. $53x^2 - 50x + 47$
 53. $54x^2 + 51x - 52$
 54. $55x^2 - 52x + 49$
 55. $56x^2 + 53x - 54$
 56. $57x^2 - 54x + 51$
 57. $58x^2 + 55x - 56$
 58. $59x^2 - 56x + 53$
 59. $60x^2 + 57x - 58$
 60. $61x^2 - 58x + 55$
 61. $62x^2 + 59x - 60$
 62. $63x^2 - 60x + 57$
 63. $64x^2 + 61x - 62$
 64. $65x^2 - 62x + 59$
 65. $66x^2 + 63x - 64$
 66. $67x^2 - 64x + 61$
 67. $68x^2 + 65x - 66$
 68. $69x^2 - 66x + 63$
 69. $70x^2 + 67x - 68$
 70. $71x^2 - 68x + 65$
 71. $72x^2 + 69x - 70$
 72. $73x^2 - 70x + 67$
 73. $74x^2 + 71x - 72$
 74. $75x^2 - 72x + 69$
 75. $76x^2 + 73x - 74$
 76. $77x^2 - 74x + 71$
 77. $78x^2 + 75x - 76$
 78. $79x^2 - 76x + 73$
 79. $80x^2 + 77x - 78$
 80. $81x^2 - 78x + 75$
 81. $82x^2 + 79x - 80$
 82. $83x^2 - 80x + 77$
 83. $84x^2 + 81x - 82$
 84. $85x^2 - 82x + 79$
 85. $86x^2 + 83x - 84$
 86. $87x^2 - 84x + 81$
 87. $88x^2 + 85x - 86$
 88. $89x^2 - 86x + 83$
 89. $90x^2 + 87x - 88$
 90. $91x^2 - 88x + 85$
 91. $92x^2 + 89x - 90$
 92. $93x^2 - 90x + 87$
 93. $94x^2 + 91x - 92$
 94. $95x^2 - 92x + 89$
 95. $96x^2 + 93x - 94$
 96. $97x^2 - 94x + 91$
 97. $98x^2 + 95x - 96$
 98. $99x^2 - 96x + 93$
 99. $100x^2 + 97x - 98$
 100. $101x^2 - 98x + 95$

Stacey Kellogg
Quality Assurance Department

088
NOV 02 2017
ent

05/04/2017 From: AMERICAN ALLOY STEEL, INC.

To: STEELTEK, INC.

P.O.#: 7924-CG

S.O.#: 570969

AA PL#: 5182534

Item: 5 (1 PC) 3/8" X 96" X 480"

ArcelorMittal Burns Harbor Plate

SHIPMENT NO. 804-07244		DATE SHIPPED 03-29-17		CAR OR VEHICLE NO. CSS-CHGO-BNSF		LMIC 007035		PAGE 2	
AMERICAN ALLOY STEEL INC PO BOX 40469 HOUSTON TX 77240-0469				AMERICAN ALLOY STEEL INC C/O SKOL TRACK #21 6350 N ERIE AVE OWASSO OK					

N O T E	SERIAL NUMBER	PAT NO.	HEAT NUMBER	NO. PCS.	SIZE AND QUANTITY				YIELD POINT	TENSILE STRENGTH	AFRAC. ELONG.	RED.
					THICKNESS	WIDTH OR DIA.	LENGTH	WEIGHT				

QUALITY STEEL MELTED & MANUFACTURED IN THE U. S. A.

PLATES - ASTM A516-06 GR 70 PVQ MOD C.20 MAX CU.15 MAX KLD FINE GRAIN PRAC.
ASTM A516-06 GR 65 PVQ, ASME SA516 GR 70 PVQ 2015 EDITION, ASME
SA516 GR 65 PVQ 2015 EDITION, FIRST TST AS ROLLED-ADD'L TENSION PER
TST PC HEAT TREATMENT --- MILL TEST PCS NORM 1650+/-25F FOR
30MIN/IN (30 MINUTES MIN), AIRCOOL --- TEST CERTS ARE PREPARED IN
ACCORD WITH PROCEDURES OUTLINED IN EN 10204:2004 TYPE 3.1
NO WELD REPAIR WAS PERFORMED ON BELOW PLATE(S)

CO# 110641-OK GH 354-5430A

E549245	813W61890	2	.375	96	480	9802	47300	77400	8	25
(M55)MFST REF#:2						52000	73900	8	26	
E549246	813W61890	3	.375	96	480	14703	46700	78100	8	23
(M55)MFST REF#:2						52400	75900	8	26	

Q-QUENCH TEMPERATURE

T-TEMPERATURE

N-NORMALIZE TEMPERATURE

SERIAL NUMBER	PAY NO.	HEAT NUMBER	HARD RHN	BEND	THICKNESS INCHES	TYPE	SIZE	DIR	TEST TEMP	CHARPY IMPACT								
										ENERGY IN LBS			SHEAR(%)			LAT. EXP MILS		
										1	2	3	1	2	3	1	2	3

Certified a true copy of the
original, retained in our file.
AMERICAN ALLOY STEEL, INC.

Reviewed By:

JF 5/4/2017

HEAT NUMBER	CHEMICAL ANALYSIS																LIQUID GRAIN SIZE
	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Ti	Al	B	Ch	N	So	
813W61890	.17	1.08	.009	.007	.316	.022	.01	.13	.082	.001	.002	.033	.0002	.002	.005	.004	

I certify that the above results are a true and correct copy of actual results contained in records maintained by ArcelorMittal Burns Harbor and are in full compliance with the requirements of the specification cited above. This test report cannot be altered and must be transmitted intact with any subsequent third party test reports, if required.

SHIPMENT

SUPV. QUALITY ASSURANCE

R. SPANGLER II LSS

RECEIVED
MAY 04 2017
BY: OK

175-3450
LN 120, 124 plate
OK

AMERICAN ALLOY
PLATE 5182534

3/8" 3367

SSAB

Test Certificate

12400 Highway 43 North, Axis, Alabama 36505, US

Form TC1: Revision 2: Date 23 Apr 2014

Customer: METALS USA PLATES & SHAPES-SOUTHCENTRAL P.O. BOX 3528 101 EAST ILLINOIS ENID OK 73702				Customer P.O.No.: MUS-245113				Mill Order No. 41-454704-12				Shipping Manifest: AR217474									
				Product Description: ASTM A516-70(10/15)/ASME SA516-70(15)				Ship Date: 11 Jan 16				Cert No: 081537297 (Page 1 of 1)									
								Cert Date: 11 Jan 16													
				Size: 0.375 X 120.0 X 480.0 (IN)																	
Tested Pieces:				Tensiles:				Charpy Impact Tests													
Heat Id	Piece Id	Tested Thickness	Tst Loc	YS (KSI)	UTS (KSI)	%RA	Elong % 2in 8in	Tst Dir	Hardness	Abs. Energy(FTLB) 1 2 3 Avg				% Shear 1 2 3 Avg				Tst Tmp	Tst Dir	Tst Siz (mm)	BDWTT Tmp %Shr
E5L176	A05	0.372 (DISCRT)	L	58	79		23	T													
Chemical Analysis																					
Heat Id	C	Mn	P	S	Si	Tot Al	Sol Al	Cu	Ni	Cr	Mo	Cb	V	Ti	B	Cev	ORGN USA				
E5L176	.20	1.04	.008	.002	.24	.028	.027	.28	.15	.07	.03	.000	.003	.008	.0001	.42					
KILLED STEEL MERCURY IS NOT A METALLURGICAL COMPONENT OF THE STEEL AND NO MERCURY WAS INTENTIONALLY ADDED DURING THE MANUFACTURE OF THIS PRODUCT. KILLED STEEL, PRODUCED TO A FINE GRAIN PRACTICE CEV (IIW) = C + MN/6 + (CR+MO+V)/5 + (NI+CU)/15 MTR EN 10204:2004 INSPECTION CERTIFICATE 3.1 COMPLIANT 100% MELTED AND MANUFACTURED IN THE USA. PRODUCTS SHIPPED: E5L176 A05 PCES: 3, LBS: 18378																					
Cust Part #:										WE HEREBY CERTIFY THAT THIS MATERIAL WAS TESTED IN ACCORDANCE WITH, AND MEETS THE REQUIREMENTS OF, THE APPROPRIATE SPECIFICATION											
										Justin Ward SENIOR METALLURGIST - PRODUCT											

173-3450
L2. 121 (c.p.) plate
OK cm

FEB 12 2016

OK CH

05/26/2017 From: AMERICAN ALLOY STEEL, INC.

To: STEELTEK, INC.

P.O.#: 7964

S.O.#: 572574

AA PL#: 5182551

Item: 4 (1 PC) 3/8" X 96" X 480"

TAG: 3402, 3403

ArcelorMittal Burns Harbor Plate

QUALITY ASSURANCE
REPORT OF TEST AND ANALYSES

US HWY 12 Burns Harbor, Indiana

SHIPMENT NO.	DATE SHIPPED	CAR OR VEHICLE NO.	ATW	PAGE
004-07243	04-04-17	CSS-CHGO-BNSF	317019	1
AMERICAN ALLOY STEEL INC PO BOX 40469 HOUSTON TX 77240-0469		AMERICAN ALLOY STEEL INC C/O SKOL TRACK #21 6350 N ERIE AVE OWASSO OK		

SERIAL NUMBER	PAY NO.	HEAT NUMBER	NO. PCS.	THICKNESS	WIDTH OR DIA.	LENGTH	WEIGHT	YIELD POINT	TENSILE STRENGTH	AF FRAC. ELONG.	RED.
				INCHES	INCHES	INCHES	POUNDS	PSI	PSI	IN	%

QUALITY STEEL MELTED & MANUFACTURED IN THE U. S. A.

