

UOP RUSSELL LLC

Tulsa, Oklahoma

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

DATE: 6/14/17
 BY: MDC

SHELL & TUBE EXCHANGER

Duty: 10,000 MBtu/hr		Tag No: E-207 HMO	
Service: Demethanizer Trim Reboiler		P.O. / S.O. No:	
Size: 20 x 192	Type: BEM/Horiz	Arrangement: 1	Parallel 1 Series
ft2/ Shell 1,191	Shells / Unit 1	ft2/ Unit 1,191	
SHELL SIDE		TUBE SIDE	
Fluid Circulated Therminol 55		Tower Liquid	
	Inlet	Outlet	Inlet
	Outlet		Outlet
Liquid lb/hr	184,691	184,591	121,438
Density lb/ft3	49.00	51.30	28.93
Molecular Weight	320.00	320.00	45.58
Specific Heat Btu/lb-F	0.5650	0.5180	0.7592
Thermal Cond. Btu/hr-ft-F	0.0656	0.0693	0.0461
Viscosity cP	1.311	3.3100	0.0844
Vapor lb/hr	0	0	0
Density lb/ft3			2.369
Molecular Weight			44.22
Specific Heat Btu/lb-F			0.5317
Thermal Cond. Btu/hr-ft-F			0.0135
Viscosity cP			0.0102
Operating Temperature F	300.0	200.0	119.6
Operating Pressure psia	50		253
Number of Passes	One		One
Velocity ft/s	Allow. 1.51	Calc.	Allow. 8.19
Pressure Drop psi	10	Allow. 3.09	1
Fouling Resistance F-ft2-hr/Btu	0.0020		0.0010
Trans. Rate-Serv. Btu/hr-ft2-F	78.68	LMTD Corrected(F) 117.4	Heat Curve Attached Yes
CONSTRUCTION			
Code Requirements ASME Section VIII	Stamp Yes	Nat'l Board Yes	TEMA C
Max. Design Pressure \ Temp. 150	psig @ 400 °F	400	psig @ 200 °F
Min. Des. Mtl. Temp. @ Press. -20	°F @ 150 psig	-50	°F @ 400 psig
Corrosion Allowance (in) 0.0625			0.0625
Insulation Thickness (in) 2" H			None
Tube Matl. SA-214	No. / Shell 465	OD (inch): 0.625	
Length (ft) 16.0	Pitch 0.7813 TRIANGULAR	BWG/Sch: 16 Ga.	
Shell Matl. CS	OD(in) 20	Thickness(in)	
Channel Matl. LT	Tube Sheet Matl. LT		
Baffles Matl. SA-36	Type Single Segmented	Spacing & Cut 17.079 / 25.4%	
Connections: Shell Inlet 8"	Out 8"	Series 150# RF	
Channel Inlet 6"	Out 10"	Series 300# RF	
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) REJ 60MM RSV Sum 850.hsc			
4) Paint System 1 with a Top Coat - Tube Side Only			
5) Paint System 2 for Shell Side Only			
REVISION	A	0	
ENGINEER/DATE	MDC 6/14/17	JRG 7/17/17	
ISSUED FOR	RFQ	Purchase	

UOP RUSSELL LLC

Tulsa, Oklahoma

JOB NO: TRJ-488

CLIENT: 0

DATE: 6/14/17

BY: MDC

Scope of Supply
Shell & Tube Exchanger

TAG NO. E-207 HMO

SERVICE Demethanizer Trim Reboiler

Vendor shall include the following checked items for design and scope of supply.

- ☒ 1) Provide National Board Registration number.
- ☒ 2) Submit weld procedures for approval prior to start of fabrication.
- ☒ 3) Exchanger to be designed in accordance with latest edition of TEMA Standard and applicable ASME Div. I and Div. II Codes.
- ☒ 4) Submit design calculations and fabrication drawings for approval prior to start of fabrication.
- ☒ 5) All welding procedures and examinations and welder qualifications shall be in accordance with applicable AWS and ASME IX code requirements.
- ☒ 6) Provide one (1) set of spare gaskets with each exchanger.
- ☒ 7) All ship loose pieces to be tagged and identified on shipping list.
- ☒ 8) Include minimum of two (2) lift lugs and provide supporting calculations.
- ☒ 9) Vendor to contact UOP Russell Inspector prior to start of fabrication to finalize inspection procedure.
- ☒ 10) Final hydrotest or pneumatic test to be witnessed by UOP Russell Inspector.
- ☒ 11) Nameplate to include equipment tag number as indicated on specification sheet.
- ☒ 12) Provide additional bracket for Company supplied 4" x 6" nameplate.
- ☒ 13) Provide three (3) certified copies of fabrication drawings prior to job completion.
- ☒ 14) Provide three (3) copies of all MTRs and material certifications at job completion.
- ☒ 15) Vendor shall provide zinc or cadmium plated bolts when design temperature is 650F or less. Bolts shall be black (non-plated) for design temperatures above 650F.

INDEX TO MANUFACTURER'S RECORD BOOK

CUSTOMER: UOP RUSSELL

PURCHASE ORDER NO.: 4500801009

PROJECT NO.: J488XX

EQUIPMENT TAG NO.: E-207

SERVICE: DEMETHANIZER TRIM REBOILER

STEELTEK JOB NO.: 17S-3451

CONTENTS

1. DATA SHEET
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

Page 1

US Units

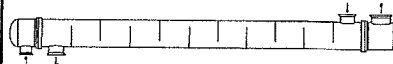
Customer	UOP RUSSELL		UOP Project No.:	J488XX	
Address			Reference No.:	4500801009	
Plant Location			Steeltek Job No.:	17S-3451	
Service of Unit	DEMETHANIZER TRIM REBOILER		Date	7-3-17	Rev 0
Size	19.25 x 192	Inch	Type	BEM	Horizontal
Surf/Unit (Gross/Eff)	1217.4 / 1191.2	ft2	Shell/Unit	1	
Item No.	E-207		Connected In	1	Parallel
Surf/Shell (Gross/Eff)	1217.4 / 1191.2		ft2	1 Series	

PERFORMANCE OF ONE UNIT

Fluid Allocation	Shell Side		Tube Side	
Fluid Name	THERMINOL 55		TOWER LIQUID	
Fluid Quantity, Total	203160		133582	
Vapor (In/Out)				
Liquid	203160	203160	133582	82500
Steam				51082
Water				
Noncondensables				
Temperature (In/Out)	F	300.00	200.00	119.60
Specific Gravity		0.8198	0.8441	0.4636
Viscosity	cP	1.2927	3.2661	0.0844
Molecular Weight, Vapor				0.0102 V/L 0.0861
Molecular Weight, Noncondensables				
Specific Heat	Btu/lb-F	0.5649	0.5180	0.7592
Thermal Conductivity	Btu/hr-ft-F	0.0655	0.0693	0.0461
Latent Heat	Btu/lb			114.60
Inlet Pressure	psia	50.000		253.00
Velocity	ft/sec	1.61		8.19
Pressure Drop, Allow/Calc	psi	10.000	3.094	1.000
Fouling Resistance (min)	ft2-hr-F/Btu	0.00200		0.00100
Heat Exchanged	11001174 Btu/hr		MTD (Corrected)	117.4 F
Transfer Rate, Service	78.68 Btu/ft2-hr-F		Clean	107.26 Btu/ft2-hr-F

CONSTRUCTION OF ONE SHELL

	Shell Side		Tube Side	
Design/Test Pressure	150 / CODE		400 / CODE	
Design Temperature	F		200 / -50	
No Passes per Shell	1		1	
Corrosion Allowance	Inch		0.0625	
Connections	In	Inch	1 @ 8-150#RF	1 @ 6-300#RF
Size & Rating	Out	Inch	1 @ 8-150#RF	1 @ 10-300#RF
	Intermediate		@	@



Tube No.	465	OD	0.8250	inch	Thk(MIN)	0.06	inch	Length	16.000	ft	Pitch	0.7813	inch
Tube Type	Plain	Material						SA-214	Tube pattern 30				
Shell	SA-106 B	ID	19.250	OD	20.000	inch	Shell Cover						
Channel or Bonnet	SA-333 6							Channel Cover					
Tubesheet-Stationary	SA-350 LF2 CL1							Tubesheet-Floating					
Floating Head Cover							Impingement Plate	None					
Baffles-Cross	SA-36	Type	Single-Seg.	%Cut (Diam)	25.4	Spacing(c/c)	17.079	Inlet	17.079	inch			
Baffles-Long							Seal Type	None					
Supports-Tube							U-Bend	Type None					
Bypass Seal Arrangement	2	pairs seal strips					Tube-Tubesheet Joint	Expanded (2 grooves)					
Expansion Joint							Type						
Rho-V2-Inlet Nozzle	619.29	lb/ft-sec2					Bundle Entrance	618.71	Bundle Exit	600.72	lb/ft-sec2		
Gaskets-Shell Side	--							Tube Side	GMGC				
- Floating Head													
Code Requirements	ASME S8 D1 / STAMP / NBR						TEMA Class C						
Weight/Shell	5746.9	lb	Filled with Water		8098.7	lb	Bundle		3174.2	lb			

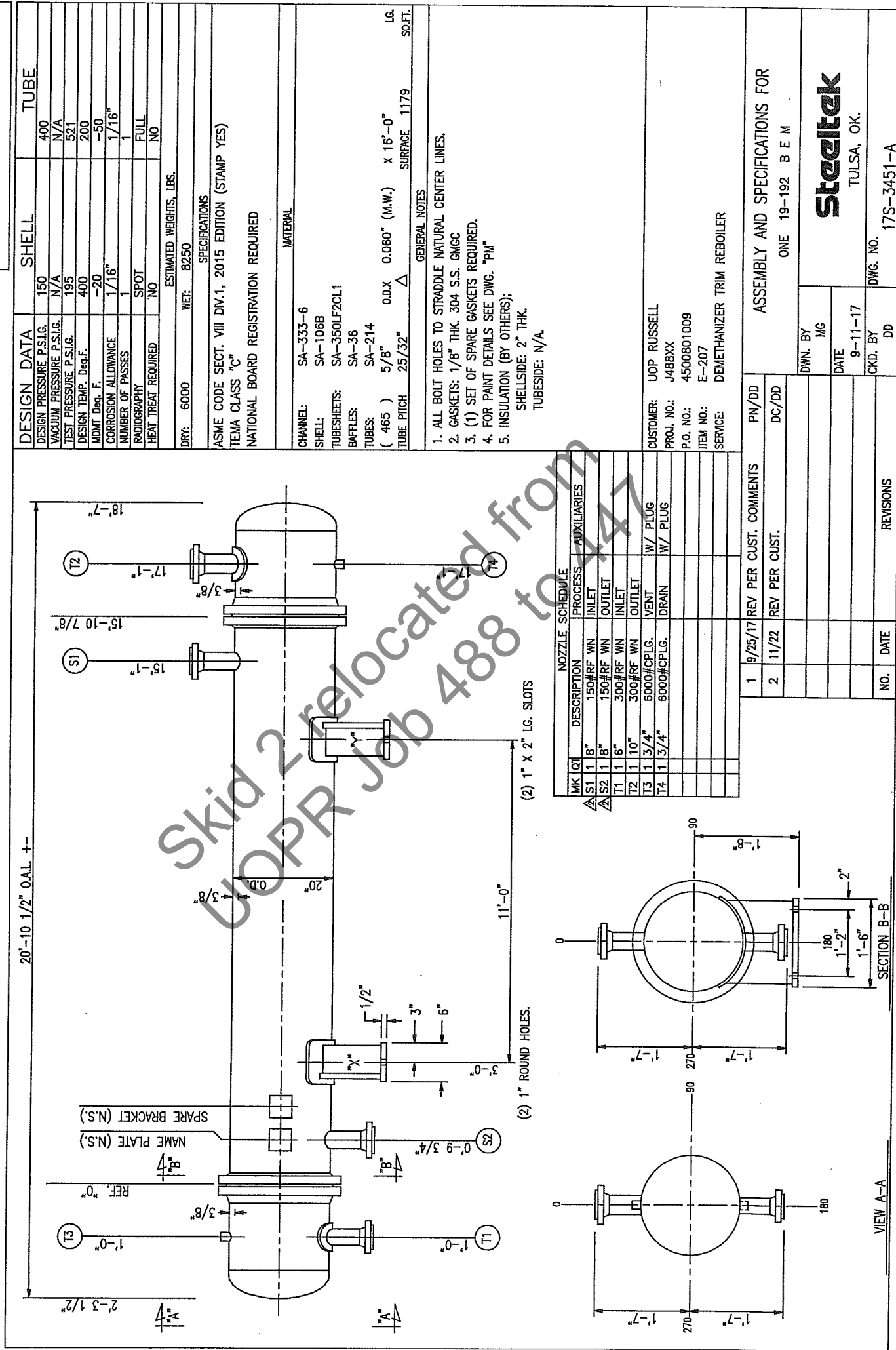
Remarks:

1. UNIT HAS THERMAL & MECHANICAL GUARANTEE. 2. FLOWS & DUTY INCREASED BY 10%.
3. MEAN METAL TEMPS. (SS/TS): 247/185°F.

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

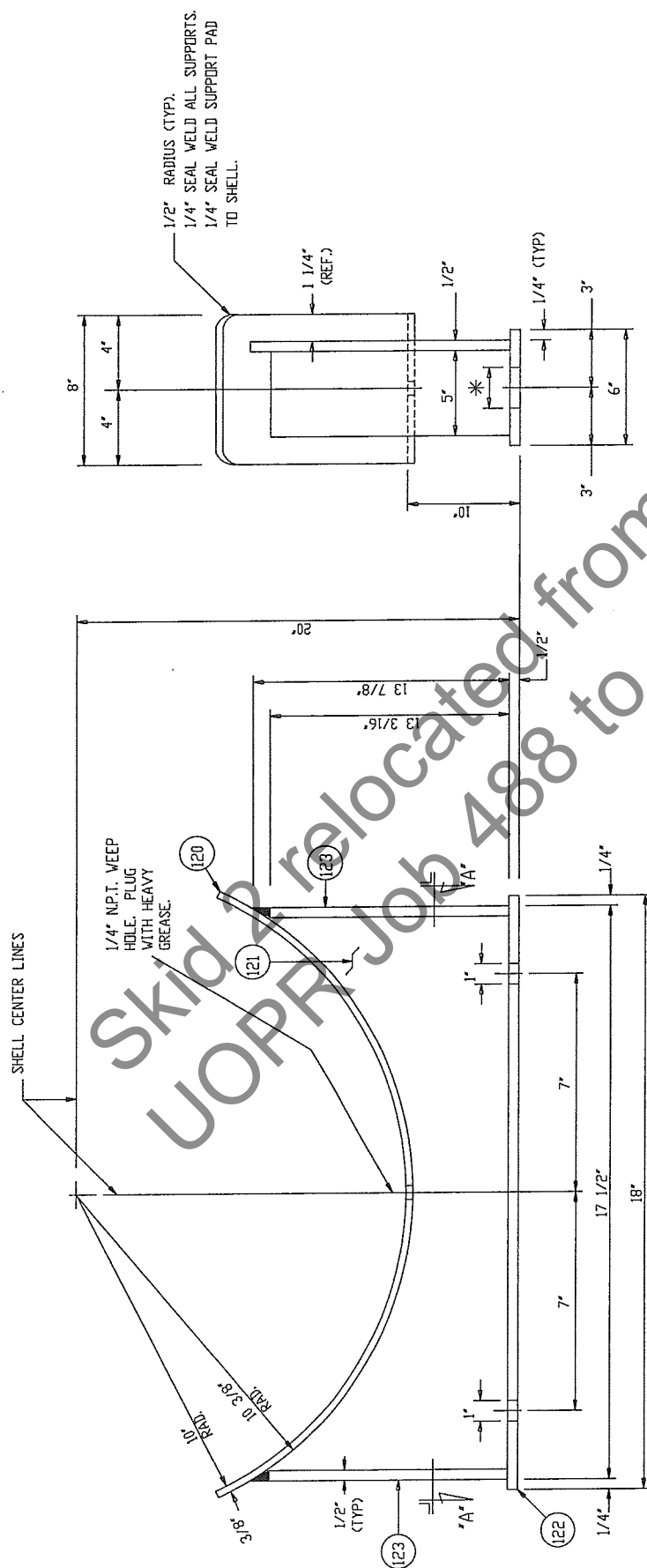
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BY: MC DATE: 11-28-17



17S-3451-B

CERTIFIED ASBUILT



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

CUSTOMER: UOP RUSSELL
P.O. NO: 4500801009
UOP RUSSELL PROJ. NO: J488XX
ITEM NO: E-207
SERVICE: DEMETHANIZER TRIM REBOILER

[illegible]

SUPPORT DETAILS

Steeltek
TULSA, OK.

SECTION "A-A"

NOTE:

1) FOR JOB NOTES SEE DWG. X.

6" NOZ. WELD
3/8" NOZ. TO PAD
3/8" PAD TO CYL.

3/4" CPLG. WELD
3/8" CPLG. TO CYL.

7 1/8"

27 1/4"

16 11/16"

3 7/16"

LIFT LUG PER DWG. N
LOCATED AS SHOWN

REF. LINE "0"

93

3/4"-6000# CPLG.
0-11 13/16"

1

5/16" MIN.

9"

81B

81A

0.3750"

4

3

19.2500"
CYL. I.D.

20"
CYL. O.D.

90°

270

FOR FLANGE DETAILS SEE DWG. L

FRONT CHANNEL END VIEW

FRONT CHANNEL SIDE VIEW

NOTES:

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

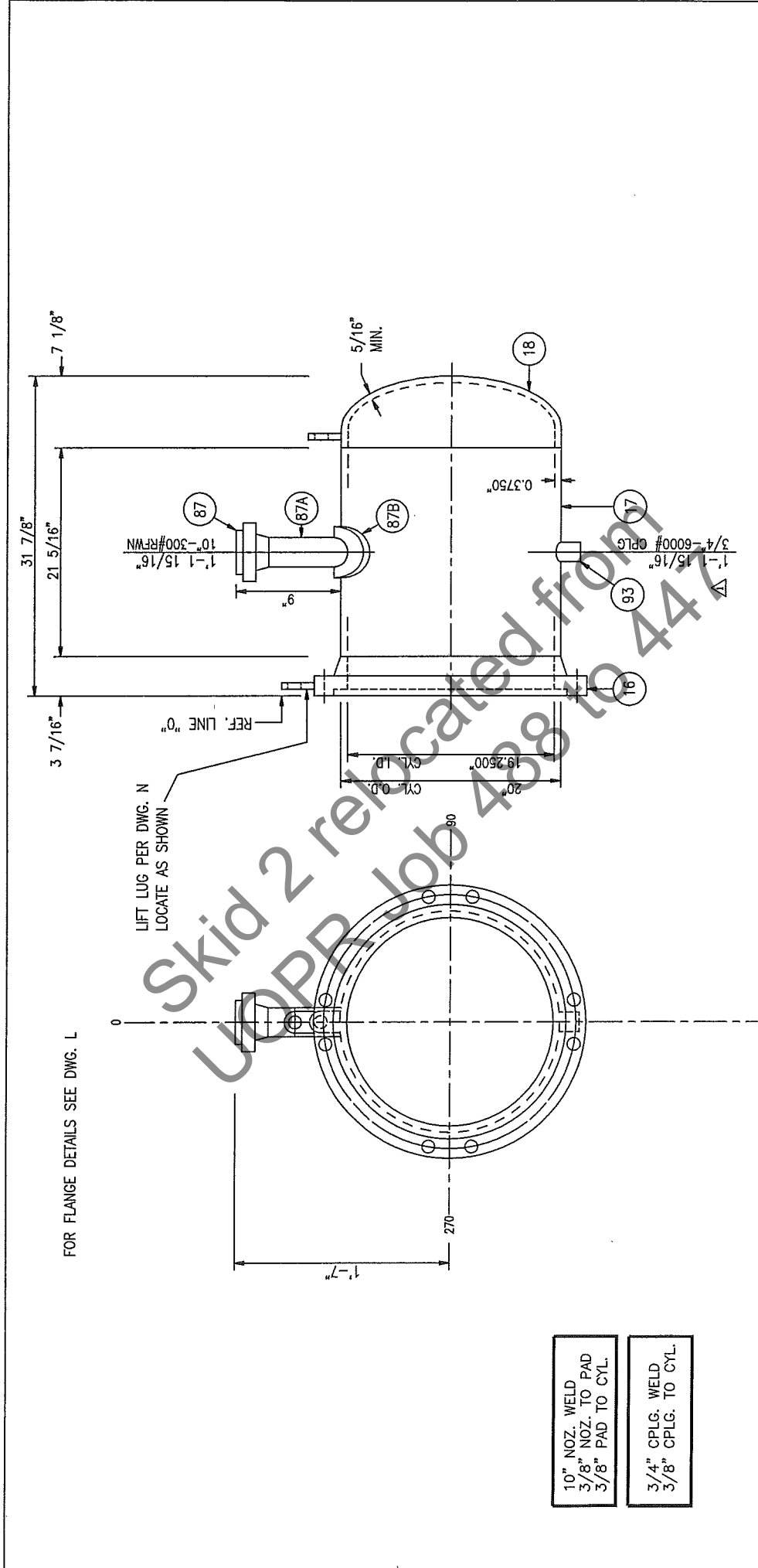
					SERVICE CENTER	DEVELOPER	TRIP NUMBER
1	9/25/17	REV PER CUST.	COMMENTS	PIN/DD	FRONT CHANNEL DETAILS		
					DWN. BY PN		
					DATE	9-11-17	
					CKD. BY DD	DWG.ND. TULSA, OK.	
N/D.	DATE	REVISIONS			17S-3451-D		

Steeltek

TULSA, OK.

DWG.NO.

17S-3451-D



10" NOZ. WELD
3/8" NOZ. TO PAD
3/8" PAD TO CYL.

3/4" CPLG. WELD
3/8" CPLG. TO CYL.

NOTES:

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

REAR CHANNEL END VIEW

1	9/25/17	REV PER	CUST. COMMENTS	PN/DD
NO.	DATE		REVISIONS	

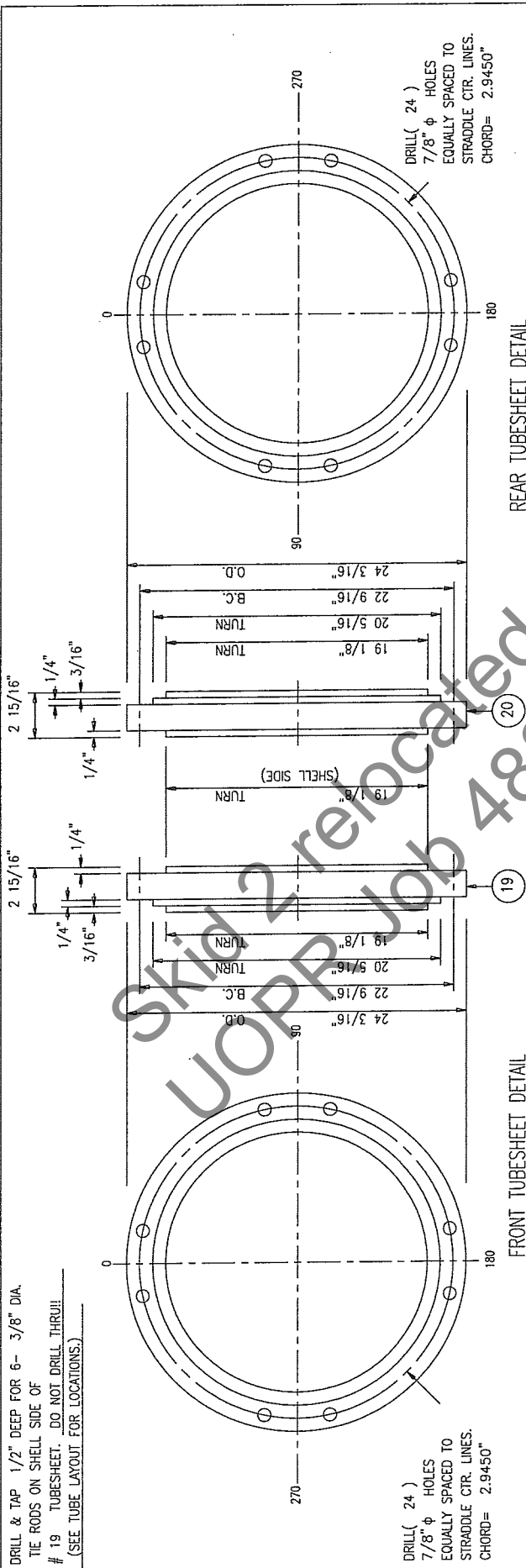
REAR CHANNEL SIDE VIEW

SERVAGE DETILITIZANZEN INAP KEDJILLEN						
REAR CHANNEL DETAILS						
<table border="1"> <tr> <td>OWN. BY PN</td> <td rowspan="2"> Steeltek TULSA, OK. </td> </tr> <tr> <td>DATE 9-11-17</td> </tr> </table>	OWN. BY PN	Steeltek TULSA, OK.	DATE 9-11-17	<table border="1"> <tr> <td>CKD. BY DD</td> <td> DWGNO. 17S-3451-E </td> </tr> </table>	CKD. BY DD	DWGNO. 17S-3451-E
OWN. BY PN	Steeltek TULSA, OK.					
DATE 9-11-17						
CKD. BY DD	DWGNO. 17S-3451-E					

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P.O. NO.: 4500801009
UOP RUSSELL PROJ. NO.:
ITEM NO.: E-207
SERVICE: DEMETHANIZER

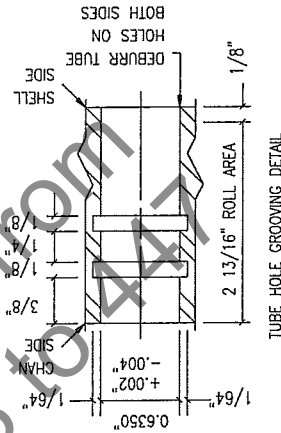
CERTIFIED
AS BUILT

DRILL & TAP 1/2" DEEP FOR 6- 3/8" 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.



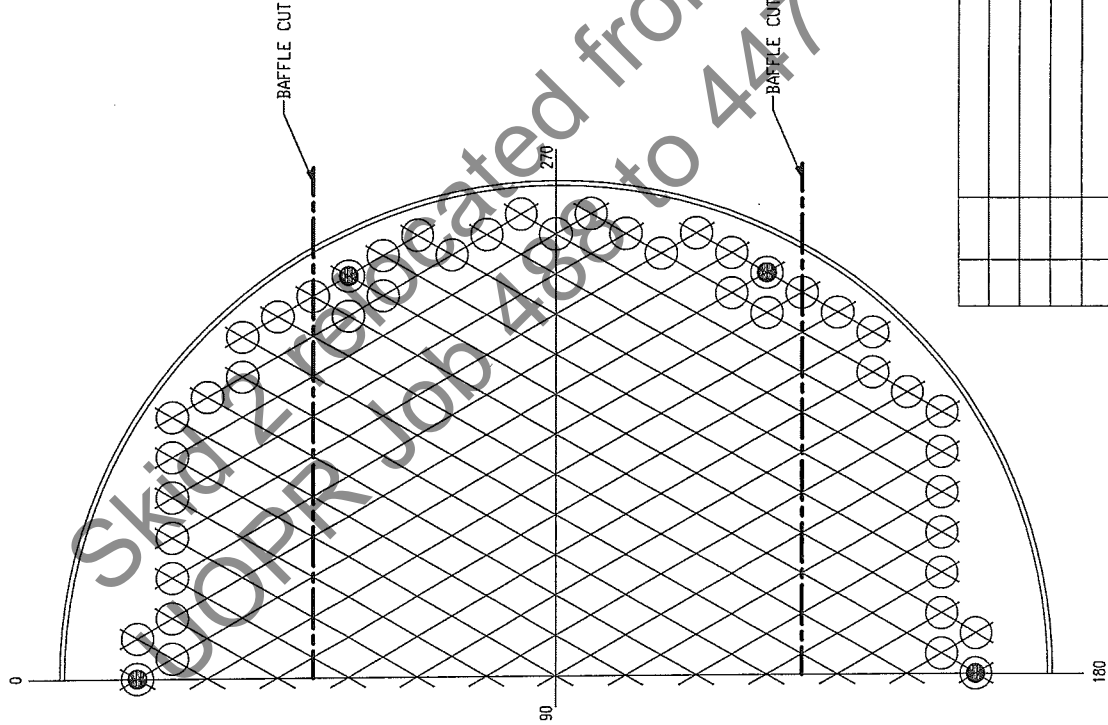
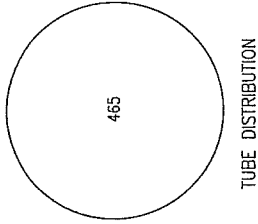
CUSTOMER: UDP RUSSELL
P.O. NO.: 4500801009
UDP RUSSELL PROJ. NO.: J488XX
ITEM NO.: E-207
SERVICE: DEMETHANIZER TRIM REBOILER

TUBESHEET DETAILS

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CERTIFIED
AS BUILT

TIE RODS.
3/8" O.D.
6 REQD. TOTAL



LAYOUT SYMMETRICAL
ABOUT VERTICAL
CENTER LINE.

NOTES:

- 1) DRILL AND REAM TUBE HOLES IN TUBESHEETS TO 0.6350" $\pm$ 0.002" DIA. FOR 465 - 5/8" O.D. TUBES.
- 2) TUBE PITCH = 25/32" TRIANGLE.
- 3) NUMBER OF PASSES = 1
- 4) SEE DWG. F FOR TUBE HOLE GROOVING DETAILS.
- 5) BAFFLE O.D. = 19 1/16"
- 6) O.T.L. = 18 11/16"
- 7) FOR JOB NOTES SEE DWG. X.

CUSTOMER: UDP RUSSELL
P.D. NO.: 4500801009
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ITEM NO.: E-207
SERVICE: DEMETHANIZER TRIM REBOILER

TUBE LAYOUT

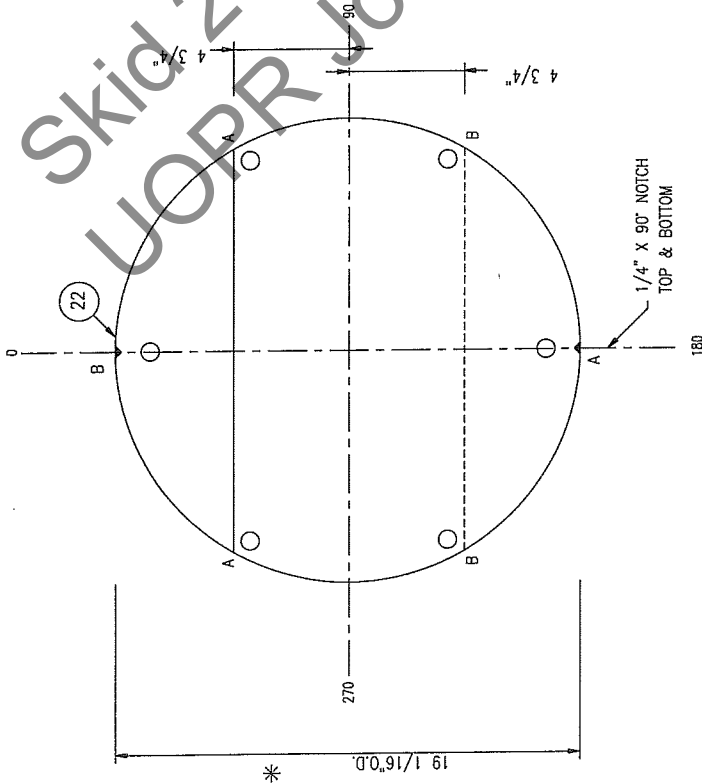
		TUBE LAYOUT	
	DNV. BY		
	PN		
	DATE		
	9-11-17		
	CKD. BY		
	DD		
	NO.	DATE	REVISIONS

Steeltek
TULSA, OK.

VIEW LOOKING AT SHELL SIDE OF NO. 19 TUBESHEET

DWG. NO. 17S-3451-G

CERTIFIED
AS BUILT



VIEW ZZ OF BAFFLES	
1/4" THK.	
5 -REQD. CUT AAA	
5 -REQD. CUT BBB	

NOTES:

- 1) DRILL TUBE HOLES IN BAFFLES 21/32" DIA. & DEBURR.
- 2) DRILL TIE ROD HOLES 7/16" DIA.
- 3) SEE TUBE LAYOUT FOR LOCATION.
- 4) RADIUS ALL CORNERS ON BAFFLE CUTS.
- 5) CHECK SHELL I.D. BEFORE MACHINING BAFFLE O.D.
- 6) MACHINE O.D. OF BAFFLES TO 250 RMS.
- * FOR JOB NOTES SEE DWG. X.

