MANUFACTURER'S DATA BOOK

KBR

ACCEPTANCE
FOR ENGINEERING USE

THIS DOCUMENT IS:

ACCEPTED	(Code 1)	
ACCEPTED WITH COMMENTS	(Code 2)	
NOT ACCEPTED	(Code 3)	
NOT REVIEWED	(Code 4)	X

ACCEPTANCE DOES NOT RELIEVE SUPPLIER FROM FURNISHING MATERIAL IN CONFORMANCE WITH ORDER. REFER TO SDR-1 FOR FULL DEFINITION OF ACCEPTANCE CONDITIONS.

DISCIPLINE EXCH BY MW
DATE 24SEP12

MISSISSIPPI POWER

DEKALB, MISSISSIPPI

KEMPER COUNTY 1 – IGCC PROJECT

P.O. NO: 17496-0001

REQ. NO: MC202

ITEM NO: HX0042

HYDROGEN SULFIDE STRIPPER REBOILER

1-23" x 168" NEN EXCHANGER

ENERGY JOB NO: X-7929

Energy Exchanger Company
Energy Industrial Park
1844 North Garnett Road/Tulsa, OK 74116-1612
(918) 437-3000/FAX (918) 437-7144

Southern Company Generation **Kemper County**
MM209937 0 Unit 1

ENERGY EXCHANGER COMPANY PO: MPC17496-0001
X-7929-MDB Rev: 0
IGCC - GASIFIER - MULTIPAGE - SHELL AND TUBE HEAT EXCHANGER - MAN

Mississippi Power
Kemper County 1 – IGCC Project
P.O. No: 17496-0001
Req. No: MC202
Item No: HX0042
Energy Job No: X-7929

MANUFACTURER'S DATA BOOK

TABLE OF CONTENTS

SECTION 1

IQS Inspection Services, Inc. Inspection & Expediting Services

117 Cornerstone Ct.
Sapulpa, OK 74066

Richard Duke –Owner
Office: 918-224-7472
Cell: 918-640-7911
Email: rmduke@cox.net

I.Q.S. Work Order 556
Inspection Shipping Release Notice 15

Client:	SOUTHERN CO.	Purchase Order #:	MPC-17645; MPC17496 & MPC- 17497
EWO:	MPC9117.T61401	Supplier:	ENERGY EXCHANGERS
Shop Order #	SO # 7929	Location:	TULSA, OK
Project:	KEMPER COUNTY IGCC UNIT	Supplier Ref. #:	

Item #	Description	Qty Ordered	Qty Released	Balance
	23-168 NEN Exchanger TAG# HX0042--SO# 7929 AND FINAL DOCUMENTATION IS NOW COMPLETE	1	1	0

This does not relieve the Vendor of any responsibility to ensure that the material or equipment meets all contractual requirements. This notice is issued according to IQS' best knowledge, experience, codes and specifications available to us during this inspection. Neither IQS nor any member of its inspection force is to be held liable for the acceptance of or payment for released items, or the default or negligence on the part of the vendors' obligation to supply quality equipment and materials or breach the conditions of his contract with the purchaser. Actual acceptance of equipment/material is predicated on the purchaser's site inspection, operational integrity and the fulfillment of all contractual warranties connected thereto.

Date: 9/8/12

Bill Bronaugh
IQS

SECTION 2

Energy Exchanger Company

HEAT EXCHANGER SPECIFICATION SHEET

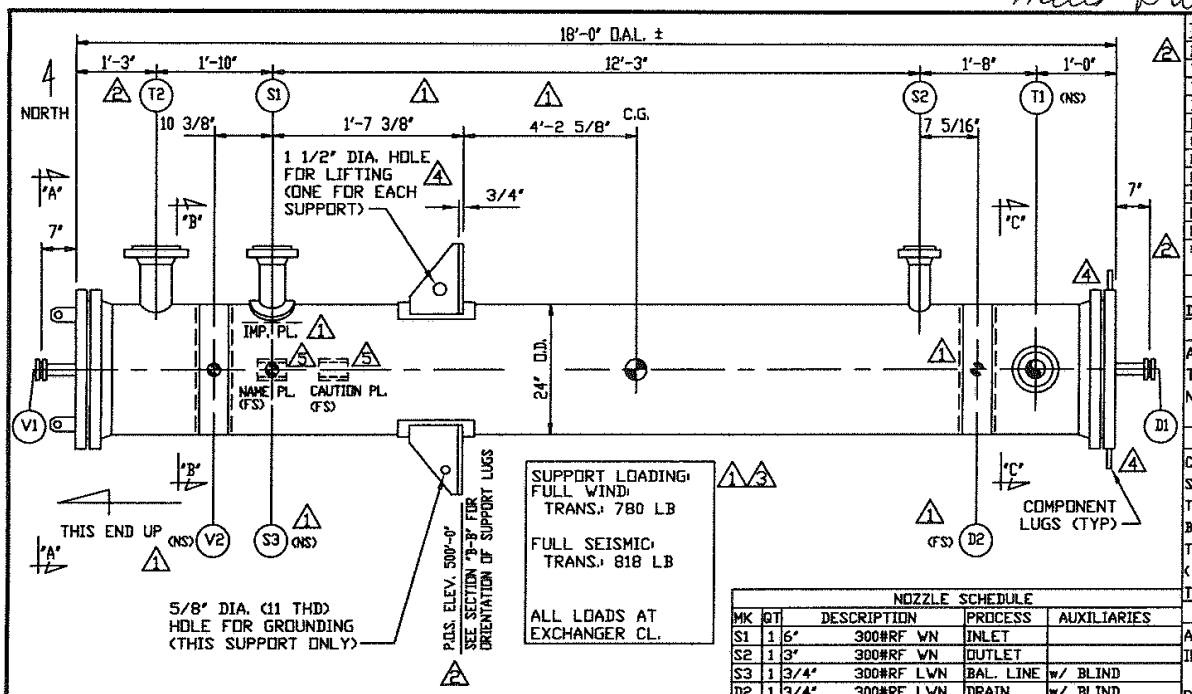
REQ. NO.: MC-202
P. No.: 17496-0001
REV. 0 AS PURCHASED