PLATES - ASTM A516-06 GR 70 PVQ MOD C.20 MAX C0.15 MAX KLD FINE GRAIN PRAC,
ASTM A516-06 GR 65 PVQ, ASME SA516 GR 70 PVQ 2015 EDITION, ASME
SA516 GR 65 PVQ 2015 EDITION, FIRST TEST AS ROLLED-ADD'L TENSION PER
TEST PC HEAT TREATMENT --- MILL TEST PCS NORM 1650 +/- 25F FOR
30MIN/IN (30 MINUTES MIN), AIRCOOL --- TEST CERTS ARE PREPARED IN
ACCORD WITH PROCEDURES OUTLINED IN EN 10204:2004 TYPE 3.1
NO WELD REPAIR WAS PERFORMED ON BELOW PLATE(S)

CO# 110641-OK GR 354-5430A

E548296	811W10880	3	.375	96	480	14703	53700	80300	8	24
							59500	79500	8	24

(M55)MFST REF#:2

E548300	813W61900	3	.375	96	480	14703	58200	79400	8	25
							54700	77200	8	21

(M55)MFST REF#:2

E548297	821W10890	3	.375	96	480	14703	59000	79200	8	24
							57900	76000	8	26

(M55)MFST REF#:2

QUENCH TEMPERATURE

TEMPERATURE

NORMALIZE TEMPERATURE

SERIAL NUMBER	PAY NO.	HEAT NUMBER	HARD ONLY SERIAL	SHEET	THICKNESS INCHES	TYPE	SIZE	DR	TEST TEMP °F	CHARACTERISTICS								
										ENERGY I LBS			SHEAR(M)			LAT. EXP MILS		
										1	2	3	1	2	3	1	2	3

Certified a true copy of the
original, retained in our file.
AMERICAN ALLOY STEEL, INC.

Reviewed By:

J.P. 5/25/2017

HEAT NUMBER	C	Mn	P	S	Si	Cu	N	Cr	Mo	V	Ti	Al	B	Cb	Ni	Sn	LIQUID GRAIN SIZE
811W10880	.18	1.10	.011	.005	.314	.030	.02	.12	.072	.002	.002	.028	.0002	.002	.006	.005	
813W61900	.18	1.11	.010	.005	.315	.026	.01	.13	.079	.002	.002	.030	.0002	.002	.006	.004	
821W10890	.18	1.10	.011	.004	.323	.028	.01	.12	.079	.002	.002	.031	.0002	.003	.006	.005	

I certify that the above results are a true and correct copy of actual results published in records maintained by ArcelorMittal Burns Harbor and are in full compliance with the requirements of the specification cited above. This test report cannot be altered and must be transmitted intact with any subsequent third party test reports, if required.

R. SPANGLER II PER LBS

CURV. QUALITY ASSURANCE

175-3450
LN-121 (1pc) plate
OK

AMERICAN ALLOY
PLATE #5182551

3/8

5495

MAY 26 2017

11/15/2016 From: AMERICAN ALLOY STEEL, INC.

To: STEELTEK, INC.

P.O.#: 7569

S.O.#: 558287

AA PL#: 5177872

Item: 1 (1 PC) 5/8" X 96" X 480"

ArcelorMittal Burns Harbor Plate

QUALITY ASSURANCE
REPORT OF TEST AND ANALYSES

US HWY 12 Burns Harbor, Indiana

SHIPMENT NO. 804-03973	DATE SHIPPED 07-06-16	CAR OR VEHICLE NO. CSS-CHGO-BNSF	OTTK 097946	PAGE 2
AMERICAN ALLOY STEEL INC PO BOX 40469 HOUSTON TX 77240-0469		AMERICAN ALLOY STEEL INC C/O SKOL TRACK #21 6350 N ERIE AVE OWASSO OK		

S E R I A L N U M B E R	P A T N O.	H E A T N U M B E R	N O. P C S.	S I Z E A N D Q U A N T I T Y				Y I E L D P O I N T	T E N S I L E S T R E N G T H	A F F R A C. E L O N G.	R E D.
				T H I C K N E S S	W I D T H O R D I A.	L E N G T H	W E I G H T				

INCHES INCHES INCHES POUNDS PSI PSI IN %

QUALITY STEEL MELTED & MANUFACTURED IN THE U. S. A.
 PLATES - ASTM A516-06 GR 70 PVQ MOD C.20 MAX CU.15 MAX KLD FINE GRAIN PRAC,
 A516-06 GR 65 PVQ, ASTM A516-06 GR 60 PVQ, ASME SA516 GR 70 PVQ 201
 EDITION, ASME SA516 GR 65 PVQ 2015 EDITION, ASME SA516 GR 60 PVQ 20
 EDITION, FIRST TST AS ROLLED-ADD'L TENSION PER TST PC HEAT TREATMEN
 MILL TEST PCS NORM 1650+/-25F FOR 30MIN/IN (30 MINUTES MIN), AIRCOO
 TEST CERTS ARE PREPARED IN ACCORD WITH PROCEDURES OUTLINED IN EN
 10204:2004 TYPE 3.1

NO WELD REPAIR WAS PERFORMED ON BELOW PLATE(S)

CO# 108591-OK GH 354-5169D

B574012	813T72960	1	.625	96	480	8168	55500	80000	8	21
							53800	75800	8	26

(M55)MFST REF#:5

B574013	813T72960	3	.625	96	480	24504	52200	79700	8	23
							52200	76200	8	25

(M55)MFST REF#:5

B651864	823T69930	1	.625	96	480	8168	50300	78300	8	26
							52400	74500	8	26

(M55)MFST REF#:5

Q-QUENCH TEMPERATURE

T-TEMPER TEMPERATURE

N-NORMALIZE TEMPERATURE

SERIAL NUMBER	PAT NO.	HEAT NUMBER	HARD BHN	BEND	CHARPY IMPACT													
					THICKNESS INCHES	TYPE	SIZE	DIR	TEST TEMP °F	ENERGY FT LBS			SHEAR(%)			LAT. EXP MILS		
										1	2	3	1	2	3	1	2	3

Certified a true copy of the
original, retained in our file.
AMERICAN ALLOY STEEL, INC.

Reviewed By:

JL 8/22/2016

H E A T N U M B E R	C H E M I C A L A N A L Y S I S																M I C R O G R A I N S I Z E
	C	Mn	P	S	Si	CU	NI	CR	MO	V	TI	AL	B	DB	N	SN	

813T72960	.18	1.11	.010	.005	.322	.027	.01	.13	.081	.002	.002	.028	.0002	.002	.007	.004
823T69930	.18	1.11	.015	.005	.317	.013	.01	.12	.083	.002	.002	.034	.0002	.002	.005	.002

I certify that the above results are a true and correct copy of actual results contained in records maintained by ArcelorMittal Burns Harbor and are in full compliance with the requirements of the specification cited above. This test report cannot be altered and must be transmitted intact with any subsequent third party test reports, if required.

BHPLTRPT.TF

SUPV. QUALITY ASSURANCE

R. SPANGLER II PER LSS

RECEIVED
NOV 15 2016
OK CH

175-3450
LN 122 plate
OK

AMERICAN ALLOY
PLATE # 5177872

5/8"

3437

NUCOR
PLATE MILL

P.O.Box 279
Winton, NC 27986
(252) 356-3700

Mill Test Report

Page 2

1505 River Rd
Cofield, NC 27922
(252) 356-3700

NUCOR
It's Our Nature.

Issuing Date : 05/30/2016 B/L No. : 445296 Load No. : 453054 Our Order No. : 137118/12 Cust. Order No. : MUS-245879
Vehicle No: NOKL 725035 Sold To: METALS USA - SOUTHCENTRAL Ship To: METALS USA - PLATES AND SHAPES
Specification: 0.3750" x 96.000" x 480.000" 2800 N 43RD ST E TRACK 747
ASTM A516 70-10(2015)/ASME SA516 70 PVQ 2013/2015 Normalized MUSKOGEE, OK 74401
Test Coupons at 1650 F NACE MR0175 Annex 2.1.2, MR0103 (2010)
Section 2.1.2(2015) 13.1.1, 13.1.2

Marking :

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Ceq	Pcm
6503425	0.19	1.08	0.008	0.003	0.21	0.23	0.09	0.09	0.01	0.029	0.007	0.001	0.003		0.0028	0.0001	0.010	0.41	0.27
6503426	0.19	1.08	0.007	0.002	0.20	0.24	0.08	0.08	0.01	0.027	0.006	0.000	0.002		0.0026	0.0000	0.010	0.41	0.27

Tensile Test										Charpy Impacts									
Plate Serial No	Pieces	Tons	Dir.	(psi) Yield	(psi) Tensile	Elongation % in 2"	Elongation % in 8"	Dir.	1	(%) shear	2	(%) shear	3	(%) shear	Ave.	(%) shear	Size	Temp	Min Ave.
6503425-07	3	7.35	T	51,700	77,500		19.6												
			T	51,800	76,900		24.1	N											
6503425-08	4	9.80	T	51,500	78,200		22.8												
			T	52,500	76,700		26.0	N											
6503425-09	4	9.80	T	53,200	78,600		22.8												
			T	51,800	76,200		27.4	N											
6503425-10	4	9.80	T	52,000	79,100		24.1												
			T	48,400	72,500		27.5	N											
6503425-11	4	9.80	T	52,000	77,600		23.0												
			T	51,900	76,900		24.0	N											
6503426-01	2	4.90	T	52,000	78,700		23.2												
			T	51,100	75,800		26.6	N											
			T	50,800	75,300		26.1	N											

NACE MR0175 ANNEX 2.1.2 COMPLIANT

Test coupons only, normalized 60 minutes per inch of thickness at 1650 F ± 25 F. Hold 30 minutes minimum. ;

Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material. Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast discrete plate as-rolled, unless otherwise noted in Specification. For Mexico shipments: nho-SalesMX@Nucor.com
Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)+((Cr+Mo+V)/5)+((Cu+Ni)/15)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B

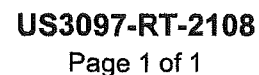
Melted and Manufactured in the USA. ISO 9001:2008 certified (#010940) by SRI Quality System Registrar (#0985-09). PED 97/23/EC 7/2 Annex 1, Para. 4.3 Compliant.
DIN 50049 3.1.B/EN 10204 3.1B(2004), DIN EN 10204 3.1(2005) compliant. For ABS grades only. Quality Assurance certificate 14-MMPQA-723

We hereby certify that the contents of this report are accurate and correct. All test results and operations performed by the material manufacturer are in compliance with the applicable specifications, including customer specifications.

T. A. Depretis
T. A. Depretis, Metallurgist

5/31/2016 10:01:22 AM

JUL 14 2016



Date: 27-Apr-18
Job #: 17S-3450
PO #: N/A
RE CHAN

B	6.625	.594	2-4	RT 3	.125
B	6.625	.594	2-4	RT 3	.125

IC - Internal Concavity
LF - Lack of Fusion
LC - Low Cover
MA - Misalignment
TI - Tungsten Inclusion

Radiography Performed By: _____

Sam Howard

(Print) _____

(Sign) _____

Interpreted By: _____

Jason Miller

(Print) _____

[Signature]

(Sign) _____

Client Representative: (Print) _____

I am in full agreement
with report contents (Sign) _____

SNT-TC-1A: _____

ASNT: _____

CERT #: _____

SNT-TC-1A: 277

ASNT: _____

CERT #: _____

www.irisnrdt.com

*Shell & Tube - Air Cooled Exchangers***HYDRO TEST CERTIFICATION**

Date & Time : May 18, 2018

Customer : UOP Russell, LLC.