CUSTOMER: UOP RUSSELL
P.D. NO: 4500801009
UOP RUSSELL PROJ. NO: J488XX
ITEM NO: E-207
SERVICE: DEMETHANIZER TRIM REBOILER

BAFFLE DETAILS

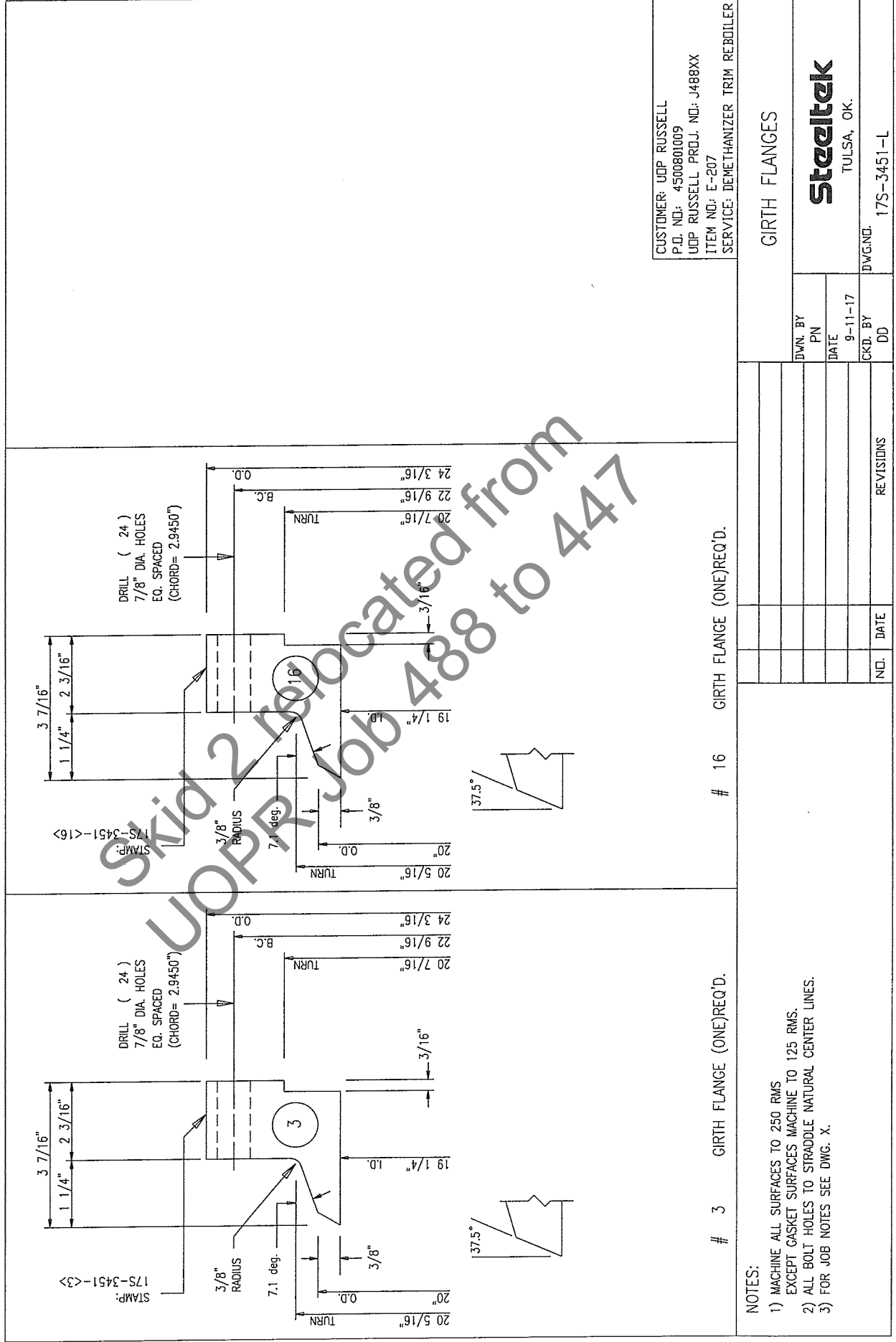
Steeltek TULSA, OK.		DWN. BY	PN
		DATE	9-11-17
NO.	DATE	CKD. BY	DD
		REVISIONS	DWG. NO.
			17S-3451-H

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

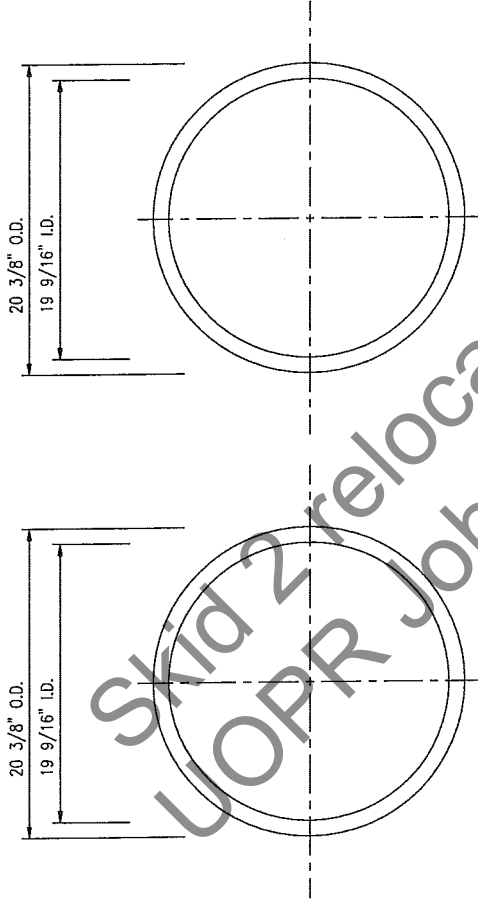
CUSTOMER: UDP RUSSELL	
P.O. NO: 4500801009	
UDP RUSSELL PROJ. NO: J488XX	
ITEM NO: E-207	
SERVICE: DEMETHANIZER TRIM REBOILER	

BUNDLE DETAILS	
DRAWN BY	PN
DATE	9-11-17
CKD BY	DD
DWG.NO.	17S-3451-J

CERTIFIED
ASBUILT



CERTIFIED
AS BUILT



(1)-REQUIRED.
FRONT CHANNEL GASKET.
.157\"

(1)-REQUIRED.
REAR CHANNEL GASKET.
.157\"

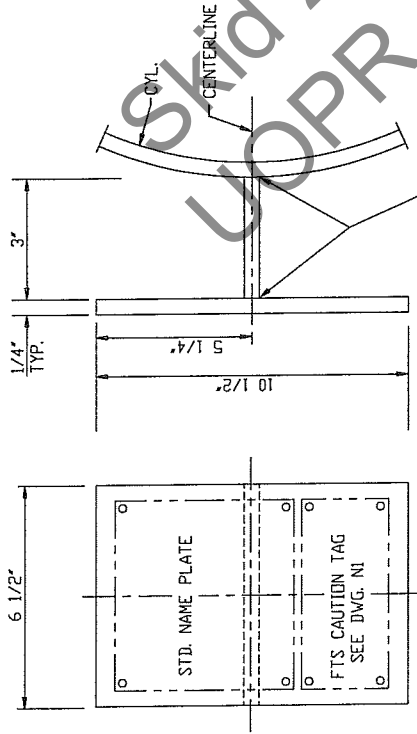
GASKET TOLERANCES
O.D. +0\"

- 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.

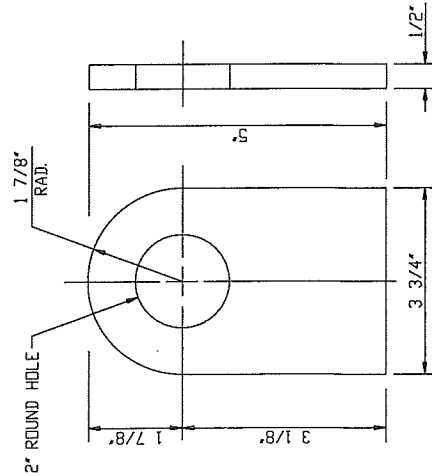
CUSTOMER: UOP RUSSELL
P.O. NO: 4500801009
UOP RUSSELL PROJ. NO: J488XX
ITEM NO: E-207
SERVICE: DEMETHANIZER TRIM REBOILER

GASKET DETAILS			
	DWN. BY	PN	Steeltek TULSA, OK.
	DATE	9-11-17	
	CKD. BY	DD	
NO.	DATE	REVISIONS	DWGNO. 17S-3451-M

CERTIFIED
AS BUILT



NAME PLATE W/ FTS CAUTION TAG BRACKET DETAIL



LIFTING LUG DETAIL

CUSTOMER: UOP RUSSELL
P.I. NO: 4500801009
UOP RUSSELL PROJ. NO: J488XX
ITEM NO: E-207
SERVICE: DEMETHANIZER TRIM REBOILER

NB		CERTIFIED BY Steeltek TULSA, OKLA.	
ASME U W RT4	SHELL TUBE	MAWP PSI 150 400	AT OF 400 200
	SHELL TUBE	MDMT OF -20 -50	AT PSI 150 400
YEAR BUILT 2017		SERIAL NO. 17S-3451	
P.I. NO. 4500801009		ITEM NO. E-207	
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	PN	Steeltek TULSA, OK.
	DATE	9-11-17	
	CKD. BY	DWGNO.	
	DD	17S-3451-N	

CERTIFIED ASBUILT

FIXED TUBE

CAUTION: THE
AND TEMPERATURE
EXCHANGER RE
CONDITIONS. TH
HAS BEEN EVAL
OPERATING CON
REEVALUATED E
DIFFERENT OPE

Skid 2 relocated from
UOPR Job 488 to 447

FIXED TUBESHEET HEAT EXCHANGER

CAUTION: THE CODE REQUIRED PRESSURES AND TEMPERATURE MARKED ON THE HEAT EXCHANGER RELATE TO THE BASIC DESIGN CONDITIONS. THE HEAT EXCHANGER DESIGN HAS BEEN EVALUATED FOR SPECIFIC OPERATING CONDITIONS AND SHALL BE REEVALUATED BEFORE IT IS OPERATED AT DIFFERENT OPERATING CONDITIONS.

CUSTOMER: UOP RUSSELL

P.O. NO.: 4500801009

UDP RUSSELL PROJ. NO: J488XX

ITEM NO: E-207

SERVICE: DEMETHANIZER TRIM REBOILER

FTS CAUTION TAG DETAILS

DWN. BY	
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PN

DATE _____

9-11-17

CKD. BY

D

REVISIONS

DATE	NO.
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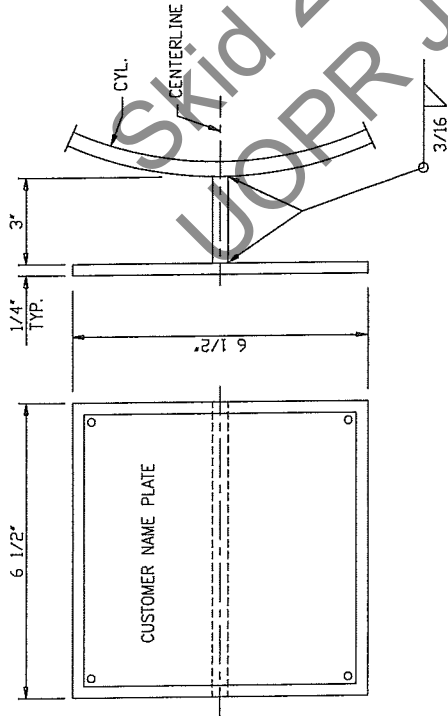
Stetk

TULSA, OK.

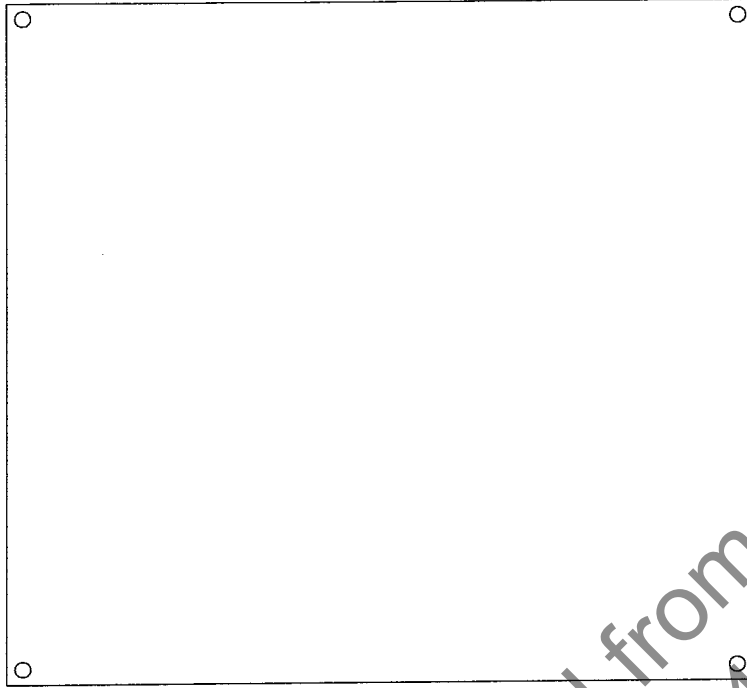
DWG. NO.

17S-3451-N1

CERTIFIED
AS BUILT



CUSTOMER NAME PLATE BRACKET DETAIL



CUSTOMER: UDP RUSSELL
P.D. NO.: 4500801009
UDP RUSSELL PROJ. NO.: J488XX
ITEM NO.: E-207
SERVICE: DEMETHANIZER TRIM REBOILER

CUSTOMER NAME PLATE BRACKET DETAILS		CUSTOMER NAME PLATE BRACKET DETAILS	
		DWN. BY	PN
		DATE	9-11-17
		CHKD. BY	DD
		REVISIONS	
NO.	DATE		

Steeltek

TULSA, OK.

DWG. NO.

17S-3451-N2

PAINT REQUIREMENTS

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

SHELL CYL.

2 COATS OF SHERWIN WILLIAMS HEAT FLEX 1200 (10.0-12.0 MILS TOTAL D.F.T.) COLOR: GRAY

 SHELL PROTRUSIONS

1 COAT OF SHERWIN WILLIAMS HEAT FLEX 1200 (5.0-6.0 MILS D.F.T.) COLOR: GRAY

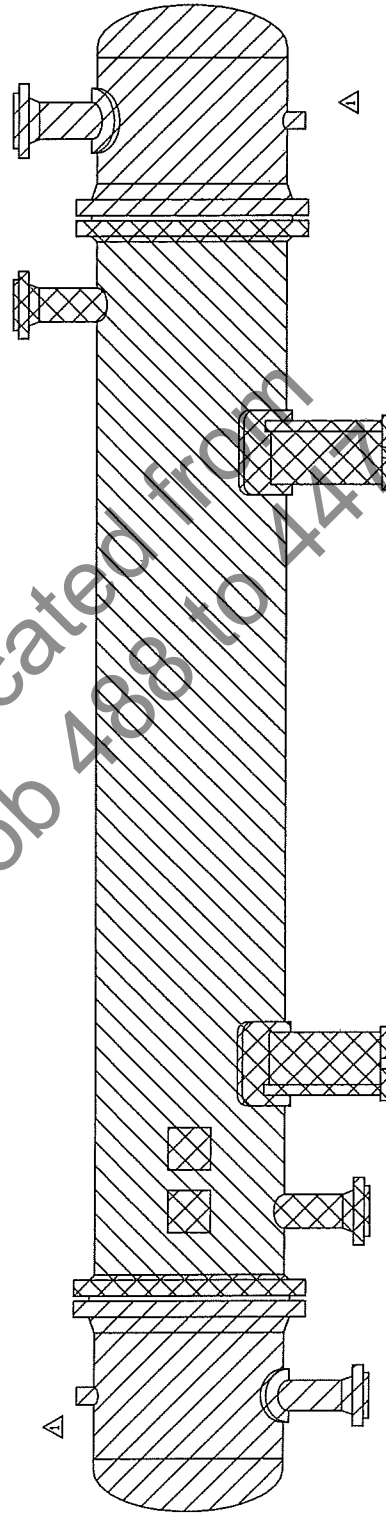
TOP COAT OF SHERWIN WILLIAMS HEAT FLEX HI-TEMP 500 B59-810 (2.0-2.5 MILS D.F.T.) COLOR: CIRRUSS GRAY

 CHANNELS

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 BEETLE



CUSTOMER: UOP RUSSELL

P.D. NO.: 4500801009

UBP RUSSELL PROJ, NO: J488XX

ITEM NO.: E-207

SERVICE: DEMETHANIZER TRIM REBOILER

1	9/25/17	REV PER	CUST. COMMENTS	PN/DD
NO.	DATE	REVISIONS		

PAINT MAP

Staltek

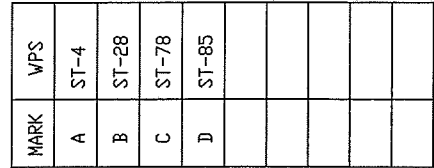
TULSA, OK.

DWG, ND,

17S-3451-PM

Technical drawing of a nozzle assembly. The drawing includes a side view and a cross-sectional view. The side view shows a nozzle with a flange and a pad. The cross-sectional view shows the internal structure of the nozzle, including the nozzle body, nozzle tip, and nozzle pad. Dimensions are provided for various parts: 1/4" N.P.T. (National Pipe Thread) for the nozzle body, 1/8" RAD. (Radius) for the nozzle tip, 1/16" GAP for the gap between the nozzle tip and the pad, and 1/8" for the thickness of the nozzle pad. The nozzle is labeled "NOZZLE WITH PAD". The drawing also includes a label "WELD-NECK FLANGE" and a label "LAND".

	1/16" GAP 70 deg.	1/16" GAP 1/16" LAND WELD-NECK FLANGE	1/16" GAP 1/8"RAD. NOZZLE WITH PAD	1/16" GAP 1/8"RAD. NOZZLE W/OUT PAD	1/4" N.P.T. air & soap test welds at 15 P.S.I.	1/16" GAP △ PIPE CPLG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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[illegible]

WITH AN EASILY
OF SHIPPING COVERS,
H RUBBER GASKETS WITH (4) BOLTS.

1. ALL BOLT HOLES TO STRADDLE NATURAL CENTERLINES.
2. GRIND 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. HIGHEST TO BE HELD FOR ONE HOUR MIN.

WELDING NOTES:

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

1. SHELL TO BE SPOT RADIOGRAPHED,
2. CHANNEL TO BE FULL RADIOGRAPHED,

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 WIND COVERS WITH RUBBER GASKETS WITH (4) BOLTS.

MK. NO.	QUAN.	DESCRIPTION	MATERIAL	DUE	P.O. NO.	RCV'D	PRICE
21	465	TUBES 5/8" O.D.X 0.060" (MIN.) WALL X 16'-0" LG.	SA-214				
		FORGED RING MATERIAL					
3	1	FLG 24 3/16" O.D.X 19 1/4" I.D.X 3 7/16" THK (F)	SA-350LF2CL1				
16	1	FLG 24 3/16" O.D.X 19 1/4" I.D.X 3 7/16" THK (F)	SA-350LF2CL1				
		TUBESHEETS & COVERS					
19	1	TUBESHEET 24 3/16" O.D.X 2 15/16" THK (F)	SA-350LF2CL1				
20	1	TUBESHEET 24 3/16" O.D.X 2 15/16" THK (F)	SA-350LF2CL1				
		BAFFLES					
22	10	BAFFLES 19 7/16" B.O.D.X 1/4" THK	SA-36				
		HEADS					
1	1	2:1 ELLIP. HD. 20" O.D.X 5/16" THK(min) W/2" SF	SA-516-70N				
18	1	2:1 ELLIP. HD. 20" O.D.X 5/16" THK(min) W/2" SF	SA-516-70N				
		CYLINDERS					
9	1	SMLS.PIPE 20" X(0.3750" Sch20)X 15'-6 1/8" LG.	SA-106B				
4	1	SMLS.PIPE 20" X(0.3750" Sch20)X 1'-4 11/16" LG.	SA-333-6				
17	1	SMLS.PIPE 20" X(0.3750" Sch20)X 1'-9 5/16" LG.	SA-833-6				
		BEVELS					
		MK. 1: TYPE "F"					
		MK. 18: TYPE "F"					
		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	

CUSTOMER: UDP RUSSELL
 P.O. NO.: 4500801009
 UDP RUSSELL PROJ. NO.: J488XX
 ITEM NO.: E-207
 SERVICE: DEMETHANIZER TRIM REBOILER

CERTIFIED
AS BUILT

BILL OF MATERIAL

DWN. BY
MG

DATE
9-11-17

CKD. BY
DD

Steeltek

TULSA, OK.

DWG. NO.

17S-3451-Y

NO. DATE REVISIONS

MK. NO.	QUAN.	DESCRIPTION	MATERIAL	DUE	P.O. NO.	RCV'D	PRICE
ASME FLANGES							
71	1	ASME 8" - 150 # RF WN W/ (SchXH BORE)	SA-105				
72	1	ASME 8" - 150 # RF WN W/ (SchXH BORE)	SA-105				
81	1	ASME 6" - 300 # RF WN W/ (SchXH BORE)	SA-350LF2CL1				
87	1	ASME 10" - 300 # RF WN W/ (Sch60 BORE)	SA-350LF2CL1				
71A	1	SMLS.PIPE 8" X(0.5000" SchXH)X 6 5/8" LG.	SA-106B				
72A	1	SMLS.PIPE 8" X(0.5000" SchXH)X 6 5/8" LG.	SA-106B				
81A	1	SMLS.PIPE 6" X(0.4320" SchXH)X 6 5/8" LG.	SA-333-6				
87A	1	SMLS.PIPE 10" X(0.5000" Sch60)X 6 7/8" LG.	SA-333-6				
81B	1	WELD PAD 10 7/8" O.D.X 7 1/8" I.D.X 3/8" THK					
ROLL TO 10" RAD			SA-516-70N				
87B	1	WELD PAD 14 7/8" O.D.X 15 1/2" O.D.X					
		11 1/4" I.D.X 11 7/8" I.D.X 3/8" THK ROLL TO 10" RAD	SA-516-70N				
BEVELS							
ALL NOZZLE PIPE: ONE END TYPE "A"; ONE END TYPE "F"							
COUPLINGS							
93	2	3/4" -6000# WELD IN COUPLINGS W/ 3" LG. RND. HD. PLUGS	SA-105				

TYPE A SQUARE CUT	TYPE B 45° O.S. NO LAND	TYPE C 30° O.S. NO LAND	TYPE D 30° O.S. 1/8" LAND	TYPE E 30° I.S. 1/8" LAND	TYPE F 37 1/2° O.S. NO LAND	TYPE G 37 1/2° O.S. 1/8" LAND	TYPE H 30° W/ 1/8" LAND BAL. I.S.	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
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CERTIFIED
AS BUILT

1	9/25/17	REV PER CUST. COMMENTS	PN/DD
2	11/22	REV PER CUST.	DC/DD
NO.	DATE	REVISIONS	

CUSTOMER: UDP RUSSELL
P.O. NO.: 4500801009
UDP RUSSELL PROJ. NO.: J488XX
ITEM NO.: E-207
SERVICE: DEMETHANIZER TRIM REBOILER

BILL OF MATERIAL

DWN. BY MG
DATE 9-11-17
CKD. BY DD

Steeltek
TULSA, OK.

DWG. NO.
17S-3451-Y1

MK.NO.	QUAN.	DESCRIPTION	MATERIAL	DUE	P.O. NO.	RCV'D	PRICE
BOLTING & GASKETS							
40	1	LOT OF GASKETS PER DWG. M					
41	24	3/4" ROUND X 10-THREAD STUDS X 6 3/4" LG. 3&19	SA-193B7				
42	24	3/4" ROUND X 10-THREAD STUDS X 6 3/4" LG. 16&20	SA-193B7				
43	96	3/4" HEAVY HEX NUTS 10-THREAD	SA-194-2H				
MISC. MATERIAL							
60	1	STD. NAME PLATE	STN. STL.				
60A	1	STD. FTS CAUTION PLATE	STN. STL.				
61	1	NAME PL BRKT. 3' x 1/4' x 6 1/2' LG.	SA-36				
61A	1	NAME PL BRKT. 6 1/2' x 1/4' x 10 1/2' LG.	SA-36				
61B	1	CUSTOMER NAME PL BRKT. 3' x 1/4' x 6 1/2' LG.	SA-36				
61C	1	CUSTOMER NAME PL BRKT. 6 1/2' x 1/4' x 6 1/2' LG.	SA-36				
62	4	LIFTING LUGS PER DWG. N	SA-516-70				
23	85	FT. 3/8" O.D. TIE RODS	SA-36				
23B	12	3/8" HEAVY HEX TIE ROD NUTS	SA-36				
23A	85	FT. 5/8" O.D. SPACER TUBING	SA-36				
SUPPORT MATERIAL							
120	2	PLATE 8" X 3/8" THK X 25" LG.	SA-516-70				
121	2	PLATE 17 1/2" X 1/2" THK X PER DWG. C LG.	SA-516-70				
122	2	PLATE 6" X 1/2" THK X 18" LG.	SA-516-70				
123	4	PLATE 5" X 1/2" THK X 13 3/16" LG.	SA-516-70				

CUSTOMER: UOP RUSSELL
P.O. NO: 4500801009
UOP RUSSELL PROJ. NO: J488XX
ITEM NO: E-207
SERVICE: DEMETHANIZER TRIM REBOILER

BILL OF MATERIAL

DWN. BY
PN
DATE
9-11-17
CKD. BY
DD

Steeltek
TULSA, OK.

DWG. NO. 17S-3451-Y2

NO. DATE REVISIONS

CERTIFIED
AS BUILT

P.O. No: 4500801009		Job No : 17S-3451	
Date: 9/11/17 By: MG		Item No: E-207	
Customer: UOP RUSSELL		HORIZONTAL	
Service : DEMETHANIZER TRIM REBOILER		FIXED T.S.	
No. Shells: 1 Par. 1 Ser. 1		Surface: 1178 Ea. 1178 Total Sq.Ft.	
Size: 19 x 192" Type: B E M			
(465) Tubes x 0.625" OD x 0.060" (m.w.) x 192" Lg 0.7813" ROT TRI Pitch			
Tubes : SA-214			
Shell : SA-106B			
Channel : SA-333-6			
Tubesheets : SA-350LF2CL1			
Cross Baffles : SA-36 No. 10 Pitch 17.000 SGL SEG HORZ			
Code Requirements: SHELL SECT VIII STAMP YES & CHANNEL SECT VIII STAMP YES			
Natl. Board #YES		Canadian Reg. #NO Tema "C"	
Weight Ea Dry: 5950 Lbs		Wet: 8250 Lbs Bundle: 3550 Lbs	
Shell		Tubes	
Design Press/Ext	150.0 / 0.0 psig	400.0 / 0.0 psig	
Test Pressure	195.0 psig	521.0 psig	
Design Temp/MDMT	400 / -20 deg.F	200 / -50 deg.F	
Corrosion Allowance	0.0625"	0.0625"	
No. of Passes	1	1	
Radiograph	SPOT	FULL	
Stress Relieve	NO	NO	
Remarks:			
1. Shell side production impacts are not required per UG-20(f).			
2. Tube side production impacts are not required per UCS-66(a).			
3. All calculations are in accordance with A.S.M.E. Code, Section VIII, Div. I, 2015 Edition.			
4. Nozzle wall thickness calculations per UG-45 have been considered.			
5. 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.			
Revisions:			
1) Revision per Customer; Page's: 5, 6, & 26; 11-15-2017			
2) Revised production impact note.			

CERTIFIED
AS BUILT

SHELL SIDE

```
=====
NOM.
SIZE      PRESS.      TEMP.      C.A.      RT      H.T.
20.000"   150.0psig   400deg.F   0.0625"   SPOT    0deg.F
=====
```

```
ASME CODE SEC.VIII DIV.I UG-27 [ CYLINDER ]
===DESIGN CONDITIONS=====CYLINDER CALCULATIONS ON O.D. FORMULA===
```

SHELL CYL

```
MATERIAL: SA-106B      PRESS = 150.0psig  TEMP = 400deg.F
O.D.      NOM. THK.      RW=0/PIPE=1  CORR.ALLOW  EFFICIENCY
20.0000"   0.3750"           1           0.0625"     0.85
ATM.STRS   DES.STRS   STRS/STRS   MAWP N-C    MAWP CORR.
17100.0psi 17100.0psi  1.000      483.273psig 390.232psig
```

P*(RO)

----- = 0.10277" + CORR. ALLOW. = 0.16527" + MTOL. = 0.18889"

S*E+(.4*P)

Skid 2 relocated from
UOPR Job 488 to 447

Item No: E-207
Job No : 17S-3451

By: Meg

P.O. No: 4500801009

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CERTIFIED
AS BUILT

NOM.					
SIZE	PRESS.	TEMP.	C.A.	RT	H.T.
20.000"	400.0psig	200deg.F	0.0625"	FULL	0deg.F

CERTIFIED
AS BUILT

FRONT CHAN.

NOM.	SIZE	PRESS.	TEMP.	C.A.	RT	H.T.
	20.000"	400.0psig	200deg.F	0.0625"	FULL	0deg.F

ASME CODE SEC.VIII DIV.I UG-27 [CYLINDER]
 ===DESIGN CONDITIONS=====CYLINDER CALCULATIONS ON O.D. FORMULA=====

CHAN. CYL

MATERIAL:	SA-333-6	PRESS =	400.0psig	TEMP =	200deg.F
O.D.	NOM. THK.	RW=0/PIPE=1	CORR.ALLOW	EFFICIENCY	
20.0000"	0.3750"	1	0.0625"	1.00	
ATM.STRS	DES.STRS	STRS/STRS	MAWP N-C	MAWP CORR.	
17100.0psi	17100.0psi	1.000	568.556psig	459.097psig	

P*(RO)
 ----- = 0.23175" + CORR. ALLOW. = 0.29425" + MTOL. = 0.33629"
 S*E+(.4*P)

ASME CODE SEC.VIII DIV.I UG-32 [ELLIPTICAL HEAD]
 ===DESIGN CONDITIONS=====ELLIPTICAL HEAD CALCULATIONS ON O.D. FORMULA=====

CHAN. HEAD

MATERIAL:	SA-516-70	PRESS =	400.0psig	TEMP =	200deg.F
O.D.	(min) THK.	CORR.ALLOW	EFFICIENCY		
20.0000"	0.3125"	0.0625"	0.85		
ATM.STRS	DES.STRS	STRS/STRS	MAWP N-C	MAWP CORR.	
20000psi	20000psi	1.000	546psig	434psig	

P*(RO)
 ----- = 0.23041" + CORR. ALLOW. = 0.29291" + MTOL. = 0.29291"
 S*E+(.9*P)

Item No: E-207
 Job No : 17S-3451

By: meg P.O. No: 4500801009 9/11/17 Page 4

CERTIFIED
 AS BUILT

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

NOZ NO= 1 8.00" 150 LB RF WN
 [INLET] SHELL SIDE
 PRESSURE = 150.0psig TEMP = 400.0deg.F

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

SA-106B		SA-106B	
OPER STRS=	17100.0 psi	OPER STRS=	17100.0 psi
ATM STRS =	17100.0 psi	ATM STRS =	17100.0 psi
C.A.	= 0.06250"	C.A.	= 0.06250"
I.D.	= 19.34375"	I.D.	= 7.62500"
O.D.	= 20.00000"	O.D.	= 8.62500"
THK.	= 0.32812"	THK. XH=	0.50000"
T	= 0.26562"	TN	= 0.43750"
TR	= 0.08741"	TRN	= 0.03770"
ET	= 0.17821"	ETN	= 0.39980"

MIN STD. WT. PIPE+C.A.= 0.34425" TR+C.A.= 0.14991"

LIMITS= 15.50000"

fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000 F= 1.00000
 Min weld sizes:NS= 0.2630" NP= 0.0000" PS= 0.0000" IF= 0.0000"

AREA REQD.	A =	0.67745in ²	
EXCESS IN CYL.	A1=	1.38115in ²	
EXCESS IN NOZ. (OUTSIDE)	A2=	0.53099in ²	H = 0.66406"
AREA OF FILLETS	=	0.14062in ²	
AREA AVAILABLE	=	2.05276in ²	

NOZ. NECK WELD= 0.37500" AREA= 0.14062in²

< AREA REQD-AREA AVAILABLE > = -1.37531in²

MAWP N-C= 374.0psig LIMITED BY AR
 MAWP COR= 297.0psig LIMITED BY AR

Item No: E-207
 Job No : 17S-3451

By: my P.O. No: 4500801009
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CERTIFIED
 AS BUILT

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

NOZ NO= 1 8.00" 150 LB RF WN
 [OUTLET] SHELL SIDE
 PRESSURE = 150.0psig TEMP = 400.0deg.F

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

SA-106B		SA-106B	
OPER STRS=	17100.0 psi	OPER STRS=	17100.0 psi
ATM STRS =	17100.0 psi	ATM STRS =	17100.0 psi
C.A.	= 0.06250"	C.A.	= 0.06250"
I.D.	= 19.34375"	I.D.	= 7.62500"
O.D.	= 20.00000"	O.D.	= 8.62500"
THK.	= 0.32812"	THK. XH=	0.50000"
T	= 0.26562"	TN	= 0.43750"
TR	= 0.08741"	TRN	= 0.03770"
ET	= 0.17821"	ETN	= 0.39980"

MIN STD. WT. PIPE+C.A.= 0.34425" TR+C.A.= 0.14991"

LIMITS= 15.50000"

fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000 F= 1.00000
 Min weld sizes: NS= 0.2630" NP= 0.0000" PS= 0.0000" IF= 0.0000"

AREA REQD.	A =	0.67745in ²
EXCESS IN CYL.	A1=	1.38115in ²
EXCESS IN NOZ. (OUTSIDE)	A2=	0.53099in ² H = 0.66406"
AREA OF FILLETS	=	0.14062in ²
AREA AVAILABLE	=	2.05276in ²

NOZ. NECK WELD= 0.37500" AREA= 0.14062in²

< AREA REQD-AREA AVAILABLE > = -1.37531in²

MAWP N-C= 374.0psig LIMITED BY AR
 MAWP COR= 297.0psig LIMITED BY AR

Item No: E-207
 Job No : 17S-3451

By: my P.O. No: 4500801009
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CERTIFIED
 AS BUILT

NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO=11 6.00" 300 LB RF WN
[INLET] FRONT CHANNEL SIDE
PRESSURE = 400.0psig TEMP = 200.0deg.F

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

SA-333-6		SA-333-6	
OPER STRS=	17100.0 psi	OPER STRS=	17100.0 psi
ATM STRS =	17100.0 psi	ATM STRS =	17100.0 psi
C.A. =	0.06250"	C.A. =	0.06250"
I.D. =	19.34375"	I.D. =	5.76100"
O.D. =	20.00000"	O.D. =	6.62500"
THK. =	0.32812"	THK. XH=	0.43200"
T =	0.26562"	TN =	0.36950"
TR =	0.23175"	TRN =	0.07677"
ET =	0.03388"	ETN =	0.29273"

MIN STD. WT. PIPE+C.A.= 0.30750" TR+C.A.= 0.29425"

LIMITS= 11.77200"

fr1= 1.0000 fr2= 1.0000 fr3= 1.0000 fr4= 1.0000 F= 1.00000

Min weld sizes: NS= 0.0000" NP= 0.3536" PS= 0.1878" IF= 0.0000"