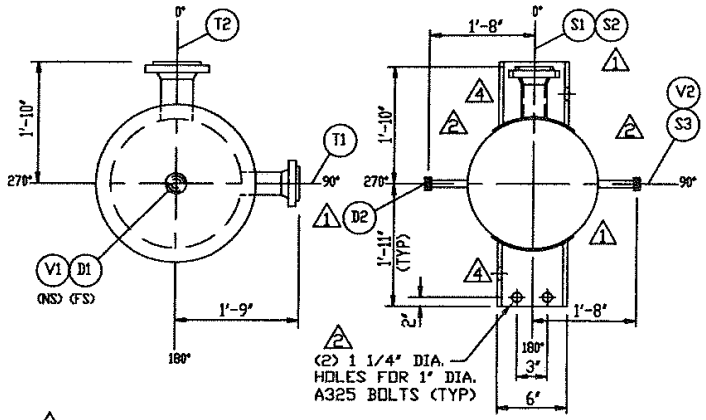
	3	Customer	SOUTHERN COMPANY									Job No.: X-7929 "AS BUILT"					
	4	Address										Rev.: 3		Date: 8/15/2012			
	5	Plant Location	KEMPER COUNTY, MS									File: 10-7309					
	6	Service of Unit	HYDROGEN SULFIDE STRIPPER REBOILER									Item: HX0042					
	7	Size 23-168		Type NEN		Vert						Connected in 1		Parallel 1		Series	
2	8	Surf./Unit ☐ Gross / ☑ Eff		1241.	ft²; Shells/Unit	1		Surf./Shell ☐ Gross ☑ Eff.		1241.	ft²						
	9	PERFORMANCE OF ONE UNIT															
	10	Fluid Allocation		Shell Side				Tube Side									
	11	Fluid Name		IP STEAM				SOUR WATER									
	12	Fluid Quantity, Total	lb/hr	19654 X 1.1				209000 X 1.1									
	13	Vapor (In/Out)								16929 X 1.1							
	14	Liquid						209000 X 1.1		192071 X 1.1							
	15	Steam		19654 X 1.1													
	16	Water				19654 X 1.1											
	17	Noncondensable															
	18	Temperature (In/Out)	°F	475.		419.4		332.7		346.							
	19	Density (Vapor/Liquid)	Lb/Ft³						45.99	0.4360	47.73						
	20	Viscosity	cP						0.137	0.0160	0.133						
	21	Molecular Weight															
	22	Molecular Weight, Noncondensable															
	23	Specific Heat	Btu/lb-F						1.1270	0.5000	1.1210						
	24	Thermal Conductivity	Btu/hr-ft-F						0.3010	0.0210	0.3210						
	25	Latent Heat	Btu/lb														
	26	Inlet Pressure	psia	310.				192.73 @ COLUMN BOTTOM									
	27	Velocity	ft/sec	15.68				7.99									
	28	Pressure Drop, Allow./Calc.	psi	5.00	/	0.77		/	2.95								
	29	Fouling Resistance (Min.)	Hr-Ft-°F/Btu	0.0005				0.002									
	30	Heat Exchanged	16392000 X 1.1					Btu/hr; M.T.D. (Corrected)		80.79	°F						
	31	Transfer Rate, Service	179.85					Btu/hr-ft²-F; Clean		461.55	Btu/hr-ft²-F						
	32	CONSTRUCTION OF ONE SHELL						Sketch (Bundle/Nozzle Orientation)									
	33			Shell Side		Tube Side											
2	34	Design/Test Pressure	psig	455 /FV/595		205/270 (4)											
1	35	Design Temperature (Max/Min)	°F	515/10		390/10											
	36	No. Passes Per Shell		1		1											
1	37	Corrosion Allowance	Inch	0.125		0.1875											
	38	Connections	In	1 - 6" 300RF		1 - 6" 300RF											
	39	Size &	Out	1 - 3" 300RF		1 - 10" 300RF											
1	40	Rating	Balance Line	1 - 3/4" 300RF													
	41	Tube No. 462	OD 0.75	in; Thk. ☑ Min ☐ Avg	0.083	In; Length	14.	ft; Pitch	0.9375	In	30°						
0	42	Tube Type	BARE			Material	SA-179										
3	43	Shell SA-106-B		☑ ID	22.876	In ;Shell Cover	N/A				☐ Integ. ☐ Remov.						
3	44	Channel or Bonnet	SA-333-6 PWHT			Channel Cover	SA-516-70N PWHT				☐ Integ. ☑ Remov.						
3	45	Tubesheet-Stationary	SA-516-70N PWHT			Tubesheet - Floating	N/A										
1	46	Floating Head Cover				Impingement Protection	YES - CS PLATE ON BUNDLE										
3	47	Baffles-Cross	9 - SA-36	Type H SEG		% Cut (☑ Dia.)	27.9	Spacing c/c	15.625	Inlet	in						
	48	Baffles-Long				Seal Type											
	49	Supports - Tube	U-Bend			Type											
	50	Bypass Seal Arrangement				Tube-Tubesheet Joint	TWO GROOVES & EXPANDED										
	51	Expansion Joint	NONE			Type											
	52	pv² - Inlet Nozzle		Bundle Entrance				Bundle Exit									
1	53	Gaskets - Shell Side				Tube Side	321 S.S. DJ GRAPH. FILLED										
	54	- Floating Head															
1	55	Code Requirements	ASME SECTION VIII, DIV. 1: STAMP: YES					TEMA Class	R								
3	56	Weight/Shell	8,700#	Filled With Water		11,700#		Bundle	N/A								
	57	REMARKS															
3	58	(1) DELETED.															
1	59	(2) UNIT IS A VERTICAL THERMOSYPHON REBOILER. INLET PIPING EQUIVALENT LENGTH = 78 FT. OUTLET PIPING EQUIVALENT															
	60	LENGTH = 30 FT. STATIC HEAD IS 14 FT.															
1	61	(3) TUBE SIDE IS IN WET H2S SERVICE. NACE COMPLIANCE REQUIRED.															
2	62	(4) TUBE SIDE SUBJECT TO STEAMOUT AT 250°F. AND 15 PSIG. STEAMOUT ON TUBE SIDE ALONE IS NOT ALLOWED FOR THIS UNIT. STEAM OUT ON															
2	63	SHELL SIDE FIRST, WHILE SHELL IS STILL HOT, STEAM OUT TUBE SIDE.															
	64																
	65																

X:\s\X-7929.xls

CERTIFIED AS-BUILT

Miles Duvall 9/13/12





VIEW A-A & SECTION C-C SECTION B-B

NOZZLE SCHEDULE				
MK	QT	DESCRIPTION	PROCESS	AUXILIARIES
S1	1	6" 300#RF WN	INLET	
S2	1	3" 300#RF WN	OUTLET	
S3	1	3/4" 300#RF LWN	BAL. LINE	w/ BLIND
D2	1	3/4" 300#RF LWN	DRAIN	w/ BLIND
V2	1	3/4" 300#RF LWN	VENT	w/ BLIND
T1	1	6" 300#RF WN	INLET	
T2	1	10" 300#RF WN	OUTLET	
D1	1	2" 300#RF LWN	DRAIN	w/ BLIND
V1	1	2" 300#RF LWN	VENT	w/ BLIND

CERTIFIED CORRECT FOR FABRICATION

BY: Miles Duvall DATE: 8/31/12

DESIGN DATA	SHELL	TUBE
DESIGN PRESSURE P.S.I.G.	455 *	205 *
VACUUM PRESSURE P.S.I.G.	FV	N/A
TEST PRESSURE P.S.I.G.	595 (SHOP: 605)	270 (SHOP: 280)
DESIGN TEMP. Deg. F.	515	390
M.D.M.T. Deg. F.	10	10
CORROSION ALLOWANCE	1/8"	3/16" 1
NUMBER OF PASSES	1	1
RADIOGRAPH	NONE	SPOT
HEAT TREAT REQUIRED	NO	YES
MAWP (H&C) P.S.I.G.	455	205
LIMITED BY:	FIXED TUBESHEET	FIXED TUBESHEET

* 9 PSI ADDED IN DESIGN TO ACCOUNT FOR STATIC HEAD WHEN ERECTED

ESTIMATED WEIGHTS, LBS.