Purchase Order No. : 4500801009

Item No. : E-202

Steeltek Serial No. : 17S-3450

This is to certify that the above item was hydro tested in accordance with ASME Section VIII, UG-99. Test pressure was held for 1-Hour minimum.

Shell Side PSIG : 2646

Tube Side PSIG : 1431


Quality Control Department

*Shell & Tube - Air Cooled Exchangers*DATE June 12, 2018

COMPANY

UOP RussellITEM / P.O. 17S-3450

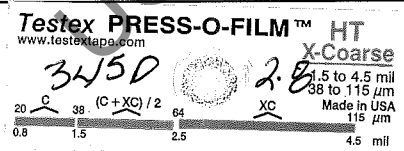
PAINT SYSTEM:

3 coat system *as specified

	DESCRIPTION	BATCH #	MFG. DATE
1st	Macropoxy 646 *prime coat shell side	(A)AXM2277LJ (B)XM2317UH	1-Apr Apr-18
2nd	Macropoxy 646 *secondary coat channel side	*same *same	*same *same
3rd	Hi-Solids Polyurethane *finish coat channel side	(A)XM2237GM (B)MQ1167GM	1-Feb 1-Feb

	RELATIVE HUMIDITY	DEW POINT	SURFACE TEMP	AMIENT TEMP	DATE
S/B	34.7	19.2	59.6	68.4	7-Jun
1st	32.2	15.9	59	69.6	7-Jun
2nd	38.2	18.6	62.5	69	8-Jun
3rd	33.2	18	60.2	70	11-Jun

SURFACE PROFILE



DRY FILM THK.

	MINIMUM	MAXIMUM	AVERAGE
1st	4	6	5.3
2nd	4	6	5.9
3rd	3	4	3.7

Prepared By :

T. Lightcap

Customer Inspector : _____

QW-482 SUGGESTED FORMAT FOR WELDING PROCEDURE SPECIFICATION (WPS)

(See QW-200.1, Section IX, ASME Boiler and Pressure Vessel Code)

Company Name STEELTEK, INC. By: PHIL SCOTT
Welding Procedure Specification No. ST-4 Date 5-1-91 Supporting PQR No.(s) ST-4
Revision No. 1 Date 3-31-97
Welding Process(es) FCAW Type(s) SEMI-AUTOMATIC
(Automatic, Manual, Machine, or Semi-Auto.)

JOINTS (QW-402)

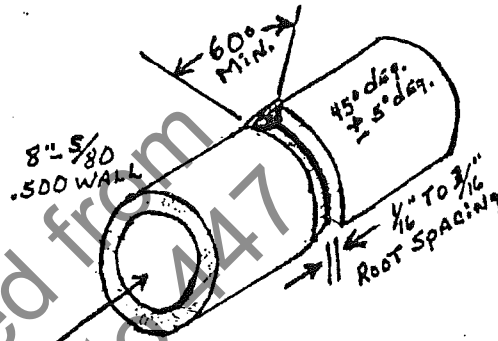
Details

Joint Design _____
Backing (Yes) _____ (No) X
Backing Material (Type) N/A
(Refer to both backing and retainers.)

- ☐ Metal ☐ Nonfusing Metal
☐ Nonmetallic ☐ Other

Sketches, Production Drawings, Weld Symbols or Written Description should show the general arrangement of the parts to be welded. Where applicable, the root spacing and the details of weld groove may be specified.

(At the option of the Mfr., sketches may be attached to illustrate joint design, weld layers and bead sequence, e.g. for notch toughness procedures, for multiple process procedures, etc.)



*BASE METALS (QW-403)

P-No. 1 Group No. 1 & 2 to P-No. 1 Group No. 1 & 2

OR

Specification type and grade SA-106-B
to Specification type and grade SA-106-B

OR

Chem. Analysis and Mech. Prop. N/A
to Chem. Analysis and Mech. Prop. N/A

Thickness Range:

Base Metal: Groove 3/16" to 1" Fillet ALL
Pipe Dia. Range: Groove 2-7/8" O.D. AND OVER Fillet ALL
Other _____

*FILLER METALS (QW-404)

Spec. No. (SFA) 5.20
AWS No. (Class) E-71T-1
F-No. 6
A-No. 1
Size of Filler Metals .035" & .045"
Weld Metal .500
Thickness Range: 3/16" to 1"
Groove 1"
Fillet ALL
Electrode-Flux (Class) N/A
Flux Trade Name N/A
Consumable Insert N/A
Other N/A

*Each base metal-filler metal combination should be recorded individually.

QW-482 (Back)

WPS No. ST-4 Rev. _____

POSITIONS (QW-405) Position(s) of Groove <u>6G</u> Welding Progression: Up <u>X</u> Down <u>X</u> Position(s) of Fillet _____	POSTWELD HEAT TREATMENT (QW-407) Temperature Range <u>N/A</u> Time Range <u>N/A</u>																
PREHEAT (QW-406) Preheat Temp. Min. <u>50° F. MIN.</u> Interpass Temp. Max. <u>350° F. MAX</u> Preheat Maintenance <u>AS WELDED</u> (Continuous or special heating where applicable should be recorded)	GAS (QW-408) <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th></th> <th style="text-align: center;">Gas(es)</th> <th style="text-align: center;">Percent Composition (Mixture)</th> <th style="text-align: center;">Flow Rate</th> </tr> </thead> <tbody> <tr> <td>Shielding</td> <td style="text-align: center;">ARGON & CO2</td> <td style="text-align: center;">75/25</td> <td style="text-align: center;">30-45 CFH</td> </tr> <tr> <td>Trailing</td> <td style="text-align: center;">N/A</td> <td style="text-align: center;">N/A</td> <td style="text-align: center;">N/A</td> </tr> <tr> <td>Backing</td> <td style="text-align: center;">N/A</td> <td style="text-align: center;">N/A</td> <td style="text-align: center;">N/A</td> </tr> </tbody> </table>		Gas(es)	Percent Composition (Mixture)	Flow Rate	Shielding	ARGON & CO2	75/25	30-45 CFH	Trailing	N/A	N/A	N/A	Backing	N/A	N/A	N/A
	Gas(es)	Percent Composition (Mixture)	Flow Rate														
Shielding	ARGON & CO2	75/25	30-45 CFH														
Trailing	N/A	N/A	N/A														
Backing	N/A	N/A	N/A														

ELECTRICAL CHARACTERISTICS (QW-409)

Current AC or DC DC Polarity REVERSE
 Amps (Range) 90-240 Volts (Range) 18-28

(Amps and volts range should be recorded for each electrode size, position, and thickness, etc. This information may be listed in a tabular form similar to that shown below.)

Tungsten Electrode Size and Type N/A

(Pure Tungsten, 2% Thoriated, etc.)

Mode of Metal Transfer for GMAW N/A

(Spray arc, short circuiting arc, etc.)

Electrode Wire feed speed range _____

TECHNIQUE (QW-410)

String or Weave Bead STRING

Orifice or Gas Cup Size 5/8"

Initial and Interpass Cleaning (Brushing, Grinding, etc.) BRUSHING, CHIPPING & GRINDING

Method of Back Gouging N/A

Oscillation 5/8"

Contact Tube to Work Distance 1/4" to 3/8"

Multiple or Single Pass (per side) MULTIPLE (WELDED FROM ONE SIDE)

Multiple or Single Electrodes SINGLE

Travel Speed (Range) MANUAL

Peening N/A

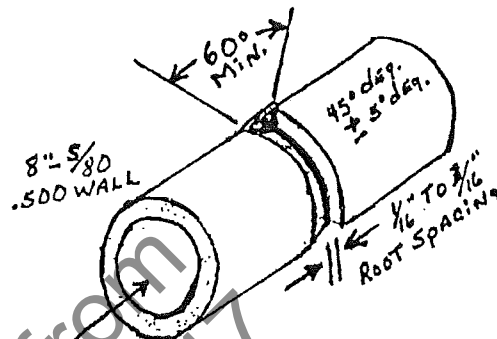
Other N/A

Weld Layer(s)	Process	Filler Metal		Current		Volt Range	Travel Speed Range	Other (e.g., Remarks, Comments, Hot Wire Addition, Technique, Torch Angle, Etc.)
		Class	Dia.	Type Polar.	Amp. Range			
1ST	FCAW	E-71T-1	.035"	REVERSE	90-130	18-23	MANUAL	
2ND	FCAW	E-71T-1	.045"	REVERSE	110-180	21-26	MANUAL	
3RD	FCAW	E-71T-1	.045"	REVERSE	110-180	21-28	MANUAL	
4TH	FCAW	E-71T-1	.045"	REVERSE	110-240	21-28	MANUAL	
5TH	FCAW	E-71T-1	.045"	REVERSE	110-240	21-28	MANUAL	
6TH	FCAW	E-71T-1	.045"	REVERSE	110-240	21-28	MANUAL	

QW-483 SUGGESTED FORMAT FOR PROCEDURE QUALIFICATION RECORD (PQR)
 (See QW-200.2, Section IX, ASME Boiler and Pressure Vessel Code)
 Record Actual Conditions Used to Weld Test Coupon.

Company Name STEELTEK, INC.
 Procedure Qualification Record No. ST-4 Date 5-3-91
 WPS No. ST-4
 Welding Process(es) FCAW
 Types (Manual, Automatic, Semi-Auto.) SEMI-AUTOMATIC

JOINTS (QW-402)



Groove Design of Test Coupon

(For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process used.)