AREA REQD.	A =	1.36408in ²
EXCESS IN CYL.	A1=	0.19939in ²
EXCESS IN NOZ. (OUTSIDE)	A2=	0.38879in ² H = 0.66406"
AREA OF FILLETS	=	0.28125in ²
AREA AVAILABLE	=	0.86943in ²

NOZ. NECK WELD= 0.37500" AREA= 0.14062in²

PAD MATL.=	SA-516-70	S=	20000.psi
PAD O.D.=	10.87500"	THK.=	0.37500" AREA= 1.59375in ²
PAD TO CYL. WELD=	0.37500"	AREA=	0.14062in ²
ARC=	6.753"		
PAD RET. DIM.=	10.875" X 11.062"		

< AREA REQD-AREA AVAILABLE > = -1.09910in²

MAWP N-C= 684.0psig LIMITED BY AR
MAWP COR= 617.0psig LIMITED BY AR

All Weld Paths are stronger than the required strength /[UG-41 UG-45 UW-15]

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By: Mag P.O. No: 4500801009
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CERTIFIED
AS BUILT

NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO=17 10.00" 300 LB RF WN
[OUTLET] REAR CHANNEL or COVER
PRESSURE = 400.0psig TEMP = 200.0deg.F

-----CYLINDER-----		-----NOZZLE-----	
SA-333-6		SA-333-6	
OPER STRS=	17100.0 psi	OPER STRS=	17100.0 psi
ATM STRS =	17100.0 psi	ATM STRS =	17100.0 psi
C.A. =	0.06250"	C.A. =	0.06250"
I.D. =	19.34375"	I.D. =	9.75000"
O.D. =	20.00000"	O.D. =	10.75000"
THK. =	0.32812"	THK. XH=	0.50000"
T =	0.26562"	TN =	0.43750"
TR =	0.23175"	TRN =	0.12457"
ET =	0.03388"	ETN =	0.31293"

MIN STD. WT. PIPE+C.A.= 0.38188" TR+C.A.= 0.29425"
LIMITS= 19.75000"
fr1= 1.0000 fr2= 1.0000 fr3= 1.0000 fr4= 1.0000 F= 1.00000
Min weld sizes: NS= 0.0000" NP= 0.3536" PS= 0.1878" IF= 0.0000"

AREA REQD. A = 2.28853in²
EXCESS IN CYL. A1= 0.33452in²
EXCESS IN NOZ. (OUTSIDE) A2= 0.41562in² H = 0.66406"
AREA OF FILLETS = 0.28125in²
AREA AVAILABLE = 1.03138in²

NOZ. NECK WELD= 0.37500" AREA= 0.14062in²

PAD MATL.= SA-516-70 S= 20000.psi
PAD O.D.= 14.87500" THK.= 0.37500" AREA= 1.54688in²
PAD TO CYL. WELD= 0.37500" AREA= 0.14062in²
ARC= 11.349"
PAD RET. DIM.= 14.875" X 15.500"

< AREA REQD-AREA AVAILABLE > = -0.28973in²

NOTE: [LARGE DIAMETER OPENING] Rn/R= 0.5072
2/3 OF REINFORCEMENT (AREA REQD)= 1.52569"
LIMITS FOR 2/3 OF REINFORCEMENT= 14.81250"
AREA AVAILABLE = 2.24694in²
< AREA REQD-AREA AVAILABLE > = -0.72125in²

MAWP N-C= 496.0psig LIMITED BY AR
MAWP COR= 424.0psig LIMITED BY AR

All Weld Paths are stronger than the required strength /[UG-41 UG-45 UW-15]

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Job No : 17S-3451

By: mg P.O. No: 4500801009 9/11/17 Page 8

CERTIFIED
AS BUILT

ASME SEC.VIII DIV.1 APPENDIX 2		Front chan to tubesheet flange	
DESIGN CONDITIONS		GASKET and BOLTING CALCULATIONS	
Design Pres=	400.0 psig	Eff.Gsk OD=	20.3125"
Neg. Pres=	None	Eff.Gsk ID=	19.5625"
Design Temp=	200 deg.F	THK=	0.1250"
Flg Matl=	SA-350LF2CL1	Gsk Matl=	304SS GMGC
Bolt Matl=	SA-193B7	Gsk Face=	FLAT FACE
Corr Allow=	0.0625"	Wm2=	118615 #
Flange Desn Sfo	20000.0 psi	Hp =	39930 #
Atm. Sfa	20000.0 psi	H =	124879 #
Bolting Desn Sb	25000.0 psi	Wm1=	164809 #
Atm. Sa	25000.0 psi	Gasket Width Check	Nmin = 0.1432"
CONDITION		LEVER ARM =	
LOAD		x	
Operating	HD = 117932 #	hD=	1.35938"
	HG = 39930 #	hG=	1.31250"
	HT = 6947 #	hT=	1.45312"
Gasket		MOMENT	
Seating	HG = 173004 #	hG=	1.31250"
Allow.Stress-STRESS CALCULATIONS-Operating		SHAPE CONSTANTS	
1.5 Sfo&2.5 Sno Long Hub,SH	26292.3 psi	K	= 1.2484 h/hc= 0.5080
Sfo Radial Flg,SR	2770.7 psi	T	= 1.8191 F = 0.8475
Sfo Tang Flg,ST	12836.0 psi	Z	= 4.5812 V = 0.3114
Sfo .5(SH+SR)or.5(SH+ST)	19564.1 psi	Y	= 8.8796 f = 1.0000
J(APP.2-14)=	0.8813	U	= 9.7577 e = 0.3444in^-1
Allow.Stress-STRESS CALCULATIONS-Gsk.Seating		g1/go= 1.5000 d = 7.531In^3	
1.5 Sfa&2.5 Sna Long Hub,SH	26793.9 psi	ho	= 2.4606"
Sfa Radial Flg,SR	2823.6 psi	OTHER STRESS FORMULA FACTORS	
Sfa Tang Flg,ST	13080.9 psi	t	2.0000"
Sfa .5(SH+SR)or.5(SH+ST)	19937.4 psi	Alpha	1.6888
J(APP.2-14)=	0.8797	Beta	1.9184
		Gamma	0.9284
		Delta	1.0623
		Lambda	1.9907
		M	11500 #
		m	11719 #
O.D.	= 24.1875"	THK	= 2.1875"
I.D.	= 19.2500"	T-Adder	= 0.0000"
GO	= 0.3750"	G1	= 0.5312"
HUB O.D.	= 20.3125"	HUB LEN	= 1.2500"
HUB ANG	= 7.1250deg	RIB LENGTH	= 0.0000"
G(MEAN)	= 19.9375"	G(CALC)	= 19.9375"
G(MIN.)	= 19.9375"	G(MAX.)	= 20.8125"
B.C.	= 22.5625"	B.S.C.F.	= 1.0000
No. BOLTS	= 24	BOLT DIAMETER	= 0.7500"
R	= 1.1250"	E	= 0.8125"
BOLT SPAC	= 2.9450"	TORQUE	= 123ft#
MIN. SPAC	= 1.7500"	TEMA MAX. SPAC	= 4.0263"
FLG TURN	= 0.1875"	FACING	= RECESS
BPRIME	= 0.0000"	BG1	= 20.7500"
FLG RWT	= 164Lbs	FLG FWT	= 109Lbs

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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 = 402.0 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 = 439.0 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-207
Job No : 17S-3451

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CERTIFIED
AS BUILT

(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-333-6	MT Shell =SA-106B
Diameter (Do)	= 18.6875"	Pass Lane Area (AL) = 0.000in ²
Perimeter of layout (CP)	= 58.7085"	Area enclosed by CP (AP) = 274.279in ²
Tubesheet thickness (h)	= 2.9375"	Tubesheet thickness HOLD = NO
Tube Pitch (p)	= 0.7813"	Pitch type = Rot Triangle (30 Deg)
Diameter of tube (dt)	= 0.6250"	Tube thickness (tt) = 0.0600"
Exp length of tube (ltx)	= 2.8125"	Exp depth ratio (Rho) = 0.9778
Groove channel side (hg)	= 0.0000"	Groove shell side = 0.0000"
Channel I.D. (Dc)	= 19.2500"	Channel thickness (Tc) = 0.3750"
Shell I.D. (Ds)	= 19.2500"	Shell thickness (Ts) = 0.3750"
Stat TS diameter (A)	= 19.1250"	Bolt circle (C) = 22.5625"
G Channel side (Gc or G1)	= 19.9375"	G Shell side (Gs or G1) = 0.0000"
Bolt load Chan side (Wc)	=173004.77#	Bolt load Sh side (Ws) = 0.0#
1.8* $\sqrt{Dc \cdot Tc}$	= 0.0000"	1.8* $\sqrt{Ds \cdot (Ts \text{ or } Ts1)}$ = 0.0000"
Thickness at Top TS (tr)	= 2.2500"	Outer Tube Circle = 18.6875"
hr Ch Wml	=164809.5#	hr Ch W =173004.77#
hr Sh Wml	= 0.0#	hr Sh W = 0.0#
hr Ch Op= 1.0152" Ch Atm= 1.0402"		Sh Op= 0.0000" Sh Atm = 0.0000"
DE Stationary Tubesheet	=19.56250"	DE Floating Tubesheet = 0.0"
Tubes welded Backside TS	=NO	Hole Size in Tubesheet = 0.0000"
Radial Differential Thermal Expansion Adjacent to Tubesheet		= NO
Tube Joint= i Expanded, enhanced w/ two or more grooves		
Design Press Chan (Pt)	= 400.0psig	Design Press Shell (Ps) = 150.0psig
Design Temp Chan	= 200.0deg.	Design Temp Shell = 400.0deg.
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)	= 465.00	F-F Tubesheets (Lt) = 191.7500"
Un-supported Tube Span (l)	= 34.00000"	Support Constant (k) = 1.00000
Expansion Joint	= None	Exp Joint I.D. = 0.00000"
Spring Rate Corr (Kj)	= 0.0#	Spring Rate Un-Corr (Kjn) = 0.0#
MT Thickened Shl	=SA-106B	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*

Item No: E-207
Job No : 17S-3451

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CERTIFIED
AS BUILT

(FTS) Configuration b

Tube sheet Thickness (h)	=	2.8125"	F-F Inside Tubesheets (L)	=	186.0000"
F-F Tubesheets (Lt)	=	191.6250"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.7500"	Channel thickness (Tc)	=	0.3125"
Channel I.D. (Dc)	=	19.3750"	Shell thickness (Ts)	=	0.3125"
Shell I.D. (Ds)	=	19.3750"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	0.0psi
Press Chan (Pt)	=	400.0psi	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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps =	61600psi
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spssc =	64199psi
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss =	59800psi

Mu=0.2001 d*=0.5463" P*=0.78130" Mu*=0.3008 hg'= 0.0" hgs'= 0.0" hrDE=0.1223"

W*	=	164809.5312#	wj	=	0.0"	ao	=	9.34375000"
Rho s	=	1.036789298	Rho c	=	1.066889644	Chi s	=	0.479871631
Chi t	=	0.660426855	Ks	=	2878440.750Lb/In	Kt	=	15860.48242Lb/In
Ks,t	=	0.390290469	j	=	1.000000000	Beta s	=	0.732884228in ⁻¹
Kappa s	=	113467.7812#	Lambda s	=	3074579.500psi	Beta c	=	0.0in ⁻¹
Kappa c	=	0.0#	Lambda c	=	0.0psi	h/p	=	3.599769592
E*	=	7815434.500psi	v*	=	0.353307545	Xa	=	2.230664015
Zd	=	0.125168428	Zv	=	0.148360491	Zm	=	0.629988849
K	=	1.023411393	F	=	0.307449400	Phi	=	0.416073591
Q1	=	-0.019760050	Qz1	=	1.513243079	Qz2	=	1.682534933
U	=	3.365069866	Gamma	=	0.0"	Omega s	=	2.432248354in ²
Omega c	=	0.0in ²	Omega s*	=	-2.372079611in ²	Omega c*	=	1.515810132in ²
Delta s	=	0.000009220In ³ /Lb	Delta c	=	0.0In ³ /Lb	Gamma b	=	-0.140468225
Ps'	=	0.0psi	Pt'	=	1370.546021psi	P Gamma	=	0.0psi
PW	=	142.0143433psi	Prim	=	23.36987877psi	Es,w	=	0.850000024
Pe	=	-291.2892761psi	Q2	=	-3399.704346#	Q3	=	0.247604758
Fm	=	0.232195675	Es,w1	=	0.850000024	lt	=	34.00000000"
Rt	=	0.200880870"	Ft	=	169.2545471	Ct	=	156.9380646
Fs	=	2.000000000	Stb	=	4771.652832psi	Ft,min	=	-0.044100132
Sigmat,1	=	-1534.248779psi	Sigmat,2	=	1750.179077psi	Ft,max	=	1.991747618
Sigma s,m	=	1542.674194psi	Sigma s,b	=	-31746.04297psi	Sigma s	=	33288.71875psi
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 = 0.053041629	Phi = 0.071781643	Q1 = 0.025008800	
Qz1 = 1.595467567	Qz2 = 2.031687737	U = 4.063375473	
Omega s* = 0.060168829in ²	Omega c* = 1.515810132in ²	Prim = 28.21950150psi	
Pe = -276.6374207psi	Q2 = -4105.197266#	Q3 = 0.364955395	
PW = 171.4845734psi	Fm = 0.275242746	Sigma = -16765 psi	
Sigma -16765 psi	<= 1.5S 30000 psi	[OK Per Simply Sup]	Org.Sigma = -14892 psi
Tau -2418 psi	<= .8S 16000 psi	[OK	]
Sigmat,max 1750 psi	< St 13411 psi	[OK	]
Sigmat,min -1534 psi	<= Stb 4771 psi	[OK	]
Sigma s 33288 psi	<= Spss 59800 psi	[OK Per Simply Sup]	
Sigmat,s,m 1542 psi	<= SsEs,w 14535 psi	[OK	]
Joint Load 186 #	<= Lmax 1073 #	[OK	]

(FTS) Configuration b

Tubesheet Thickness (h)	=	2.8125"	F-F Inside Tubesheets (L)	=	186.0000"
F-F Tubesheets (Lt)	=	191.6250"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.7500"	Channel thickness (Tc)	=	0.3125"
Channel I.D. (Dc)	=	19.3750"	Shell thickness (Ts)	=	0.3125"
Shell I.D. (Ds)	=	19.3750"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	150.0psi
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"			

 CERTIFIED
AS BUILT

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spssc = 64199psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss = 59800psi	

Mu=0.2001 d*=0.5463" P*=0.78130" Mu*=0.3008 hg' = 0.0" hgs' = 0.0" hrDE=0.0458"

W*	=	0.0#	wj	=	0.0"	ao	=	9.34375000"
Rho s	=	1.036789298	Rho c	=	1.066889644	Chi s	=	0.479871631
Chi t	=	0.660426855	Ks	=	2878440.750Lb/In	Kt	=	15860.48242Lb/In
Ks,t	=	0.390290469	j	=	1.000000000	Beta s	=	0.732884228in ⁻¹
Kappa s	=	113467.7812#	Lambda s	=	3074579.500psi	Beta c	=	0.0in ⁻¹
Kappa c	=	0.0#	Lambda c	=	0.0psi	h/p	=	3.599769592
E*	=	7815434.500psi	v*	=	0.353307545	Xa	=	2.230664015
Zd	=	0.125168428	Zv	=	0.148360491	Zm	=	0.629988849
K	=	1.023411393	F	=	0.307449400	Phi	=	0.416073591
Q1	=	-0.019760050	Qz1	=	1.513243079	Qz2	=	1.682534933
U	=	3.365069866	Gamma	=	0.0"	Omega s	=	2.432248354in ²
Omega c	=	0.0in ²	Omega s*	=	-2.372079611in ²	Omega c*	=	1.515810132in ²
Delta s	=	0.000009220In ³ /Lb	Delta c	=	0.0In ³ /Lb	Gamma b	=	-0.140468225
Ps'	=	337.8703613psi	Pt'	=	0.0psi	P Gamma	=	0.0psi
PW	=	0.0psi	Prim	=	13.71425343psi	Es,w	=	0.850000024
Pe	=	84.97849274psi	Q2	=	-281.9157104#	Q3	=	-0.095757291
Fm	=	0.119142547	Es,w1	=	0.850000024	lt	=	34.000000000"
Rt	=	0.200880870"	Ft	=	169.2545471	Ct	=	156.9380646
Fs	=	2.000000000	Stb	=	4771.652832psi	Ft,min	=	0.535332680
Sigmat,1	=	146.7084656psi	Sigmat,2	=	-246.1387939psi	Ft,max	=	1.370021820
Sigma s,m	=	1365.398804psi	Sigma s,b	=	8939.749023psi	Sigma s	=	10305.14746psi
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,Omeas=0	Betac,Kappac,Lambdac,Deltac,Omeac=0		
F = 0.053041629	Phi = 0.071781643	Q1 = 0.025008800	
Qz1 = 1.595467567	Qz2 = 2.031687737	U = 4.063375473	
Omega s* = 0.060168829in ²	Omega c* = 1.515810132in ²	Prim = -0.420056134psi	
Pe = 79.73013306psi	Q2 = 8.634841919#	Q3 = 0.027489761	
PW = 0.0psi	Fm = 0.159657314	Sigma = 2802 psi	
Sigma 2802 psi	<= 1.5S 30000 psi	[OK Per Simply Sup] Org.Sigma = 2229 psi	
Tau 705 psi	<= .8S 16000 psi	[OK]	
Sigmat,max 246 psi	< St 13411 psi	[OK]	
Sigmat,min -246 psi	<= Stb 4771 psi	[OK]	
Sigma s 10305 psi	<= Spss 59800 psi	[OK Per Simply Sup]	
Sigmat,s,m 1365 psi	<= SsEs,w 14535 psi	[OK] Step 10	
Joint Load 26 #	<= Lmax 1073 #	[OK]	

Item No: E-207

Job No : 17S-3451

By: Weg

P.O. No: 4500801009

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(FTS) Configuration b

Tube sheet Thickness (h)	=	2.8125"	F-F Inside Tubesheets (L)	=	186.0000"
F-F Tubesheets (Lt)	=	191.6250"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.7500"	Channel thickness (Tc)	=	0.3125"
Channel I.D. (Dc)	=	19.3750"	Shell thickness (Ts)	=	0.3125"
Shell I.D. (Ds)	=	19.3750"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	150.0psi
Press Chan (Pt)	=	400.0psi	Corr Shell	=	0.06250"
Corr Chan	=	0.06250"	Corr Shell side TS (cs)	=	0.06250"
Corr Chan side TS (ct)	=	0.06250"			

CERTIFIED
 AS BUILT

Temp	Stress	Yield	Modulus x10 ⁶	Coef x10 ⁻⁶	Poisson Ratio	Prim Plus Stress
Temp TS T = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps =	61600psi
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spss =	64199psi
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300		59800psi

Mu=0.2001 d*=0.5463" P*=0.78130" Mu*=0.3008 hg'= 0.0" hgs'= 0.0" hrDE=0.0764"

W*	= 164809.5312#	wj	= 0.0"	ao	= 9.34375000"
Rho s	= 1.036789298	Rho c	= 1.066889644	Chi s	= 0.479871631
Chi t	= 0.660426855	Ks	= 2878440.750Lb/In	Kt	= 15860.48242Lb/In
Ks,t	= 0.390290469	j	= 1.000000000	Beta s	= 0.732884228in ⁻¹
Kappa s	= 113467.7812#	Lambda s	= 3074579.500psi	Beta c	= 0.0in ⁻¹
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 3.599769592
E*	= 7815434.500psi	v*	= 0.353307545	Xa	= 2.230664015
Zd	= 0.125168428	Zv	= 0.148360491	Zm	= 0.629988849
K	= 1.023411393	F	= 0.307449400	Phi	= 0.416073591
Q1	= -0.019760050	Qz1	= 1.513243079	Qz2	= 1.682534933
U	= 3.365069866	Gamma	= 0.0"	Omega s	= 2.432248354in ²
Omega c	= 0.0in ²	Omega s*	= -2.372079611in ²	Omega c*	= 1.515810132in ²
Delta s	= 0.000009220In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.140468225
Ps'	= 337.8703613psi	Pt'	= 1370.546021psi	P Gamma	= 0.0psi
PW	= 142.0143433psi	Prim	= 37.08413315psi	Es,w	= 0.850000024
Pe	= -206.3107910psi	Q2	= -3681.620117#	Q3	= 0.389034033
Fm	= 0.284665108	Es,w1	= 0.850000024	lt	= 34.00000000"
Rt	= 0.200880870"	Ft	= 169.2545471	Ct	= 156.9380646
Fs	= 2.000000000	Stb	= 4771.652832psi	Ft,min	= -0.282765895
Sigmat,1	= -1387.540283psi	Sigmat,2	= 1504.040405psi	Ft,max	= 2.247833729
Sigma s,m	= 2908.072754psi	Sigma s,b	= -22806.29492psi	Sigma s	= 25714.36719psi
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	= 0.053041629	Phi	= 0.071781643	Q1	= 0.025008800
Qz1	= 1.595467567	Qz2	= 2.031687737	U	= 4.063375473
Omega s*	= 0.060168829in^2	Omega c*	= 1.515810132in^2	Prim	= 27.79944420psi
Pe	=-196.9072876psi	Q2	=-4096.562500#	Q3	= 0.501599312
PW	= 171.4845734psi	Fm	= 0.330639482	Sigma	= -14335 psi
Sigma	-14335 psi	<= 1.5S	30000 psi [OK Per Simply Sup]	Org.Sigma	= -12931 psi
Tau	-1713 psi	<= .8S	16000 psi [OK]		
Sigmat,max	1504 psi	< St	13411 psi [OK]		
Sigmat,min	-1387 psi	<= Stb	4771 psi [OK]		
Sigma s	25714 psi	<= Spss	59800 psi [OK Per Simply Sup]		
Sigmat,s,m	2908 psi	<=SsEs,w	14535 psi [OK]		Step 10
Joint Load	160 #	<=Lmax	1073 # [OK]		

(FTS) Configuration b

Tubesheet Thickness (h)	=	2.8125"	F-F Inside Tubesheets (L)	=	186.0000"
F-F Tubesheets (Lt)	=	191.6250"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.7500"	Channel thickness (Tc)	=	0.3125"
Channel I.D. (Dc)	=	19.3750"	Shell thickness (Ts)	=	0.3125"
Shell I.D. (Ds)	=	19.3750"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	0.0psi
Press Chan (Pt)	=	400.0psi	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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spss = 64199psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss = 59800psi	
Tt,m	= 185deg.F			At,m = 6.6700In/In		
Ts,m	= 247deg.F			As,m = 6.7940In/In		

Mu=0.2001	d*=0.5463"	P*=0.78130"	Mu*=0.3008	hg' = 0.0"	hgs' = 0.0"	hrDE=0.1223"
W*	= 173004.7656#	wj	= 0.0"	ao	= 9.34375000"	
Rho s	= 1.036789298	Rho c	= 1.066889644	Chi s	= 0.479871631	
Chi t	= 0.660426855	Ks	= 2878440.750Lb/In	Kt	= 15860.48242Lb/In	
Ks,t	= 0.390290469	j	= 1.000000000	Beta s	= 0.732884228in ⁻¹	
Kappa s	= 113467.7812#	Lambda s	= 3074579.500psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 3.599769592	
E*	= 7815434.500psi	v*	= 0.353307545	Xa	= 2.230664015	
Zd	= 0.125168428	Zv	= 0.148360491	Zm	= 0.629988849	
K	= 1.023411393	F	= 0.307449400	Phi	= 0.416073591	
Q1	= -0.019760050	Qz1	= 1.513243079	Qz2	= 1.682534933	
U	= 3.365069866	Gamma	= -0.081000768"	Omega s	= 2.432248354in ²	
Omega c	= 0.0in ²	Omega s*	= -2.372079611in ²	Omega c*	= 1.515810132in ²	
Delta s	= 0.000009220In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.140468225	
Ps'	= 0.0psi	Pt'	= 1370.546021psi	P Gamma	= -2178.041748psi	
PW	= 149.0760803psi	Prim	= 23.36987877psi	Es,w	= 0.850000024	
Pe	= -816.0181885psi	Q2	= 3544.868164#	Q3	= 0.079754777	
Fm	= 0.176838294	Es,w1	= 0.850000024	lt	= 34.00000000"	
Rt	= 0.200880870"	Et	= 169.2545471	Ct	= 156.9380646	
Fs	= 2.000000000	Stb	= 4771.652832psi	Ft,min	= 0.239151269	
Sigmat,1	= -382.2595520psi	Sigmat,2	= 6164.997070psi	Ft,max	= 1.687821627	
Sigma s,m	= -5903.562012psi	Sigma s,b	= -53357.77734psi	Sigma s	= 59261.33984psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	-31773 psi	<= Sps	61600 psi	[OK	]
Tau	-6775 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	6164 psi	<= 2St	26823 psi	[OK	]
Sigmat,min	-382 psi	<= Stb	4771 psi	[OK	]
Sigma s	59261 psi	<= Spss	59800 psi	[OK	]
Sigmat,s,m	-5903 psi	<= Spss	59800 psi	[OK	] Step 10
Sigmat,s,m	-5903 psi	<= Ss,b	14676 psi	[OK	] Step 10
Joint Load	656 #	<= Lmax	2147 #	[OK	]

Item No: E-207

Job No : 17S-3451

P.O. No: 4500801009

By: WJ

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CERTIFIED
AS BUILT

(FTS) Configuration b

Tube sheet Thickness (h)	= 2.8125"	F-F Inside Tubesheets (L)	= 186.0000"
F-F Tubesheets (Lt)	= 191.6250"	Exp depth ratio (Rho)	= 0.9778"
Exp length of tube (ltx)	= 2.7500"	Channel thickness (Tc)	= 0.3125"
Channel I.D. (Dc)	= 19.3750"	Shell thickness (Ts)	= 0.3125"
Shell I.D. (Ds)	= 19.3750"	Area enclosed by CP (AP)	= 274.279in ²
Perimeter of layout (CP)	= 58.7085"	Press Shell (Ps)	= 150.0psi
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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spss = 64199psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss = 59800psi	
Tt,m	= 185deg.F			At,m = 6.6700In/In		
Ts,m	= 247deg.F			As,m = 6.7940In/In		

Mu=0.2001 d*=0.5463" P*=0.78130" Mu*=0.3008 hg' = 0.0" hgs' = 0.0" hrDE=0.0458"

W* = 173004.7656#	wj = 0.0"	ao = 9.34375000"
Rho s = 1.036789298	Rho c = 1.066889644	Chi s = 0.479871631
Chi t = 0.660426855	Ks = 2878440.750Lb/In	Kt = 15860.48242Lb/In
Ks,t = 0.390290469	j = 1.000000000	Beta s = 0.732884228in ⁻¹
Kappa s = 113467.7812#	Lambda s = 3074579.500psi	Beta c = 0.0in ⁻¹
Kappa c = 0.0#	Lambda c = 0.0psi	h/p = 3.599769592
E* = 7815434.500psi	v* = 0.353307545	Xa = 2.230664015
Zd = 0.125168428	Zv = 0.148360491	Zm = 0.629988849
K = 1.023411393	F = 0.307449400	Phi = 0.416073591
Q1 = -0.019760050	Qz1 = 1.513243079	Qz2 = 1.682534933
U = 3.365069866	Gamma = -0.081000768"	Omega s = 2.432248354in ²
Omega c = 0.0in ²	Omega s* = -2.372079611in ²	Omega c* = 1.515810132in ²
Delta s = 0.000009220In ³ /Lb	Delta c = 0.0In ³ /Lb	Gamma b = -0.140468225
Ps' = 337.8703613psi	Pt' = 0.0psi	P Gamma = -2178.041748psi
PW = 149.0760803psi	Pprim = 13.71425343psi	Es,w = 0.850000024
Pe = -405.4253235psi	Q2 = -3346.383301#	Q3 = 0.169322908
Fm = 0.206281841	Es,w1 = 0.850000024	lt = 0.0"
Rt = 0.0"	Et = 0.0	Ct = 0.0
Fs = 0.0	Stb = 0.0psi	Ft,min = 0.088002630
Sigmat,1 = 596.2676392psi	Sigmat,2 = 4552.727051psi	Ft,max = 1.850002646
Sigma s,m = -5593.742676psi	Sigma s,b = -25999.72070psi	Sigma s = 31593.46289psi
Sigma c,m = 0.0psi	Sigma c,b = 0.0psi	Sigma c = 0.0psi

Thermal Expansion Acting on this Case (Yes)

Sigma	-18414 psi	<= Sps	61600 psi	[OK	]
Tau	-3366 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	4552 psi	<= 2St	26823 psi	[OK	]
Sigma s	31593 psi	<= Spss	59800 psi	[OK	]
Sigmat,s,m	-5593 psi	<= Spss	59800 psi	[OK	] Step 10
Sigmat,s,m	-5593 psi	<= Ss,b	14676 psi	[OK	] Step 10
Joint Load	484 #	<= Lmax	2147 #	[OK	]

Item No: E-207

Job No : 17S-3451

By: meg

P.O. No: 4500801009

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AS BUILT

(FTS) Configuration b

Tubesheet Thickness (h)	=	2.8125"	F-F Inside Tubesheets (L)	=	186.0000"
F-F Tubesheets (Lt)	=	191.6250"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.7500"	Channel thickness (Tc)	=	0.3125"
Channel I.D. (Dc)	=	19.3750"	Shell thickness (Ts)	=	0.3125"
Shell I.D. (Ds)	=	19.3750"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	150.0psi
Press Chan (Pt)	=	400.0psi	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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spss = 64199psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss = 59800psi	
Tt,m	= 185deg.F			At,m = 6.6700In/In		
Ts,m	= 247deg.F			As,m = 6.7940In/In		

Mu=0.2001	d*=0.5463"	P*=0.78130"	Mu*=0.3008	hg' = 0.0"	hgs' = 0.0"	hrDE=0.0764"
W*	= 173004.7656#	wj	= 0.0"	ao	= 9.34375000"	
Rho s	= 1.036789298	Rho c	= 1.066889644	Chi s	= 0.479871631	
Chi t	= 0.660426855	Ks	= 2878440.750Lb/In	Kt	= 15860.48242Lb/In	
Ks,t	= 0.390290469	j	= 1.000000000	Beta s	= 0.732884228in ⁻¹	
Kappa s	= 113467.7812#	Lambda s	= 3074579.500psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 3.599769592	
E*	= 7815434.500psi	v*	= 0.353307545	Xa	= 2.230664015	
Zd	= 0.125168428	Zv	= 0.148360491	Zm	= 0.629988849	
K	= 1.023411393	F	= 0.307449400	Phi	= 0.416073591	
Q1	= -0.019760050	Qz1	= 1.513243079	Qz2	= 1.682534933	
U	= 3.365069866	Gamma	= -0.081000768"	Omega s	= 2.432248354in ²	
Omega c	= 0.0in ²	Omega s*	= -2.372079611in ²	Omega c*	= 1.515810132in ²	
Delta s	= 0.000009220In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.140468225	
Ps'	= 337.8703613psi	Pt'	= 1370.546021psi	P Gamma	= -2178.041748psi	
PW	= 149.0760803psi	Prim	= 37.08413315psi	Es,w	= 0.850000024	
Pe	= -731.0396729psi	Q2	= 3826.783936#	Q3	= 0.100156903	
Fm	= 0.183545038	Es,w1	= 0.850000024	lt	= 34.00000000"	
Rt	= 0.200880870"	Et	= 169.2545471	Ct	= 156.9380646	
Fs	= 2.000000000	Stb	= 4771.652832psi	Ft,min	= 0.204722151	
Sigmat,1	= -235.5511017psi	Sigmat,2	= 5918.857910psi	Ft,max	= 1.724763751	
Sigma s,m	= -4538.163086psi	Sigma s,b	= -44418.02734psi	Sigma s	= 48956.19141psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	-29544 psi	<= Sps	61600 psi	[OK	]
Tau	-6070 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	5918 psi	<= 2St	26823 psi	[OK	]
Sigmat,min	-235 psi	<= Stb	4771 psi	[OK	]
Sigma s	48956 psi	<= Spss	59800 psi	[OK	]
Sigmat,m	-4538 psi	<= Spss	59800 psi	[OK	] Step 10
Sigmat,m	-4538 psi	<= Ss,b	14676 psi	[OK	] Step 10
Joint Load	630 #	<= Lmax	2147 #	[OK	]

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Job No : 17S-3451

By: Weg

P.O. No: 4500801009

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AS BUILT

(FTS) Configuration b

Tubesheet Thickness (h)	=	2.8125"	F-F Inside Tubesheets (L)	=	186.0000"
F-F Tubesheets (Lt)	=	191.6250"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.7500"	Channel thickness (Tc)	=	0.3125"
Channel I.D. (Dc)	=	19.3750"	Shell thickness (Ts)	=	0.3125"
Shell I.D. (Ds)	=	19.3750"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Chan (Pt)	=	0.0psi
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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spss = 64199psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss = 59800psi	
Tt,m	= 185deg.F			At,m = 6.6700In/In		
Ts,m	= 247deg.F			As,m = 6.7940In/In		