DRY: 8700 BUNDLE: NA WET: 11700

SPECIFICATIONS

ASME CODE SECT. VIII DIV.1, 2007 ED. A09 Addn.(STAMP YES)
TEMA CLASS R and API-660 APPLIES
NATIONAL BOARD REGISTRATION REQUIRED

MATERIAL

CHANNEL: SA-333-6
SHELL: SA-106-B
TUBESHEETS: SA-516-70N 2
BAFFLES: SA-36
TUBES: SA-179
(462) 3/4" O.D.X 0.083" (MW) X 14'-0" L.G.
TUBE PITCH 15/16" 1 30° △ SURFACE 1241 SQ. FT.

GENERAL NOTES

ALL BOLT HOLES TO STRADDLE NATURAL CENTER LINES.
INSULATION: 2" THK. TYPE "HC" (BOTH SIDES) 2
PAINT: SEE PAINT MAP DWG X-7929-AA
GASKETS: 1/8" THK 321 S.S. DJ FLEXIBLE GRAPHITE FILLED
(1) SPARE SET OF GASKETS REQUIRED.
TUBE-TS JOINT: EXPANDED (2 GROOVES)
TUBE SIDE IS IN WET H2S SERVICE. NACE MR0175 APPLY 3
NITROGEN PURGE REQUIRED BOTH SIDES 6

CUST: MISSISSIPPI POWER CO.
c/o SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ. No.: MC202 1
ITEM NO.: HX0042
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
SHIP TO: KEMPER CO, MS

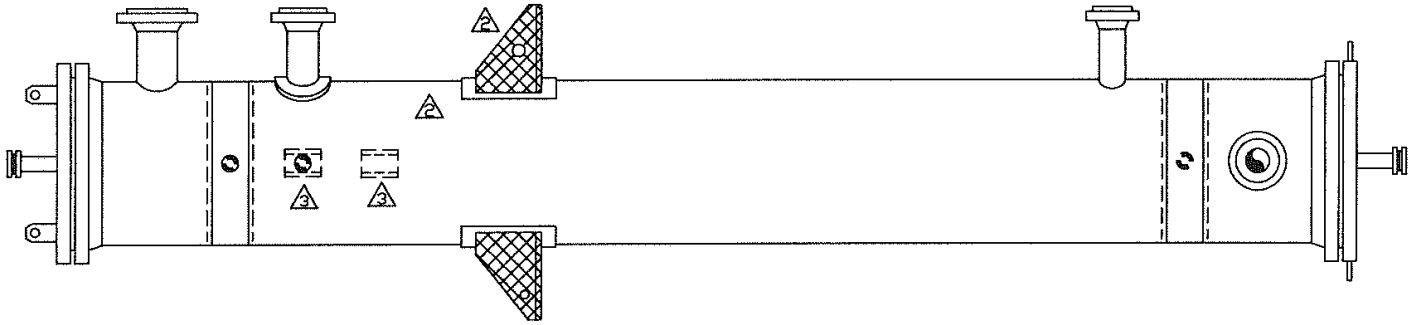
NO.	DATE	REVISIONS	
6	8-31-12	REV'D PER CUST.	DM/MD
5	8-24-12	REV'D PER EEC	DM/JD
4	8-10-11	REV'D PER CUST.	WE/SM
3	6-24-11	REV'D PER CUST.	WE/DN
2	5/12/11	REV'D PER CUST.	MD/SG
1	3-9-11	REV'D PER CUST.	DN/SG

ASSEMBLY AND SPECIFICATIONS FOR
ONE (1) 23-168 N E N

DWN. BY MD
DATE 1/19/11
CKD. BY DN

Energy Exchanger Co.
3944 Mt. Bernard Rd. - Tulsa, Okla. 74135

DWG. NO. X-7929-A REV 6



△1 COATING DATA SHEET - SYSTEM 5 APPLIES.
ABRASIVE BLAST PER SSPC-SP10 WITH AN ANCHOR PROFILE OF 1 TO 2 MILS.
PAINT WITH AMERON , PPG AMERCOTE, DIMETCOTE 9 or 9HS (3.0-4.0 MILS DFT)

△1 COATING DATA SHEET - SYSTEM 3 APPLIES.
ABRASIVE BLAST PER SSPC-SP10 WITH AN ANCHOR PROFILE OF 1 TO 2 MILS.
PAINT WITH AMERON, PPG AMERCOTE, DIMETCOTE 9 or 9HS (2.0-3.0 MILS DFT)
FINISH WITH AMERON, PPG AMERCOTE, PSX 892HS (1.0-2.0 MILS DFT) (COLOR: ALUMINUM)

CERTIFIED AS-BUILT

CUSTOMER: MISSISSIPPI POWER
/ SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

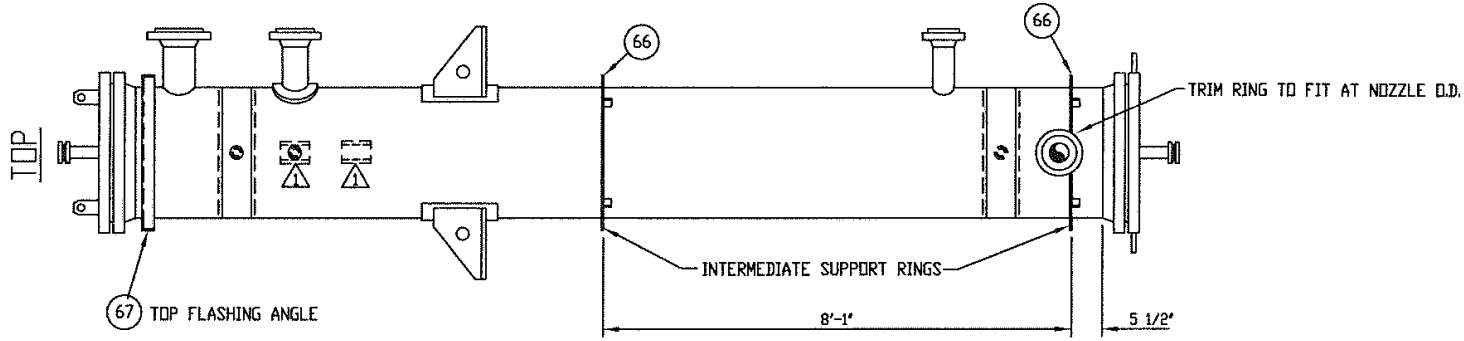
NOTES:
1. A DAILY INSPECTION REPORT SHALL BE MAINTAINED.
2. PAINT SPECIFICATION V42-1TS AND APPLICABLE COATING DATA SHEET SHALL BE BE FURNISHED TO THE PAINTER.