BASE METALS (QW-403)

Material Spec. SA-106
 Type or Grade B
 P-No. 1 to P-No. 1
 Thickness of Test Coupon .500"
 Diameter of Test Coupon 8.625" O.D.
 Other _____

POSTWELD HEAT TREATMENT (QW-407)

Temperature N/A
 Time N/A
 Other N/A

GAS (QW-408)

	Percent Composition		
	Gas(es)	(Mixture)	Flow Rate
Shielding	ARGON / CO2	75 / 25	40 CFH
Trailing	N/A	N/A	N/A
Backing	N/A	N/A	N/A

FILLER METALS (QW-404)

SFA Specification 5.20
 AWS Classification E-71T-1
 Filler Metal F-No. 6
 Weld Metal Analysis A-No. 1
 Size of Filler Metal .035"
 Other N/A
 Weld Metal Thickness .500

ELECTRICAL CHARACTERISTICS (QW-409)

Current DC
 Polarity REVERSE
 Amps. 190 Volts 24
 Tungsten Electrode Size N/A
 Other N/A

POSITION (QW-405)

Position of Groove 6G
 Weld Progression (Uphill, Downhill) UP & DOWN
 Other _____

TECHNIQUE (QW-410)

Travel Speed MANUAL
 String or Weave Bead STRING
 Oscillation 5/8"
 Multipass or Single Pass (per side) MULTIPASS
 Single or Multiple Electrodes SINGLE
 Other N/A

PREHEAT (QW-406)

Preheat Temp. 70° F.
 Interpass Temp. 350° F.
 Other _____

QW-483 (Back)

POR No. ST-4

Tensile Test (QW-150)

Specimen No.	Width	Thickness	Area	Ultimate Total Load lb	Ultimate Unit Stress psi	Type of Failure & Location
1	.744	.454	.3378	29,910	88,544	BASE METAL
2	.740	.455	.3367	28,560	84,823	BASE METAL

Guided-Bend Tests (QW-160)

Type and Figure No.	Result
SIDE BEND PER QW-462.2	SATISFACTORY, NO DEFECTS GREATER THAN 1/8
"	" " " "
"	" " " "
"	" " " "

Toughness Tests (QW-170)

Specimen No.	Notch Location	Notch Type	Test Temp.	Impact Values	Lateral Exp.		Drop Weight	
					% Shear	Mils	Break	No Break

Fillet-Weld Test (QW-180)

Result — Satisfactory: Yes _____ No _____ Penetration into Parent Metal: Yes _____ No _____
 Macro-Results _____

Other Tests

Type of Test _____
 Deposit Analysis _____
 Other _____

BRINELL HARDNESS SURVEY

WM 159, 174, 163
 HAZ 187, 197, 212
 BM 146, 149, 152

Welder's Name RUSTY SUMMERS Clock No. _____ Stamp No. 11
 Tests conducted by: METLAB TESTING SERVICES, INC. Laboratory Test No. 91-2813

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Manufacturer STEELTEK, INC.

Date 5-3-91

By Phil Scott

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.)

METLAB Testing Services, Inc.

6825 East 38th Street Tulsa, Oklahoma 74145
(918) 664-7767

TO: Steeltek, Inc.
602 W. 41st
Tulsa, OK 74107

REPORT NO.: 91-2813

DATE: 05/03/91

ATTN: Phil Scott

PO #: 7426

QW-483 PROCEDURE QUALIFICATION REPORT (PQR)

Material Description: WPS No. ST-4, 8" Sch 80 SA-106B, FCAW with E70T1, Welder Rusty Sommers, as welded.

TENSILE TEST (QW-150)

Parameter	Specimen No.	
	1	2
Width (inch)	.744	.740
Thickness (inch)	.454	.455
Area (inch ²)	.3378	.3367
Ultimate Load (lbs)	29,910	28,560
Ultimate Strength (psi)	88,544	84,823
Type of Fracture:	Base Metal	Base Metal

GUIDED BEND TEST (QW-160)

Specimen Type: Side Bends, QW-462.2

No. of Specimens Tested: 4

Results: Satisfactory with no defects greater than 1/8".

BRINELL HARDNESS SURVEY

Weld 159, 174, 163
HAZ 187, 197, 212
Base 146, 149, 152

Approved by: _____

Dan M. Lawson,
President

lm



TEST REPORT



MIDSTATES ANALYTICAL LABORATORIES, INC.

3100 N. Hemlock Circle
Broken Arrow, OK 74012

P.O. Box 500328
Tulsa, OK 74189

(918) 258-6066
Fax: (918) 258-1154

TO: Phil Scott
Steeltek
602 W. 41st
Tulsa, OK 74107

Page 1 of 2
NO. 98-18279-1
DATE October 20, 1998
P.O. 31818-1

Sample Number

810MS239

Customer's Material Description

3/4" Groove Welded A516-70N Plate Per
WPQ ST-2, ST-4, One Side
3/8" Thick GMAW Welded And One Side FCAW
Welded. No Heat Treat.

Test Required: Hardness Profile

Test Method: Vickers Per ASTM E92-89(92)

test Load: 10 Kg

Specimen Orientation: Perpendicular To Weld Direction

Indent Locations: As Shown In Figure 1

<u>Indent Designation</u>	<u>Location</u>	<u>VHN</u>	<u>Indent Designation</u>	<u>Location</u>	<u>VHN</u>
1	Base	150	14	HAZ	194
2	HAZ	215	15	Base	153
3	Weld	215	16	Base	158
4	HAZ	203	17	HAZ	200
5	Base	153	18	Weld	202
6	Base	153	19	HAZ	203
7	HAZ	197	20	Base	157
8	Weld	198	21	Base	153
9	HAZ	207	22	HAZ	208
10	Base	155	23	Weld	208
11	Base	162	24	HAZ	210
12	HAZ	234	25	Base	167
13	Weld	186			

Before me, the undersigned, a Notary Public in and for said County and State, on this _____ day of _____, 19____, personally appeared _____ to me known to be the identical person who executed the within and foregoing instrument and acknowledged to me that he executed the same as his free and voluntary act and deed for the uses and purposes therein set forth.
Given under my hand and seal the day and year last above written.
My commission expires: _____

Notary Public

This is to certify that the above is a true report of the results obtained by Midstates Analytical Laboratories. Test results relate only to the items tested. Report shall not be reproduced except in full, without the written approval of Midstates Analytical Laboratories.

By Sheldon B. Rudin
Sheldon B. Rudin, Met. Supvr.

TEST REPORT



MIDSTATES ANALYTICAL LABORATORIES, INC.

3100 N. Hemlock Circle
Broken Arrow, OK 74012P.O. Box 600328
Tulsa, OK 74169(918) 258-6068
Fax: (918) 258-1154TO: Phil Scott
Steeltek
602 W. 41st
Tulsa, OK 74107Page 2 of 2
NO. 98-18279-1
DATE October 20, 1998
P.O. 31818-1

Sample Number 810MS239 - Continued

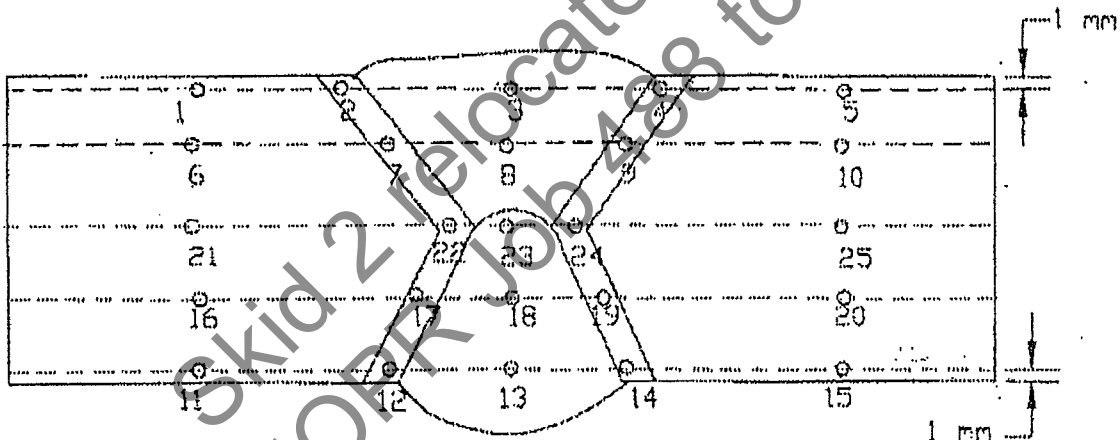


Figure 1: Illustration showing approximate location of Vickers indentations. No scale or proportion.

Before me, the undersigned, a Notary Public in and for said County and State, on this _____ day of _____, 19____, personally appeared _____ to me known to be the identical person who executed the within and foregoing instrument and acknowledged to me that he executed the same as his free and voluntary act and deed for the uses and purposes therein set forth.
Given under my hand and seal the day and year last above written.
My commission expires: _____

Notary Public

This is to certify that the above is a true report of the results obtained by Midstates Analytical Laboratories. Test results relate only to the items tested. Report shall not be reproduced except in full, without the written approval of Midstates Analytical Laboratories.

By Sheldon B. Rudin
Sheldon B. Rudin, Met. Supvr.

QW-482 SUGGESTED FORMAT FOR WELDING PROCEDURE SPECIFICATION (WPS)
(See QW-200.1, Section IX, ASME Boiler and Pressure Vessel Code)

Company Name Steeltek, Inc. By: Phil Scott
Welding Procedure Specification No. ST-28 Date 8-7-92 Supporting PQR No. (s) ST-28
Revision No. 1 Date 6/19/14
Welding Process(es) GTAW, SMAW & SAW Type(s) Manual & Automatic
(Automatic, Manual, Machine, or Semi-Auto.)

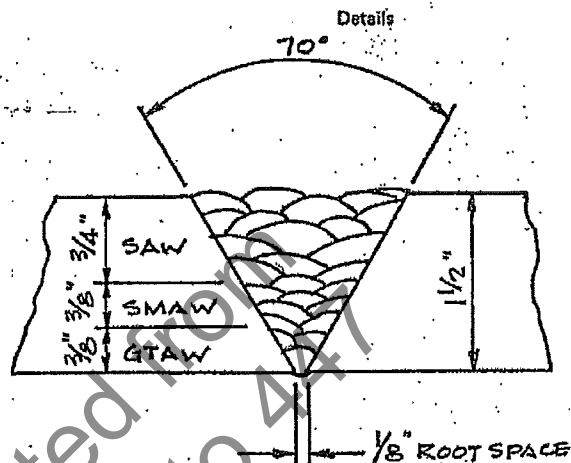
JOINTS (QW-402)

Joint Design Per Drawing Specifications
Backing (Yes) (No) GTAW
Backing Material (Type) SMAW, & SAW Weld Metal
(Refer to both backing and retainers.)

☒ Metal ☐ Nonfusing Metal
☐ Nonmetallic ☐ Other

Sketches, Production Drawings, Weld Symbols or Written Description should show the general arrangement of the parts to be welded. Where applicable, the root spacing and the details of weld groove may be specified.

(At the option of the Mfr., sketches may be attached to illustrate joint design, weld layers and bead sequence, e.g. for notch toughness procedures, for multiple process procedures, etc.)