Mu=0.2001	d*=0.5463"	P*=0.78130"	Mu*=0.3008	hg'= 0.0"	hgs'= 0.0"	hrDE= 0.0"
W*	= 173004.7656#	wj	= 0.0"	ao	= 9.34375000"	
Rho s	= 1.036789298	Rho c	= 1.066889644	Chi s	= 0.479871631	
Chi t	= 0.660426855	Ks	= 2878440.750lb/In	Kt	= 15860.48242lb/In	
Ks,t	= 0.390290469	j	= 1.000000000	Beta s	= 0.732884228in ⁻¹	
Kappa s	= 113467.7812#	Lambda s	= 3074579.500psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 3.599769592	
E*	= 7815434.500psi	v*	= 0.353307545	Xa	= 2.230664015	
Zd	= 0.125168428	Zv	= 0.148360491	Zm	= 0.629988849	
K	= 1.023411393	F	= 0.307449400	Phi	= 0.416073591	
Q1	= -0.019760050	Qz1	= 1.513243079	Qz2	= 1.682534933	
U	= 3.365069866	Gamma	= -0.081000768"	Omega s	= 2.432248354in ²	
Omega c	= 0.0in ²	Omega s*	= -2.372079611in ²	Omega c*	= 1.515810132in ²	
Delta s	= 0.000009220In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.140468225	
Ps'	= 0.0psi	Pt'	= 0.0psi	P Gamma	= -2178.041748psi	
PW	= 149.0760803psi	Prim	= 0.0psi	Es,w	= 0.850000024	
Pe	= -490.4038086psi	Q2	= -3064.467529#	Q3	= 0.123389103	
Fm	= 0.191182107	Es,w1	= 0.850000024	lt	= 0.0"	
Rt	= 0.0"	Et	= 0.0	Ct	= 0.0	
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.165517181	
Sigmat,1	= 449.5591736psi	Sigmat,2	= 4798.865723psi	Ft,max	= 1.766830206	
Sigma s,m	= -6959.141602psi	Sigma s,b	= -34939.46875psi	Sigma s	= 41898.60938psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	-20643 psi	<= Sps	61600 psi	[OK	]
Tau	-4072 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	4798 psi	<= 2St	26823 psi	[OK	]
Sigma s	41898 psi	<= Spss	59800 psi	[OK	]
Sigmatas,m	-6959 psi	<= Spss	59800 psi	[OK	] Step 10
Sigmatas,m	-6959 psi	<= Ss,b	14676 psi	[OK	] Step 10
Joint Load	511 #	<= Lmax	2147 #	[OK	]

Item No: E-207

Job No : 17S-3451

P.O. No: 4500801007

By: ne

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AS BUILT

(FTS) Configuration b

Tubesheet Thickness (h)	=	2.9375"	F-F Inside Tubesheets (L)	=	185.8750"
F-F Tubesheets (Lt)	=	191.7500"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.8125"	Channel thickness (Tc)	=	0.3750"
Channel I.D. (Dc)	=	19.2500"	Shell thickness (Ts)	=	0.3750"
Shell I.D. (Ds)	=	19.2500"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	0.0psi
Press Chan (Pt)	=	400.0psi	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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spss = 64199psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss = 59800psi	

Mu=0.2001 d*=0.5480" P*=0.78130" Mu*=0.2987 hg'= 0.0" hgs'= 0.0" hrDE=0.1223"

W*	=	164809.5312#	wj	=	0.0"	ao	=	9.34375000"
Rho s	=	1.030100346	Rho c	=	1.066889644	Chi s	=	0.479871631
Chi t	=	0.660426855	Ks	=	3445479.000Lb/In	Kt	=	15871.14844Lb/In
Ks,t	=	0.466861755	j	=	1.000000000	Beta s	=	0.670093179in ⁻¹
Kappa s	=	179273.5156#	Lambda s	=	4007422.000psi	Beta c	=	0.0in ⁻¹
Kappa c	=	0.0#	Lambda c	=	0.0psi	h/p	=	3.759759426
E*	=	7739415.000psi	v*	=	0.354747713	Xa	=	2.164102554
Zd	=	0.136644870	Zv	=	0.151512057	Zm	=	0.639281213
K	=	1.023411393	F	=	0.387551039	Phi	=	0.525033891
Q1	=	-0.037022300	Qz1	=	1.437045336	Qz2	=	1.402048588
U	=	2.804097176	Gamma	=	0.0"	Omega s	=	2.784597874in ²
Omega c	=	0.0in ²	Omega s*	=	2.744451761in ²	Omega c*	=	1.807801843in ²
Delta s	=	0.000007580In ³ /Lb	Delta c	=	0.0In ³ /Lb	Gamma b	=	-0.140468225
Ps'	=	0.0psi	Pt'	=	1202.453003psi	P Gamma	=	0.0psi
PW	=	118.3398972psi	Prim	=	23.22530746psi	Es,w	=	0.850000024
Pe	=	-292.9650574psi	Q2	=	-3300.008545#	Q3	=	0.221017569
Fm	=	0.232059285	Es,w1	=	0.850000024	lt	=	34.00000000"
Rt	=	0.200880870"	Ft	=	169.2545471	Ct	=	156.9380646
Fs	=	2.000000000	Stb	=	4771.652832psi	Ft,min	=	0.088637479
Sigmat,1	=	-1319.280884psi	Sigmat,2	=	1564.315552psi	Ft,max	=	1.865806460
Sigma s,m	=	1269.775757psi	Sigma s,b	=	-29073.62500psi	Sigma s	=	30343.40039psi
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,Omeas=0	Betac,Kappac,Lambdac,Deltac,Omeac=0		
F = 0.053443350	Phi = 0.072402246	Q1 = 0.018284241	
Qz1 = 1.528943062	Qz2 = 1.789796710	U = 3.579593420	
Omega s* = 0.040146060in ²	Omega c* = 1.807801843in ²	Prim = 29.64845657psi	
Pe = -274.3080750psi	Q2 = -4212.653320#	Q3 = 0.370091408	
PW = 151.0677643psi	Fm = 0.285063177	Sigma = -15894 psi	
Sigma -15894 psi	<= 1.5S	30000 psi	[OK Per Simply Sup] Org.Sigma = -13818 psi
Tau -2329 psi	<= .8S	16000 psi	[OK]
Sigmat,max 1564 psi	< St	13411 psi	[OK]
Sigmat,min -1319 psi	<= Stb	4771 psi	[OK]
Sigma s 30343 psi	<= Spss	59800 psi	[OK Per Simply Sup]
Sigmat,s,m 1269 psi	<= SsEs,w	14535 psi	[OK] Step 10
Joint Load 166 #	<= Lmax	1073 #	[OK]

(FTS) Configuration b

Tube sheet Thickness (h)	=	2.9375"	F-F Inside Tubesheets (L)	=	185.8750"
F-F Tubesheets (Lt)	=	191.7500"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.8125"	Channel thickness (Tc)	=	0.3750"
Channel I.D. (Dc)	=	19.2500"	Shell thickness (Ts)	=	0.3750"
Shell I.D. (Ds)	=	19.2500"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	150.0psi
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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spss = 59800psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300		

Mu=0.2001 d*=0.5480" P*=0.78130" Mu*=0.2987 hg'= 0.0" hgs'= 0.0" hrDE=0.0458"

W*	=	0.0#	wj	=	0.0"	ao	=	9.34375000"
Rho s	=	1.030100346	Rho c	=	1.066889644	Chi s	=	0.479871631
Chi t	=	0.660426855	Ks	=	3445479.000Lb/In	Kt	=	15871.14844Lb/In
Ks,t	=	0.466861755	j	=	1.000000000	Beta s	=	0.670093179in ⁻¹
Kappa s	=	179273.5156#	Lambda s	=	4007422.000psi	Beta c	=	0.0in ⁻¹
Kappa c	=	0.0#	Lambda c	=	0.0psi	h/p	=	3.759759426
E*	=	7739415.000psi	v*	=	0.354747713	Xa	=	2.164102554
Zd	=	0.136644870	Zv	=	0.151512057	Zm	=	0.639281213
K	=	1.023411393	F	=	0.387551039	Phi	=	0.525033891
Q1	=	-0.037022300	Qz1	=	1.437045336	Qz2	=	1.402048588
U	=	2.804097176	Gamma	=	0.0"	Omega s	=	2.784597874in ²
Omega c	=	0.0in ²	Omega s*	=	-2.744451761in ²	Omega c*	=	1.807801843in ²
Delta s	=	0.000007580In ³ /Lb	Delta c	=	0.0In ³ /Lb	Gamma b	=	-0.140468225
Ps'	=	303.7155762psi	Pt'	=	0.0psi	P Gamma	=	0.0psi
PW	=	0.0psi	Prim	=	13.22201061psi	Es,w	=	0.850000024
Pe	=	87.52258301psi	Q2	=	-308.2166138#	Q3	=	-0.117694423
Fm	=	0.115512617	Es,w1	=	0.8500000024	lt	=	34.000000000"
Rt	=	0.200880870"	Ft	=	169.2545471	Ct	=	156.9380646
Fs	=	2.000000000	Stb	=	4771.652832psi	Ft,min	=	0.610705256
Sigmat,1	=	102.6292267psi	Sigmat,2	=	-232.9545898psi	Ft,max	=	1.302999854
Sigma s,m	=	1147.035156psi	Sigma s,b	=	7425.149902psi	Sigma s	=	8572.185547psi
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 = 0.053443350	Phi = 0.072402246	Q1 = 0.018284241	
Qz1 = 1.528943062	Qz2 = 1.789796710	U = 3.579593420	
Omega s* = 0.040146060in ²	Omega c* = 1.807801843in ²	Prim = -0.246902466psi	
Pe = 81.47295380psi	Q2 = 5.755512238#	Q3 = 0.019902529	
PW = 0.0psi	Fm = 0.162858054	Sigma = 2696 psi	
Sigma 2696 psi	<= 1.5S 30000 psi	[OK Per Simply Sup] Org. Sigma = 2054 psi	
Tau 695 psi	<= .8S 16000 psi	[OK]	
Sigmat,max 232 psi	< St 13411 psi	[OK]	
Sigmat,min -232 psi	<= Stb 4771 psi	[OK]	
Sigma s 8572 psi	<= Spss 59800 psi	[OK Per Simply Sup]	
Sigmat,s,m 1147 psi	<= SsEs,w 14535 psi	[OK] Step 10	
Joint Load 24 #	<= Lmax 1073 #	[OK]	

(FTS) Configuration b

Tubesheet Thickness (h)	=	2.9375"	F-F Inside Tubesheets (L)	=	185.8750"
F-F Tubesheets (Lt)	=	191.7500"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.8125"	Channel thickness (Tc)	=	0.3750"
Channel I.D. (Dc)	=	19.2500"	Shell thickness (Ts)	=	0.3750"
Shell I.D. (Ds)	=	19.2500"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	150.0psi
Press Chan (Pt)	=	400.0psi	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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spssc = 64199psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss = 59800psi	

Mu=0.2001 d*=0.5480" P*=0.78130" Mu*=0.2987 hg' = 0.0" hgs' = 0.0" hrDE=0.0764"

W*	= 164809.5312#	wj	= 0.0"	ao	= 9.34375000"
Rho s	= 1.030100346	Rho c	= 1.066889644	Chi s	= 0.479871631
Chi t	= 0.660426855	Ks	= 3445479.000Lb/In	Kt	= 15871.14844Lb/In
Ks,t	= 0.466861755	j	= 1.000000000	Beta s	= 0.670093179in ⁻¹
Kappa s	= 179273.5156#	Lambda s	= 4007422.000psi	Beta c	= 0.0in ⁻¹
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 3.759759426
E*	= 7739415.000psi	v*	= 0.354747713	Xa	= 2.164102554
Zd	= 0.136644870	Zv	= 0.151512057	Zm	= 0.639281213
K	= 1.023411393	F	= 0.387551039	Phi	= 0.525033891
Q1	= -0.037022300	Qz1	= 1.437045336	Qz2	= 1.402048588
U	= 2.804097176	Gamma	= 0.0"	Omega s	= 2.784597874in ²
Omega c	= 0.0in ²	Omega s*	= -2.744451761in ²	Omega c*	= 1.807801843in ²
Delta s	= 0.000007580In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.140468225
Ps'	= 303.7155762psi	Pt'	= 1202.453003psi	P Gamma	= 0.0psi
PW	= 118.3398972psi	Prim	= 36.44731903psi	Es,w	= 0.850000024
Pe	= -205.4424896psi	Q2	= -3608.225098#	Q3	= 0.365315586
Fm	= 0.283255309	Es,w1	= 0.850000024	lt	= 34.00000000"
Rt	= 0.200880870"	Ft	= 169.2545471	Ct	= 156.9380646
Fs	= 2.000000000	Stb	= 4771.652832psi	Ft,min	= -0.133773744
Sigmat,1	= -1216.651611psi	Sigmat,2	= 1331.361084psi	Ft,max	= 2.105573177
Sigma s,m	= 2416.810791psi	Sigma s,b	= -21648.47461psi	Sigma s	= 24065.28516psi
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 = 0.053443350	Phi = 0.072402246	Q1 = 0.018284241	
Qz1 = 1.528943062	Qz2 = 1.789796710	U = 3.579593420	
Omega s* = 0.040146060in ²	Omega c* = 1.807801843in ²	Prim = 29.40155411psi	
Pe = -192.8351288psi	Q2 = -4206.897461#	Q3 = 0.518046379	
PW = 151.0677643psi	Fm = 0.344140351	Sigma = -13488 psi	
Sigma -13488 psi	<= 1.5S 30000 psi	[OK Per Simply Sup]	Org.Sigma = -11828 psi
Tau -1633 psi	<= .8S 16000 psi	[OK]	
Sigmat,max 1331 psi	< St 13411 psi	[OK]	
Sigmat,min -1216 psi	<= Stb 4771 psi	[OK]	
Sigma s 24065 psi	<= Spss 59800 psi	[OK Per Simply Sup]	
Sigmat,s,m 2416 psi	<= SsEs,w 14535 psi	[OK]	Step 10
Joint Load 141 #	<= Lmax 1073 #	[OK]	

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(FTS) Configuration b

Tubesheet Thickness (h)	=	2.9375"	F-F Inside Tubesheets (L)	=	185.8750"
F-F Tubesheets (Lt)	=	191.7500"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.8125"	Channel thickness (Tc)	=	0.3750"
Channel I.D. (Dc)	=	19.2500"	Shell thickness (Ts)	=	0.3750"
Shell I.D. (Ds)	=	19.2500"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Chan (Pt)	=	400.0psi
Press Chan (Pt)	=	400.0psi	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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps =	61600psi
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spss =	64199psi
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss =	59800psi
Tt,m	= 185deg.F			At,m =	6.6700In/In	
Ts,m	= 247deg.F			As,m =	6.7940In/In	

Mu=0.2001	d*=0.5480"	P*=0.78130"	Mu*=0.2987	hg' = 0.0"	hgs' = 0.0"	hrDE=0.1223"
W*	= 173004.7656#	wj	= 0.0"	ao	= 9.34375000"	
Rho s	= 1.030100346	Rho c	= 1.066889644	Chi s	= 0.479871631	
Chi t	= 0.660426855	Ks	= 3445479.000Lb/In	Kt	= 15871.14844Lb/In	
Ks,t	= 0.466861755	j	= 1.000000000	Beta s	= 0.670093179in ⁻¹	
Kappa s	= 179273.5156#	Lambda s	= 4007422.000psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 3.759759426	
E*	= 7739415.000psi	v*	= 0.354747713	Xa	= 2.164102554	
Zd	= 0.136644870	Zv	= 0.151512057	Zm	= 0.639281213	
K	= 1.023411393	F	= 0.387551039	Phi	= 0.525033891	
Q1	= -0.037022300	Qz1	= 1.437045386	Qz2	= 1.402048588	
U	= 2.804097176	Gamma	= -0.080946334"	Omega s	= 2.784597874in ²	
Omega c	= 0.0in ²	Omega s*	= -2.744451761in ²	Omega c*	= 1.807801843in ²	
Delta s	= 0.000007580In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.140468225	
Ps'	= 0.0psi	Pt'	= 1202.453003psi	P Gamma	= -2178.041748psi	
PW	= 124.2244034psi	Prim	= 23.22530746psi	Es,w	= 0.850000024	
Pe	= -892.8081665psi	Q2	= 3437.181396#	Q3	= 0.051170249	
Fm	= 0.173616901	Es,w1	= 0.850000024	lt	= 0.0"	
Rt	= 0.0"	Et	= 0.0	Ct	= 0.0	
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.350428671	
Sigmat,1	= 269.6949768psi	Sigmat,2	= 6367.406250psi	Ft,max	= 1.583586812	
Sigma s,m	= -5846.276855psi	Sigma s,b	= -51321.12891psi	Sigma s	= 57167.40625psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	-31506 psi	<= Sps	61600 psi	[OK	]
Tau	-7097 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	6367 psi	<= 2St	26823 psi	[OK	]
Sigma s	57167 psi	<= Spss	59800 psi	[OK	]
Sigmat,s,m	-5846 psi	<= Spss	59800 psi	[OK	] Step 10
Sigmat,s,m	-5846 psi	<= Ss,b	15010 psi	[OK	] Step 10
Joint Load	678 #	<= Lmax	2147 #	[OK	]

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(FTS) Configuration b

Tubesheet Thickness (h)	=	2.9375"	F-F Inside Tubesheets (L)	=	185.8750"
F-F Tubesheets (Lt)	=	191.7500"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.8125"	Channel thickness (Tc)	=	0.3750"
Channel I.D. (Dc)	=	19.2500"	Shell thickness (Ts)	=	0.3750"
Shell I.D. (Ds)	=	19.2500"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	150.0psi
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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spssc = 64199psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss = 59800psi	
Tt,m	= 185deg.F			At,m = 6.6700In/In		
Ts,m	= 247deg.F			As,m = 6.7940In/In		

Mu=0.2001	d*=0.5480"	P*=0.78130"	Mu*=0.2987	hg' = 0.0"	hgs' = 0.0"	hrDE=0.0458"
W*	= 173004.7656#	wj	= 0.0"	ao	= 9.34375000"	
Rho s	= 1.030100346	Rho c	= 1.066889644	Chi s	= 0.479871631	
Chi t	= 0.660426855	Ks	= 3445479.000lb/In	Kt	= 15871.14844lb/In	
Ks,t	= 0.466861755	j	= 1.000000000	Beta s	= 0.670093179in ⁻¹	
Kappa s	= 179273.5156#	Lambda s	= 4007422.000psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 3.759759426	
E*	= 7739415.000psi	v*	= 0.354747713	Xa	= 2.164102554	
Zd	= 0.136644870	Zv	= 0.151512057	Zm	= 0.639281213	
K	= 1.023411393	F	= 0.387551039	Phi	= 0.525033891	
Q1	= -0.037022300	Qz1	= 1.437045336	Qz2	= 1.402048588	
U	= 2.804097176	Gamma	= -0.080946334"	Omega s	= 2.784597874in ²	
Omega c	= 0.0in ²	Omega s*	= -2.744451761in ²	Omega c*	= 1.807801843in ²	
Delta s	= 0.000007580In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.140468225	
Ps'	= 303.7155762psi	Pt'	= 0.0psi	P Gamma	= -2178.041748psi	
PW	= 124.2244034psi	Prim	= 13.22201061psi	Es,w	= 0.850000024	
Pe	= -479.6408386psi	Q2	= -3203.995850#	Q3	= 0.116003051	
Fm	= 0.195925072	Es,w1	= 0.850000024	lt	= 0.0"	
Rt	= 0.0"	Et	= 0.0	Ct	= 0.0	
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.250499755	
Sigmat,1	= 1064.110229psi	Sigmat,2	= 4891.599121psi	Ft,max	= 1.691313505	
Sigma s,m	= -5581.332520psi	Sigma s,b	= -27019.27148psi	Sigma s	= 32600.60352psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	-19101 psi	<= Sps	61600 psi	[OK	]
Tau	-3813 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	4891 psi	<= 2St	26823 psi	[OK	]
Sigma s	32600 psi	<= Spss	59800 psi	[OK	]
Sigmat,s,m	-5581 psi	<= Spss	59800 psi	[OK	] Step 10
Sigmat,s,m	-5581 psi	<= Ss,b	15010 psi	[OK	] Step 10
Joint Load	520 #	<= Lmax	2147 #	[OK	]

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(FTS) Configuration b

Tubesheet Thickness (h)	=	2.9375"	F-F Inside Tubesheets (L)	=	185.8750"
F-F Tubesheets (Lt)	=	191.7500"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.8125"	Channel thickness (Tc)	=	0.3750"
Channel I.D. (Dc)	=	19.2500"	Shell thickness (Ts)	=	0.3750"
Shell I.D. (Ds)	=	19.2500"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	150.0psi
Press Chan (Pt)	=	400.0psi	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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps =	61600psi
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spssc =	64199psi
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300	Spss =	59800psi
Tt,m	= 185deg.F			At,m =	6.6700In/In	
Ts,m	= 247deg.F			As,m =	6.7940In/In	

Mu=0.2001	d*=0.5480"	P*=0.78130"	Mu*=0.2987	hg' = 0.0"	hgs' = 0.0"	hrDE=0.0764"
W*	= 173004.7656#	wj	= 0.0"	ao	= 9.34375000"	
Rho s	= 1.030100346	Rho c	= 1.066889644	Chi s	= 0.479871631	
Chi t	= 0.660426855	Ks	= 3445479.000Lb/In	Kt	= 15871.14844Lb/In	
Ks,t	= 0.466861755	j	= 1.000000000	Beta s	= 0.670093179in ⁻¹	
Kappa s	= 179273.5156#	Lambda s	= 4007422.000psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 3.759759426	
E*	= 7739415.000psi	v*	= 0.354747713	Xa	= 2.164102554	
Zd	= 0.136644870	Zv	= 0.151512057	Zm	= 0.639281213	
K	= 1.023411393	F	= 0.387551039	Phi	= 0.525033891	
Q1	= -0.037022300	Qz1	= 1.437045336	Qz2	= 1.402048588	
U	= 2.804097176	Gamma	= -0.080946334"	Omega s	= 2.784597874in ²	
Omega c	= 0.0in ²	Omega s*	= -2.744451761in ²	Omega c*	= 1.807801843in ²	
Delta s	= 0.000007580In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.140468225	
Ps'	= 303.7155762psi	Pt'	= 1202.453003psi	P Gamma	= -2178.041748psi	
PW	= 124.2244034psi	Prim	= 36.44731903psi	Es,w	= 0.850000024	
Pe	= -805.2855835psi	Q2	= -3745.398193#	Q3	= 0.069523327	
Fm	= 0.179931968	Es,w1	= 0.850000024	lt	= 0.0"	
Rt	= 0.0"	Et	= 0.0	Ct	= 0.0	
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.322140455	
Sigmat,1	= 372.3241272psi	Sigmat,2	= 6134.451660psi	Ft,max	= 1.614082456	
Sigma s,m	= -4699.241699psi	Sigma s,b	= -43895.98047psi	Sigma s	= 48595.22266psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	-29451 psi	<= Sps	61600 psi	[OK	]
Tau	-6402 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	6134 psi	<= 2St	26823 psi	[OK	]
Sigma s	48595 psi	<= Spss	59800 psi	[OK	]
Sigmat,s,m	-4699 psi	<= Spss	59800 psi	[OK	] Step 10
Sigmat,s,m	-4699 psi	<= Ss,b	15010 psi	[OK	] Step 10
Joint Load	653 #	<= Lmax	2147 #	[OK	]

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(FTS) Configuration b

Tubesheet Thickness (h)	=	2.9375"	F-F Inside Tubesheets (L)	=	185.8750"
F-F Tubesheets (lt)	=	191.7500"	Exp depth ratio (Rho)	=	0.9778"
Exp length of tube (ltx)	=	2.8125"	Channel thickness (Tc)	=	0.3750"
Channel I.D. (Dc)	=	19.2500"	Shell thickness (Ts)	=	0.3750"
Shell I.D. (Ds)	=	19.2500"	Area enclosed by CP (AP)	=	274.279in ²
Perimeter of layout (CP)	=	58.7085"	Press Shell (Ps)	=	0.0psi
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 = 400deg.F	S = 20000psi	Sy = 30800psi	E = 27.7000psi	V = .300	Sps = 61600psi	
Temp TBS Tt = 400deg.F	St = 13411psi	Syt = 22200psi	Et = 27.7000psi	Vt = .300		
Temp TBS T = 400deg.F	St = 13411psi		Et = 27.7000psi			
Temp CH Tc = 200deg.F	Sc = 17100psi	Syc = 32099psi	Ec = 28.6000psi	Vc = .300	Spss = 59800psi	
Temp SH Ts = 400deg.F	Ss = 17100psi	Sys = 29900psi	Es = 27.7000psi	Vs = .300		
Tt,m	= 185deg.F			At,m = 6.6700In/In		
Ts,m	= 247deg.F			As,m = 6.7940In/In		

Mu=0.2001	d*=0.5480"	P*=0.78130"	Mu*=0.2987	hg'= 0.0"	hgs'= 0.0"	hrDE= 0.0"
W*	= 173004.7656#	wj	= 0.0"	ao	= 9.34375000"	
Rho s	= 1.030100346	Rho c	= 1.066889644	Chi s	= 0.479871631	
Chi t	= 0.660426855	Ks	= 3445479.000lb/In	Kt	= 15871.14844Lb/In	
Ks,t	= 0.466861755	j	= 1.000000000	Beta s	= 0.670093179in ⁻¹	
Kappa s	= 179273.5156#	Lambda s	= 4007422.000psi	Beta c	= 0.0in ⁻¹	
Kappa c	= 0.0#	Lambda c	= 0.0psi	h/p	= 3.759759426	
E*	= 7739415.000psi	v*	= 0.354747713	Xa	= 2.164102554	
Zd	= 0.136644870	Zv	= 0.151512057	Zm	= 0.639281213	
K	= 1.023411393	F	= 0.387551039	Phi	= 0.525033891	
Q1	= -0.037022300	Qz1	= 1.437045336	Qz2	= 1.402048588	
U	= 2.804097176	Gamma	= -0.080946334"	Omega s	= 2.784597874in ²	
Omega c	= 0.0in ²	Omega s*	= -2.744451761in ²	Omega c*	= 1.807801843in ²	
Delta s	= 0.000007580In ³ /Lb	Delta c	= 0.0In ³ /Lb	Gamma b	= -0.140468225	
Ps'	= 0.0psi	Pt'	= 0.0psi	P Gamma	= -2178.041748psi	
PW	= 124.2244034psi	Prim	= 0.0psi	Es,w	= 0.850000024	
Pe	= -567.1633911psi	Q2	= -2895.779297#	Q3	= 0.079939723	
Fm	= 0.183516115	Es,w1	= 0.850000024	lt	= 0.0"	
Rt	= 0.0"	Et	= 0.0	Ct	= 0.0	
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.306085348	
Sigmat,1	= 961.4808960psi	Sigmat,2	= 5124.553223psi	Ft,max	= 1.631390333	
Sigma s,m	= -6728.367188psi	Sigma s,b	= -34444.42188psi	Sigma s	= 41172.78906psi	
Sigma c,m	= 0.0psi	Sigma c,b	= 0.0psi	Sigma c	= 0.0psi	

Thermal Expansion Acting on this Case (Yes)

Sigma	-21156 psi	<= Sps	61600 psi	[OK	]
Tau	-4509 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	5124 psi	<= 2St	26823 psi	[OK	]
Sigma s	41172 psi	<= Spss	59800 psi	[OK	]
Sigmat,s,m	-6728 psi	<= Spss	59800 psi	[OK	] Step 10
Sigmat,s,m	-6728 psi	<= Ss,b	15010 psi	[OK	] Step 10
Joint Load	545 #	<= Lmax	2147 #	[OK	]

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---- SHELL NOZZLES -----DESIGN PRESS= 150.0 DESIGN TEMP= 400.0
NOZ# 1 8.0- 150# MT# FLG= 70 GROUP=1.1 @70deg.= 285.00 @TEMP= 200.00
NOZ# 2 8.0- 150# MT# FLG= 70 GROUP=1.1 @70deg.= 285.00 @TEMP= 200.00

---- FRONT CHANNEL NOZZLES -----DESIGN PRESS= 400.0 DESIGN TEMP= 200.0
NOZ#11 6.0- 300# MT# FLG= 74 GROUP=1.1 @70deg.= 740.00 @TEMP= 680.00

---- REAR CHANNEL/COVER NOZZLES ----DESIGN PRESS= 400.0 DESIGN TEMP= 200.0
NOZ#17 10.0- 300# MT# FLG= 74 GROUP=1.1 @70deg.= 740.00 @TEMP= 680.00

Skid 2 relocated from
UOPR Job 488 to 447

Item No: E-207
Job No: 17S-3451

By: ng

P.O. No: 4500801009
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***** TUBE CALCULATIONS *****

Tube size.....=	0.62500"	Straight or U-Tube.=	Straight Tube
Internal Press...=	400.00000psig	External press.....=	150.00000psig
Temperature used.=	400.00000deg.	Tube Matl MT# 61...=	SA-214
Stress Oper.....=	11400.00000psi	Stress Atm.....=	11400.00000psi
Yield.....=	22200.00000psi	Inside Radius.....=	0.25250"
Joint Eff.....=	1.00000	Mill tol...= 0.00% =	0.00000"
Wall Thk. t.....=	0.06000"	Tube gauge.....=	
Mean Rad., R.....=	0.00000"	Tube Length.....=	192.00000"
Corrosion ID.....=	0.00000"	Corrosion OD.....=	0.00000"
Thinning factor..=	1.00000		
tr = PR/SE - .6P =	0.00905"	(tr*TF)+MT+CA.....=	0.00905"
MAWP Internal H/C=	2370.88379psig	MAWP Internal N/C..=	2370.88379psig
MAWP External H/C=	1649.76038psig	MAWP External N/C..=	1766.40002psig

Skid 2 relocated from
UOPR Job 488 to 447

Item No: E-207
Job No: 17S-3451

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Input Echo, Horizontal Vessel Item 3451, Description: E-207

Design Internal Pressure	150.00	psig
Design Temperature	400.00	F
Corrosion Allowance for Vessel	0.0625	in.
Shell Material	SA-516 70	
Shell Material UNS Number	K02700	
Shell Operating Allowable Stress	20000.00	psi
Shell Ambient Allowable Stress	20000.00	psi
Head Material	SA-516 70	
Head Material UNS Number	K02700	
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	62.4000	lb./ft ³
Liquid Height in Vessel	19.2500	in.
Extra Weight	4301.000	lb.
Saddle Reaction Force Factor	3.00	ftr
Distance from Center of Vessel to Support B	20.00	in.
Baseplate Length	18.0000	in.
Baseplate Thickness	0.5000	in.
Baseplate Width	6.0000	in.
Number of Ribs (inc. outside ribs)	2	
Rib Thickness	0.5000	in.
Web Thickness	0.5000	in.
Web Location	Side	
Height of Center Web	9.1250	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	3.000	
Wind Velocity	120.000	mile/hr
Exposure Category	C	
Height above Grade	20.000	ft.
Type of Hill	None	
Friction Coefficient	0.40	mu
User defined Longitudinal Force	5500.00	Flu lb.
Seismic Zone Identifier, Zone	4 Zone 3	
User Entered Seismic Zone Coefficient	0.4000	
Diameter Basis for Vessel	OD	
Shell Diameter	20.000	in.
Shell Length Tangent to Tangent	20.040	ft.
Thickness of Shell	0.3750	in.
Shell Joint Efficiency	1.0000	
Head Type	Elliptical	
Head Thickness	0.3125	in.

Item No: E-207
Job No : 17S-3451

By: hcg

P.O. No: 4500801009

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Head Joint Efficiency	1.0000	
Distance from Saddle to Vessel Tangent	50.000	in.
Saddle Width	5.500	in.
Saddle Bearing Angle	115.0000	degrees
Wear Pad Thickness	0.3750	in.
Wear Pad Extension above Horn of Saddle	2.0000	in.
Wear Pad Width	8.000	in.

Stiffening Ring Present N

Results for Horizontal Vessel Number 3451, Description: E-207

Wind Load Results per ASCE-7 95

Alpha factor from Table C6-2	: 9.5
Zg from Table C6-2	: 900.00 ft.
Velocity Pressure Exposure Coeff. Kz (C3)	: 0.9019
Gust Effect Factor (Rigid) G per Eq. 6-4	: 0.8500
Wind velocity Pressure qz at mid from Eq 6-15	: 99.741 psf
Wind velocity Pressure, P = qz * G	: 84.780 psf

Vessel Stress Summary

Shell Allowable Stress used in Calculation	20000.00	psi
Shell Compressive Yield used in Calculation	32500.00	psi
Head Allowable Stress used in Calculation	20000.00	psi
Volume of Vessel	42.15	ft.**3
Weight of Vessel, Empty	5938.96	lb.
Weight of Vessel, Full	8565.78	lb.

	Actual	Allowable	
Long. Stress at Top of Saddles	15125.87	20000.00	psi
Long. Stress at Bottom of Saddles	-10535.87	-14865.87	psi
Long. Stress at Top of Midspan	1322.79	20000.00	psi
Long. Stress at Bottom of Midspan	3267.21	20000.00	psi
Tangential Shear in Shell	2372.23	16000.00	psi
Circ. Stress at Horn of Saddle	-10085.90	-29250.00	psi
Circ. Stress at Tip of Wear Plate	-7263.82	-29250.00	psi
Circ. Compressive Stress in Shell	-1466.32	-16250.00	psi

Wind(ASCE #7) and Seismic Results :

Transverse Wind Load Component, Ftw:

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

$$F_{tw} = (7514.401 * 0.600 * 84.7801 * 0.00694) * 0.5$$

Ftw = 1327.233 lb.

Longitudinal Wind Load Component, Flw:

$$Flw = (AFL * QZ * C_{nv_fac})$$

$$Flw = (706.858 * 84.7801 * 0.00694)$$

Flw = 416.163 lb.

Transverse Earthquake Load Component, Fte:

$$F_{te} = (C_s * W_o) * 0.5$$

$$F_{te} = (0.4000 * 8565.78) * 0.5$$

Fte = 1713.156 lb.

Longitudinal Earthquake Load Component, Fle:

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Fl_e = Cs * W_o
Fl_e = 0.4000 * 8565.78
Fl_e = 3426.312 lb.

Longitudinal force due to Friction, Fl_f:

Fl_f = μ * W_o/2
Fl_f = 0.400 * 4282.89
Fl_f = 1713.156 lb.

Saddle Reaction Force due to Transverse Forces, Q_r:

Q_r = f_{tr} * Max(F_{tw}, F_{te}) * B / E
Q_r = 3.0 * Max(1327.23 , 1713.16) * 20.0000 / 16.9733
Q_r = 6055.962 lb.