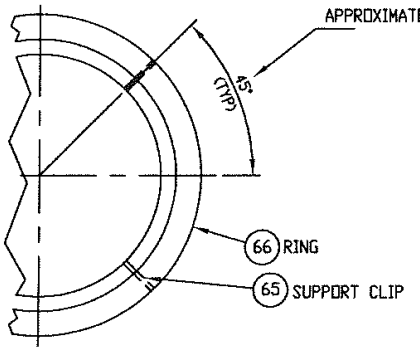
NO.	DATE	REVISIONS	
△			
△			
△			
△3	8-24-12	REV'D PER EEC	DM/
△2	8-10-11	REV'D PER CUST.	WE/MD
△1	5/12/11	REVISED PER CUSTOMER	MD/SG

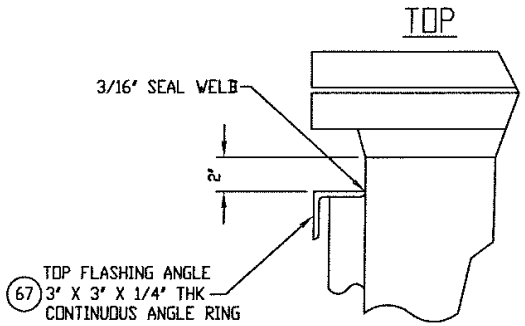
PAINT MAP

DWN. BY	D.MORRISON
DATE	3-14-11
CKD. BY	SM
DWG. NO.	X-7929-AA
REV	3

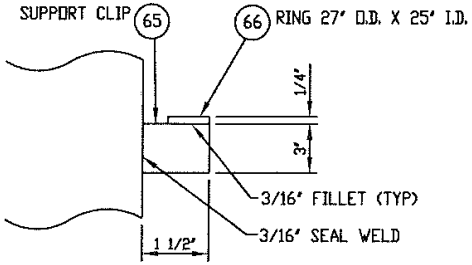
Energy Exchanger Co.
3944 No. Garnett Rd. - Tulsa, Okla. 74116







TOP FLASHING ANGLE



INTERMEDIATE SUPPORT RINGS

CERTIFIED AS-BUILT

CUSTOMER: MISSISSIPPI POWER
/ SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NO.	DATE	REVISIONS
1	8-24-12	REV'D PER EEC DM/

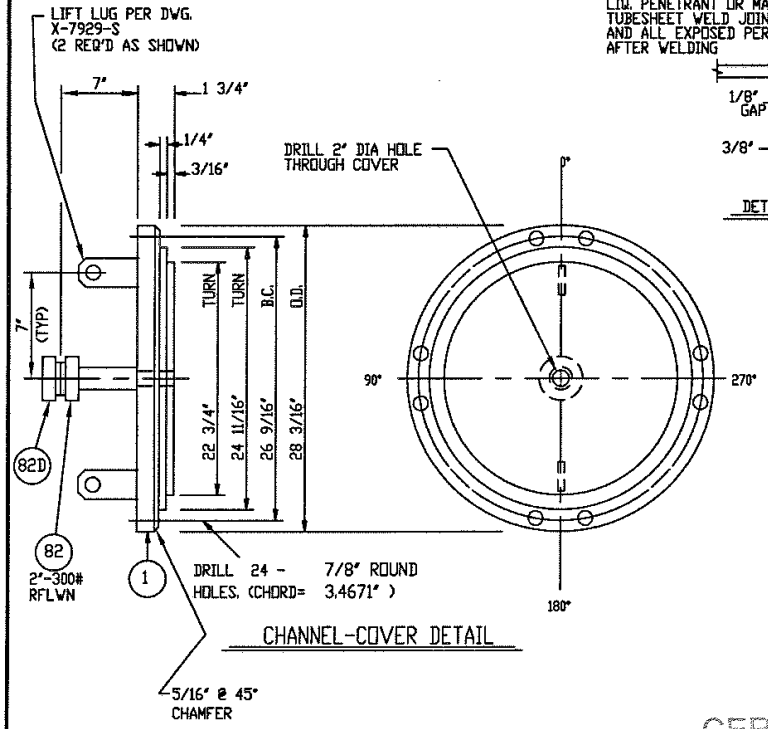
INSULATION SUPPORT DETAILS

DWN. BY D.MORRISON
DATE 8-17-11
CKD. BY MD
DWG. NO. X-7929-AB
REV 1

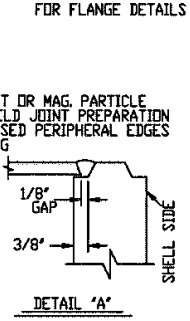
Energy Exchanger Co.
3944 No. Garnett Rd. · Tulsa, Okla. 74116

COVER NOTES:
1) MACHINE ALL COVER SURFACES TO 250 Ra
EXCEPT GASKET FACE TO BE 125 Ra.

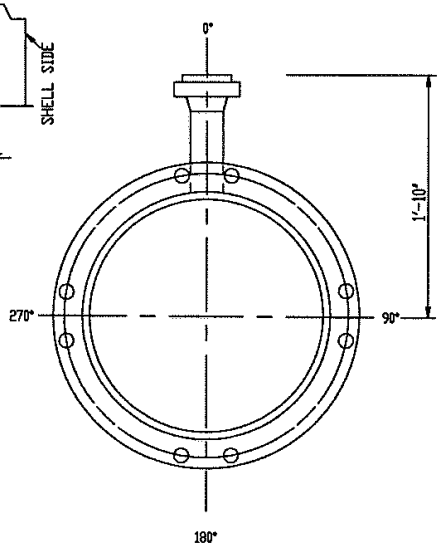
FOR FLANGE DETAILS SEE DWG. X-7929-K



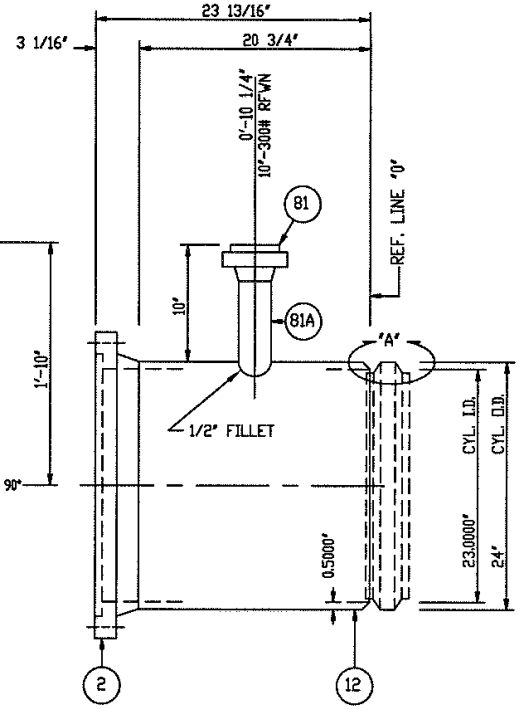
CHANNEL-COVER DETAIL



DETAIL 'A'



CHANNEL TOP VIEW



CHANNEL SIDE VIEW

CERTIFIED AS-BUILT

CUSTOMER:	MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O. NO:	17496-0001 REQ No.: MC202
SERVICE:	HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO:	HX0042

NOTES:
1) ALL BOLT HOLES TO STRADDLE CENTER LINES.
2) FOR WELD AND BEVEL DETAILS SEE DWG. X-7929-S
3) FOR JOB NOTES SEE DWG. X-7929-R
4) NOZZLE SWING DIMENSION = 47 1/4"