***BASE METALS (QW-403)**

P.No. 1 Group No. 1 or 2 to P.No. 1 Group No. 1 or 2
OR
Specification type and grade SA-516-70
to Specification type and grade SA-516-70
OR
Chem. Analysis and Mech. Prop. N/A
to Chem. Analysis and Mech. Prop. N/A
Thickness Range:
Base Metal: Groove 3/16" to 8" Weld & EM Fillet All
Pipe Dia. Range: Groove All Fillet All
Other N/A

① F7A2-EM12K (LINCOLN 61W/800 FLUX) OR F7A2-EM14K-H8 (LINCOLN LA-71W/800 FLUX)

*FILLER METALS (QW-404)	GTAW	SMAW	SAW
Spec. No. (SFA)	<u>5.18</u>	<u>5.1</u>	<u>5.23</u>
AWS No. (Class)	<u>ER-70S-2</u>	<u>E-7018</u>	<u>①</u>
F.No.	<u>6</u>	<u>4</u>	<u>6</u>
A.No.	<u>1</u>	<u>1</u>	<u>1</u>
Size of Filler Metals	<u>3/32" & 1/8"</u>	<u>1/8"</u>	<u>1/8"</u>
Weld Metal	<u>3/8"</u>	<u>3/8"</u>	<u>3/4"</u>
Thickness Range:	<u>Thru 3/4" *</u>	<u>Thru 3/4"</u>	<u>Thru 8"</u>
Groove	<u>Thru 3/4"</u>	<u>Thru 3/4"</u>	<u>Thru 8"</u>
Fillet	<u>All</u>	<u>All</u>	<u>All</u>
Electrode-Flux (Class)	<u>N/A</u>	<u>N/A</u>	<u>SFA 5.23</u>
Flux Trade Name	<u>N/A</u>	<u>N/A</u>	<u>① Lincoln 860 ***</u>
Consumable Insert	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Other	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>

*Each base metal-filler metal combination should be recorded individually.

* Max Pass = 1/4" or 1/3" T. FOR GTAW; 1/2" FOR SMAW & SAW

*** NO SUPPLEMENTARY FILLER METALS OR POWDERED FILLER METAL USED.

*** NEUTRAL FLUX, RECRUSHED SLAG SHALL NOT BE USED.

(12/91) This form (E00006) may be obtained from the Order Dept., ASME, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

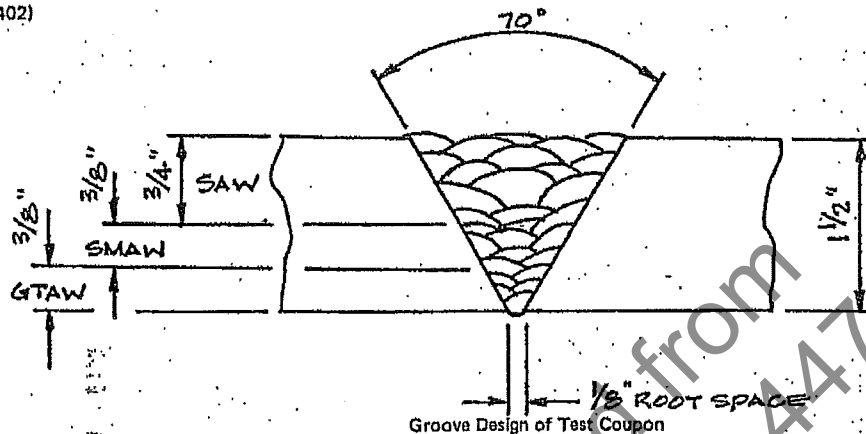
REPRINT 5/92

POSITIONS (QW-405) Position(s) of Groove <u>(GTAW & SMAW) 3G (SAW) 1G</u> Welding Progression: Up <u>GTAW & SMAW</u> Down <u>(SAW) Flat</u> Position(s) of Fillet <u>N/A</u>				POSTWELD HEAT TREATMENT (QW-407) Temperature Range <u>N/A</u> Time Range <u>N/A</u>																																												
PREHEAT (QW-406) Preheat Temp. Min. <u>50 Deg. F.</u> <u>50 Deg. F.</u> Interpass Temp. Max. <u>350 Deg. F.</u> <u>600 Deg. F.</u> Preheat Maintenance <u>From 1-1/4" to 1-1/2" 200 Deg</u> (Continuous or special heating where applicable should be recorded)				GAS (QW-408) <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>Gas(es)</th> <th>Percent Composition (Mixture)</th> <th>Flow Rate</th> </tr> </thead> <tbody> <tr> <td>Shielding</td> <td><u>Argon</u></td> <td><u>100%</u></td> <td><u>10-45 CFH</u></td> </tr> <tr> <td>Trailing</td> <td><u>N/A</u></td> <td><u>N/A</u></td> <td><u>N/A</u></td> </tr> <tr> <td>Backing</td> <td><u>N/A</u></td> <td><u>N/A</u></td> <td><u>N/A</u></td> </tr> </tbody> </table>					Gas(es)	Percent Composition (Mixture)	Flow Rate	Shielding	<u>Argon</u>	<u>100%</u>	<u>10-45 CFH</u>	Trailing	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	Backing	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>																									
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Backing	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>																																													
ELECTRICAL CHARACTERISTICS (QW-409) Current AC or DC <u>DC</u> Polarity <u>See Below</u> Amps (Range) <u>See Below</u> Volts (Range) <u>See Below</u> (Amps and volts range should be recorded for each electrode size, position, and thickness, etc. This information may be listed in a tabular form similar to that shown below.) Tungsten Electrode Size and Type <u>(GTAW) 1/8" Pure Tungsten 2% Thoriated</u> (Pure Tungsten, 2% Thoriated, etc.) Mode of Metal Transfer for GMAW <u>N/A</u> (Spray arc, short circuiting arc, etc.) Electrode Wire feed speed range <u>N/A</u>				NON-PULSING CURRENT FOR GTAW.																																												
TECHNIQUE (QW-410) String or Weave Bead <u>(GTAW & SMAW) String and Weave</u> <u>(SAW) String</u> Orifice or Gas Cup Size <u>(GTAW) 5/8"</u> Initial and Interpass Cleaning (Brushing, Grinding, etc.) <u>Backgouge Brushing, Chipping, Grinding to Sound Metal</u> Method of Back Gouging <u>Arc Air</u> Oscillation <u>(GTAW) 5/16"</u> <u>(SMAW) 5/16"</u> Contact Tube to Work Distance <u>1/2"</u> Multiple or Single Pass (per side) <u>Multiple</u> Multiple or Single Electrodes <u>Single</u> Travel Speed (Range) <u>See Below</u> Peening <u>NONE</u> Other <u>N/A</u>																																																
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">Weld Layer(s)</th> <th rowspan="2">Process</th> <th colspan="2">Filler Metal</th> <th colspan="2">Current</th> <th rowspan="2">Volt Range</th> <th rowspan="2">Travel Speed Range</th> <th rowspan="2">Other (e.g., Remarks, Comments, Hot Wire Addition, Technique, Torch Angle, Etc.)</th> </tr> <tr> <th>Class</th> <th>Dia.</th> <th>Type Polar.</th> <th>Amp. Range</th> </tr> </thead> <tbody> <tr> <td>1 & 2</td> <td>GTAW</td> <td>ER-70S-2</td> <td>3/32 & 1/8"</td> <td>Straight</td> <td>60 -150</td> <td>10-15</td> <td>Manual</td> <td>N/A</td> </tr> <tr> <td>3 & 4</td> <td>SMAW</td> <td>E-7018</td> <td>1/8"</td> <td>Reverse</td> <td>70 - 160</td> <td>18-26</td> <td>Manual</td> <td>N/A</td> </tr> <tr> <td>Remainer</td> <td>SAW</td> <td>EM-12K or EM-14K</td> <td>1/8"</td> <td>Reverse</td> <td>250-450</td> <td>28-34</td> <td>14-16IPM</td> <td>N/A</td> </tr> </tbody> </table>									Weld Layer(s)	Process	Filler Metal		Current		Volt Range	Travel Speed Range	Other (e.g., Remarks, Comments, Hot Wire Addition, Technique, Torch Angle, Etc.)	Class	Dia.	Type Polar.	Amp. Range	1 & 2	GTAW	ER-70S-2	3/32 & 1/8"	Straight	60 -150	10-15	Manual	N/A	3 & 4	SMAW	E-7018	1/8"	Reverse	70 - 160	18-26	Manual	N/A	Remainer	SAW	EM-12K or EM-14K	1/8"	Reverse	250-450	28-34	14-16IPM	N/A
Weld Layer(s)	Process	Filler Metal		Current		Volt Range	Travel Speed Range	Other (e.g., Remarks, Comments, Hot Wire Addition, Technique, Torch Angle, Etc.)																																								
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1 & 2	GTAW	ER-70S-2	3/32 & 1/8"	Straight	60 -150	10-15	Manual	N/A																																								
3 & 4	SMAW	E-7018	1/8"	Reverse	70 - 160	18-26	Manual	N/A																																								
Remainer	SAW	EM-12K or EM-14K	1/8"	Reverse	250-450	28-34	14-16IPM	N/A																																								

QW-483 SUGGESTED FORMAT FOR PROCEDURE QUALIFICATION RECORD (PQR)
 (See QW-200.2, Section IX, ASME Boiler and Pressure Vessel Code)
 Record Actual Conditions Used to Weld Test Coupon.

Company Name Steeltek, Inc.
 Procedure Qualification Record No. ST-28 Date 8-7-92
 WPS No. ST-28
 Welding Process(es) GTAW, SMAW & SAW
 Types (Manual, Automatic, Semi-Auto.) Manual & Automatic

JOINTS (QW-402)



(For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process used.)