Saddle Reaction Force due to Longitudinal forces, Q_l:

Q_l = Max(Fl_w, Fl_e, Fl_f, Fl_u) * B / L_s
Q_l = Max(416.16 , 3426.31 , 1713.16 , 5500.00) * 20.0000 / 140.4800
Q_l = 783.030 lb.

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

Q = W_o/2 + Max(Q_r, Q_l)
Q = 4282.89 + Max(6055.96 , 783.03)
Q = 10338.853 lb.

Summary of Loads on this Saddle Support:

Vertical Load on this Saddle	10338.85 lb.
Transverse Shear Load on this Saddle	1713.16 lb.
Longitudinal Shear Load on this Saddle	5500.00 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)
= (150.70*(20.0000/2-0.000))/(20000.00*1.00+0.4*150.70)
= 0.0751 + 0.0625 = 0.1376 in.

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

Less Operating Hydrostatic Head Pressure of 0.70 psig
= (S*E*(T-CA-CAE)) / ((D/2-CAE)-0.4*(T-CA-CAE)) per Appendix 1-1 (a) (1)
= (20000.00*1.00*(0.3125))/((20.0000/2-0.000-0.4*0.3125))
= 632.91 - 0.70 = 632.22 psig

Maximum Allowable Pressure, New and Cold (MAPNC):

= (SA*E*T) / (D/2-0.4*T) per Appendix 1-1 (a) (1)
= (20000.00*1.00*0.3750)/(20.0000/2-0.4*0.3750)
= 761.42 psig

Actual stress at given pressure and thickness (S_{act}):

= (P*((D/2-CAE)-0.4*(T-CA-CAE))) / (E*(T-CA-CAE))
= (150.70*(((20.0000/2-0.000)-0.4*(0.3125)))/(1.00*(0.3125)))
= 4761.97 psi

Elliptical Head:

Thickness Due to Internal Pressure:
= (P*(D-2.0*CAE)*K) / (2*S*E+2*P*(K-0.1)) per Appendix 1-4 (c)
= (150.70*(20.0000-2*0.000)*1.00)/(2*20000.00*1.00+2*150.70*(1.00-0.1))
= 0.0748 + 0.0625 = 0.1373 in.

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

$$\begin{aligned} & \text{Less Operating Hydrostatic Head Pressure of } 0.70 \text{ psig} \\ & = (2 * S * E * (T - CA - CAE)) / (K * (D - 2 * CAE) - 2 * (T - CA - CAE) * (K - 0.1)) \text{ per Appendix 1-4(c)} \\ & = (2 * 20000.00 * 1.00 * (0.2500)) / (1.00 * 20.0000 - 2 * (0.2500) * (1.00 - 0.1)) \\ & = 511.51 - 0.70 = 510.81 \text{ psig} \end{aligned}$$

Maximum Allowable Pressure, New and Cold (MAPNC):

$$\begin{aligned} & = (2 * S * E * T) / (K * D - 2 * T * (K - 0.1)) \text{ per Appendix 1-4 (c)} \\ & = (2 * 20000.00 * 1.00 * 0.3125) / (1.00 * 20.0000 - 2 * 0.3125 * (1.00 - 0.1)) \\ & = 643.09 \text{ psig} \end{aligned}$$

Actual stress at given pressure and thickness (Sact):

$$\begin{aligned} & = (P * (K * (D - 2 * CAE) - 2 * (T - CA - CAE) * (K - 0.1))) / (2 * E * (T - CA - CAE)) \\ & = (150.70 * (1.00 * 20.0000 - 2 * (0.2500) * (1.00 - 0.1))) / (2 * 1.00 * (0.2500)) \\ & = 5892.18 \text{ psi} \end{aligned}$$

Longitudinal Bending (+-) at Midspan

$$\begin{aligned} & = (3 * Q * L * K.2 / (PI * R^2 * (T - CA))) \\ & = (3 * 10338 * 20.04 * 0.1441) / \\ & \quad (PI * 9.6875 * 9.6875 * (0.3750 - 0.0625)) \\ & = 972.21 \text{ psi} \end{aligned}$$

Compute the area ratio [K]:

$$\begin{aligned} & = PI * (\sin(\Delta) / \Delta - \cos(\Delta)) / (\Delta + \sin(\Delta) * \cos(\Delta) - \\ & \quad (\Delta + \sin(\Delta) * \cos(\Delta) - 2 * \sin(\Delta) * \sin(\Delta) / \Delta)) \\ & = PI * (\sin(1.360) / 1.360 - \cos(1.360)) / (1.360 + \sin(1.360) * \\ & \quad \cos(1.360) - 2 * \sin(1.360) * \sin(1.360) / 1.360) \\ & = 10.1125 \end{aligned}$$

Compute the moment fraction [X]:

$$\begin{aligned} & = (1 - (1 - A/L + (R^2 - H^2) / (2 * A * L)) / (1 + (4 * H) / (3 * L))) \\ & = (1 - (1 - 4.167 / 20.040 + (0.807^2 - 0.410^2) / (2 * 4.167 * 20.040)) / \\ & \quad (1 + (4 * 0.410) / (3 * 20.040))) \\ & = 0.2261 \end{aligned}$$

Intermediate Product [K.1]:

$$\begin{aligned} & = K * X * 4 * A / L \\ & = 10.113 * 0.226 * 4 * 4.167 / 20.040 = 1.9019 \end{aligned}$$

Longitudinal Bending (+-) at Saddle

$$\begin{aligned} & = (3 * Q * L * K.1 / (PI * R^2 * (T - CA))) \\ & = (3 * 10338 * 20.04 * 1.9019) / \\ & \quad (PI * 9.6875 * 9.6875 * (0.3750 - 0.0625)) \\ & = 12830.87 \text{ psi} \end{aligned}$$

Longitudinal Pressure Stress

$$\begin{aligned} & = DP * ((SID / 2 + CA) - 0.4 * (T - CA)) / (2.0 * (T - CA)) \\ & = 150.0 * ((19.25 / 2 + 0.0625 - 0.4 * (0.375 - 0.0625)) / \\ & \quad (2.0 * (0.375 - 0.0625))) \\ & = 2295.00 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} & = Q * K.4 * ((L - H - 2A) / (L + H)) / (R * (T - CA)) \\ & = 10338 * 1.2575 * ((20.04 - 0.41 - 2 * 4.17) / \\ & \quad (20.04 + 0.41)) / (9.6875 * (0.3750 - 0.0625)) \\ & = 2372.23 \text{ psi} \end{aligned}$$

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

$$= -Q / (4 * (T-CA) * (SADWTH + 1.56 * \sqrt{R * (T-CA)})) - 3.0 * Q * K13 / (2 * (T-CA)^2)$$

$$= -10338 / (4 * 0.3125 * (5.50 + 1.56 * \sqrt{9.6875 * 0.3125}))$$

$$- 3 * 10338 * 0.0394 / (2 * 0.3125^2)$$

$$= -7263.82 \text{ psi}$$

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

Saddle-Tangent Distance A (50.0) is > R/2 (4.8 in.)

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

$$= -Q / (4 * TEM * (SADWTH + 1.56 * \sqrt{R * (T-CA)})) - 3.0 * Q * K.7 / (2 * TEB)$$

$$= -10338 / (4 * 0.3125 * (5.50 + 1.56 * \sqrt{9.6875 * 0.3125}))$$

$$- 3 * 10338 * 0.0572 / (2 * 0.0977)$$

$$= -10085.90 \text{ psi}$$

Circumferential Compression at Bottom of Shell

$$= (Q * (K.9 / (TEM9 * WPDWTH)))$$

$$= (10338 * (0.7800 / (0.6875 * 8.000)))$$

$$= -1466.32 \text{ psi}$$

RESULTS for VESSEL RIBS, WEB and BASE

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Ay ²	Io
Shell	0.1562	3.3482	0.5232	0.0817	0.0272
Wearplate	0.5000	3.0000	1.5000	0.7500	0.0352
Web	4.6562	3.9688	18.4795	86.0451	20.8372
BasePlate	8.8750	3.0000	26.6250	236.2969	0.0625
Totals	14.1875	13.3170	47.1277	323.1738	20.9621

Value C1 = Sumof(Ay) / Sumof(A) = 3.5389 in.
 Value I = Sumof(Ay²) + Sumof(Io) - C1 * Sumof(Ay) = 177.3550 in**4
 Value As = Sumof(A) - Ashell = 9.9688 in²

$K1 = (1 + \cos(b) - .5 * \sin(b)^2) / (\pi - b + \sin(b) * \cos(b)) = 0.1945$

$Fh = K1 * Q = 0.1945 * 10338.853 = 2010.738 \text{ lb.}$

Tension Str., St = (Fh / As) = 201.7041 psi
 Allowed Str., Sa = .6 * Yield Stress = 22800.0000 psi

$d = B - R * \sin(\theta) / \theta = 10.6712 \text{ in.}$
 Bending Moment, M = Fh * d = 1788.0758 ft.lb.

Bending Stress, Sbd = (M * C1 / I) = 428.1484 psi
 Allowed Str., Sa = .66 * Yield Str. = 25080.0020 psi

Minimum Thickness of Baseplate

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

$$= (3 * 10338 * 6.00 / (2 * 18.000 * 25080.002))^{1/2}$$

$$= 0.454 \text{ in.}$$

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Effective Baseplate Length (e)

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$$= (B_{plen} - Clearance) / (N_{ribs} - 1)$$

$$= (18.0000 - 1.0) / (2 - 1) = 17.0000 \text{ in.}$$

Baseplate Pressure Area (A_p)

$$= e * B_{pwid} / 2$$

$$= 17.0000 * 6.0000 / 2 = 51.0000 \text{ in}^2$$

Axial Load (P)

$$= A_p * B_p$$

$$= 51.00 * 95.73 = 4882.24 \text{ lb.}$$

Area of the Rib and Web (A_r)

$$= (B_{pwid} - Clearance - Web_{tk}) * Rib_{tk} + e/2 * Web_{tk}$$

$$= (6.000 - 1.0 - 0.500) * 0.500 + 17.0000 / 2 * 0.500$$

$$= 6.500 \text{ in}^2$$

Compressive Stress (S_c)

$$= P/A_r$$

$$= 4882.24 / 6.5000 = 751.1132 \text{ psi}$$

Check of Outside Ribs

Inertia of Saddle, Outer Ribs - Axial Direction

	Y	A	AY	Ay ²	I _o
Rib	2.7500	2.3750	6.5312	6.1087	6.0293
Web	0.2500	4.2500	1.0625	3.4137	0.1771
Values	1.1462	6.6250	7.5938	9.5224	6.2064

KL/R < C_c (8.6396 < 123.2882) per AISC E2-1 9th Edition

$$S_{ca} = (1 - (K_{lr})^2 / (2 * C_c^2)) * F_y / (5/3 + 3 * (K_{lr}) / (8 * C_c) - (K_{lr}^3) / (8 * C_c^3))$$

$$S_{ca} = (1 - (8.64)^2 / (2 * 123.29^2)) * 38000 / (5/3 + 3 * (8.64) / (8 * 123.29) - (8.64^3) / (8 * 123.29^3))$$

$$S_{ca} = 22391.54 \text{ psi}$$

AISC Unity Check on Outside Ribs (must be <= 1.0)

$$Check = S_c / S_{ca} + (R_m / Z) / S_{ba}$$

$$Check = 751.11 / 22391.54 + (17452.69 / 4.081) / 25080.00$$

$$Check = 0.20$$

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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-3451
(Horizontal, vertical, or sphere) (Tank, separator, jkt. vessel, heat exch., etc.) (Manufacturer's serial number)
NONE 17S-3451-A 3216 2017
(CRN) (Drawing number) (National Board number) (Year built)
5. ASME Code, Section VIII, Div. 1 2015 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 15' - 6-1/8"

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
1	19.25"ID	15'-6.125"	SA-106B	.375"	.0625"	S	None	.85	1	Spot	.85	NONE	NONE

Body Flanges on Shells												
No.	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Location	Num & Size	Bolting		
										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 150 PSI NONE at max. temp. 400 F. NONE Min. design metal temp. -20 F. at 150 PSI
(Internal) (External) (Internal) (External)
10. Impact test NO ; Impacts 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]

11. Hydro., pneu., or comb. test pressure 195 PSI Proof test NO

Items 12 and 13 to be completed for tube sections.

12. Tubesheet SA-350LF2CL.1 19.125" 2.9375" .125" Welded
[Stationary (material spec. no.)] [Diameter (subject to press.)] (Nominal thickness) (Corr. allow.) [Attachment (welded or bolted)]
SA-350LF2CL.1 19.125" 2.9375" .125 Welded
[Floating (material spec. no.)] (Diameter) (Nominal thickness) (Corr. allow.) (Attachment)
13. Tubes SA-214 .625" .060"MW 465 Straight
(material spec. no., grade or type) (O. D.) (Nominal thickness) (Number) [Type (straight or U)]

FORM U-1 (Cont'd)

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 3' - 2"

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	19.250"ID	1'-4.6875"	SA-333-6	.375"	.0625"	S	None	1.0	1	Full	1.0	NONE	NONE
1	19.250"ID	1'-9.3125"	SA-333-6	.375"	.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	19.2"	20.4"	2.1875"	.375"	*Ln22	WELDED	CH.	(24) 3/4"	SA-193-B7	NONE	NONE	
1	RING	19.2"	20.4"	2.1875"	.375"	*Ln22	WELDED	CH.	(24) 3/4"	SA-193-B7	NONE	NONE	
-	-	-	-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	-	-	-	-	-	-	

15. Heads: (a) SA-516-70N ; NONE (b) SA-516-70N ; NONE
(Material spec. number, grade or type)(H.T. - time and temp.) (Material spec. number, grade or type)(H.T. - time and temp.)

(a)	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)	FRT. CH. END	.3125"	.0625"	NONE	NONE	2:1	NONE	NONE	NONE	NONE	X	-	Seamless	-
(b)	Rear CH. END	.3125"	.0625"	NONE	NONE	2:1	NONE	NONE	NONE	NONE	X	-	Seamless	-

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 400 PSI NONE at max. temp. 200 F. NONE Min. design metal temp. -50 F. at 400 PSI.
(Internal) (External) (Internal) (External)

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

18. Hydro., pneu., or comb. test pressure 521 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	8"-150#	FLG	SA106B	SA-105	.500"	.0625"	NONE	E	1	N/A
CH. INLET	1	6"-300#	FLG	SA333-6	**Ln22	.432"	.0625"	SA-516-70N	E	1	N/A
CH. OUTLET	1	10"-300#	FLG	SA333-6	**Ln22	.500"	.0625"	SA-516-70N	E	1	N/A
CH. VENT / DRAIN	1/1	3/4"-6000#	CPLG	SA-105	N/A	.500"	.0625"	NONE	E	N/A	N/A
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-

20. Supports: Skirt NO Lugs NONE 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):
NONE

22. Remarks LN. 19 - SAFETY VALVES BY OTHERS *Ln. 14 - CHAN. MAT'L = SA-350LF2.CL.1.
TYPE : BEM SIZE : 19-192 **Ln. 19 - FLG. MAT'L = SA-350LF2.CL.
P.O. No. : 4500801009 ITEM NO. : E-207.
SERVICE : DEMETHANIZER TRIM.

FORM U-1 (Cont'd)

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 05/16/2018

Date 1-5-18 Name STEELTEK, INC. Signed Carmen Moffett
(Manufacturer) (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 N/A

have inspected the pressure vessel described in this Manufacturer's Data Report on 12-29-2017, 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 1-5-2018 Signed [Signature] Commissions NB11448 B R
(Authorized Inspector) [National Board (incl. endorsements)]

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 _____ Expires _____

Date _____ Name _____ Signed _____
(Assembler) (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 _____ Commissions _____
(Authorized Inspector) [National Board (incl. endorsements)]

NB 3216

CERTIFIED BY

Steeltek

TULSA, OKLA.

MAWP PSI

AT °F

$\{A_{SM}E\}$

U
W
RT4

SHELL

TUBE

150

400

400

200

MDMT °F

AT PSI

SHELL

TUBE

-20

-50

150

100

YEAR BUILT

2017

SERIAL NO.

17S-3451

P.O. NO.

4500801009

ITEM NO.

E-207

UOP RUSSELL PROJ. NO.: J488XX

STEELTEK

4141 SOUTH JACKSON
TULSA, OKLAHOMA 74107

INSPECTION AND TEST PLAN

STEELTEK JOB NUMBER: 17S-3451				P. O. NUMBER: 4500801009		REV. 0, 1/8/18	
CUSTOMER: UOP RUSSELL				ITEM NUMBER: E-207			
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-3451-Y	DWG. 17S-3451-Y					
MILL TEST REPORTS	ASME SECT. II	ASME SECT. VIII, DIV. 1					
MATERIAL TRACEABILITY	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1					
WELD AND NDE PROCEDURE REVIEW	WELD MAP & ASME SECT. IX	ASME SECT. IX					
WELDER QUALIFICATIONS	ASME SECT. IX	ASME SECT. IX					
ORIENTATION & FITUP CHECKED	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1					
FLANGE FINISH & RATING	DWG. 17S-3451-Y1 AND CUSTOMER SPECS.	DWG. 17S-3451-Y1 AND CUST. SPECS.					
FLANGES CHECKED	DWG. 17S-3451-L AND 17S-3451-X	DWG. 17S-3451-X					
PROJECTION CHECKED	DWG. 17S-3451-A	TEMA					
WELDER OPERATOR	ASME SECT. IX AND VIII, DIV. 1	ASME SECT. IX					
WELDING ELECTRODES	APPLICABLE WPS	ASME SECT. VIII, DIV. 1, WPS					
VERIFY CORRECT WELDING PREHEAT	APPLICABLE WPS	WPS					
VERIFY CORRECT WELDING PROCEDURE	APPLICABLE WPS	WPS, DWG. 17S-3451-WM					
VISUAL INSPECTION OF WELDS	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1					
PLUG SHELL FOR DIAMETER	DWG. 17S-3451-X	DWG. 17S-3451-X					
NDE OPERATOR QUALIFICATIONS	ASME SECT. V	ASME SECT. V					
MT BACKGROUGED ROOT PASSES	DWG. 17S-3451-X	ASME SECT. V					
REPAD AIR/SOAP SUDS TEST	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1					
PRODUCTION IMPACT TEST	DWG. 17S-3451-X	ASME SECT. VIII, DIV. 1					
MT	DWG. 17S-3451-X	ASME SECT. V					
UT	DWG. 17S-3451-X	ASME SECT. V					
RT	DWG. 17S-3451-X, ASME SECT. V	ASME SECT. V					
PT	DWG. 17S-3451-X, ASME SECT. V	ASME SECT. VIII, DIV. 1					
INTERNAL INSPECTION	ASME SECT. VIII, DIV. 1 & DWG. 17S-3451-X	ASME SECT. VIII, DIV. 1					
BUNDLE INSERTION	DWG. 17S-3451-X	DWG. 17S-3451-X					
FINAL VISUAL / DIMENSIONAL INSPECTION	TEMA, DWG. 17S-3451-A	TEMA, DWG. 17S-3451-A					
HYDROSTATIC TEST	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1					
NAME PLATE STAMPING	DWG. 17S-3451-N	ASME SECT. VIII, DIV. 1, TEMA					
NAME PLATE RUBBING							
PAINT	DWG. 17S-3451-A	DWG. 17S-3451-A					
MARKING / TAGGING	DWG. 17S-3451-X	DWG. 17S-3451-X					
SHIPPING PREPARATION	DWG. 17S-3451-X	DWG. 17S-3451-X					
MANUFACTURER'S DATA REPORT	ASME SECT. VIII, DIV. 1	ASME SECT. VIII, DIV. 1					
COMPLETED DATA PACKAGE	ASME SECT. VIII, DIV. 1 & P. O. DOCUMENTS	ASME SECT. VIII, DIV. 1					
FINAL INSPECTION RELEASE							



SGS/ISO 9001:2008
ABS QUALITY EVALUATIONS
CERTIFICADO No. 32110

PRECITUBO, S.A. DE C.V.
DEPTO. DE ASEGURAMIENTO DE CALIDAD

CERTIFICADO DE CALIDAD MILL TEST REPORT



PRECITUBO, S.A. DE C.V. / Km. 11.4 Carretera a El Castillo, El Salto Jal. México C.P. 45680 Tel. (52) 33 3688-0002 / 3688-0530. Fax (52) 33 3688-0631 www.precitubo.com.mx

Pag: 1

DATE: 10/26/2017

No. 54544

CUSTOMER: HEAT TRANSFER TUBULAR PRO

CUSTOMER REFERENCE: 7303

Ship No.: 5127

S.O.: OV18430

SPECIFICATION: ASTM/ASME-A/SA-214/SA-214M Ed.2015

DESCRIPTION: ELECTRIC-RESISTANCE-WELDED CARBON STEEL HEAT-EXCHANGER AND CONDENSER TUBES

ITEM	SIZE	QUANTITY (Pces.)	LENGTH (Ft.)	WEIGHT (Lb.)	HEAT No.	# F.O.
1	0.625"X0.060"MW	239	15.997	1464.81	1707170860	18430/1
1	0.625"X0.060"MW	226	15.997	1385.14	1707170860	184301X

MECHANICAL TESTING RESULTS										
# F.O.	# Heat	Tensile Str (PSI)	Yield Str (PSI)	Elongation 2"	Hardness (HRB)	Flattening	Fla-Rev	Flaring	Flange	Bending
SPECIFIED	MIN:	0.00	0.00	0.00	0.00					
	MAX:				72.00					
18430/1	1707170860	0.00	0.00	0.00	51.00	O.K.	O.K.	N.A.	O.K.	N.A.
184301X	1707170860	0.00	0.00	0.00	48.00	O.K.	O.K.	N.A.	O.K.	N.A.

CHEMICAL ANALYSIS												
	% C	% S	% Si	% Mn	% P	% Mo	% Cr	% Ni	% Cu	% V	% Co	% Al
Std												
SPECIFIED MIN:	0.000	0.000	0.000	0.270	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MAX:	0.180	0.035		0.630	0.035							
F.O.	Heat											
18430/1	1707170860	0.067	0.004	0.023	0.450	0.006	0.004	0.015	0.014	0.035	0.003	0.029
184301X	1707170860	0.067	0.004	0.023	0.450	0.006	0.004	0.015	0.014	0.035	0.003	0.029

NON DESTRUCTIVE TEST

RECEIVED
NOV 10 2017
BY: *[Signature]*

[Signature]
Isidro Juárez Meléndez
Inspector Reg. de Calidad
Quality Assurance Inspector

- Este documento certifica que los productos aquí descritos fueron manufacturados, probados o inspeccionados conforme a la especificación de referencia y cumplen satisfactoriamente los requerimientos de la O.C. correspondiente. Este documento fue elaborado y validado por un representante autorizado del staff de aseguramiento de Calidad, con total independencia al departamento de manufactura.
- This document certifies that the products supplied and described here were manufactured, sampled, inspected and tested in compliance with the referenced specification and P.O. requirements and meets all of them. This document was issued and validated by our QA. authorized representative staff with total independence of the manufacturing department.

175-3451
LN-21 Tubes
OK am

GAC-06-020/5



SAC/ISO 9001:2008

ABS QUALITY EVALUATIONS
CERTIFICADO No. 32110

PRECITUBO, S.A. DE C.V.
DEPTO. DE ASEGURAMIENTO DE CALIDAD

CERTIFICADO DE CALIDAD MILL TEST REPORT



PRECITUBO, S.A. DE C.V. / Km. 11.4 Carretera a El Castillo, El Salto Jal. México C.P. 45680 Tel. (52) 33 3688-0002 / 3688-0530. Fax (52) 33 3688-0631 www.precitubo.com.mx

Pag: 2

FECHA: 10/26/2017

No. 54544

NON DESTRUCTIVE TEST

Product was 100% Eddy Current tested with satisfactory results. Test performed accordingly to ASME SA-450 and SE-309 latest editions.

REMARKS:

Aluminum Killed Steel.

Not repaired by welding.

Heat Treatment: Fully Annealed.

Specification: ASME-SA-214 / SA-214M Ed.2015/// ASTM-A 214/A 214M-96 (Reapproved 2012)

Material fabricated according to NACE MR0175- 2003//ISO- 15156 2005

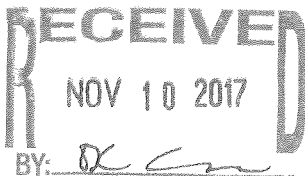
This inspection certificate was issued according to DIN/ EN 10204, Part 3.1.

Materials according to ASME Code Section II Ed. 2015 or acceptable ASTM editions per ASME Ed. 2015

Country of Origin: Melted and Manufactured in Mexico.

REMARKS:

Skid 2 relocated from
UOPR Job 488 to 447



Isidro Juárez Meléndez
Inspector Asoc. de Calidad
Quality Assurance Inspector

- Este documento certifica que los productos aquí descritos fueron manufacturados, probados e inspeccionados conforme a la especificación de referencia y cumplen satisfactoriamente los requerimientos de la O.C. correspondiente. Este documento fue elaborado y validado por un representante autorizado del staff de aseguramiento de Calidad, con total independencia al departamento de manufactura.
- This document certifies that the products supplied and described here were manufactured, sampled, inspected and tested in compliance with the referenced specification and P.O. requirements and meets all of them. This document was issued and validated by our Q.A. authorized representative staff with total independence of the manufacturing department.

175-3451
LN-21 Tubes
OK

GAC-06-020/5



OKLAHOMA FORGE, INC.

Certification of Analysis and Tests

INVOICE NUMBER

118-01436

Date: 9/26/17

Toll Free (866)909-5553

e-Mail ~ sales@oklahomaforge.com

5259 S. 49TH West Ave

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

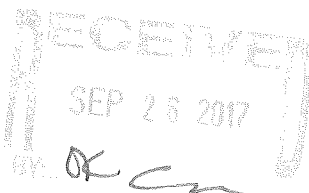
Web Site ~ www.oklahomaforge.com

Tulsa, OK 74107

Sold To	Your Purchase Order	Sales Order
STEELTEK, INC. 4141 SOUTH JACKSON TULSA, OK 74107 USA	Number 94784-3451 By CHRISTY GRAHAM Dated 9/15/2017	Number 117-78198 Shipped Via DELIVERY Ship Date 9/26/2017

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-3451-3/16		117-78198-01		RING		24.188"OD x 19.250"ID x 3.438"TH											2	
			NUCOR		174202		A/SA350-15 LF2 CL1 NORMALIZED												
	C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other				
	.17	1.17	.007	.0018	.24	.09	.08	.22	.03	.02	.0051	.027		.41	SN-.008;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	
	51,000		76,000		32		64		149				FINE	CVN	-50F	84	85	78	88

Skid 2 relocated from
UOPR Job 488 to 441



17S-3451
LN 3, 16 FLG
OK cm

Notes:

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.

W. Weston

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

OFI

OKLAHOMA FORGE, INC.

Certification of Analysis and Tests

INVOICE NUMBER

118-01462

Date: 9/27/17

Toll Free (866)909-5553

e:Mail ~ sales@oklahomaforge.com

5259 S. 49TH West Ave

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

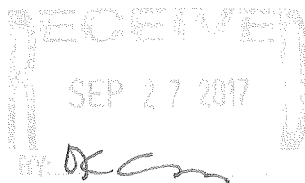
Web Site ~ www.oklahomaforge.com

Tulsa, OK 74107

Sold To	Your Purchase Order	Sales Order
STEELTEK, INC. 4141 SOUTH JACKSON TULSA, OK 74107 USA	Number 94784-3451 By CHRISTY GRAHAM Dated 9/15/2017	Number 117-78198 Shipped Via DELIVERY Ship Date 9/27/2017

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.)								
2	17S-3451-19/20				117-78198-02			DISC		24.188"OD x 2.938"TH										2
					NUCOR			173537		A/SA350-15 LF2 CL1 NORMALIZED										
	C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other					
	.17	1.20	.008	.0042	.19	.1	.11	.20	.04	.02	.005	.029		.42	SN-.01;CO.008					
	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		74,000		34		71		143				FINE	CVN	-50F	72	67 69 79			

Skid 2 relocated from
UOPR Job 488 to 441



Notes:

17S-3451
LN-19, 20 Tubesheet
OK

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.

W. Lupton

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

(580) 363-1312

FAX: (580) 363-1317

(800) 421-9830

Los Angeles Boiler Works Inc.

707 North 20th Street

P.O. Box 948

Blackwell, OK 74631

Material Test Report

Customer: STEELTEK, INC.

Customer PO #: 94783-3451 LABW Invoice #: 17-3265

Tank Heads

Size & Type: 3/8" NOM. X 20" O.D. 2:1 ELLIPTICAL HEAD

Min. Thickness: N/A Dish Rad: N/A Knuckle Rad: N/A

I.D. Number: HUN Straight Flange: 2"

Miscellaneous Items

Description: _____

I.D. Number: _____ Special Requirements: _____

Material Specifications

Material Specifications: ASME SA-516-70 / ASTM A-516-70 NORMALIZED

Mill: SSAB Heat #: E4K185 Slab #: E19

Heat Treatment

HOT FORMED YES ALL HOT FORMED HEADS OR PARTS ARE FORMED AT THE NORMALIZED TEMPERATURE ABOVE 1650°F AND BELOW 1800°F.

COLD FORMED NO STRESS RELIEVED NO MINUTES @ N/A °F

OTHER HEAT TREATMENT NONE

THE ITEMS LISTED ABOVE WERE FORMED IN STRICT ACCORDANCE WITH ALL APPLICABLE REQUIREMENTS OF THE ASME BOILER AND PRESSURE VESSEL CODE SECTION VIII, DIVISION I. COLD FORMED HEADS COMPLY WITH PARAGRAPHS UCS-79. ALL HEADS COMPLY WITH UG-81. NO DESIGN FUNCTIONS PERFORMED. CERTIFIED TO MATERIAL AND WORKMANSHIP ONLY.