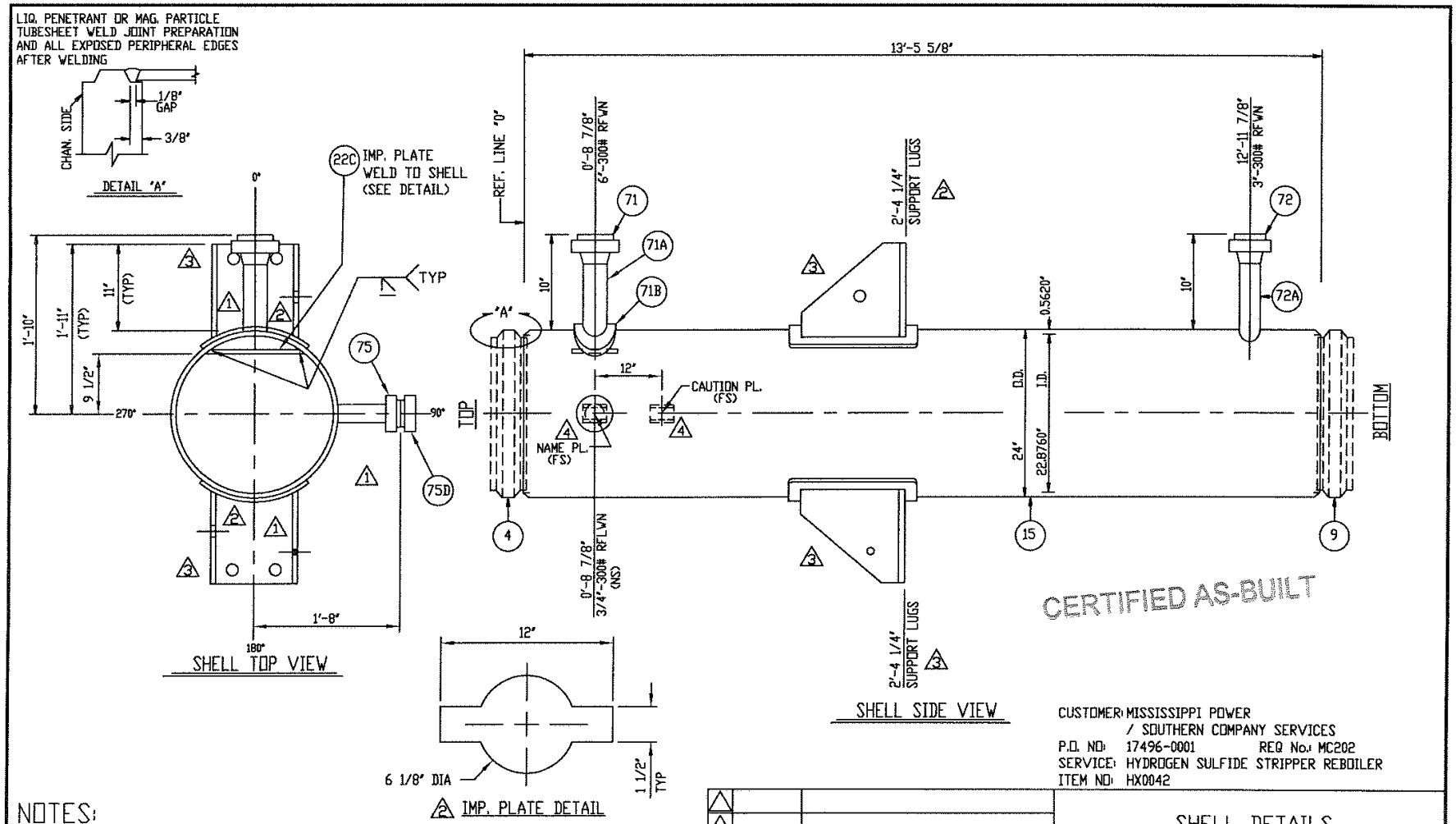
NO.	DATE	REVISIONS

TOP CHANNEL DETAILS

DWN. BY: D.MORRISON
DATE: 3-14-11
CKD. BY:

Energy Exchanger Co.
3944 No. Garnett Rd. - Tulsa, Okla. 74116

DWG. NO.: X-7929-B
REV: 0



CUSTOMER: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NOTES:

1) ALL BOLT HOLES TO STRADDLE CENTER LINES.
2) FOR WELD AND BEVEL DETAILS SEE DWG. X-7929-S
3) FOR JOB NOTES SEE DWG. X-7929-R
4) SEE SUPPORT DETAILS (DWG. X-7929-D1) FOR REFERENCE. 2
5) SEE NAME PLATE DETAILS (DWG. X-7929-Q1 & Q2) FOR REFERENCE.
6) DELETED 4

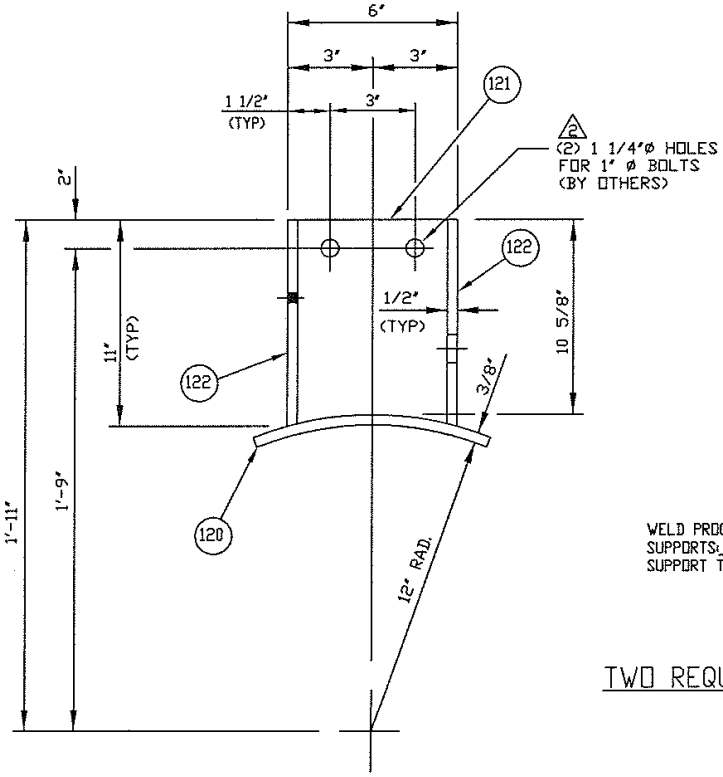
NO.	DATE	REVISIONS	
4	8-24-12	REV'D PER EEC	DM/
3	8-10-11	REV'D PER CUST.	WE/SM
2	6-24-11	REV'D PER CUST.	WE/DN
1	5/12/11	REVISED PER CUSTOMER	MD/SG

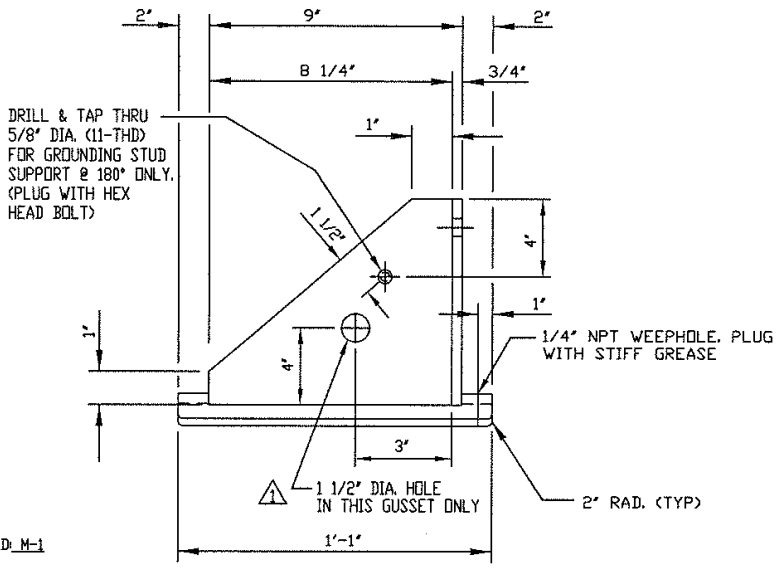
SHELL DETAILS

DWN. BY: D.MORRISON
DATE: 3-14-11
CKD. BY: SM

Energy Exchanger Co.
3944 No. Garnett Rd. - Tulsa, Okla. 74116

DWG. NO.: X-7929-C
REV: 4





WELD PROC:
SUPPORTS: M-1
SUPPORT TO PAD: M-1

TWO REQUIRED

CERTIFIED AS-BUILT

CUSTOMER: MISSISSIPPI POWER
/ SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NOTE:

1. SEE DWG. X-7929-R FOR JOB NOTES.
2. SEE DWG. X-7929-A FOR ORIENTATION.

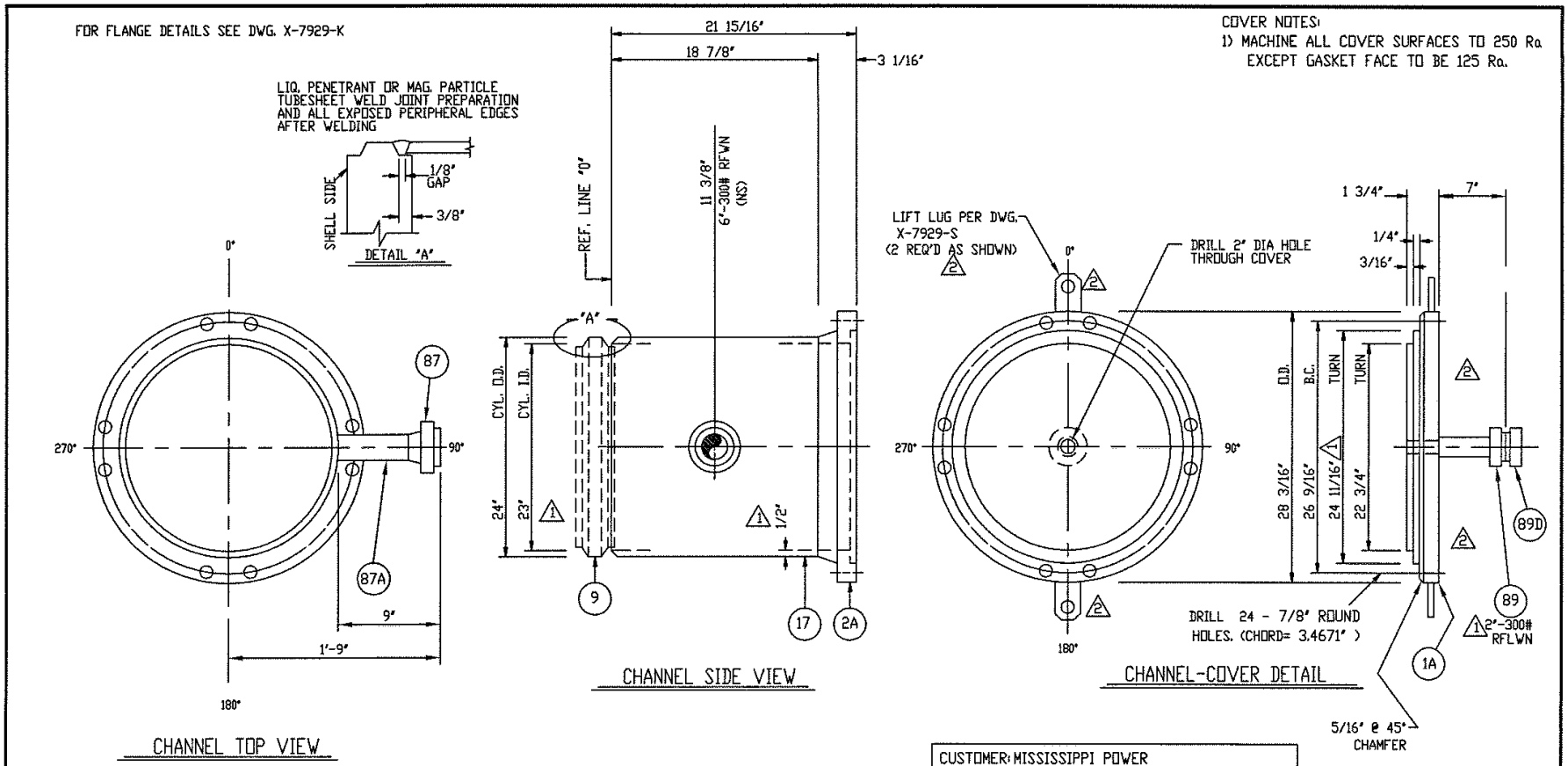
NO.	DATE	REVISIONS
2	9-8-11	REV'D PER CUST. BC/MA
1	8-10-11	REV'D PER CUST. WE/

SUPPORT DETAILS

DWN. BY D.MORRISON
DATE 3-11-11
CKD. BY SM

Energy Exchanger Co.
1844 No. Garnett Rd. - Tulsa, Okla. 74116

DWG. NO. X-7929-D1
REV 2



CERTIFIED AS-BUILT

CUSTOMER: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NOTES:

1) ALL BOLT HOLES TO STRADDLE CENTER LINES.
2) FOR WELD AND BEVEL DETAILS SEE DWG. X-7929-S
3) FOR JOB NOTES SEE DWG. X-7929-R
4) NOZZLE SWING DIMENSION = 45 5/8"

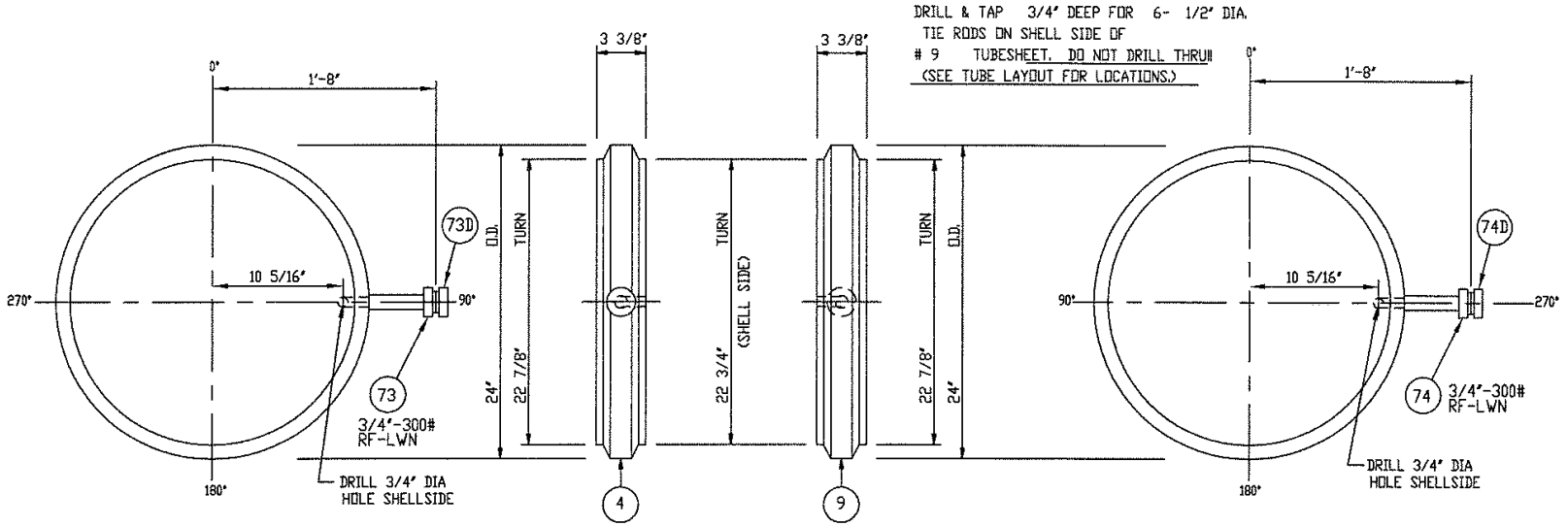
NO.	DATE	REVISIONS
2	7-14-11	MOVED LIFT LUGS DM/
1	5/12/11	REVISED PER CUSTOMER MD/SG