BASE METALS (QW-403)
 Material Spec. SA-516
 Type or Grade 70
 P-No. 1 to P-No. 1
 Thickness of Test Coupon 1-1/2"
 Diameter of Test Coupon N/A
 Other N/A

POSTWELD HEAT TREATMENT (QW-407)
 Temperature N/A
 Time N/A
 Other N/A

FILLER METALS (QW-404)

	GTAW	SMAW	SAW
SFA Specification	5.18	5.1	5.23
AWS Classification	ER-70S-2	E-7018	EM-12K
Filler Metal F-No.	6	4	6
Weld Metal Analysis A-No.	1	1	1
Size of Filler Metal	3/32" & 1/8"	1/8"	1/8"
Other	N/A	N/A	L-860 F1
Weld Metal Thickness	3/8"	3/8"	3/4"

GAS (QW-408)

	Percent Composition		
	Gas(es)	(Mixture)	Flow Rate
(GTAW ONLY) Shielding	Argon	100%	25 CFH
Trailing	N/A	N/A	N/A
Backing	N/A	N/A	N/A

POSITION (QW-405)
 Position of Groove (GTAW & SMAW) 3G (SAW) 1G
 Weld Progression (Uphill, Downhill) (GTAW & SMAW) Uphill
 Other (SAW) Flat

ELECTRICAL CHARACTERISTICS (QW-409)
 Current DC
 Polarity (GTAW) Straight (SMAW & SAW) Reverse
 Amps See Other Volts See Other
 Tungsten Electrode Size See Other
 Other Amps (GTAW) 80 (SMAW) 110 (SAW) 350
 Volts (GTAW) 14 (SMAW) 22 (SAW) 34

PREHEAT (QW-406)
 Preheat Temp. 70 Deg. F.
 Interpass Temp. (GTAW) & (SMAW) 300°F (SAW) 500°F
 Other N/A

TECHNIQUE (QW-410)
 Travel Speed (GTAW) 3-5IPM (SMAW) 10-15IPM (SAW) 16IPM
 String or Weave Bead (GTAW & SMAW) Either (SAW) String
 Oscillation (GTAW & SMAW) 5/16"
 Multipass or Single Pass (per side) Multipass
 Single or Multiple Electrodes Single
 Other N/A

QW-483 (Back)

PQR No. ST-28

Tensile Test (QW-150)

Specimen No.	Width	Thickness	Area	Ultimate Total Load lb	Ultimate Unit Stress psi	Type of Failure & Location
1 Face	1.003	.688	.690	52,375	75,900	Ductile - Weld
1 Root	1.000	.720	.720	54,300	75,400	Ductile - Weld
2 Face	1.002	.715	.716	53,850	75,200	Ductile - Weld
2 Root	1.005	.699	.702	52,850	75,300	Ductile - Weld

Guided-Bend Tests (QW-160)

Type and Figure No.	Result
1-Transverse Guided Bend Tests Per QW-462.2	Satisfactory
2-Transverse Guided Bend Tests Per QW-462.2	Satisfactory
3-Transverse Guided Bend Tests Per QW-462.2	Satisfactory
4-Transverse Guided Bend Tests Per QW-462.2	Satisfactory

Toughness Tests (QW-170)

Specimen No.	Notch Location	Notch Type	Test Temp.	Impact Values	Lateral Exp.		Drop Weight	
					% Shear	Mils	Break	No Break

Filler-Weld Test (QW-180)

Result — Satisfactory: Yes No Penetration into Parent Metal: Yes No
 Macro—Results

Other Tests

BHN Survey

Type of Test BM 144 144 147
 Deposit Analysis HAZ 169 176 190
 Other WM 144 150 162

Root & Hot Pass — Chris Enevoldsen

Welder's Name Filler & Cap — Randy BurchClock No. Stamp No. Tests conducted by: Sun Material TestingLaboratory Test No. 92-3677-T1

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Manufacturer Steeltek, Inc.Date 8-7-92By Phil Scott

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.)

TEST REPORT



MIDSTATES ANALYTICAL LABORATORIES, INC.

3100 N. Hemlock Circle
Broken Arrow, OK 74012P.O. Box 690328
Tulsa, OK 74169(918) 258-6066
Fax: (918) 258-1154TO: Phil Scott
Steeltek
602 W. 41st
Tulsa, OK 74107Page 1 of 2
NO. 98-18152-1
DATE October 13, 1998
P.O. 31818Sample Number

810MS139

Customer's Material Description3/8" Groove Welded A516-70N Plate
Per WPQ ST-28 (Addendum)
(GTAW)Test Required: Hardness Test
Test Method: 10kg Vickers Per ASTM E92-89(92)
Specimen Orientation: Transverse To Weld Direction
Test Location: See Figure 1

<u>Indent Number</u>	<u>VHN</u>	<u>Indent Number</u>	<u>VHN</u>	<u>Indent Number</u>	<u>VHN</u>
1	164	6	156	11	169
2	194	7	182	12	179
3	208	8	159	13	162
4	203	9	174	14	200
5	173	10	164	15	170

Before me, the undersigned, a Notary Public in and for said County and State, on _____ day of _____, 19____, personally appeared _____, to me known to be the identical person who executed the within and foregoing instrument and acknowledged to me that he executed the same as his free and voluntary act and deed for the uses and purposes therein set forth.
Given under my hand and seal the day and year last above written.
My commission expires: _____

Notary Public

This is to certify that the above is a true report of the results obtained by Midstates Analytical Laboratories. Test results relate only to the items tested. Report shall not be reproduced except in full, without the written approval of Midstates Analytical Laboratories.

By: Sheldon B. Rudin, Met. Supvr.

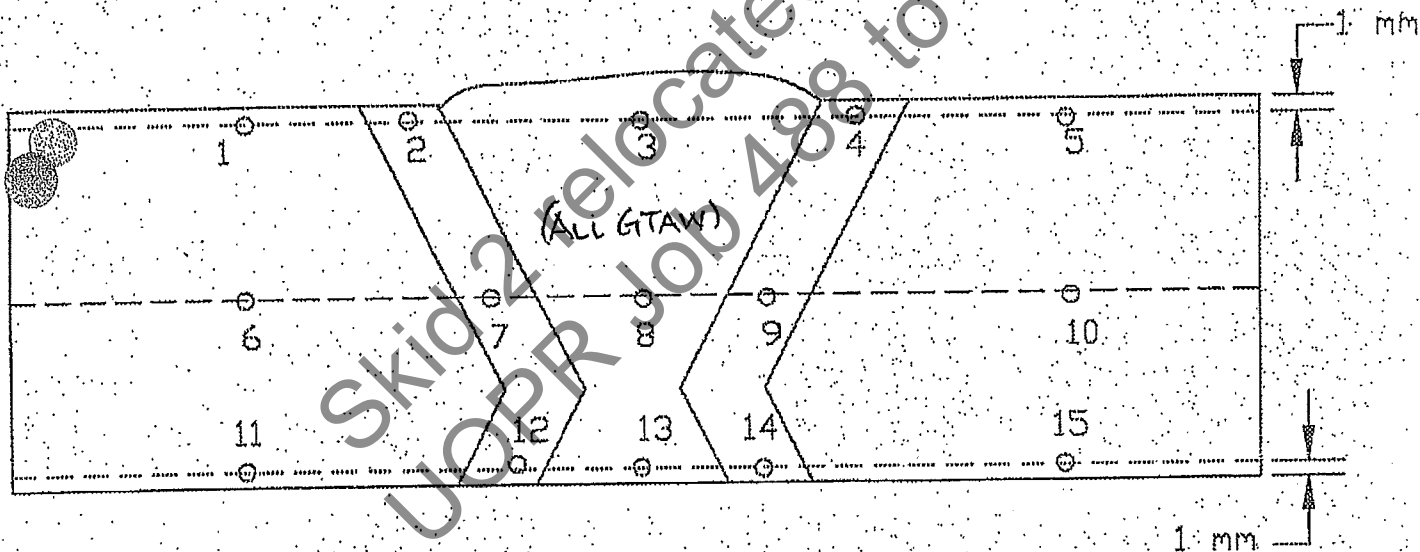


Figure 1: Illustration showing approximate location of Vickers indentations. No scale or proportion.

TEST REPORT



MIDSTATES ANALYTICAL LABORATORIES, INC.

3100 N. Hemlock Circle
Broken Arrow, OK 74012P.O. Box 680328
Tulsa, OK 74169(918) 258-6086
Fax: (918) 258-1154TO: Phil Scott
Steeltek
602 W. 41st
Tulsa, OK 74107Page 1 of 2
NO. 98-18236-1
DATE October 19, 1998
P.O. 31818Sample Number
810MS138Customer's Material Description
3/4" Groove Welded A516-70N Plate
Per WPQ ST-28 (SMAW/SAW) Addendum
No Post Weld Heat TreatmentTest Required: Hardness Test
Test Method: Vickers Per ASTM E92-89(92)
Test Load: 10 Kg
Specimen Orientation: Perpendicular To Weld Direction
Indent Locations: As Shown In Figure 1

<u>Indent Designation</u>	<u>Location</u>	<u>VHN</u>	<u>Indent Designation</u>	<u>Location</u>	<u>VHN</u>
1	Base	153	14	HAZ	166
2	HAZ	193	15	Base	144
3	Weld	157	16	Base	145
4	HAZ	200	17	HAZ	158
5	Base	144	18	Weld	137
6	Base	147	19	HAZ	158
7	HAZ	181	20	Base	142
8	Weld	155	21	Base	145
9	HAZ	184	22	HAZ	171
10	Base	147	23	Weld	156
11	Base	145	24	HAZ	159
12	HAZ	189	25	Base	143
13	Weld	145			

Before me, the undersigned, a Notary Public in and for said County and State, on _____ day of _____, 19____, personally appeared _____, to me known to be the identical person who executed the within and foregoing instrument and acknowledged to me that he executed the same as his free and voluntary act and deed for the uses and purposes therein set forth.
Given under my hand and seal the day and year last above written.
My commission expires: _____

Notary Public

This is to certify that the above is a true report of the results obtained by Midstates Analytical Laboratories. Test results relate only to the items tested. Report shall not be reproduced except in full, without the written approval of Midstates Analytical Laboratories.

By

Sheldon B. Rudin, Met. Supvr.

TEST REPORT



MIDSTATES ANALYTICAL LABORATORIES, INC.