SEP 19 2017

September 18, 2017

Date OC

Signature

Randy J. Jirj

175-3451
LN. 1.18 ELLIP. HD.
OC

Quality Control Officer

Title



Tenaris

INSPECTION CERTIFICATE
CERTIFICATO DI COLLAUDO
(UNI EN 10204 3.1 / ISO 10474 3.1.B)

Number / Numero:
01/17/05885

Page / Pagina:
3 / 7

Date / Data: May 27, 2017

Dalmine S.p.A. - Dalmine plant
Piazza Caduti 6 Luglio 1944, 1
24044 Dalmine (BS) - Italy
+39 035 560 111 tel
+39 035 560 3827 fax

Customer / Cliente: MATTISCO SUPPLY		Customer's Order Item / Rifer. Ordine Cliente: 523-S-17		Manufacturer's Works Order N° / Conferma-Posizione: 1293572/002	
Manufacture Process / Processo di fabbricazione:		Product Type / Tipo di prodotto:		Surface / Superficie:	
		SEAMLESS LINE PIPES		BARE INSIDE, EXTERNALLY PROTECTED BY VARNISH	
		TUBI S.S. LINE PIPE		GREZZI INTERNAMENTE, OLEATI ESTERNAMENTE	
Standard or Specification / Norme o specifica:		Steel Grade / Grado dell'Acciaio:		Ends / Estremità:	
See note nr.1		See note nr.2		BEVEL API 5L / ISO 3183 CT4:8825	
Vedi nota nr.1		Vedi nota nr.2		SMUSSATI SECONDO API 5L / ISO 3183 CT4:8825	
Dimensions / Dimensioni:		Length / Lunghezza:		Nominal Weight / Peso nominale:	
ø 20.000" O.D. x 0.375" W.T.		37.999 ft ÷ 42.001 ft		13313,7 lb	
ø 508.00mm O.D. x 9.53mm W.T.		11582 mm ÷ 12802 mm		6039 kg	
		11582 mm ÷ 12802 mm		78.72 lb/ft	
				117.15 kg/m	

IMPACT TEST / PROVA DI RESILIENZA

Type/Type	KCV	Orientation/Dirigenza: °		Unit / Unità: FT/LB		Shear area / Area d'utile %	
Position/Posizione:		Temp: 32	Unit/Unità: °F	Ind./Min.Req: 11	Req./Min.Avg: 15	Ind./Min.Req: --	Req./Min.Avg: --
		Size / Dimensioni		Results / Risultato		Results / Risultato	
Heat N°	Sample N°	Zone	Ls	Sc	1	2	3
Colata N°	Prova N°	Zone			Avg.	1	2
971520	M1628	outside	8	AM	128.0	140.0	100
					134.0	134.0	100
							100

AM: As manufactured / Come laminato	Ind. Min. Req. Individual Minimum Required /	Req. Min. Avg. Required minimum average / Minima
Av: Average / Media	Minimo singolo richiesto	media richiesta
B: Body / Corpo	Ls: Location of sample / Ubicazione provetta	Sc: Specimen condition / Condizioni Provetta

FLATTENING TEST / PROVA DI SCHIACCIAMENTO

Standard / Norma:	Heat N°	Sample N°	Zone	Sc	Test Frequency	Result
Colata N°	Prova N°	Zone			Frequenza prova	Esito
971520	M1627	E1	AM		pieces of the lot	Good / Buono

AM: As manufactured / Come laminato	E1 / E2: Ends of Sampling / Estremità della	provetta	Sc: Specimen condition / Condizioni Provetta
-------------------------------------	---	----------	--

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INSPECTION CERTIFICATE
CERTIFICATO DI COLLAUDO
(UNI EN 10204 3.1 / ISO 10474 3.1.B)

Number / Numero:
01/17/05885

Page / Pagina:
4 / 7

Dalmine S.p.A. - Dalmine plant
Piazza Caduti 6 Luglio 1944, 1
24044 Dalmine (BS) - Italy
+39 035 560 111 tel
+39 035 560 3827 fax

Customer / Cliente: MATTSCO SUPPLY		Customer's Order Item / Rifer. Ordine Cliente - Item Customer's Reference / Posizione Cliente: 523-S-17		Date / Data: May 27, 2017	
Manufacture Process / Processo di fabbricazione:		Product Type / Tipo di prodotto: SEAMLESS LINE PIPES		Manufacturer's Works Order N° / Contorno-Posizione: 1293672002	
Standard or Specification / Norme o specificat:		Steel Grade / Grado dell'Acciaio: See note nr.2		Surface / Superficie: BARE INSIDE, EXTERNALLY PROTECTED BY VARNISH	
See note nr.1		Vedi nota nr.2		Ends / Estremità: GREZZI INTERNAMENTE, OLEATI ESTERNAMENTE	
Dimensions / Dimensioni: Ø 20.000" O.D. x 0.375" W.T.		Schedule / Scheda: 20		BEVEL API 5L / ISO 3183 CT4-8825	
Length / Lunghezza: 11562 mm ± 12802 mm		Quantity / Quantità: 162.73 ft		SMUSSATI SECONDO API 5L / ISO 3183 CT4-8825	
Weight / Peso: 508.00mm O.D. x 9.53mm W.T.		Weight / Peso: 13313.7 lb		Nominal Weight / Peso nominale:	
		Weight / Peso: 6039 kg		117.15 Kg/m	

HYDROSTATIC TEST / PROVA IDRAULICA

Pressure / Pressione	Time / Tempo	Results / Risultato
Unit / Unità	Value / Valore	Seconds / Secondi
psi	1.420	5
Satisfactory / Satisfacente		

SUPPLEMENTARY INFORMATION / INFORMAZIONI SUPPLEMENTARI

STANDARD EDITIONS / EDIZIONI NORME			
Norma: API 5L	Year: 2012	Revision: 45°	Anno della revisione: 45°
Standard: ASTM A53/A106	Year: 2012	Revision: 2015	Anno della revisione: 2015
Standard: ASME SA53/SA106	Year: 2015	Revision: 2015	Anno della revisione: 2015
Standard: NACE MR0175/ISO 15156	Year: 2015	Revision: 2015	Anno della revisione: 2015
Standard: NACE MR0103	Year: 2015	Revision: 2015	Anno della revisione: 2015

PRODUCT DESCRIPTION NOTES / NOTE DI DESCRIZIONE DEL PRODOTTO	
Note 1 is the full description of the 'Standard or specification'.	Note 1 è la descrizione completa delle 'Norme o specifiche'.
ACC TO THE NORM API 5L PSL2 45TH ED. 7 ASTM/ASME A/SA 106/53, NACE	NORMA API 5L PSL2 45A EDIZ. 7 ASTM/ASME A/SA 106/53, NACE
MR0103/0175/ISO15156/17945 (API 5L TOLERANCES)	MR0103/0175/ISO15156/17945 (TOLLERANZE API 5L)
Note 2 is the full description of the 'Steel grade'.	La nota 2 è la descrizione completa del 'Grado acciaio'.
STEEL GR. X42 B, GR. B R PSL2, GR. B/C A/SA 106 AND GR. B A/SA 53 NDE	ACCIAIO GR. X42 B, GR. B R PSL2, GR. B/C A/SA 106 E GR. B A/SA 53 NDE

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Tenaris

INSPECTION CERTIFICATE
CERTIFICATO DI COLLAUDO
(UNI EN 10204 3.1 / ISO 10474 3.1.B)

Number / Numero:
01/17/05885

Page / Pagina:
5 / 7

Dalmine S.p.A. - Dalmine plant
Piazza Caduti 6 Luglio 1944, 1
24044 Dalmine (BG) - Italy
+39 035 560 111 tel
+39 035 560 3827 fax

Customer / Cliente: MATTISCO SUPPLY		Customer's Order Item / Rifer. Ordine Cliente: Item		Manufacturer's Works Order N° / Contingente-Posizione: 1293672/002	
Manufacture Process / Processo di fabbricazione: SEAMLESS LINE PIPES		Product Type / Tipo di prodotto: TUBI S.S. LINE PIPE		Surface / Superficie: BARE INSIDE, EXTERNALLY PROTECTED BY VARNISH	
Standard or Specification / Norme o specifiche: See note nr.1		Steel Grade / Grado dell'acciaio: See note nr.2		Ends / Estremità: BEVEL API 6L / ISO 3183 CT4-8825	
Dimensions / Dimensioni: ø 20.000" O.D. x 0.375" W.T. ø 508.00mm O.D. x 9.53mm W.T.		Length / Lunghezza: 37.999 ft ± 42.001 ft 11582 mm ± 12802 mm		Nominal Weight / Peso nominale: 78.72 lb/ft 117.15 Kg/m	
Schedule / Schedule: 20		Quantity / Quantità: 4Pcs/Pz 162,73 ft 49.6 mt		SMUSSATI SECONDO API 6L / ISO 3183 CT4-8825	

SUPPLEMENTARY INFORMATION / INFORMAZIONI SUPPLEMENTARI

Country of melt ITALY	Supplementary Information Informazioni supplementari
Continuous casting and Fully killed	Sease di colaggio acciaio ITALIA Colaggio continuo ed acciaio di tipo calmato

AFTER INSPECTION OPERATION, THE MATERIAL HAS NOT A RESIDUAL MAGNETISM	
GREATER THAN 20 GAUSS	
HARDNESS HRC 22 MAX, ACCORDING TO NACE MR0175/ISO 15156	
HARDNESS HBW 225 MAX, ACCORDING TO NACE MR0103	
ALL PIPES HAVE BEEN TESTED BY ELECTROMAGNETIC TEST	
WITH SATISFACTORY RESULT (LONG. INT/EXT NOTCH 12,5%)	
THE ENDS (FOR 150 mm) HAVE BEEN TESTED BY DRY MAGNETIC PARTICLES, WITH SATISFACTORY RESULT	
BEVEL SURFACE HAVE BEEN TESTED BY DRY MAGNETIC PARTICLES	
FOR LAMINATIONS CHECK, WITH SATISFACTORY RESULT	
SIZE (OD MT) ACCORDING TO ASME B36.10	
SEAMLESS HOT FINISHED PIPES	
VISUAL AND DIMENSIONAL CONTROL HAS BEEN CARRIED OUT WITH SATISFACTORY RESULT	
STEEL IS FULLY KILLED AND PRODUCED BY ELECTRIC FURNACE TO A FINE GRAIN PRACTICE	
THE PRODUCT SUPPLIED IS IN COMPLIANCE WITH THE REQUIREMENTS OF THE ORDER	
MANUFACTURED BY TENARIS DALMINE	
NO WELD REPAIR, MERCURY AND RADIATION FREE	

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Tenaris

INSPECTION CERTIFICATE CERTIFICATO DI COLLAUDO (UNI EN 10204 3.1 / ISO 10474 3.1.B)

Number / Numero:
01/17/05885

Page / Pagina:
6 / 7

Dalmine S.p.A. - Dalmine plant
Piazza Caduti 6 Luglio 1944, 1
24044 Dalmine (BG) - Italy
+39 035 560 111 tel
+39 035 560 3827 fax

Customer / Cliente: MATTISCO SUPPLY		Customer's Order Item / Rifer. Ordine Cliente - Item Customer's Reference / Posizione Cliente: 523-S-17		Manufacturer's Works Order N° / Conferma-Posizione: 1293672/002	
Manufacture Process / Processo di fabbricazione: SEAMLESS LINE PIPES		Product Type / Tipo di prodotto: TUBES S.S. LINE PIPE		Surface / Superficie: BARE INSIDE, EXTERNALLY PROTECTED BY VARNISH	
Standard or Specification / Norma o specificazione: See note nr.1		Steel Grade / Grado dell'Acciaio: See note nr.2		GREZZI INTERNAMENTE, OLEATI ESTERNAMENTE	
Dimensions / Dimensioni: ø 20.000" O.D. x 0.375" W.T.		Schedule / Schedia: 20		Ends / Estremità: BEVEL API 5L / ISO 3183 CT4-8825	
Length / Lunghezza: 11582 mm ± 12802 mm		Quantity / Quantità: 4Pcs/Pz		SMUSSATI SECONDO API 5L / ISO 3183 CT4-8825	
Weight / Peso: 11582 mm ± 12802 mm		Nominal Weight / Peso nominale: 13313,7 lb		Nominal Weight / Peso nominale: 78.72 lb/ft	
				117.15 Kg/m	

SUPPLEMENTARY INFORMATION / INFORMAZIONI SUPPLEMENTARI

Supplementary Information / Informazioni supplementari	
Tenaris IT identification number for MTC: 57*9108\	
Numero identificativo Tenaris IT per MTC: 57*9108\	

MARKING / MARCATURA

STENCILING T SPEC 5L 0036.1 API DATA 20 0.375 BR-X42R PSL 2 SMLS ASTM ASME A SA 106 B/C PSI1420NDE ASTM ASME A SA 53 B S HEAT: COLATA FT_FT_LBS_LBS NR_NR	VERNICIATURA T SPEC 5L 0036.1 API DATA 20 0.375 BR-X42R PSL 2 SMLS ASTM ASME A SA 106 B/C PSI1420NDE ASTM ASME A SA 53 B S HEAT: COLATA FT_FT_LBS_LBS NR_NR
LEGENDA T = TENARIS Logo API = API Logo DATA = Marking Date COLATA = Heat Number FT = Pipe/Tube Length in feet LBS = Pipe/Tube Weight in pounds NR = Pipe/Tube Identifier	LEGENDA T = Logo TENARIS API = Logo API DATA = Data di marcatura COLATA = Numero di colata FT = Lunghezza del tubo in piedi LBS = Peso del tubo in libbre NR = Identificativo numerico del tubo

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CERTIFICATO DI COLLAUDO
(UNI EN 10204 3.1 / ISO 10474 3.1.B)

Number / Numero:
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Piazza Caduti 6 Luglio 1944, 1
24044 Dalmine (BG) - Italy
+39 035 550 111 tel
+39 035 550 3827 fax

17S-3451
LN-9 PIPE
OK

Customer / Cliente: MATTSCO SUPPLY		Customer's Order Item / Rifer. Ordine Cliente: Item		Manufacturer's Works Order N° / Conteggio Posizione: 1293572/002	
Manufacture Process / Processo di fabbricazione: SEAMLESS LINE PIPES		Product Type / Tipo di prodotto: TUBI S.S. LINE PIPE		Surface / Superficie: BARE INSIDE, EXTERNALLY PROTECTED BY VARNISH	
Standard or Specification / Norme o specifica: See note nr.1		Steel Grade / Grado dell'Acciaio: See note nr.2		Ends / Estremità: GREZZI INTERNAMENTE, OLEATI ESTERNAMENTE	
Dimensions / Dimensioni: Ø 20.000" O.D. x 0.375" W.T.		Length / Lunghezza: 37.999 ft ± 42.001 ft		BEVEL API 5L / ISO 3183 CT4-8825	
Schedule / Scheda: 20		Quantity / Quantità: 4Pcs/Pz		SMUSSATI SECONDO API 5L / ISO 3183 CT4-8825	
Ø 506.00mm O.D. x 9.53mm W.T.		162.73 ft		Nominal Weight / Peso nominale: 78.72 lb/ft	
		49.6 mt		117.15 Kg/m	

This is to certify that the product described here has been manufactured, sampled, tested, and inspected in accordance with purchaser order requirements. This certificate is not a declaration of origin nor may it be used as a declaration of origin.

Si certifica che il prodotto descritto è stato prodotto, provato, testato e controllato in conformità ai requisiti dell'ordine del cliente. Questo certificato non è una dichiarazione d'origine e non può essere usato come tale.

CUSTOMER THIRD PARTY		TENARIS QUALITY DEPARTMENT SIGNATURE	
INSPECTION COMPANY COMPAGNIA DI SPERIMENTAZIONE		CHIEF OF QUALITY CERTIFICATION DEPT. RESPONSABILE DELL'UFFICIO CERTIFICAZIONE QUALITÀ FERRARI Donato	

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4 OF 4

175-3451
L.V. 4.17 PIPE
OK cm

002 07 dHS

•

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

ORDER NUMBER 0141305

PO NUMBER 344-S-16

ORDER DATE 07/29/16

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
009	2	8" 150 RF WN SCH 120	SA105-14	QV1	61290
010	50	8" 150 RF WN XH	SA105-14	M976	CM3053643
011	5	12" 150 RF WN SCH 80	SA105-14	J817	CM3026092
012	6	14" 150 RF WN SCH 80	SA105-N-14	3UX	446600
014	3	18" 150 RF WN XH	SA105-14	X066	WR16966
015	2	20" 150 RF WN STD	SA105-14	K992	NUMM14105798
016	4	20" 150 RF WN XH	SA105-14	X146	NUMM15103330

CHEMICAL PROPERTIES

HEAT CODE	C	SI	MN	P	S	CR	AL	CU	NI	MO	V	CB	SN	N	CE
QV1	0.180	0.240	1.120	0.011	0.005	0.100	0.028	0.020	0.010	0.000	0.019	0.000	0.000	0.000	0.393
M976	0.200	0.220	1.010	0.009	0.020	0.090	0.002	0.180	0.060	0.017	0.001	0.002	0.010	0.000	0.406
J817	0.190	0.230	0.980	0.009	0.020	0.070	0.002	0.230	0.070	0.020	0.004	0.001	0.011	0.000	0.392
3UX	0.180	0.200	1.130	0.010	0.008	0.060	0.037	0.020	0.020	0.010	0.020	0.000	0.000	0.005	0.389
X066	0.160	0.230	1.210	0.007	0.005	0.090	0.020	0.200	0.120	0.040	0.070	0.020	0.012	0.014	0.423
K992	0.170	0.190	1.180	0.008	0.003	0.100	0.024	0.180	0.080	0.030	0.020	0.004	0.007	0.010	0.414
X146	0.170	0.210	1.180	0.009	0.003	0.090	0.032	0.190	0.090	0.030	0.019	0.002	0.006	0.009	0.413

PHYSICAL PROPERTIES

HEAT CODE	TENSIL	YIELD	%ELONG	%R.A.	HBW	CHARPY	FT-LBS	LAT EXPN	SHR FRACT	TEST TEMP
QV1	71485	46545	36.00	68.10	147					
M976	82700	48300	35.60	60.50	167/170					
J817	77100	45300	32.20	54.30	166/166					
3UX	71920	40020	28.20	52.67	144/151					
X066	80700	57600	39.70	74.40	174/179					
K992	80600	51500	31.90	71.30	170/170					
X146	81500	53500	32.30	68.30	159/167					

NOTES**HEAT CODE NOTE**

QV1
M976
J817
3UX NORMALIZED, TEMP/1650F, TIME @ TEMP/1 HR PER INCH, AIR COOL
X066
K992
X146

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)

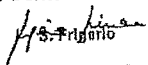
NOTICE: Any unauthorized downloading, reproduction, distribution, or use of this electronic media is hereby prohibited. Violators shall be prosecuted to the fullest extent of the law.

M. S. H.
Quality Assurance Manager

RECEIVED
DEC 04 2017
BY: *[Signature]*

175-3451
LN: 71, 72 RFWN
OK CM

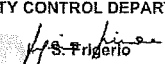
 METALFAR PRODOTTI INDUSTRIALI SPA 23861 CESANA BRIANZA (LC) - ITALY VIA G. PARINI, 28 PHONE + 39 031 655441 - FAX +39 031 655149 quality.mff@fermas.com		COMPANY WITH MANAGEMENT SYSTEM CERTIFIED BY DNV = ISO 9001 = = ISO 14001 =																																																									
INSPECTION CERTIFICATE EN 10204:2004 / 3.1		Nr. 2014-C_MFF-02175 Date / Dated 28.04.2014																																																									
US		Ordine / PO I-3035BB/TEAM Item 011 Packing List 2014-3E301-0001817 Fattura / Invoice 2014-3E401-0001602 Nr. rif. / Our ref. 2013-3E201-0002790-0007																																																									
US		US																																																									
Cod. colata Heat Code	Nr. colata Heat Nr	Quantità Quantity	Descrizione Description																																																								
	13/38704	20.00	W/N 300 RF 6" XS LF2CL1																																																								
Mat. in acc. a / Mat. in acc. to ASTM/ASME A 350/SA 350 M-13 ASME CODE SECT. II, PART A, ED. 2013 ASTM A350 LF2 CL1 NACE MR 0175/2008 ISO 16158 NACE MR 0103/2012 O.A.S. IN ACCORD WITH PRESS EQUIP. DIRECT 97/23/EC (PED) ANNEX I, PARAGRAPH 4.3 CERT. MLN 0551016/01																																																											
<table border="1"> <thead> <tr> <th>Elementi / Elements</th> <th>C</th> <th>Si</th> <th>Mn</th> <th>S</th> <th>P</th> <th>Cr</th> <th>Ni</th> <th>Mo</th> <th>Ti</th> <th>Cu</th> <th>V</th> <th>Nb</th> <th>N</th> </tr> </thead> <tbody> <tr> <td>LADLE ANALYSIS</td> <td>0,180</td> <td>0,220</td> <td>0,870</td> <td>0,007</td> <td>0,009</td> <td>0,080</td> <td>0,050</td> <td>0,010</td> <td>0,016</td> <td>0,150</td> <td>0,002</td> <td>0,002</td> <td>0,010</td> </tr> <tr> <td>LADLE ANALYSIS</td> <td>Al</td> <td>0,025</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>CE LF</td> <td>CE SF</td> <td>F1</td> <td>F2</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0,385</td> <td>0,352</td> <td>0,302</td> <td>0,100</td> </tr> </tbody> </table>				Elementi / Elements	C	Si	Mn	S	P	Cr	Ni	Mo	Ti	Cu	V	Nb	N	LADLE ANALYSIS	0,180	0,220	0,870	0,007	0,009	0,080	0,050	0,010	0,016	0,150	0,002	0,002	0,010	LADLE ANALYSIS	Al	0,025								CE LF	CE SF	F1	F2											0,385	0,352	0,302	0,100
Elementi / Elements	C	Si	Mn	S	P	Cr	Ni	Mo	Ti	Cu	V	Nb	N																																														
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										0,385	0,352	0,302	0,100																																														
CE LF=C+Mn+V/(C+Mn+V)+1/(Ni+Cu)/16 CE SF=C+Mn/6 F1=Cu+Ni+Cr+Mo+V F2=Cr+Mo																																																											
<table border="1"> <thead> <tr> <th>Provetta Test specimen</th> <th>Forma Shape</th> <th>Snervamento > 0,2% Yield strength > 0,2%</th> <th>Snervamento > 1,0% Yield strength > 1,0%</th> <th>Rottura Tensile</th> <th>Allungamento Elongation</th> <th>Contrazione Reduction of area</th> </tr> </thead> <tbody> <tr> <td>128,80</td> <td>60,80</td> <td>20</td> <td>354,0</td> <td>521,0</td> <td>31,0</td> <td>80,0</td> </tr> </tbody> </table>				Provetta Test specimen	Forma Shape	Snervamento > 0,2% Yield strength > 0,2%	Snervamento > 1,0% Yield strength > 1,0%	Rottura Tensile	Allungamento Elongation	Contrazione Reduction of area	128,80	60,80	20	354,0	521,0	31,0	80,0																																										
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128,80	60,80	20	354,0	521,0	31,0	80,0																																																					
DUREZZA / HARDNESS HBW 165,0 - 185,0 Tipo / Type KV 10x10 mm 46 72 73 69 71,3																																																											
RESILLENZA / IMPACT TEST Provetta / Test Specimen 10x10 mm 46 72 73 69 71,3																																																											
Tratt. Term. / Heat treatment NORMALIZED AT 930 °C - COOLED IN STILL AIR ELECTRIC FURNACE																																																											
Dim in acc. a / Dim. acc. to ASME/ANSI B16.5-2013 ASME/ANSI B36.10M-2010																																																											
Finitura / Roughness 125/250 MICRONS AARH																																																											
Marcatura in acc. / Marking in acc. to MSS SP25 Ed. 2013 Vis. & Dim. SATISFACTORY Origine / Origin of Steel ITALY																																																											
Note / Notes 100% MANUFACTURED IN ITALY MANUFACTURING IN ACCORDANCE WITH ORDER AND SPECIFICATION																																																											

UFFICIO CONTROLLO QUALITA' QUALITY CONTROL DEPARTMENT 	ENTE UFFICIALE DI COLLAUDO INSPECTION AUTHORITY	MARCHIO PRODUZIONE MANUFACTURER'S SYMBOL 
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SEP 28 2017

175-3451
LN. 81 RFWN

 METALFAR PRODOTTI INDUSTRIALI SPA 23861 CESANA BRIANZA (LC) - ITALY VIA G. PARINI, 28 PHONE + 39 031 655441 - FAX +39 031 655149 certificate@metalfaritaly.com		COMPANY WITH MANAGEMENT SYSTEM CERTIFIED BY DNV = ISO 9001 = = ISO 14001 =																																											
INSPECTION CERTIFICATE EN 10204:2004 / 3.1		Nr 2015-C_MFF-03838	Data / Dated 10.09.2015																																										
Ordine / PO I-628-S-15/MAT Item 061 DDT / Delivery note 2015-3E301-0003338 Packing List 2015-3E401-0002929 Fattura / Invoice 2015-3E401-0002929 Ns. rif. / Our ref. 2014-3E201-0003536-0061																																													
Cod. colata 007 Heat Code		Nr. colata B07 Heat Nr 15/38552	Quantità B08 Quantity 20,00																																										
Mat. in acc. a / Mat. in acc. to B02 ASTM/ASME A 350/SA 350 M - 15 ASME CODE SECT. II, PART A, ED. 2013 ASTM A350 LF2.CL1 NACE MR-0175/2009 ISO 15156 NACE MR-0103/2012 Q.A.S. IN ACCORD WITH PRESS. EQUIPM. DIRECT. 97/23/EC (PED) ANNEX I, PARAGRAPH 4.3 CERT. 4687-2014-CE-ITA-ACCREDIA		Descrizione B01 - (B09 - B11) Description W/N 300 RF 10" XS LF2CL1																																											
<table border="1"> <thead> <tr> <th>Elementi / Elements</th> <th>C</th> <th>Si</th> <th>Mn</th> <th>S</th> <th>P</th> <th>Cr</th> <th>Ni</th> <th>Mo</th> <th>Ti</th> <th>Cu</th> <th>V</th> <th>Nb</th> <th>N</th> </tr> </thead> <tbody> <tr> <td>LADLE ANALYSIS</td> <td>0,185</td> <td>0,240</td> <td>0,980</td> <td>0,008</td> <td>0,009</td> <td>0,090</td> <td>0,060</td> <td>0,020</td> <td>0,019</td> <td>0,160</td> <td>0,002</td> <td>0,001</td> <td>0,010</td> </tr> <tr> <td>LADLE ANALYSIS</td> <td>0,028</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0,385</td> <td>0,348</td> <td>0,332</td> <td>0,110</td> </tr> </tbody> </table>				Elementi / Elements	C	Si	Mn	S	P	Cr	Ni	Mo	Ti	Cu	V	Nb	N	LADLE ANALYSIS	0,185	0,240	0,980	0,008	0,009	0,090	0,060	0,020	0,019	0,160	0,002	0,001	0,010	LADLE ANALYSIS	0,028									0,385	0,348	0,332	0,110
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UFFICIO CONTROLLO QUALITA' QUALITY CONTROL DEPARTMENT 	ENTE UFFICIALE DI COLLAUDO INSPECTION AUTHORITY	MARCHIO PRODUZIONE MANUFACTURER'S SYMBOL 
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175-3451
 LN-87 RFWN
 OK

TO: STEELTEK

DATE: 09/10/16
TIME: 10:37:01
SERIAL NO: F0101237
EBS NO: 20018065

FAIRFIELD TUBULAR OPERATIONS
CERTIFIED TEST REPORT
(IN ACCORDANCE WITH ISO 10474/EN10204/DIN5004)

U.S.S. SEAMLESS TUBULAR OPS	
ORDER/ITEM NO	SHIPPERS NO.

MILL ORDER/ITEM NO DR94862 01	SHIPPERS NO.	P.O. NUMBER 335-S-16	VEHICLE ID
SOLD TO ADDRESS MATTSO SUPPLY CO 1111 N 161ST EAST AVE TULSA OK 74116-4035		MAIL TO ADDRESS MATTSO SUPPLY CO 1111 N 161ST EAST AVE TULSA OK 74116-4035	
		VENDOR U.S.S. SEAMLESS TUBULAR OPS FAIRFIELD TUBULAR OPERATIONS 5700 VALLEY ROAD P.O. BOX 599 FAIRFIELD, AL 35064	

SPECIFICATION AND GRADE

SMLS STANDARD AND LINE PIPE API 5L 45TH EDITION DATED 12/1/12 GRADE B/X42 R N OR Q PSL-2, ASTM A106-15 GRADE B/C, ASTM A53-12 GRADE B, ASME SA106-2015 GRADE B/C, ASME SA53-2015 GRADE B REG MILL COAT PE BEV 30 DEGREE APPLICABLE REQUIREMENTS OF NACE MR0103-2012 ED AND NACE MR0175/ISO 15156-2:2015 ED

MATERIAL COND:		AS-ROLLED		OD.: 8.625 (219.075)		In (mm)		WALL: 0.500 (12.700)		In (mm)		
PRODUCT IDENTIFICATION		TEST TYPE/ ORIENTATION	TEST COND.	GAUGE WIDTH IN	YIELD MIN: MAX:	EXT % PSI	TENSILE PSI MIN: MAX:	YIT	ELONG % (IN 2")	HARDNESS SCALE: MIN: MAX:	MIN HYDRO PSI	DWELL(SEC)
MA8523		STRIP/L/B	AR	1.5	48,900 MIN: MAX:	.50 PSI	70,000 MIN: MAX:	0.64	29.0 MIN: MAX:	2970 MIN: MAX:	2970	5
** END OF DATA THIS SHEET **												

LEGEND:		L - LONGITUDINAL U - UPSET		T - TRANSVERSE NM - NORMALIZED		QT - QUENCH & TEMPERED SR - STRESS RELIEVED		AR - AS ROLLED TR - THERMO MECHANICAL ROLLED		B - BODY		W - WELD						
PRODUCT IDENTIFICATION	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	AL	N	V	B	TI	GB	CO	G.E.T. MAX
MA8523	HEAT	20	1.09	0.09	0.01	22	.08	.04	.06	.02	.025	.00	.0003	.002	.002			.41
MA8523	PROD	22	1.13	0.10	0.02	23	.07	.04	.07	.02	.024	.00	.0004	.002	.001			.43
MA8523	PROD	22	1.12	0.10	0.02	23	.07	.04	.07	.02	.023	.00	.0004	.002	.001			.43
** END OF DATA THIS SHEET **																		

*C.E. IS BASED ON THE FOLLOWING EQUATION(S): C+MN/6+CR/5+MO/5+V/5+NI/15+CU/15 (EUROPEAN CEV)

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT. ELEMENTS REPORTED IN MASS FRACTION (%)

00000000	TQ45232	0158554030	0-0-0	PAGE	1 OF 2
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PAGE 1 OF 2

0158554030

TQ452B32

00000000

DATE: 09/10/16
TIME: 10:37:01
SERIAL NO: F0101237
EBS NO: 2001806535 1

U.S.S. SEAMLESS TUBULAR OPS
FAIRFIELD TUBULAR OPERATIONS
CERTIFIED TEST REPORT
(IN ACCORDANCE WITH ISO 10474/EN10204/DIN50049 "type 3.1")

MILL ORDER ITEM NO DR94862 01		SHIPPERS NO.		P.O. NUMBER 335-S-16		O.D.: 8.625 (219.075)		WALL: 0.500 (12.700)		In (mm)		In (mm)	
MATERIAL COND: AS-ROLLED		MIN COLLAPSE		DIR		TEST LOC		TEMP		SIZE		CHARPY V-NOTCH IMPACT TESTING	
PRODUCT IDENTIFICATION		BEND		FLAT		OK		T B		FULL AR		70 78 75 74 40 45 45 43	
MA8523		**		END OF DATA THIS SHEET **		T B		+ 32		DEG F		15 15 15 20 1	
LEGEND		L- LONGITUDINAL		T- TRANSVERSE		B- BODY		W- WELD		HAZ- HEAT AFFECTED ZONE			
TEST / INSPECTION		YES		RESULTS / COMMENTS									
FULL LENGTH VISUAL		X		OD		OD		X		L		UT X 10.0/10.0% NOTCH	
FULL LENGTH EMI		X		ID		ID		X		L		UT	
FULL LENGTH MPI		X		MPI		MPI		UT		UT		UT	
END AREA INSPECTION (PLAIN END)		X		MPI		MPI		UT		UT		UT	
SPECIAL END AREA (SEA) INSP				DRIFT		DRIFT		MANDREL SIZE:					
FULL LENGTH DRIFT													
ADDITIONAL NOTES/COMMENTS													
ALL MELTING AND MANUFACTURING TOOK PLACE IN THE USA.													
MANUFACTURED IN AN ISO 9001 CERTIFIED FACILITY - CERTIFICATE #30727.													
NO REPAIRS BY WELDING. NO MERCURY OR MERCURY COMPOUNDS ARE ADDED TO THE STEEL AND ALL MERCURY BEARING EQUIPMENT IS PROTECTED BY A DOUBLE BOUNDARY OF CONTAINMENT.													
** END OF DATA **													

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS MANUFACTURED, SAMPLED, TESTED AND/OR INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS THE REQUIREMENTS IN SUCH RESPECTS.

PREPARED BY THE OFFICE OF: MICHAEL HENRY - MANAGER, Q.A.
FAIRFIELD TUBULAR OPERATIONS

DATE 09/10/16

00000000 TQ452B32 0158554030

0-0-0 PAGE 2 OF 2

**

RECEIVED
JAN 11 2017
STC

8
w yg-2053

175-3451
LN-714.72A
PIPE

DATE: 09/10/16
TIME: 10:37:04
PAGE: 1 OF 1

TUBULAR PRODUCTS
ADDITIONAL COMMENTS SHEET

U.S.S. SEAMLESS TUBULAR OPS
FAIRFIELD TUBULAR OPERATIONS

MILL ORDER ITEM NO DR94862 01	SHIPPERS NO.	P.O. NUMBER 335-S-16	HEAT	SERIAL NUMBER: F0101237
SOLD TO ADDRESS MATTSO SUPPLY CO 1111 N 161ST EAST AVE TULSA OK 74116-4035		MAIL TO ADDRESS		VENDOR U.S.S. SEAMLESS TUBULAR OPS FAIRFIELD TUBULAR OPERATIONS P.O. BOX 599 FAIRFIELD ALABAMA 35064

HEAT MA8523 - MELTED AT: NUCOR STEEL MEMPHIS, MEMPHIS, TN 38109
END OF DATA

Skid 2 relocated from
UOPR Job 488 to 447

17S-3451
LN-71A.72A
PIPE

RECEIVED
JAN 11 2017

U.S.S. SEAMLESS TUBULAR OPS
 DATE: 08/06/17
 TIME: 10:06:52
 SERIAL NO: F0106312
 EBS NO: 200231933 1

FAIRFIELD TUBULAR OPERATIONS
 CERTIFIED TEST REPORT
 (IN ACCORDANCE WITH ISO 10474/EN10204/DIN50049 "type 3.1")

SHIPPER'S NO. 678-S-17
 VEHICLE ID

SOLD TO ADDRESS
 MATTSO SUPPLY CO
 1111 N 161ST EAST AVE
 TULSA OK 74116-4035

MAIL TO ADDRESS
 MATTSO SUPPLY CO
 1111 N 161ST EAST AVE
 TULSA OK 74116-4035

VENDOR
 U.S.S. SEAMLESS TUBULAR OPS
 FAIRFIELD TUBULAR OPERATIONS
 5700 VALLEY ROAD
 P.O. BOX 599
 FAIRFIELD, AL 35064

SPECIFICATION AND GRADE
 SMLS STANDARD AND LINE PIPE API 5L 45TH EDITION DATED 12/1/12 GRADE X52Q PSL-2, ASTM A333-16 GRADE 6,
 ASME SA333-2015 GRADE 6 REG MILL COAT PE BEV 30 DEGREE APPLICABLE REQUIREMENTS OF NACE MR0103-2012 ED
 AND NACE MR0175/ISO 15156-2 2015 ED

PRODUCT IDENTIFICATION	TEST TYPE/ ORIENTATION	TEST COND.	GAGE WIDTH	QUENCHED & TEMPERED				O.D. 6.625 (168.275)				I.D. 0.432 (10.972)				In (mm)	
				YIELD	UTS	ELONG %	HARDNESS	MIN HYDRO	PSI	MIN	MAX	MIN	MAX	MIN	MAX	IN (mm)	DWELL (SEC)
MB4299	STRIP/L/B	QT	1.5	66,000	81,000	0.82	87.3	2970		30.0	49.3	87.3	2970			5	
MB4299	STRIP/L/B	QT	1.5	64,500	79,500	0.81				51.6						5	
MB4300	STRIP/L/B	QT	1.5	64,000	79,500	0.81				42.6						5	
MB4300	STRIP/L/B	QT	1.5	63,500	79,000	0.81				43.1						5	

LEGEND: L-LONGITUDINAL T-TRANSVERSE NM-NORMALIZED SR-STRESS RELIEVED AR-AS ROLLED TR-THERMO MECHANICAL ROLLED B-BODY W-WELD

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT. ELEMENTS REPORTED IN MASS FRACTION (%)									
00000000	KHJ10B22	0158554030	0-0-0	PAGE	1	QF	4		

*C.E. IS BASED ON THE FOLLOWING EQUATION(S): C+MN/5+CR/5+MO/5+V/5+NI/15+CU/15 (EUROPEAN CEV)

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT. ELEMENTS REPORTED IN MASS FRACTION (%)



U.S.S. SEAMLESS TUBULAR OPS

FAIRFIELD TUBULAR OPERATIONS

DATE: 08/06/17
TIME: 10:06:52
SERIAL NO: F0106312
EBS NO: 2002331933 1CERTIFIED TEST REPORT
(IN ACCORDANCE WITH ISO 10474/EN10204/DIN50049 "Type 3.1")

MILL ORDER ITEM NO DR96377 01		SHIPPER'S NO. 678-S-17		P.O. NUMBER 678-S-17		O.D. 6.625 (168.275)		I.D. 5.913 (150.025)		WALL 0.432 (10.972)		IN (mm)		IN (mm)	
MATERIAL COND: QUENCHED & TEMPERED		MIN COLLAPSE		GRAIN SIZE		FLAT		BEND		CHARPY V-NOTCH IMPACT TESTING		F.T.L.B.		% SHEAR	
PRODUCT IDENTIFICATION		OK		OK		OK		OK		TEST LOC.		TEMP		SIZE	
MB4299		OK		OK		OK		OK		DEG F		1		2	
MB4299		OK		OK		OK		OK		*NOTE A		1		2	
MB4300		OK		OK		OK		OK		*NOTE B		1		2	
MB4300		OK		OK		OK		OK		*NOTE B		1		2	
LEGEND		L - LONGITUDINAL		T - TRANSVERSE		B - BODY		W - WELD		HAZ - HEAT AFFECTED ZONE					
TEST / INSPECTION INFORMATION												RESULTS / COMMENTS			
TEST / INSPECTION												YES			
FULL LENGTH VISUAL												X			
FULL LENGTH EMI												X			
FULL LENGTH MPI												X			
FULL LENGTH UT												X			
END AREA INSPECTION (PLAIN END)												X			
SPECIAL END AREA (SEA) INSP												X			
FULL LENGTH DRIFT												X			
ADDITIONAL NOTES/COMMENTS															
ALL MELTING AND MANUFACTURING TOOK PLACE IN THE USA MANUFACTURED IN AN ISO 9001 CERTIFIED FACILITY - CERTIFICATE #30727. NO REPAIRS BY WELDING. NO MERCURY OR MERCURY COMPOUNDS ARE ADDED TO THE STEEL AND ALL MERCURY BEARING EQUIPMENT IS PROTECTED BY A DOUBLE BOUNDARY OF CONTAINMENT. IMPACT STRIKER RADIUS 8MM. *NOTE A SEE ATTACHED REPORT FOR IMPACT RESULTS. *NOTE B SEE ATTACHED REPORT FOR IMPACT RESULTS. *NOTE C SEE ATTACHED REPORT FOR ADDITIONAL NOTES. ** END OF DATA **															

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS MANUFACTURED, SAMPLED, TESTED AND/OR INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS THE REQUIREMENTS IN SUCH RESPECTS.