3100 N. Hemlock Circle
Broken Arrow, OK 74012

P.O. Box 690328
Tulsa, OK 74169

(918) 258-8088
Fax: (918) 258-1154

TO: Phil Scott
Steeltek
602 W. 41st
Tulsa, OK 74107

Page 2 of 2
NO. 98-18236-1
DATE October 19, 1998
P.O. 31818

Sample Number 810MS138 - Continued

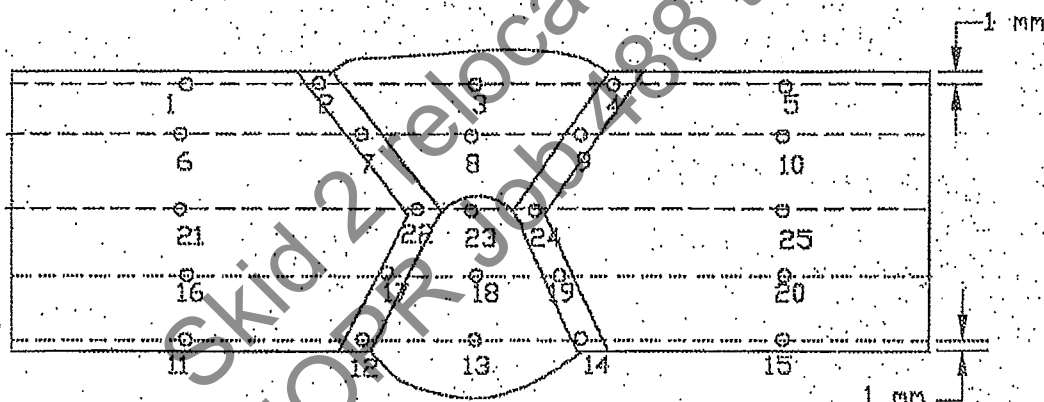


Figure 1: Illustration showing approximate locations of Vickers indentations. No scale or proportion.

Before me, the undersigned, a Notary Public in and for said County and State, on _____ day of _____, 19____, personally appeared _____, to me known to be the identical person who executed the within and foregoing instrument and acknowledged to me that he executed the same as his free and voluntary act and deed for the uses and purposes therein set forth.
Given under my hand and seal the day and year last above written.
My commission expires: _____

Notary Public

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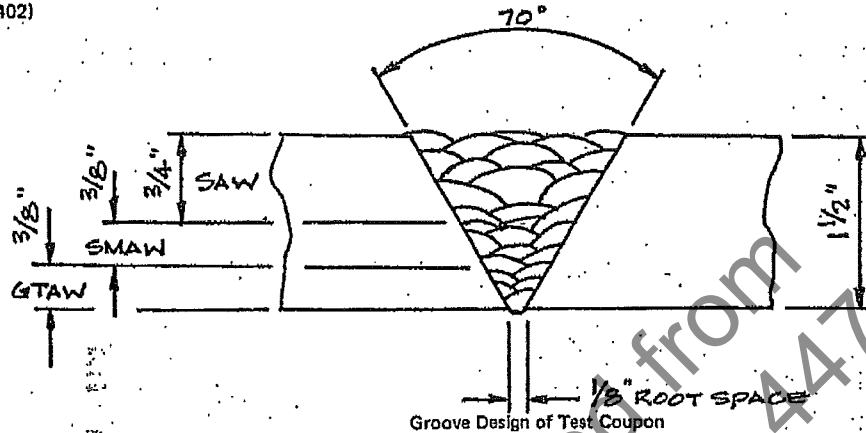
By

Sheldon B. Rudin, Met. Supvr.

QW-483 SUGGESTED FORMAT FOR PROCEDURE QUALIFICATION RECORD (PQR)
 (See QW-200.2, Section IX, ASME Boiler and Pressure Vessel Code)
 Record Actual Conditions Used to Weld Test Coupon.

Company Name Steeltek, Inc.
 Procedure Qualification Record No. ST-28 C Date 6/19/14
 WPS No. ST-28
 Welding Process(es) GTAW, SMAW & SAW
 Types (Manual, Automatic, Semi-Auto.) Manual & Automatic

JOINTS (QW-402)



(For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process used.)

BASE METALS (QW-403)

Material Spec. SA-516
 Type or Grade 70
 P-No. 1 to P-No. 1
 Thickness of Test Coupon 1-1/2"
 Diameter of Test Coupon N/A
 Other N/A

POSTWELD HEAT TREATMENT (QW-407)

Temperature N/A
 Time N/A
 Other N/A

GAS (QW-408)

(GTAW ONLY)	Gas(es)	Percent Composition (Mixture)	Flow Rate
Shielding	<u>Argon</u>	<u>100%</u>	<u>25 CFH</u>
Trailing	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Backing	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>

FILLER METALS (QW-404)

	GTAW	SMAW	SAW
SFA Specification	<u>5.18</u>	<u>5.1</u>	<u>5.23</u>
AWS Classification	<u>ER-70S-2</u>	<u>E-7018</u>	<u>EM-14K</u>
Filler Metal F-No.	<u>6</u>	<u>4</u>	<u>6</u>
Weld Metal Analysis A-No.	<u>1</u>	<u>1</u>	<u>1</u>
Size of Filler Metal	<u>3/32" & 1/8"</u>	<u>1/8"</u>	<u>1/8"</u>
Other	<u>N/A</u>	<u>N/A</u>	<u>L-860 F11xx</u>
Weld Metal Thickness	<u>3/8"</u>	<u>3/8"</u>	<u>3/4"</u>

ELECTRICAL CHARACTERISTICS (QW-409)

Current DC
 Polarity (GTAW) Straight (SMAW & SAW) Reverse
 Amps See Other Volts See Other
 Tungsten Electrode Size
 Other Amps (GTAW) 80 (SMAW) 110 (SAW) 350
 Volts (GTAW) 14 (SMAW) 22 (SAW) 34

POSITION (QW-405)

Position of Groove (GTAW & SMAW) 3G (SAW) 1G
 Weld Progression (Uphill, Downhill) (GTAW & SMAW) Uphill
 Other (SAW) Fla

TECHNIQUE (QW-410)

Travel Speed (GTAW) 3-5IPM (SMAW) 10-15IPM (SAW) 16IPM
 String or Weave Bead (GTAW & SMAW) Either (SAW) String
 Oscillation (GTAW & SMAW) 5/16"
 Multipass or Single Pass (per side) Multipass
 Single or Multiple Electrodes Single
 Other N/A

PREHEAT (QW-406)

Preheat Temp. 70 Deg. F.
 Interpass Temp. (GTAW) & (SMAW) 300°F (SAW) 500°F
 Other N/A

QW-483 (Back)

PQR No. ST-28

Tensile Test (QW-150)

Specimen No.	Width	Thickness	Area	Ultimate Total Load lb	Ultimate Unit Stress psi	Type of Failure & Location
1 TOP	.7440	.6750	.5056	40,059	79,123	Ductile - BM
1 BTM	.7500	.7000	.5295	40,074	76,949	Ductile - BM
2 TOP	.7470	.7000	.5229	40,428	77,697	Ductile - BM
2 BTM	.7480	.6500	.4862	38,831	78,838	Ductile - BM

Guided-Bend Tests (QW-160)

Type and Figure No.	Result
1-Transverse Guided Bend Tests Per QW-462.3	Satisfactory
2-Transverse Guided Bend Tests Per QW-462.3	Satisfactory
3-Transverse Guided Bend Tests Per QW-462.3	Satisfactory
4-Transverse Guided Bend Tests Per QW-462.3	Satisfactory

Toughness Tests (QW-170)

Specimen No.	Notch Location	Notch Type	Test Temp.	Impact Values	Lateral Exp.		Drop Weight	
					% Shear	Mils	Break	No Break

Fillat-Weld Test (QW-180)

Result — Satisfactory: Yes ☐ No ☐ Penetration into Parent Metal: Yes ☐ No ☐
 Macro-Results _____

Other Tests
BHN Survey

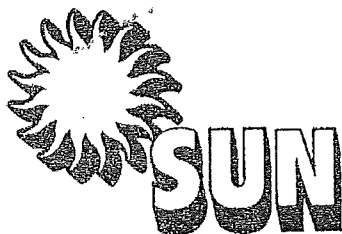
Type of Test	BM	137	137	132
Deposit Analysis	HAZ	190	176	176
Other	WM	165	190	159

Welder's Name JEFFREY DEWITT Clock No. _____ Stamp No. 4
 Tests conducted by: Sun Material Testing Laboratory Test No. 14-14046

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Manufacturer Steeltek, Inc.

Date 6/19/14 By [Signature]
 (Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.)



MATERIALS TESTING

Division of Sun Heat Treating Inc.

Client: **Steeltek**
4141 South Jackson
Tulsa, Oklahoma 74107

Report No: 14-14046
Date: May 22, 2014
Auth By: Mr. Phil Pennington

Subject: **Weld Procedure Qualification per ASME Section IX.**

Identification: Procedure No: ST-28C
Materials: SA-516-70N 1 1/2" Thick
Heat No: 2506529 Slab No: 06
Heat Treatment: None – as welded

TENSILE TEST (QW-150)

	Tensile 1 Top	Tensile 1 Bottom	Tensile 2 Top	Tensile 3 Bottom
Width (in)	0.7490	0.7500	0.7470	0.7480
Thickness (in)	0.6750	0.7060	0.7000	0.6500
Area (sqin)	0.5056	0.5295	0.5229	0.4862
Ultimate load (lbs)	40,059	40,744	40,628	38,331
Ultimate stress (psi)	79,231	76,948	77,697	78,838
Failure Type	Ductile	Ductile	Ductile	Ductile
Failure Location	Base Material	Base Material	Base Material	Base Material

TRANSVERSE GUIDED BEND TEST (QW-160)

Specimen Type	Accept/Reject QW-163	Specimen Type	Accept/Reject QW-163
No 1 Side Bend QW-462.3	Acceptable	No 2 Side Bend QW-462.3	Acceptable
No 3 Side Bend QW-462.3	Acceptable	No 4 Side Bend QW-462.3	Acceptable

BRINELL HARDNESS OF WELD CROSS SECTION

Location	Reading 1	Reading 2	Reading 3	Average Rb/BHN
Weld Zone	85/165	91/190	83/159	86Rb/169BHN
Heat Affected Zone	91/190	88/176	88/176	89Rb/180BHN
Base Material	75/137	75/137	73/132	74Rb/135BHN

Hardness reading taken using Rockwell B Scale and converted to Brinell Hardness per ASTM A370.

SUN HEAT TREATING INC.
Materials Testing Division
Paul R. Secrest
Paul R. Secrest/President

P.O. Box 9921

Tulsa, Oklahoma 74157

(918) 227-2188

Shell & Tube Heat Exchangers

CUSTOMER: UOP RUSSELL
PURCHASE ORDER NO.: 4500801009
UOP PROJECT NO.: J488XX
EQUIPMENT TAG NO: E-202
SERVICE: GAS / PRODUCT EXCHANGER
STEELTEK JOB NO.: 17S-3450

DATE: July 17, 2018

RECOMMENDED SPARE PARTS LIST

STEELTEK JOB NO.	CUSTOMER TAG NO.	DESCRIPTION OF PART	UNIT	QUANTITY RECOMMENDED	UNIT PRICE	EXTENDED PRICE	DELIVERY TIME AFTER RECEIPT OF ORDER
17S-3450	E-202	SPARE GASKETS	SET	1-SET	\$225.00	\$225.00	3 WEEKS

IT IS RECOMMENDATION THAT ONE SPARE SET OF GASKETS BE KEPT ON HAND FOR ROUTINE MAINTENANCE. THE AMOUNT OF SPARES REQUIRED FOR TWO YEARS OF OPERATION WOULD DEPEND ON YOUR PLANTS ROUTINE MAINTENANCE SHUT DOWN SCHEDULE.