PREPARED BY THE OFFICE OF:

MICHAEL HENRY - MANAGER, Q.A.
FAIRFIELD TUBULAR OPERATIONS

DATE: 08/06/17

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PAGE

2 OF

4



U.S.S. SEAMLESS TUBULAR OPS
FAIRFIELD TUBULAR OPERATIONS

TUBULAR PRODUCTS
ADDITIONAL COMMENTS SHEET

DATE: 08/06/17
TIME: 10:06:59
PAGE: 1 OF 1

MILL ORDER/ITEM NO DR96377 01	SHIPPER'S NO.	P.O. NUMBER 678-S-17	HEAT	SERIAL NUMBER: R0106312
SOLD TO ADDRESS MATSCO SUPPLY CO 1111 N 161ST EAST AVE TULSA OK 74116-4035		MAIL TO ADDRESS		VENDOR U.S.S. SEAMLESS TUBULAR OPS FAIRFIELD TUBULAR OPERATIONS P.O. BOX 599 FAIRFIELD ALABAMA 35064
HEAT MB4299 - MELTED AT:NUCOR STEEL MEMPHIS, MEMPHIS, TN 38109 HEAT MB4300 - MELTED AT:NUCOR STEEL MEMPHIS, MEMPHIS, TN 38109 HEAT MB4302 - MELTED AT:NUCOR STEEL MEMPHIS, MEMPHIS, TN 38109 END OF DATA				

175-3451
LC-814 PIPE
OC

SEP 20 2017



U.S.S. SEAMLESS TUBULAR OPS
FAIRFIELD TUBULAR OPERATIONS

TUBULAR PRODUCTS
SUPPLEMENTAL STATEMENT SHEET

DATE: 08/06/17
TIME: 10:06:59
PAGE: 1

MILL ORDER/ITEM NO DR96377 01	SHIPPERS NO.	P.O. NUMBER 678-S-17	HEAT	SERIAL NUMBER: F0106312
SOLD TO ADDRESS MATSCO SUPPLY CO 1111 N 161ST EAST AVE TULSA OK 74116-4035		MAIL TO ADDRESS		VENDOR U.S.S. SEAMLESS TUBULAR OPS FAIRFIELD TUBULAR OPERATIONS P.O. BOX 599 FAIRFIELD ALABAMA 35064
HEAT MB4299 MINIMUM TEMPERING TEMPERATURE IS 910 DEG F. HEAT MB4300 MINIMUM TEMPERING TEMPERATURE IS 910 DEG F. HEAT MB4302 MINIMUM TEMPERING TEMPERATURE IS 910 DEG F.				

SKIN 2 relocated from
USPR Job 488 to 447

175-3451
Lvl. 814 PIPE
OK

SEP 28 2017
OK



U.S.S. SEAMLESS TUBULAR OPS

TUBULAR PRODUCTS
IMPACT TEST REPORT

DATE: 08/06/17
TIME: 10:06:58
PAGE: 1

MILL ORDER ITEM NO DR96377 01		SHIPPERS NO.	P.O. NUMBER 678-S-17	HEAT	SERIAL NUMBER: F0106312
SOLD TO ADDRESS MATSCO SUPPLY CO 1111 N 161ST EAST AVE TULSA OK 74116-4035		MAIL TO ADDRESS		VENDOR U.S.S. SEAMLESS TUBULAR OPS FAIRFIELD TUBULAR OPERATIONS P.O. BOX 599 FAIRFIELD ALABAMA 35064	

HEAT / LOT / PIPE # LOC/CND	TEST TYPE/ FT SIZE LBS.	% SHR.	LAT EXP.	MIN AVG FT LBS.
+ 32 DEG F				
MB4299				+ 15 + 12
000001	TCVN 3/4	112 120 100 100		
B QT				
+ 10 + 08				
MB4299				+ 10 + 08
000324	LCVN 3/4	183 179 100 100		
B QT				
+ 32 DEG F				
MB4300				+ 15 + 12
000245	TCVN 3/4	103 102 100 100		
B QT				

To: STEELTEK

09/22/2017 From: MATSCO SUPPLY COMPANY

17S 3451
L2.814 pipe

SEP 28 2017

Skid relocated from
UOPR Job 488 to 447

Ord# 702873-1; PO# 839-S-12; Ht# T21780; 10 .500 A333 GR6 API5LB X42/X5 2 A53B/A



TRINECKÉ ŽELEZÁRNY

Sheet: 1

Number: A 2010/12/005163-JAN

TRINECKÉ ŽELEZÁRNY, a.s. / Průmyslová 1000 / 739 70 Trinec - Staré Město / Czech republic
 Production mill: VT - VÁLCOVNA TRUB / Výstavní 1132 / 706 02 Ostrava - Vítkovice / Czech Republic



1020093

Purchase Order No.:
008020-A Rev:1

Shop Order No./DS:
9700201403
0041155305 / 176

Advice Note No.:
10/12/002652/02 14.12.2010

Inspection certificate 3.1, EN 10204:2004

Products, Dimension, Specifications		Quantity	Grade	Norm										
Line Pipes 10.750 in x 0.500 in Bevelled ends acc. to API 5L		13 pcs 534,17 ft 13848 kgs	X62N/PSL2 X42N/PSL2 BN/PSL2 Gr.B Gr.B Gr.B	API SPEC 5L 44. EDITION API SPEC 5L 44. EDITION API SPEC 5L 44. EDITION ASTM A53 08/2007 ASTM A108 07/2008 ASTM A333 03/2005 ASME B36.10										
API5L X52N/X42N/BN/PSL2, ASTM A-53 GR.B/A108 GR.B/A333 GR.B, ASME SA53/SA108B/SA333 GR.B NACE MR-01-75														
Requirements (pipes):														
Heat No.	Specimen No.	Yield Strength R _{0.2} psi	Tensile Strength R _m psi	Elongation Z %										
		52200-55300	66700-110200	min 30										
		Methods: L	Temperature(°F): 70											
T21780	66781	52678	73389	47.20										
T21780	66801	54027	74448	48.70										
Heat No.	Specimen No.	Impact test ft.lb	Lateral expandit	Shear fracture area %										
		0.394in x 0.394in												
		Methods: L	Temperature(°F): 32											
T21780	66781	103 89 102												
Heat No.	Specimen No.	Impact test ft.lb	Lateral expandit	Shear fracture area %										
		0.394in x 0.394in												
		Methods: L	Temperature(°F): -50											
T21780	66781	140 130 133												
Heat No.	Specimen No.	Hardness HBW NACE MR 01-75 max 237												
T21780	66781/0	145 148 140												
Heat chemical analysis in % (pipes):														
Heat No.	C	Mn	Si	P	S	Cu	Ni	Cr	Mo	V	Ti	Nb	B	Ceq
T21780	0.16	1.19	0.20	0.014	0.009	0.04	0.02	0.17	0.003	0.021	0.001	0.003	0.0003	0.40
Ceq max: 0.43														
ALL PRODUCTS MEET REQUIREMENTS OF ABOVE MENTIONED STANDARDS AND REQUIREMENTS SPECIFIED IN ORDER THE DECLARATION IS ISSUED UNDER THE SOLE RESPONSIBILITY OF THE SUPPLIER														

Ostrava-Vítkovice:
16.12.2010

tel.: 00420/58/595/2354
fax: 00420/58/595/2158



TRINECKÉ ŽELEZÁRNY, a.s.
Trinec - Staré Město, Průmyslová 1000
PSČ 739 70

Work's Inspector

SEP 28 2017

175-3451
LN-87A pipe
brcm

Ord# 702873-1; PO# 839-S-12; Ht# T21780; 10 .500 A333 GR6 API5LB X42/X5 2 A53B/A



TŘINECKÉ ŽELEZÁŘNY

Sheet : 2

Number : A 2010/12/005163-JAN

TŘINECKÉ ŽELEZÁŘNY, a.s. / Průmyslová 1000 / 739 70 Třinec - Staré Město / Czech republic
 Production mill : VT - VÁLCOVNA TRUB / Výstavní 1132 / 708 02 Olomouc - Vítkovice / Czech Republic

Product chemical analysis in % (pipes):														Ceq max.: 0,43	
Heat No.	Specimen No.	C	Mn	Si	P	S	Cu	Ni	Cr	Mo	V	Ti	Al	B	Ceq
T21780	66781	0,18	1,18	0,21	0,011	0,010	0,04	0,02	0,18	0,005	0,020	0,002	0,003	0,0003	0,42
T21780	66782	0,17	1,18	0,21	0,011	0,009	0,03	0,02	0,18	0,005	0,020	0,002	0,003	0,0003	0,41

Other requirements:

Visual and dimensional inspections

- satisfactory

Flattening test

ASTM A 530

- satisfactory

Hydrostatic test - test pressure

2970 psi/6a

- satisfactory

Ultrasonic testing

ASTM E213 L 12,5%

- satisfactory

The tubes are free of mercury contamination and no weld repair was performed.

The width of gauge length of the tension test specimen is 1 1/2 in.

Exported by MORAVIA-STEEL.

JAN 2 2017

Olomouc-Vítkovice:
18.12.2010

tel.: 00420/59/595/2354
fax: 00420/59/595/2168



TŘINECKÉ ŽELEZÁŘNY, a.s.
Třinec - Staré Město, Průmyslová 1000
PSC 739 70

Work's Inspector

175-3451
LN. 87A PIPE
OK

SEP 20 2017

NUCOR
PLATE MILL

P.O. Box 273
Winston, NC 27386
(282) 356-3700

Mill Test Report Page 1

1505 River Rd
Cofield, NC 27922
(282) 356-3700

AMERICAN ALLOY
PLATE #0148850
NUCOR
It's Our Nature.

Issuing Date: 04/17/2017 B/L No.: 469287
Vehicle No: LW 62121
Specifications: 0.5000" x 96.000" x 480.000"
ASTM A516 70/65/60-10/2015/ASME SA516-70/65/60 P/Q 2013/2016
Normalized Plates NACE MR0175 Annex 2.1.2, MR0103 (2010) Section
2.1.2 Compliant (2016) 13.1.1, 14.1.2/Vacuum Degassed
Marking: 4801/58812 110933-OK

Load No.: 478516 Our Order No.: 1452803
Sold To: AMERICAN ALLOY STEEL INC
6230 N HOUSTON ROSSLYN RD
PO BOX 40469
NORTH HOUSTON, TX 77061

Cust. Order No.: 110933-OK
Ship To: AMERICAN ALLOY STEEL
6350 N ERIE AVE
C/O SKOL TRACK #21
OWASSO, OK 74055

Heat No	C	Mn	P	S	Si	Cu	NI	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Cuq	Pcm
7502104	0.20	1.05	0.010	0.001	0.18	0.23	0.08	0.12	0.03	0.020	0.006	0.000	0.002	0.0088	0.0029	0.0030	0.009	0.42	0.28
7502115	0.18	1.04	0.010	0.001	0.23	0.22	0.11	0.11	0.04	0.033	0.007	0.001	0.002	0.0057	0.0025	0.0026	0.014	0.41	0.26
Tensile Test																			
Plate Serial No	Plates	Tons	Dir.	Yield (ksi)	Tensile (ksi)	Elong. % to 2"	Elong. % in 8"	Norm F	Heat Treat	Time (min)	Temp F	Time (min)	Temp F	Absorbed Energy (Ft-lb)	Ave	Min	1	2	3
7502104-01	1	3.26 T	T	51,700	76,400	40.0		1650	23					H-L 88.5	83.4	93.2	81.7	15	
7502115-03	5	16.33 T	T	49,400	74,000	40.7		1650	23					H-L 76.0	80.4	49.6	68.7	15	
															Charpy Impacts				
															Shear (%)				
															Temp F				
															Size				
															-50 10mm				
															-50 10mm				

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

Reviewed By

[Signature]

HOT ROLLED CARBON STEEL PLATE
Place frequency change:

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, unless otherwise noted in Specification. For Mexico shipments: nbc-Sales@NuCor.com
Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)+(Cr/20)+(Ni/15)+(Cu/15)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/20)+(Cr/20)
Metall and Manufactured in the USA. ISO 9001:2008 certified (0470840) by SRI Quality System Registrar (00985-09). PED 97/23/EC 712 Annex 1, Para. 4.3 Compliant
DIN 50049 3.1.8/EN 10204 3.1B(2004). DIN EN 10204 3.1(2006) 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.

[Signature]

T.A. Depietre, Metallurgist

4/19/2017 12:00:23 AM

AA PL#: 5184850

TO: STEELTEK, INC.

S.O.#: 581319

Item: 1 (1 PC) 1/2" X 96" X 480"

09/14/2017 From: AMERICAN ALLOY STEEL, INC.

P.O.#: 8263

Item: 1 (1 PC) 1/2" X 96" X 480"

Item: 1 (1 PC) 1/2" X 96" X 480"

Item: 1 (1 PC) 1/2" X 96" X 480"

TEST CERTIFICATE

No: 1 111192

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

P/O No 3161
Rel
S/O No 1 261534-001
B/L No 1 211215-001 Shp 04Apr14
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 111192
03Apr14

1 3/4" SA105

38K

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

ASTM A105-10
ASME SA105
HEAT NUMBER
Cu .23 , V .004 AND Cb/Nb <.008
LOT NUMBER 288529 WEIGHT 35114
TENSILE 75000
YIELD 44000
ELONGATION 28 %
REDUCTION OF AREA 52 %
HARDNESS 144 -144 AT SURFACE
MADE IN THE USA

Heat Number
397168

*** Chemical Analysis ***
C=0.2200 Mn=0.8300 P=0.0100 S=0.0330 Si=0.2100 Cu=0.2300
Ni=0.1100 Cr=0.1000 Mo=0.0200 Al=<.033> Cb=<.008> V=<.004>
Ti=<.001>

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]

PRODUCTION, TULSA, OKLA
CUSTOMER STEELTEK
P.O.# 7450
ITEM 3/4"-6000"x2" TOE Coupling
HEAT CODE 38K

Page: 1 Last
RECEIVED
SEP 07 2016
OK CH

175-3451
LN-93 coupling
OK CH

06Feb15 9:58

TEST CERTIFICATE

No: 1 113288

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 272542-001
B/L No 1 221072-002
Inv No
Shp 06Feb15
Inv

2-10-15

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

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

CERTIFICATE of ANALYSIS and TESTS

Cert. No: 1 113288
06Feb15

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

ASTM A105-
ASME SA105
HEAT NUMBER 145074
Cu .18 , V .038 AND Cb/Nb .003
LOT NUMBER 71496 WEIGHT 15840
TENSILE 83,900
YIELD 60,700
ELONGATION 22 %
REDUCTION OF AREA 41 %
HARDNESS 165 -
MADE IN THE USA

AT SURFACE

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.

B. Papp

RECEIVED
SEP 23 2016
BY: *OK CM*

Page: 1 Last

PRODUCTION MFG, TULSA, OKLA.
CUSTOMER STEELTEK
P.O. # 91409-3321
ITEM 3/4"-6000# X 2" TOE COUPLIS
HEAT CODE 14/K
175-3451
LN-93 coupling
OK CM

Material Test Report Data

725 North Drennan, Houston, Texas
77003-1320
Phone: 713-356-3563
E-mail: qa@danloc.com

MTS THREADED PRODUCTS
P.O. BOX 4748

CORPUS CHRISTI, TX 78469

DAN-LOC Order Number: 532913

Customer PO Number: 23906

Item	Qty	DAN-LOC Heat Code		Product	Size	Mill Heat Code	Standard									
18	800	QCJ11	C	B7 ATS	3/4" X 6-3/4"	10157730	ASTM A193 09									
Item	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Ti	V	B	Cb	Al	Other	Macro Etch
18	.43	.84	.010	.015	.26	.93	.07	.17	.14	-	-	-	-	.028	-	S1R1C1

Charpy Test = Impact V-Notch

Item	Yield 0.2% Offset	Tensile	% Elong	% RA	Hardness Type	Actual Hardness	Temp (F)	Spcm #1 (ft-lb)	Spcm #2 (ft-lb)	Spcm #3 (ft-lb)	24 Hour Test Temp (F)	Hardness	Proof Load (lbf)
18	128375	141370	22.1	62.2	HRC	30	-	-	-	-	-	-	-

Item	Quench Temp (F)	Tempered (F)
18	1600	1200

Additional Data

Additional Certificate Data: USA

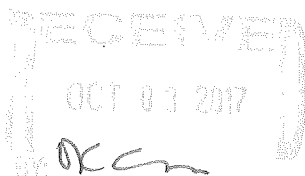
The products referenced in this report were manufactured, sampled, tested and inspected in accordance with the specifications listed and any supplementary requirements or other requirements designated in the purchase order or contract and were found to meet those requirements. This report also certifies that the results shown are correct as contained in the company records and conform to the requirements of the listed standards. The results shown relate only to the items tested as identified above. The material noted within this document complies with the mechanical testing requirements within ASTM/ASME 193/194, as applicable. This certificate shall not be reproduced except in full, without the written approval of Dan-Loc Bolt & Gasket.

Linda Clements

Authorized Signatory (Typeset signatory indicates the use of Digital Password Authorization.)

PO # 94786-3451

MK # 41



175-3451
LN. 41 studs
OK

Material Test Report Data

725 North Drennan, Houston, Texas
77003-1320
Phone: 713-356-3563
E-mail: qa@danloc.com

MTS THREADED PRODUCTS
P.O. BOX 4748

CORPUS CHRISTI, TX 78469

DAN-LOC Order Number: 532913

Customer PO Number: 23906

Item	Qty	DAN-LOC Heat Code		Product	Size	Mill Heat Code	Standard
18	800	QCJ11	C	B7 ATS	3/4" X 6-3/4"	10157730	ASTM A193 09

Item	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Ti	V	B	Cb	Al	Other	Macro Etch
18	.43	.84	.010	.015	.26	.93	.07	.17	.14	-	-	-	-	.028	-	S1R1C1

Charpy Test = Impact V-Notch

Item	Yield 0.2% Offset	Tensile	% Elong	% RA	Hardness Type	Actual Hardness	Temp (F)	Spcm #1 (ft-lb)	Spcm #2 (ft-lb)	Spcm #3 (ft-lb)	24 Hour Test Temp (F)	Hardness	Proof Load (lbf)
18	128375	141370	22.1	62.2	HRC	30							

Item	Quench Temp (F)	Tempered (F)
18	1600	1200

Additional Data

Additional Certificate Data: USA

The products referenced in this report were manufactured, sampled, tested and inspected in accordance with the specifications listed and any supplementary requirements or other requirements designated in the purchase order or contract and were found to meet those requirements. This report also certifies that the results shown are correct as contained in the company records and conform to the requirements of the listed standards. The results shown relate only to the items tested as identified above. The material noted within this document complies with the mechanical testing requirements within ASTM/ASME 193/194, as applicable. This certificate shall not be reproduced except in full, without the written approval of Dan-Loc Bolt & Gasket.

Linda Clements

Authorized Signatory (Typeset signatory indicates the use of Digital Password Authorization.)

PO # 94786-3451

MK # 42

RECEIVED
OCT 03 2017
OK cm

175-3451
LN-42 studs
OK cm

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	IN13-0214	TESTING SAMPLE Q'TY	5PCS	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	CU
(mm)		x100		x1000		x100	
25.0	45	22	69	13	17	6	13

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
	2. Macroetch test : OK

PO # 94786-3451
MK # 43

Soo Bong

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.

175-3451
LN-43 nuts
OK

OCT 03 2017

OK

3407

2/8

175-345
L2-62 Lifting lugs

NUCOR
PLATE MILL

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

Mill Test Report

Page 1

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



Issuing Date : 04/06/2016 B/L No. : 440916 Load No. : 448380 Our Order No. : 1357599 Cust. Order No. : MUS-245481
Vehicle No: LW 62024 Sold To: METALS USA - SOUTHCENTRAL Ship To: METALS USA - PLATES AND SHAPES
Specification: 0.6250" x 120.000" x 480.000" 2800 N 43RD ST E TRACK 747
ASTM A516 70-10(2015)/ASME SA516 70 PVQ 2013/2015 Normalized MUSKOGEE, OK 74403
Test Coupons at 1650 F NACE MR0175 Annex 2.1.2, MR0103 Section 2.1.2

Marking :

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Ceq	Pcm
6502000	0.18	1.05	0.014	0.008	0.20	0.27	0.09	0.07	0.02	0.021	0.006	0.002	0.002		0.0030	0.0003	0.012	0.40	0.27

Tensile Test												Charpy Impacts									
Plate Serial No	Pieces	Tons	Dir.	Yield	(psi)	Tensile	(psi)	Elongation % in 2"	Elongation % in 8"	Dir.	1	(%) shear	2	(%) shear	3	(%) shear	Ave.	(%) shear	Size	Temp	Min Ave.
6502000-05	4	20.41	T	51,300	77,200	23.3															
			T	47,000	70,000	27.3	N														

Charpy Impacts

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: nhc-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 3.1(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. Depreits, Metallurgist

4/6/2016 3:46:30 PM

JUL 14 2016

08/11/2017 From: AMERICAN ALLOY STEEL, INC.

To: STEELTEK, INC.

P.O.#: 8147

S.O.#: 578630

AA PL#: 5183720

Item: 2 (1 PC) 3/8" X 96" X 480"
3420,21

ArcelorMittal Burns Harbor Plate

SHIPMENT NO. 803-19512		DATE SHIPPED 05-01-17		CAR OR VEHICLE NO. CSS-CHGO-BNSF		LMIC 007063		PAGE 5	
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	PAT NO.	HEAT NUMBER	NO. PCS.	THICKNESS	WIDTH OR DIA.	LENGTH	WEIGHT	YIELD POINT	TENSILE STRENGTH	AF FRAC. ELONG.	RED.
---------------	---------	-------------	----------	-----------	---------------	--------	--------	-------------	------------------	-----------------	------

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# 110779-OK GR 354-5454B

→ E549702 813W64050 3 .375 96 480 14703 49600 78400 8 24
(M55)MFST REF#:3 51600 75000 8 25

E549703 813W64050 3 .375 96 480 14703 52600 79100 8 24
(M55)MFST REF#:3 52200 73900 8 25

E549704 813W64050 3 .375 96 480 14703 59900 81500 8 22
(M55)MFST REF#:3 53200 74500 8 24

E549705 813W64050 2 .375 96 480 9802 65100 83100 8 23
(M55)MFST REF#:3 54800 78200 8 26

Q-QUENCH TEMPERATURE

T-TEMPER TEMPERATURE

N-NORMALIZE TEMPERATURE

SERIAL NUMBER	PAT NO.	HEAT NUMBER	HARD MIN. SHIN	BEND	THICKNESS INCHES	TYPE	SIZE	DR	TEST TEMP	ENERGY FT LBS	CHARPY IMPACT	SHEAR(W)	LAT. EXP	MILS

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

Reviewed By:

J. E. Helzer

HEAT NUMBER	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Ti	Al	B	Ca	N	Sn	MOULD GRAIN SIZE
813W64050	.18	1.14	.009	.005	.342	.021	.02	.13	.086	.001	.002	.034	.0002	.003	.004	.004	

I certify that the above results are a true and correct copy of actual results determined 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.

ENR TRPT.TIF

SUPV. QUALITY ASSURANCE

R. SPANGLER II PER LSS

AUG 11 2017

OK cm

175-3451
LN-120 plate
OK cm

AMERICAN ALLOY
PLATE #5183720

5/8"
3514

08/11/2017 From: AMERICAN ALLOY STEEL, INC.

To: STEELTEK, INC.

P.O.#: 8147

S.O.#: 578630

AA PL#: 5182593

Item: 1 (1 PC) 1/2" X 96" X 480"

TAG: 3424,25,26,27

ArcelorMittal Burns Harbor Plate

QUALITY ASSURANCE
REPORT OF TEST AND ANALYSES

US HWY 12 Burns Harbor, Indiana

SHIPMENT NO. 804-07195		DATE SHIPPED 03-29-17		CAR OR VEHICLE NO. CSS-CHGO-BNSF		LMIC 200011		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					

NOTES	SERIAL NUMBER	PAT NO.	HEAT NUMBER	NO. PCS.	SIZE AND QUANTITY				YIELD POINT	TENSILE STRENGTH	AF FRAC. 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 354-5430D

E549208	813W61900	3	.5	96	480	19602	48000	78000	8	24
(M55)MFST REF#:5						52400	75200	8	27	

E549209	813W61900	3	.5	96	480	19602	48000	78700	8	24
(M55)MFST REF#:5						53200	75800	8	29	

QUENCH TEMPERATURE

T-TEMPERATURE

N-NORMALIZE TEMPERATURE

SERIAL NUMBER	PAT NO.	HEAT NUMBER	HARD EN BEN	BEND	THICKNESS INCHES	TYPE	SIZE	DIR	TEST TEMP F	CHARPY IMPACT									LAT. EXP	MILE
										FT LBS			SHEAR(%)							
										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.K. 5/18/2017

HEAT NUMBER	CHEMICAL ANALYSIS																MOULD GRAIN SIZE
	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Ti	Al	B	Co	N	Sn	
813W61900	.18	1.11	.010	.005	.315	.026	.01	.13	.079	.002	.002	.030	.0002	.002	.006	.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.

BHPLTRPT.TF

SUPV. QUALITY ASSURANCE

R. SPANGLER II PER LSS

RECEIVED
AUG 11 2017
OK

175-3451
LN. 121, 122, 123 plate
OK

AMERICAN ALLOY
PLATE # 5182593

3515

Gamma Type: IP 192 Film Brand: fuji
 Curies: 68 Film Type: 80
 EFSS: 0.014 #Film/cassette: 1
 Code: ASME III UW 51
 Material: 333-C

Client: Steel test Date: 12-12-17
 Job #: 178-3451 RECHW IRISNDT #: 1706081
 Location: TULSA P.O. #: _____
 Item Inspected: _____

Film ID	Interval	Size, Thickness	Welder ID	IQI	S.O.D. Inches	O.F.D. Inches	Density	Technique	Type and Location of Discontinuities (rejectable discontinuities in square brackets [])	(A)ccept (R)eject
RS1	1-2	20/375		B	10"	375	2.4	RT.1		A
	2-3									A
	3-4									A
	4-5									A
	5-1									A
RS2	1-2									A
	2-3									A
	3-4									A
	4-5									A
	5-1									A

Skid 2 relocated from
UOPR Job 488 to 447

RT Techniques:
 Exposure Viewing Technique
 S.W.E S.W.V 1, 2, 2A, 6, 7
 D.W.E S.W.V 3, 3A
 D.W.E D.W.V 4, 5, 8

S.O.D. = Source-to-object distance
 O.F.D. = Distance from source side of object to film

AB - Arc Burns
 BT - Burn Through
 CK - Crack
 EP - Excessive Penetration
 P - Porosity
 EI - Elongated Indication

EUC - External Undercut
 IUC - Internal Undercut
 HB - Hollow Bead
 IP - Incomplete Penetration
 S - Slag

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

Unit#: _____ Miles: _____
 In: _____ Out: _____ Hrs: _____
 In: _____ Out: _____ Hrs: _____
 Personnel: S. Howard
Macklin

Film Quantity:

3 1/2 x 8 1/2 /10	
3 1/2 x 17	
4 1/2 x 8 1/2 /10	
4 1/2 x 17	
7 x 17	
14 x 17	
8 x 10	

Interpretation by:

Jason mize SNT-TC-1A II
 (Print)
 ASNT
 (Level)
 CERT # _____
 (Signature)
 Client Representative: _____
 (Print)
 I am in full agreement with report contents
 (Sign) _____

Client: Steel Ter Date: 12-12-17
Job #: 17S-3451 TE Chm IRISND #: 170688
Location: TWA P.O. #: _____
Item Inspected: _____

Skid 2 relocated from
UOPR Job 488 to 447

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

(Sign)

Client: STEEL TEL Date: 12-A-17
Job #: 175-3451 FLCHW IRISNDT #: 1706025
Location: TJUA P.O. #: _____
Item inspected: _____

Skid 2 relocated from
UOPR Job 488 to 447

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

(Sign)

HYDRO TEST CERTIFICATION

Date : Dec. 29, 2017

Customer : UOP Russell

Purchase Order No. : 4500801009

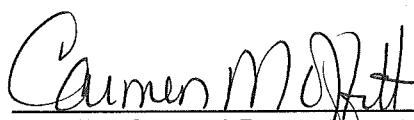
Item No. : E-207

Steeltek Serial No. : 17S-3451

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 : 195

Tube Side PSIG : 521


Quality Control Department

*Shell & Tube Heat Exchangers*DATE February 24, 2018

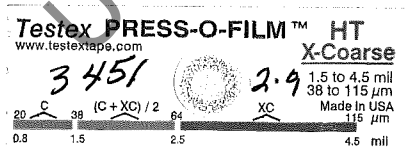
COMPANY _____ UOP _____

ITEM / P.O. 17S-3451PAINT SYSTEM: 7 coat system *as specified

	DESCRIPTION	BATCH #	MFG. DATE
1st	Heat Flex 1200 (prime shell side)	XM1467NP	1-Sep
	Heat Flex 1200 (stickouts shell side)	XM1467NP	Sep-17
2nd	Hi-Temp 500 (finish coat S/O shell side)	1000-01809	1-Nov
3,4	Macropoxy 646	(A)XM2637RA	Nov-17
	*prime and secondary coat channels	(B)XM0088TB	1-Nov
5th	Hi-Solids Poly	(A)XM2917LB	1-Sep
	*finish coat channels	(B)MQ2767NB	1-Sep

	RELATIVE HUMIDITY	DEW POINT	SURFACE TEMP	AMIENT TEMP	DATE
S/B	40.5	32.6	62.4	70	17-Feb
1st	42.6	37	64.3	62.1	18-Feb
2nd	38.5	29.6	64	60.6	19-Feb
3rd	37.4	30.1	63.4	66.5	20-Feb
4,5	38.6	29.3	60.4	63.2	21-Feb

SURFACE PROFILE



DRY FILM THK.