PRICES QUOTED ARE VALID FOR THREE (3) WEEKS FROM DATE SHOWN ABOVE.

INSTALLATION, OPERATING AND MAINTENANCE MANUAL

Steeltek Shell and Tube Heat Exchangers are custom engineered for specific operating conditions. Their successful performance and long life with little maintenance and attention can be best assured by careful installation and periodic inspection.

INSTALLATION PLANNING

1. On removable bundle heat exchangers, provide sufficient clearance at the stationary end to permit the removal of the tube bundle from the shell. On the floating head type exchangers, provide space to permit removal of the shell cover and floating head cover.
2. On fixed bundle heat exchangers, provide sufficient clearance at one end to permit removal and replacement of tubes and at both ends provide sufficient clearance to permit rolling of tubes into the tubesheet.
3. Provide valves and bypasses in the piping system so that both the shell side and tube side may be bypassed to permit isolation of the heat exchanger for inspection, cleaning and repairs.
4. Provide convenient means for cleaning as suggested under maintenance.
5. Provide thermometer wells and pressure gauges pipe taps in all piping to and from the heat exchanger located as close to the heat exchanger as possible.
6. Provide necessary air vent valves for the heat exchanger so that it can be purged to relieve vapor or prevent gas binding on both the tube side and shell side.
7. Provide adequate foundations for mounting the heat exchanger so that it will not settle and cause piping strains. Foundation bolts should be set accurately. In concrete footings, pipe sleeves at least one pipe size larger than the bolt diameter slipped over the bolt and cast in place are best for this purpose as they allow the bolt centers to be adjusted after the foundation has set.
8. Install proper liquid level controls, relief valves, liquid level and temperature alarms, etc.
9. Install gauge glasses or liquid level alarms in all vapor or gas spaces to indicate any failure occurring in the condensate drain system and prevent flooding of the heat exchanger.
10. Install a surge drum upstream from the heat exchanger to guard against pulsation of fluids caused by pumps, compressors or other equipment.

11. Do not pipe drain connections to a common closed manifold; it makes it more difficult to determine that the exchanger has been thoroughly drained.

INSTALLATION

1. If the heat exchanger has been in storage, thoroughly inspect it prior to installation. Make sure it is thoroughly cleaned to remove all preservation materials unless a preservation coating was used which is soluble in the system. Where special preservations were applied, you should consult the preservative manufacturer's product information data for removal instructions.

2. If the heat exchanger has not been stored, inspect for shipping damage to all protective covers upon arrival at the jobsite. If damage is evident, inspect for possible contamination and replace protective covers as required. If damage is extensive, notify the carrier immediately.

3. When installing, set heat exchanger level and square so that pipe connections can be made without forcing.

4. Before piping, inspect all openings in the heat exchanger for foreign material. Remove all bags of desiccant and shipping covers immediately prior to installing. Do not expose internal passages of the heat exchanger to the atmosphere since moisture or harmful contaminants may enter the unit and cause severe damage to the system due to freezing and/or corrosion.

5. After piping is complete, if support cradles or feet are fixed to the heat exchanger, loosen foundation bolts at one end of the exchanger to allow free movement. Oversize holes in support

saddles are provided for this purpose.

6. If heat exchanger shell is equipped with a bellows type expansion joint, remove shipping supports.

OPERATION

1. Be sure entire system is clean before starting operation to prevent plugging of tubes or shell side passages. The use of strainers or settling tanks in pipelines leading to the heat exchanger is recommended.

2. Open vent connections before starting flow through the exchanger.

3. The first fluid admitted is that whose temperature most nearly approximates the ambient temperature of the unit. The heat exchanger should never be shocked by the sudden admission of extremely hot or cold fluids; repeated stresses set up by such a procedure cause metal fatigue. Thermal and physical shocks should be avoided whenever possible. For fixed tubesheet exchangers fluids must be introduced in a manner to minimize differential expansion between the shell and tubes.

4. Start operating gradually after the system is completely filled with the operating fluids and all air has been vented, close all manual vent connections.

5. Retighten bolting on all gasketed or packed joints after the heat exchanger has reached operating temperatures to prevent leaks and gasket failures.

6. Sufficient circulation of the cold medium should be maintained at all times to prevent overheating, which could result in the depositing of scale, coke or sludge.

7. Do not operate the heat exchanger under pressure and temperature conditions in excess of those specified on the nameplate.

8. To guard against water hammer, drain condensate from steam heated exchangers both when starting up and shutting down.

9. In all installations there should be no pulsation of fluids, since this causes vibration and will result in reduced operating life.

10. The heat exchanger is not to be operated at a flowrate greater than that shown on the design specifications. Excessive flows can cause vibration and severely damage the heat exchanger tube bundle.

11. As a general rule, the hot fluid should be shut down first when ceasing operation. If it is necessary to shut down the cold fluid circulation, the hot medium should first be bypassed to prevent the tubes and tube to tubesheet joints from excessive temperatures.

12. For fixed tubesheet type units, having tubes and shell of the same material, the tube side fluid should be shut down first, to avoid an excessive temperature difference between tubes and shell that might result when the tubes are brought to tube side fluid temperature while the shell cylinder is insulated from the tubes by a stagnant shell side fluid. If the tube side fluid cannot be shut down a bypass system should be incorporated into the piping so the tube side fluid is bypassed before the shell side fluid is shut down.

13. Drain all fluids when shutting down to eliminate possible freezing and corroding. Heat exchangers that are out of service for short periods and use water as the flowing

medium should be thoroughly drained and blown dry with warm air if possible. If this not practical, the water should be circulated through the heat exchanger on a daily basis to prevent stagnant water conditions that can ultimately precipitate corrosion.

MAINTENANCE

1. Clean exchangers subject to fouling (scale, sludge deposits, etc.) periodically, depending on specific conditions. A light sludge or scale coating on either side of the tube greatly reduces its effectiveness. A marked increase in pressure drop and/or reduction in performance usually indicates cleaning is necessary. Since the difficulty of cleaning increases rapidly as the scale thickens or deposits increase, the intervals between cleanings should not be excessive.

2. Neglecting to keep tubes clean may result in random tube plugging. Consequent overheating or cooling of the plugged tubes, as compared to surrounding tubes, will cause physical damage and leaking tubes due to differential thermal expansion of the metals.

3. To clean or inspect the inside of the tubes, remove only the necessary tube side channel covers or bonnets depending on type of exchanger construction.

4. If the heat exchanger is equipped with sacrificial anodes or plates, replace these as required.

5. To clean or inspect the outside of the tubes, it may be necessary to remove the tube bundle.

6. When removing tube bundles from heat exchangers for inspection or cleaning, exercise care to see that they are not damaged by improper handling. The weight

of the tube bundle should not be supported on individual tubes but should be carried by the tubesheets, support or baffle plates or on blocks contoured to the periphery of the tube bundles. Do not handle tube bundles with hooks, chains, or other tools which might damage tubes. After removal, move tube bundles on cradles or skids. To withdraw tube bundles, pass rods through two or more of the tubes and take the load on the floating tubesheet. Rods should be threaded at both ends, with the ends passing through a steel bearing plate at the face of each tubesheet. Insert a soft wood filler board between the bearing plate and tubesheet face to prevent damage to the tube ends. Screw steel eye bolts into both bearing plates for pulling and lifting. As an alternate to the rods, thread a steel cable through one tube and return through another tube. A hardwood spreader block must be inserted between the cable and each tubesheet to prevent damage to the tube ends.

7. If the heat exchanger has been in service for a considerable length of time without being removed, it may be necessary to use a jack on the floating tubesheet to break the bundle free. Use a good-sized steel bearing plate with a filler board between the tubesheet face and bearing plate to protect the tube ends.

8. Lift tube bundles horizontally by means of a cradle formed by bending a light-gauge plate or plates into a U-shape. Make attachments in the legs of the U for lifting.

9. Do not drag bundles, since baffles or support plates may become easily bent. Avoid any damage to baffles so that the heat exchanger will function properly.

10. Some suggested methods of cleaning either the shell side or tube side are:

Circulating hot wash oil or light distillate through tube side or shell side. This will usually effectively remove sludge or similar soft deposits. Soft salt deposits may be washed out by circulating hot fresh water. Some commercial cleaning compounds may be effective in removing more stubborn deposits. Use in accordance with the manufacturer's instructions. If the scale is hard and the above methods are not effective, use a mechanical cleaning means. Neither the inside nor the outside of the tube should be hammered with a metallic tool. If it is necessary to use scrapers, they should not be sharp enough to cut the metal of the tubes. Take extra care when employing scrapers, to prevent tube damage. Some tubes have inserts or longitudinal fins and can be damaged by cleaning when mechanical means are employed. Clean these types of tubes chemically.

11. Do not attempt to clean tubes by blowing steam through individual tubes. This overheats the individual tube and results in severe expansion strains and leaking tube to tubesheet joints.

12. To locate ruptured or corroded tubes or leaking joints between tubes and tubesheets, the following procedure is recommended. Remove tube side channel covers or bonnets. Pressurize the shell side of the exchanger with a liquid, preferably water. Observe tube joints and tube ends for indication of test fluid leakage.

13. With certain styles of exchangers, it will be necessary to buy or make a test ring to seal off the space between the floating tubesheet and inside shell diameter to apply the test in paragraph 12.

14. To tighten a leaking tube joint, use a suitable parallel roller tube expander. Do

not roll tube beyond the back face of the tubesheet. Maximum rolling depth should be tubesheet thickness minus 1/8". Do not reroll tubes which are not leaking since this needlessly thins the tube wall.

15. When a heat exchanger is dismantled, new gaskets should be used in reassembly. Composition gaskets become brittle and dry out in service and do not provide an effective seal when reused. Metal or metal jacketed gaskets in initial compression match the contact surfaces and tend to work-harden and cannot be recompressed on reuse.

16. Use of new bolting in conformance with dimensions and ASTM specifications of the original design is recommended where frequent dismantling is encountered.

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