	MINIMUM	MAXIMUM	AVERAGE
1st	1	2	1.7
2nd	5	6	5.3
3rd	2	2.5	2.4
4th	4	6	6
5th	3	4	3.5

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)

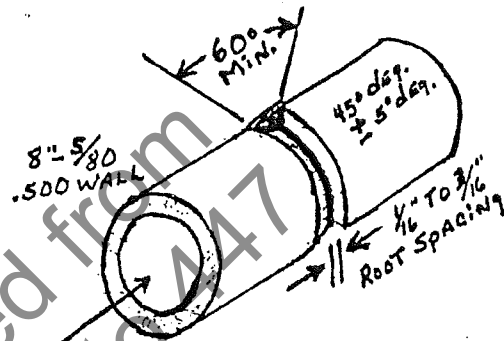
Details

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

*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;"> <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>ARGON & CO2</td> <td>75/25</td> <td>30-45 CFH</td> </tr> <tr> <td>Trailing</td> <td>N/A</td> <td>N/A</td> <td>N/A</td> </tr> <tr> <td>Backing</td> <td>N/A</td> <td>N/A</td> <td>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																																																			
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Backing	N/A	N/A	N/A																																																																							
ELECTRICAL CHARACTERISTICS (QW-409) Current AC or DC <u>DC</u> Polarity <u>REVERSE</u> Amps (Range) <u>90-240</u> Volts (Range) <u>18-28</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>N/A</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 _____																																																																										
TECHNIQUE (QW-410) String or Weave Bead <u>STRING</u> Orifice or Gas Cup Size <u>5/8"</u> Initial and Interpass Cleaning (Brushing, Grinding, etc.) <u>BRUSHING, CHIPPING & GRINDING</u> Method of Back Gouging <u>N/A</u> Oscillation <u>5/8"</u> Contact Tube to Work Distance <u>1/4" to 3/8"</u> Multiple or Single Pass (per side) <u>MULTIPLE (WELDED FROM ONE SIDE)</u> Multiple or Single Electrodes <u>SINGLE</u> Travel Speed (Range) <u>MANUAL</u> Peening <u>N/A</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>1ST</td> <td>FCAW</td> <td>E-71T-1</td> <td>.035"</td> <td>REVERSE</td> <td>90-130</td> <td>18-23</td> <td>MANUAL</td> <td></td> </tr> <tr> <td>2ND</td> <td>FCAW</td> <td>E-71T-1</td> <td>.045"</td> <td>REVERSE</td> <td>110-180</td> <td>21-26</td> <td>MANUAL</td> <td></td> </tr> <tr> <td>3RD</td> <td>FCAW</td> <td>E-71T-1</td> <td>.045"</td> <td>REVERSE</td> <td>110-180</td> <td>21-28</td> <td>MANUAL</td> <td></td> </tr> <tr> <td>4TH</td> <td>FCAW</td> <td>E-71T-1</td> <td>.045"</td> <td>REVERSE</td> <td>110-240</td> <td>21-28</td> <td>MANUAL</td> <td></td> </tr> <tr> <td>5TH</td> <td>FCAW</td> <td>E-71T-1</td> <td>.045"</td> <td>REVERSE</td> <td>110-240</td> <td>21-28</td> <td>MANUAL</td> <td></td> </tr> <tr> <td>6TH</td> <td>FCAW</td> <td>E-71T-1</td> <td>.045"</td> <td>REVERSE</td> <td>110-240</td> <td>21-28</td> <td>MANUAL</td> <td></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	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	
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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5TH	FCAW	E-71T-1	.045"	REVERSE	110-240	21-28	MANUAL																																																																			
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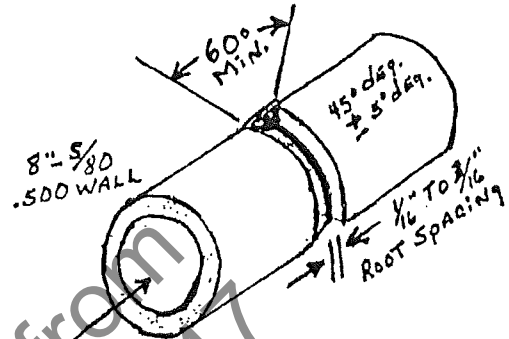
QW-483 SUGGESTED FORMAT FOR PROCEDURE QUALIFICATION RECORD (PQR)

(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

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

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

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. 
 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)

<u>Parameter</u>	<u>Specimen No.</u>	
	<u>1</u>	<u>2</u>
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 590328
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) 258-6066
Fax: (918) 258-1154

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

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

Sample Number 810MS239 - Continued

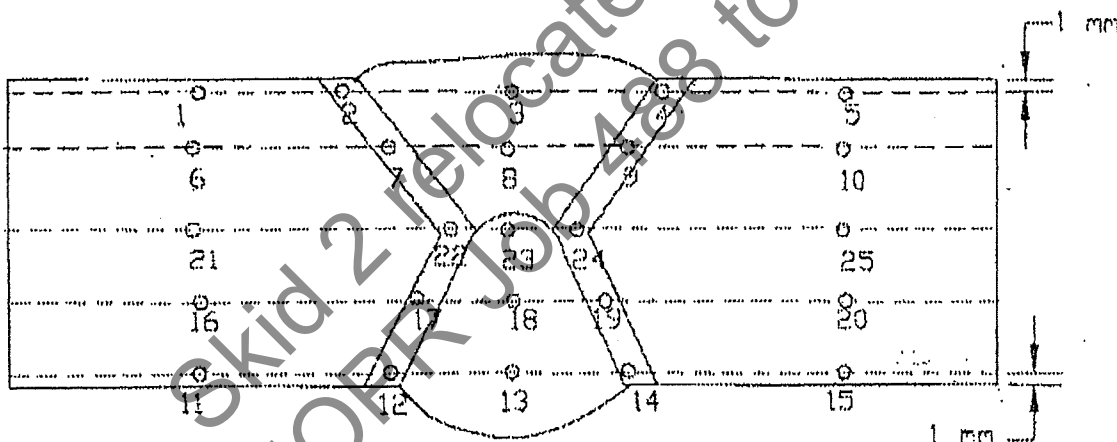


Figure 1: Illustration showing approximate location of Vickers indentations. No scale or proportion.

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

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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.)

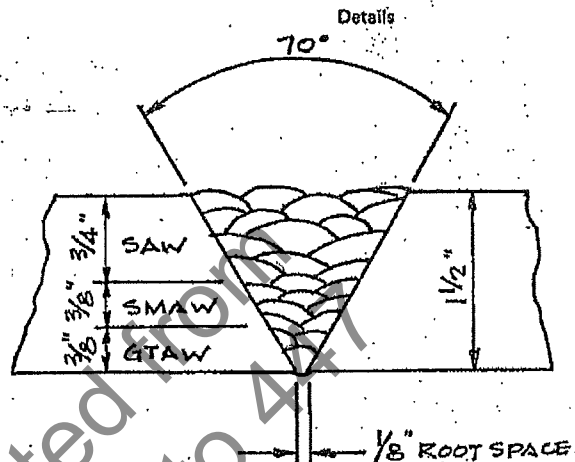
JOINTS (QW-402)

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 & FM Fillet All
Pipe Dia. Range: Groove All Fillet All
Other N/A

① F7A2-EM12K (LINCOLN 61W/800 FLUX) OR F7A2-EM14K-HB (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

QW-482 (Back)

WPS No. ST-28

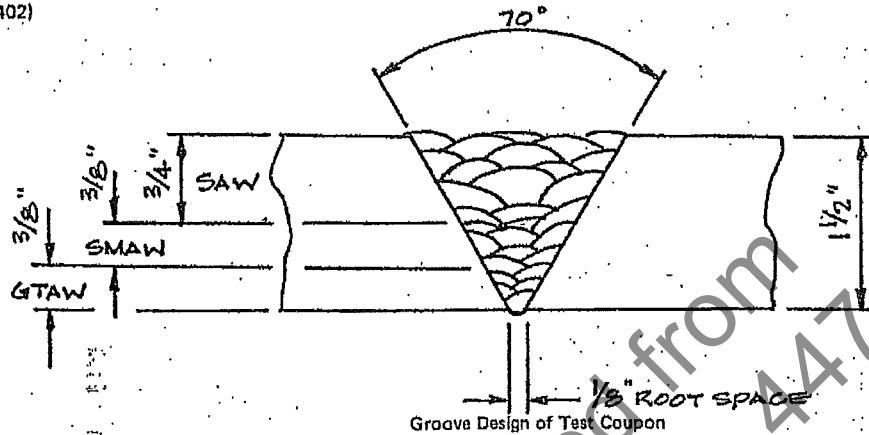
Rev. 1

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>
	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>																				
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>																							
		Filler Metal		Current																			
Weld Layer(s)	Process	Class	Dia.	Type Polar.	Amp. Range	Volt Range	Travel Speed Range	Other (e.g., Remarks, Comments, Hot Wire Addition, Technique, Torch Angle, Etc.)															
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-12K02 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

GAS (QW-408)

(GTAW ONLY)	Percent Composition		
	Gas(es)	(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-12K</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 Flux</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 See Other
 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) Flat

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 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 Burch Clock No. Stamp No.
 Tests conducted by: Sun Material Testing Laboratory 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. Hamlock 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. Supv.

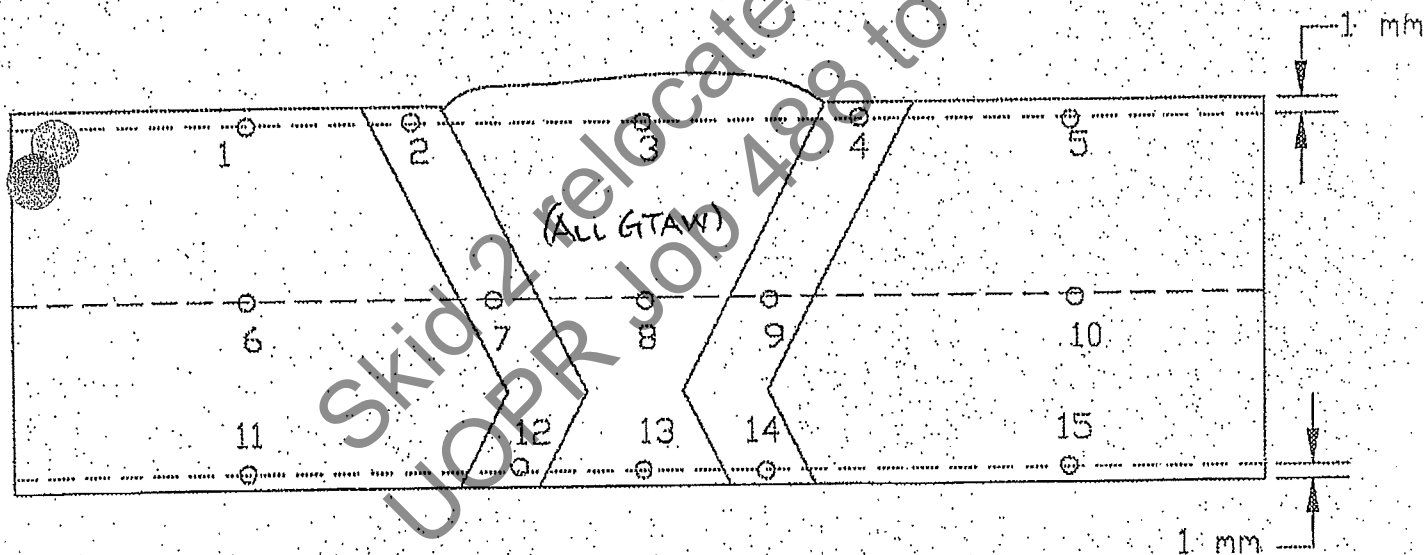
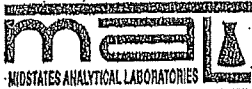


Figure 1: Illustration showing approximate location of Vickers indentations. No scale or proportion.

TEST REPORT



MIDSTATES ANALYTICAL LABORATORIES, INC.

3100 N. Hemlock Circle
Broken Arrow, OK 74012P.O. Box 680328
Tulsa, OK 74169(918) 258-6066
Fax: (918) 258-1154TO: Phil Scott
Steeltek
602 W. 41st
Tulsa, OK 74107Page 1 of 2
98-18236-1

NO.

DATE: October 19, 1998

P.O. 31818

Sample Number
810MS138Customer's Material Description
3/4" Groove Welded A516-70N Plate
Per WPQ ST-28 (SMAW/SAW) Addendum
No Post Weld Heat Treatment

Test 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

SOPP5BREVO

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By Sheldon B. Rudin
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) 258-6066
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

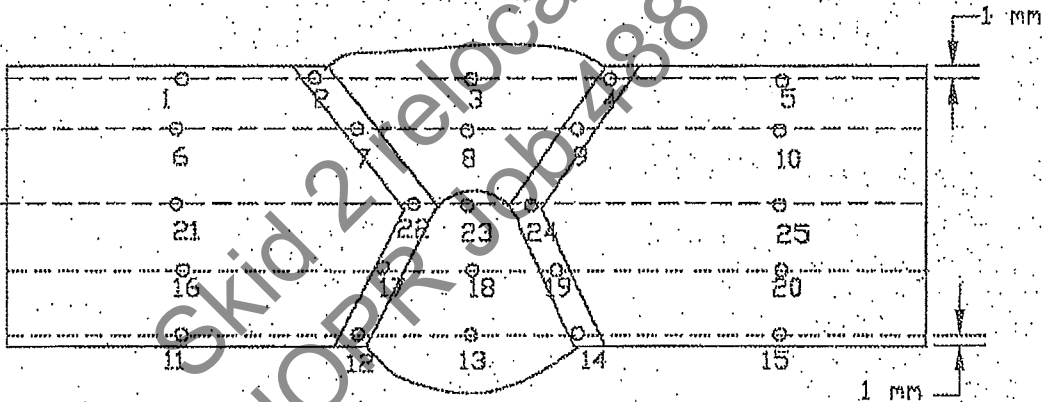


Figure 1: Illustration showing approximate locations of Vickers indentations. No scale or proportion.

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

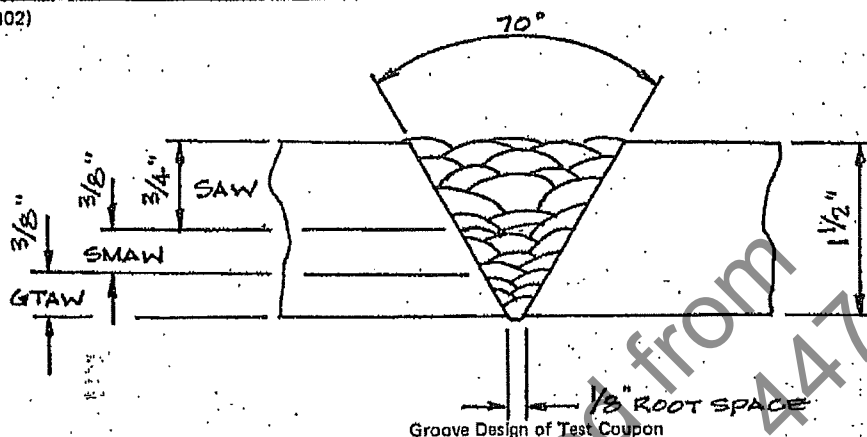
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By Sheldon B. Rudin
Sheldon B. Rudin, Met. Supvr.

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-28C 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

FILLER METALS (QW-404)

	GTAW	SMAW	SAW
SFA Specification	<u>E-5.18</u>	<u>E-5.1</u>	<u>E-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 F1</u>
Weld Metal Thickness	<u>3/8"</u>	<u>3/8"</u>	<u>3/4"</u>

(Lincoln)

GAS (QW-408)

(GTAW ONLY)	Percent Composition		
	Gas(es)	(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>

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

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

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)

FOR 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	.7060	.5295	40,074	76,049	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

Fillet-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. Q
 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.

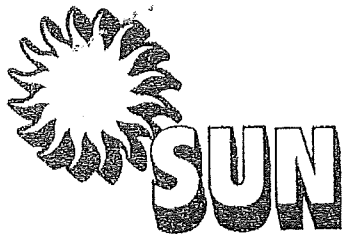
Date

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

Steeltek, Inc.
4141 S Jackson Tulsa, OK 74107
WELDING PROCEDURE SPECIFICATION (WPS)

WPS No.: ST-78 Date: 4/16/99 Revision No.: 0
Supporting PQRs: ST-78

BASE METAL (QW-403, QW-405) P No. <u>1</u> Gr. <u>1</u> to P No.: <u>1</u> Gr. <u>2</u> Thickness range. <u>0.2800"</u> to <u>0.5600"</u> Position(s) <u>All positions</u> Progression <u>Vertical Up</u> notes _____	JOINT (QW-402) Joint design <u>Groove/Fillet (see pg 2)</u> Backing..... <u>With backing only</u> Backing Matl <u>Weld metal</u> Fillet Weld Size <u>All (QW-451.4)</u> notes _____
PREHEAT (QW-406) Minimum Temperature. <u>55</u> Degrees F. Interpass Temp. Max. <u>450</u> Degrees F. Preheat Maintenance. <u>None</u>	POSTWELD HEAT TREATMENT (QW-407) Temperature range <u>None</u> Time range <u>None</u> notes _____

Process / type	All pass(es) SMAW / manual	None
Process thickness limit. _____	<u>0.2800" to 0.5600"</u>	None

GAS (QW-408)		
Shielding Gas / CFH.....	<u>N/A</u> / -	None / -
Trailing Gas / CFH.....	<u>N/A</u> / -	None / -
Backing Gas / CFH.....	<u>N/A</u> / -	None / -

FILLER METAL (QW-404)		
AWS classification.....	<u>E7018-1</u>	
SFA Spec. No. & F No.... SFA#:	<u>5.1</u> F#:	None F#:
A No. or Chem. Comp.....	<u>1</u>	None
Filler metal trade name. _____	<u>n/r</u>	None
SAW flux trade name/type	<u>N/A</u> / -	None / -
Elec./Wire size (in) ...	<u>3/32</u> <u>1/8</u> -	- - -

ELECTRICAL (QW-409)		
Welding amperage range...	<u>70-110</u> <u>90-160</u> -	- - -
Welding voltage range...	<u>18-26</u> <u>18-26</u> -	- - -
Travel speed (ipm).....	<u>Var.</u> <u>Var.</u> -	- - -
Max. Heat Input (J/in)...	<u>18150</u>	
Tungsten Type/Size.....	<u>N/A</u> / -	None / -
Current & Polarity.....	<u>DCEP (reverse)</u>	N/A

TECHNIQUE (QW-410)		
String / weave bead.....	<u>String Bead</u>	N/A
Orifice / gas cup.....	<u>N/A</u>	None
Contact tube to work....	<u>N/A</u>	None
Oscillation.....	<u>N/A</u>	None
Mult./Single electrode..	<u>Single Electrode</u>	N/A
Other Technique Notes...		None

Multiple or Single Pass (per side).... Single Pass

(n1) No peening done with this procedure.

(n2) No pass greater than 1/2" allowed.

(n3) _____

(n4) _____

(n5) _____

(n6) Preheat to 175F if "T" > 1" and C > 0.30%; To 200F if 1.25" < "T" <= 1.5"

(n7) Preheat to 175F if "T" > 1" and C > 0.30%; To 200F if 1.25" < "T" <= 1.5"

WPS No.: ST-78

Date: 4/16/99 Revision No.: 0

JOINT (QW-402)

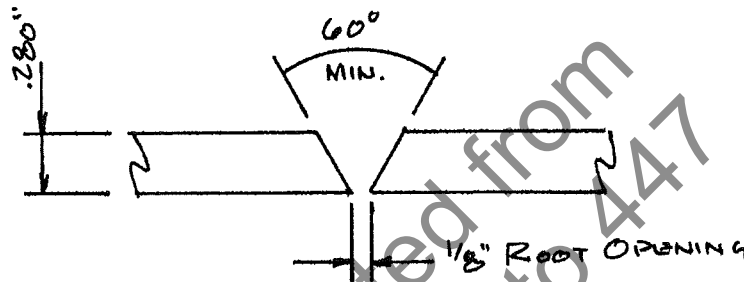
Double-V groove

Backing : gouged & back welded

Root Opening: 1/4" max.

Groove Angle: 50 degree min.

Root Face : 3/16" max.



WELD JOINT DESCRIPTIONS SHOWN ARE NOT INCLUSIVE OF ALL OF THOSE FOUND ON A JOB SITE. WELD JOINT DESIGN REFERENCE IN AN ENGINEERING SPECIFICATION OR DESIGN DRAWING SHALL TAKE PRECEDENCE OVER WELD JOINTS SHOWN IN THIS WPS.

Initial cleaning With wire brush clean 1" both sides of weld joint.

Method of back gouging Arc-Air

- (a) Minimum preheat must be maintained during thermal cutting, tacking, and welding operations.
- (b) Welds shall be cleaned between each pass. When completed, remove all slag and projections.
- (c)
- (d)
- (e)

Steeltek, Inc.
4141 S Jackson Tulsa, OK 74107
Procedure Qualification Record (PQR)

PQR No.: **ST-78**

Date: **4/16/99**

WPS No.: **ST-78**

Rev **0**

JOINT DESIGN (QW-402)

WELD JOINT CONFIGURATION

Double-V groove
Back-gouged & back welded
Groove Angle : 70 Degrees
Root Opening : .125 Inches
Root Face : 0 Inches

note: _____

POSITION (QW-405)

Position of Joint : **6G - 45 Deg.**
Progression: **Vertical Up**

note: _____

BASE METAL (QW-403)

Material form. **Pipe / Tube**
Material Spec. **SA-333, Grade 6**
To **SA-106, Grade C**
P No. **1** Gr. **1** to P No. **1** Gr. **2**
Thickness (in) **0.2800** Dia.(in) **6.6250**

HEAT TREATMENT (QW-406, QW-407)

Preheat Temperature: **70** Degrees F.
Preheat Maintenance: **None**
Interpass Temperature: **350** Degrees F.
PWHT temperature ... : **None** Degrees F.
PWHT Holding time(hr): **None**
note: _____

All pass(es)		None	
SMAW / manual			
Weld Process / type			
GAS (QW-408)			
Shielding Gas / CFH.....	N/A / -	None	-
Trailing Gas / CFH.....	N/A / -	None	-
Backing Gas / CFH.....	N/A / -	None	-
FILLER METAL (QW-404)			
AWS Classification.....	E7018-1	None	
SFA Spec. No. & F No....	SFA#: 5.1 F#: 4	SFA#: None	F#: -
A No. or Chem. Comp.....	1	None	
Filler Metal Trade Name.			
SAW Flux Trade Name/Type	N/A / -	None / -	
Weld Deposit 't' (in)...	0.2800	None	
Elec./Wire Size (in)...	1/8 3/32	-	-
ELECTRICAL (QW-409)			
Amperage USED	110 110	-	-
Voltage USED	22 22	-	-
Travel Speed (ipm).....	8 10	-	-
Max. Heat Input (J/in)...	18150	None	
Tungsten Type & Size....	N/A / -	N/A	-
Current Type/Polarity...	DCEP (reverse)	N/A	
TECHNIQUE (QW-410)			
String or Weave Bead....	String Bead	N/A	
Orifice/Gas Cup Size....	N/A	None	
Contact Tube to Work....	N/A	None	
Oscillation.....	N/A	N/A	
Mult./Single Electrodes.	Single Electrode	N/A	
Other Technique Notes...		None	
Multiple or Single Pass (per side).... Multiple Passes			

n1) Peening was not used with this weld test.

n2) _____

n3) _____

n4) _____

n5) _____

Procedure Qualification Record (PQR)

PQR No.: ST-78

Page 2 of 2

TENSILE TEST (QW-150)

Specimen No.	Width (in.)	Thick. (in.)	Area (sq.in.)	Ultimate total load (lb)	Ultimate stress (psi)	Type of failure and location
1	0.506	0.233	0.118	8080	68500	Base metal
2	0.507	0.242	0.123	8360	68000	Base metal

GUIDED BEND TEST (QW-160)

Figure No. and Type	Result	Figure No. and Type	Result
QW-462.3(a) Face bend	Acceptable	QW-462.3(a) Root bend	Acceptable
QW-462.3(a) Face bend	Acceptable	QW-462.3(a) Root bend	Acceptable

TOUGHNESS TEST (QW-170)

Spec. No.	Notch Location	Notch Type	Test Temp. (°F)	Impact Values (ft-lbs)	Lateral exp.		Drop weight break
					Shear %	Mils	
1	Base metal	"V"	-50	148, 124, 138			No
2	Weld metal	"V"	-50	96, 10, 113			No
3	Base metal	"V"	-50	135, 186, 149			No
4	HAZ	"V"	-50	86, 135, 128			No
5	HAZ	"V"	-50	142, 132, 135			No

HARDNESS TEST - Brinell hardness

Base metal	-1-	-2-	-3-	HAZ	-1-	-2-	-3-	WM	-1	-2-	-3-
SA-333	123	127	132	156	150	141	165	156	150		
SA-106	132	135	138	156	153	150	165	156	150		

(Heat Affected Zone=HAZ, Weld Metal=WM)

Notes: _____

Stamp: F Welder's Name: Doug Farris ID: _____
 Tests conducted by: Sun Materials Testing Laboratory Test No: 98-5707-2

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.

By [Signature] (4/16/99) Vice President

Steeltek, Inc.
4141 S Jackson Tulsa, OK 74107
WELDING PROCEDURE SPECIFICATION (WPS)

WPS No.: ST-85 Date: 5/27/99 Revision No.: 0
Supporting PQRs: ST-85

BASE METAL (QW-403, QW-405) P No. <u>1</u> Gr. <u>1</u> to P No.: <u>1</u> Gr. <u>1</u> Thickness range. <u>0.3220"</u> to <u>0.6440"</u> Position(s) <u>Flat, Horz. & Overhead</u> Progression. <u>N/A</u> notes <u>Flat & Horizontal with SAW.</u>	JOINT (QW-402) Joint design <u>Groove/Fillet</u> (see pg 2) Backing..... <u>With backing only</u> Backing Matl <u>Weld metal</u> Fillet Weld Size <u>All</u> (QW-451.4) notes _____
PREHEAT (QW-406) Minimum Temperature. <u>55</u> Degrees F. Interpass Temp. Max. <u>550</u> Degrees F. Preheat Maintenance. <u>None</u>	POSTWELD HEAT TREATMENT (QW-407) Temperature range <u>None</u> Time range <u>None</u> notes _____

	1st process GTAW / manual	2nd process SAW / automatic
Process / type	0.2500" Max.	0.3940" Max.
Process thickness limit.		

GAS (QW-408)	
Shielding Gas / CFH..... <u>75% Argon, 25% CO2/ 23-30</u>	<u>N/A</u> / <u>-</u>
Trailing Gas / CFH..... <u>None</u>	<u>N/A</u> / <u>-</u>
Backing Gas / CFH..... <u>None</u>	<u>N/A</u> / <u>-</u>

FILLER METAL (QW-404)	
AWS classification..... <u>ER70S-6</u>	<u>L-56</u> <u>EM12K</u>
SFA Spec. No. & F No.... SFA#: <u>5.18</u> F#: <u>6</u>	SFA#: <u>5.23</u> F#: <u>6</u>
A No. or Chem. Comp..... <u>(verify chemistry)</u>	<u>1</u>
Filler metal trade name. <u>n/r</u>	<u>n/r</u>
SAW flux trade name/type <u>N/A</u> / <u>-</u>	<u>LINCOLN 880M</u> / <u>Neutral</u>
Elec./Wire size (in).... <u>1/8</u> <u>-</u> <u>-</u>	<u>3/32</u> <u>-</u> <u>-</u>
ELECTRICAL (QW-409)	
Welding amperage range.. <u>60-100</u> <u>-</u> <u>-</u>	<u>300-320</u> <u>-</u> <u>-</u>
Welding voltage range... <u>10-13</u> <u>-</u> <u>-</u>	<u>31-36</u> <u>-</u> <u>-</u>
Travel speed (ipm)..... <u>7</u> <u>-</u> <u>-</u>	<u>17</u> <u>-</u> <u>-</u>
Max. Heat Input (J/in).. <u>11520</u>	<u>51000</u>
Tungsten Type/Size..... <u>EWTh-2 / 1/16" - 3/16"</u>	<u>N/A</u> / <u>-</u>
Current & Polarity..... <u>DCEN (straight)</u>	<u>DCEP (reverse)</u>

TECHNIQUE (QW-410)	
String / weave bead..... <u>String & Weave Bead</u>	<u>String Bead</u>
Orifice / gas cup..... <u># 5 to # 10</u>	<u>N/A</u>
Contact tube to work.... <u>N/A</u>	<u>3/4" - 1"</u>
Oscillation..... <u>5/16</u> <u>N/A</u>	<u>None</u>
Mult./Single electrode.. <u>Single Electrode</u>	<u>Single Electrode</u>
Other Technique Notes...	
Multiple or Single Pass (per side).... <u>Multiple Passes</u>	

- (n1) No peening done with this procedure.
- (n2) _____
- (n3) No supplementary filler metal will be used with this procedure.
- (n4) _____
- (n5) _____
- (n6) _____
- (n7) _____

I ; No.: ST-85

Date: 5/27/99 Revision No.: 0

JOINT (QW-402)

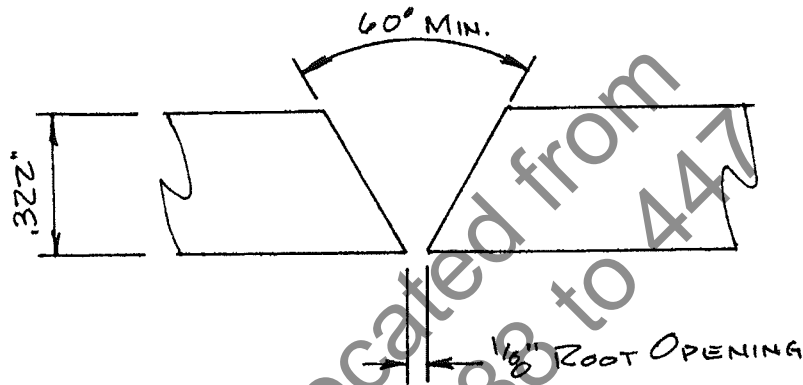
Double-V groove

Backing : gouged & back welded

Root Opening: 1/4" max.

Groove Angle: 50 degree min.

Root Face : 3/16" max.



WELD JOINT DESCRIPTIONS SHOWN ARE NOT INCLUSIVE OF ALL OF THOSE FOUND ON A JOB SITE. WELD JOINT DESIGN REFERENCE IN AN ENGINEERING SPECIFICATION OR DESIGN DRAWING SHALL TAKE PRECEDENCE OVER WELD JOINTS SHOWN IN THIS WPS.

Initial cleaning With wire brush clean 1" both sides of weld joint.
Method of back gouging When required, grind until all defects are removed.

- (a) Minimum preheat must be maintained during thermal cutting, tacking, and welding operations.
- (b) Welds shall be cleaned between each pass. When completed, remove all slag and projections.
- (c)
- (d)
- (e)

Steeltek, Inc.
4141 S Jackson Tulsa, OK 74107
Procedure Qualification Record (PQR)

PQR No.: ST-85 Date: 5/27/99 WPS No.: ST-85 Rev 0

JOINT DESIGN (QW-402)

WELD JOINT CONFIGURATION

Double-V groove
Back-gouged & back welded
Groove Angle : 70 Degrees
Root Opening : 1/8 Inches
Root Face : N/A Inches

note: _____

POSITION (QW-405)

Position of Joint : 1G - Rotated

Progression: N/A

note: _____

BASE METAL (QW-403)

Material form. Pipe / Tube
Material Spec. SA-333, Grade 6
To SA-333, Grade 6
P No. 1 Gr. 1 to P No. 1 Gr. 1
Thickness (in) 0.3220 Dia. (in) 8.6250

HEAT TREATMENT (QW-406, QW-407)

Preheat Temperature: 70 Degrees F.
Preheat Maintenance: None
Interpass Temperature: 550 Degrees F.
PWHT temperature ... : None Degrees F.
PWHT Holding time (hr): None
note: _____

	1st process GTAW / manual	2nd process SAW / automatic
Weld Process / type		
GAS (QW-408)		
Shielding Gas / CFH.....	<u>75% Argon, 25% CO2 / 25</u>	<u>N/A / -</u>
Trailing Gas / CFH.....	<u>None / -</u>	<u>N/A / -</u>
Backing Gas / CFH.....	<u>None / -</u>	<u>N/A / -</u>

FILLER METAL (QW-404)

AWS Classification..... ER70S-6
SFA Spec. No. & F No.... SFA#: 5.18 F#: 6
A No. or Chem. Comp..... (verify chemistry)
Filler Metal Trade Name. n/a
SAW Flux Trade Name/Type N/A / -
Weld Deposit 't' (in)... 0.1250
Elec./Wire Size (in)... 1/8 - -
ELECTRICAL (QW-409)
Amperage USED 80 - -
Voltage USED 12 - -
Travel Speed (ipm)..... 5 - -
Max. Heat Input (J/in)... 11520
Tungsten Type & Size.... EWTh-2 / 3/32"
Current Type/Polarity... DCEN (straight)

EM12K
SFA#: 5.23 F#: 6
1
LINCOLN-56
LINCOLN 880M / Neutral
0.1970
3/32 - -
400 - -
34 - -
16 - -
51000
N/A / -
DCEP (reverse)

TECHNIQUE (QW-410)

String or Weave Bead.... String & Weave Bead
Orifice/Gas Cup Size.... 5/8
Contact Tube to Work.... N/A
Oscillation..... 5/16 N/A
Mult./Single Electrodes. Single Electrode
Other Technique Notes... _____
Multiple or Single Pass (per side).... Multiple Passes

String Bead
N/A
3/4" - 1"
None
Single Electrode

- n1) Peening was not used with this weld test.
n2) _____
n3) No supplementary filler metal was used with this weld test.
n4) _____
n5) _____

Procedure Qualification Record (PQR)

PQR No.: ST-85

Page 2 of 2

TENSILE TEST (QW-150)

Specimen No.	Width (in.)	Thick. (in.)	Area (sq.in.)	Ultimate total load (lb)	Ultimate stress (psi)	Type of failure and location
1	0.759	0.264	0.200	12940	64700	Ductile - BM
2	0.763	0.270	0.206	13250	64300	Ductile - BM

GUIDED BEND TEST (QW-160)

Figure No. and Type	Result	Figure No. and Type	Result
QW-462.3(a) Face bend	Acceptable	QW-462.3(a) Root bend	Acceptable
QW-462.3(a) Face bend	Acceptable	QW-462.3(a) Root bend	Acceptable

TOUGHNESS TEST (QW-170)

Spec. No.	Notch Location	Notch Type	Test Temp. (°F)	Impact Values (ft-lbs)	Lateral exp.		Drop weight break
					Shear %	Mils	
1	Weld metal	"V"	-50	75/55/27			No
2	HAZ	"V"	-50	175/180/173			No
3	Base metal	"V"	-50	183/185/174			No

HARDNESS TEST - Brinell hardness

Base metal	-1-	-2-	-3-	HAZ	-1-	-2-	-3-	WM	-1	-2-	-3-
SA-333	125	125	125		135	139	141		176	150	141

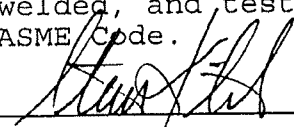
(Heat Affected Zone=HAZ, Weld Metal=WM)

Notes:

Impact test specimen size, 10 mm. X 7.25 mm.

Stamp: S/F Welder's Name: Billy Dearman/Doug Farris ID: _____
 Tests conducted by: Sun Materials Testing Laboratory Test No: 99-5806

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.

By  (5/27/99) Vice President

Shell & Tube Heat Exchangers

CUSTOMER: UOP RUSSELL
PURCHASE ORDER NO.: 4500801009
PROJECT NO.: J488XX
EQUIPMENT TAG NO: E-207
SERVICE: DEMETHANIZER TRIM REBOILER
STEELTEK JOB NO.: 17S-3451

DATE: March 1, 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-3451	E-207	SPARE GASKETS	SET	1-SET	\$659.00	\$659.00	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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