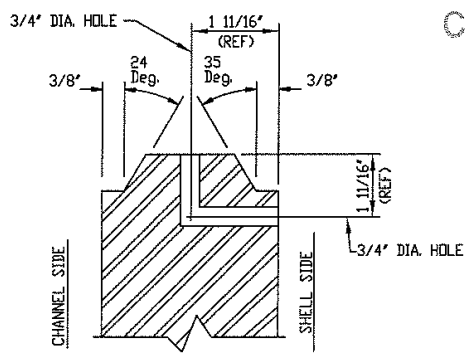
BOTTOM CHANNEL DETAILS

DWN. BY D.MORRISON
DATE 3-14-11
CKD. BY SM

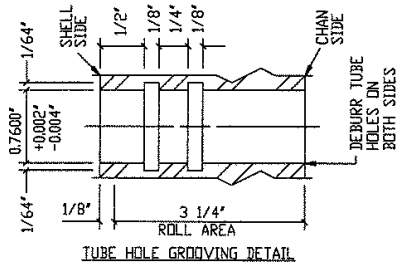
Energy Exchanger Co.
1844 No. Garnett Rd. • Tulsa, Okla. 74116

DWG. NO. X-7929-E
REV 2





CERTIFIED AS-BUILT



NOTES:

1) MACHINE ALL SURFACES TO 250 Ra. EXCEPT GASKET FACE TO BE 125 Ra.
2) REAM & RING-GROOVE TUBE HOLES AFTER POST-WELD HEAT TREAT.
3) FOR JOB NOTES SEE DWG. X-7929-R
1 4) SEE DWG. X-7929-S FOR WELD AND BEVEL DETAILS.

CUSTOMER: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

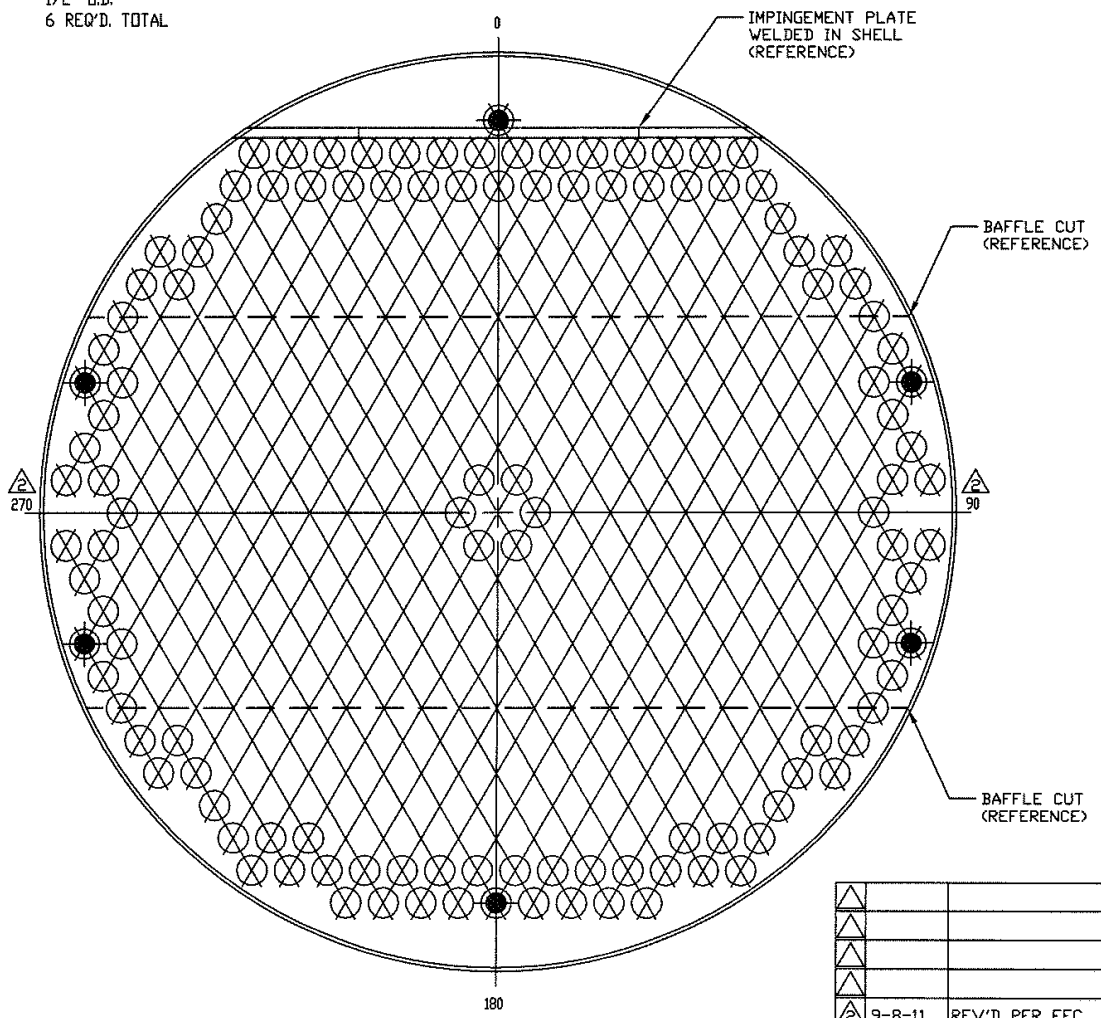
NO.	DATE	REVISIONS
1	5/12/11	REVISED PER CUSTOMER MD/SG

TUBESHEET DETAILS

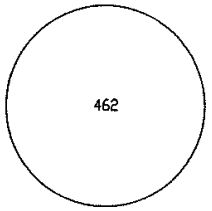
DWN. BY D.MORRISON
DATE 3-14-11
CKD. BY SM

Energy Exchanger Co.
1844 No. Garnett Rd. - Tulsa, Okla. 74116

DWG. NO. X-7929-F
REV 1



VIEW LOOKING AT SHELL SIDE OF NO. 9 TUBESHEET △1



TUBE DISTRIBUTION

CERTIFIED AS-BUILT

NOTES:

1) DRILL AND REAM TUBE HOLES IN TUBESHEETS TO 0.7600" +0.002"/-0.004" DIA. FOR 462 - 3/4" O.D. TUBES.
△1 2) TUBE PITCH = 15/16" 30° TRIANGLE.
3) NUMBER OF PASSES = 1
4) SEE DRAWING X-7929-F FOR TUBE GROOVING DETAILS.
5) BAFFLE O.D. = 22 11/16"
△1 6) O.T.L. = 22 3/8"

CUSTOMER: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202 △1
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

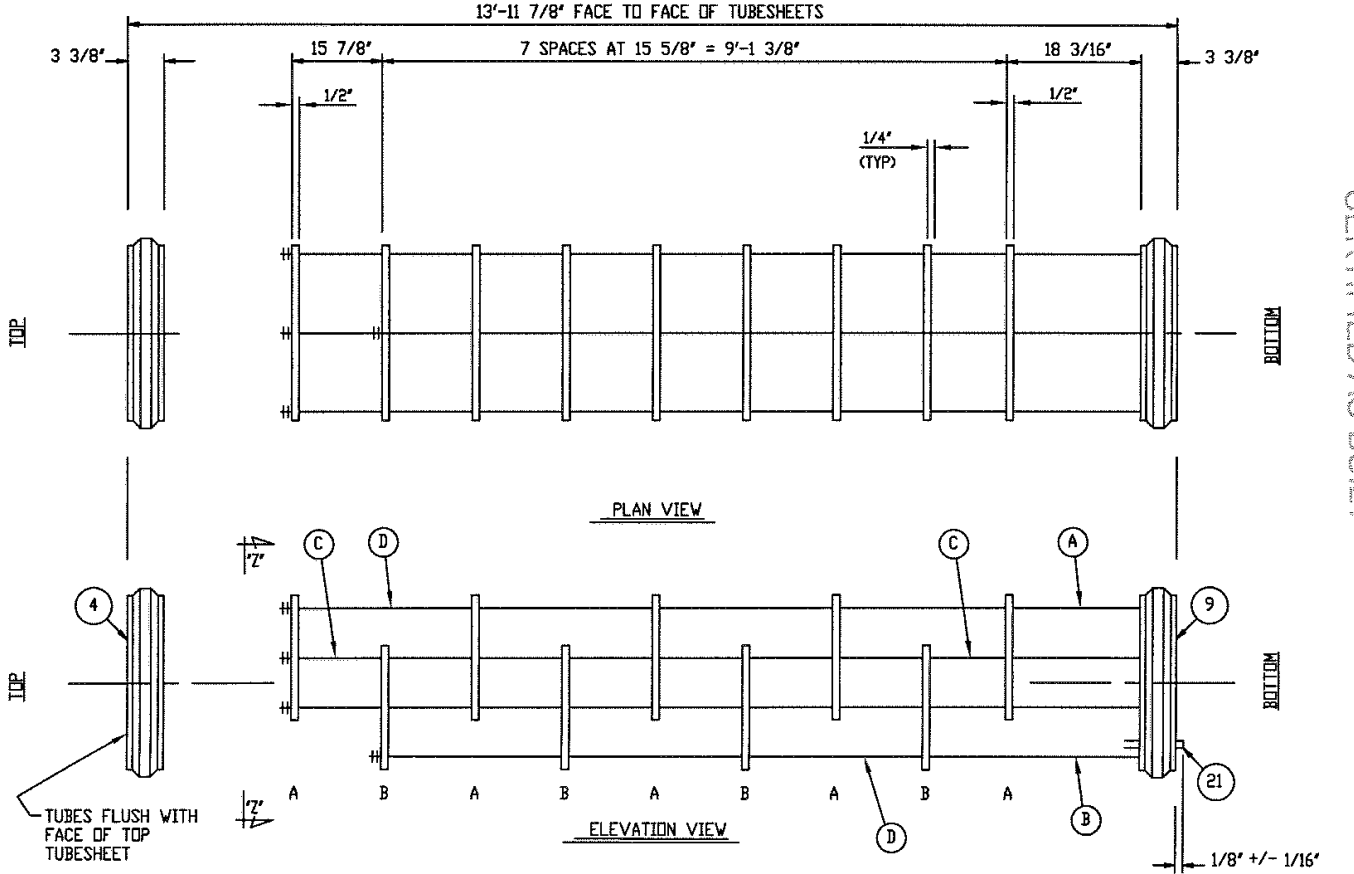
NO.	DATE	REVISIONS	
△2	9-8-11	REV'D PER EEC	BC/MD
△1	3-9-11	REV'D PER CUST.	DN/SG

TUBE LAYOUT

DWN. BY: MD
DATE: 1-18-11
CKD. BY: BD

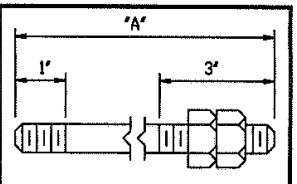
Energy Exchanger Co.
1844 No. Garnett Rd. - Tulsa, Okla. 74116

DWG. NO. X-7929-H
REV 2



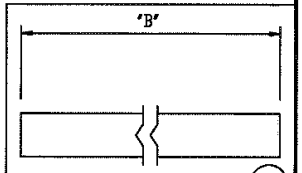
CERTIFIED AS-BUILT

NOTES:
1) FOR SECTION AND VIEW DETAILS SEE DWG. X-7929-J
2) FOR JOB NOTES SEE DWG. X-7929-R



1/2" O.D. TIE RODS (23)

	REQ'D.	"A"
R1	5	12'-1 5/8"
R2	1	10'-10"
R3		
R4		



3/4" O.D. SPACER TUBING

	REQ'D.	"B"
A	5	17 11/16"
B	1	33 9/16"
C	32	15 3/8"
D	7	31"
E		
F		
G		

CUSTOMER: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

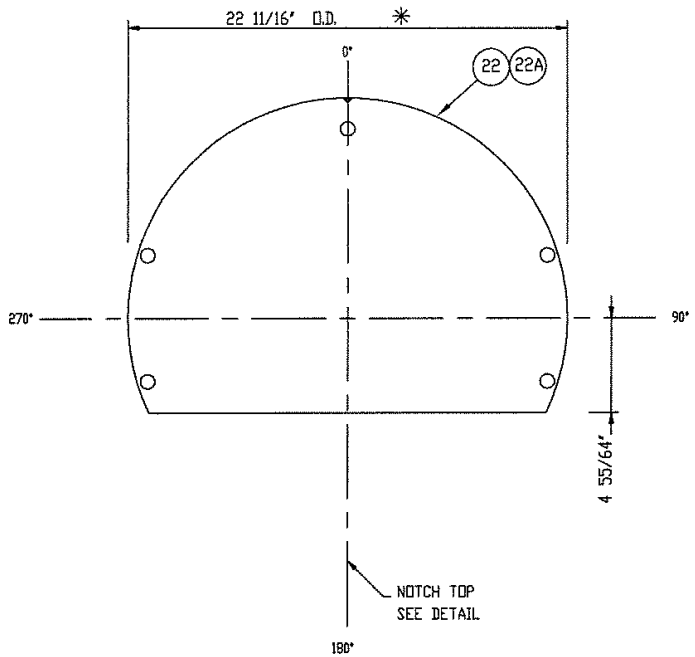
NO.	DATE	REVISIONS

BUNDLE DETAILS

DWN. BY D.MORRISON
DATE 3-14-11
CKD. BY

Energy Exchanger Co.
1044 No. Garnett Rd. • Tulsa, Okla. 74116

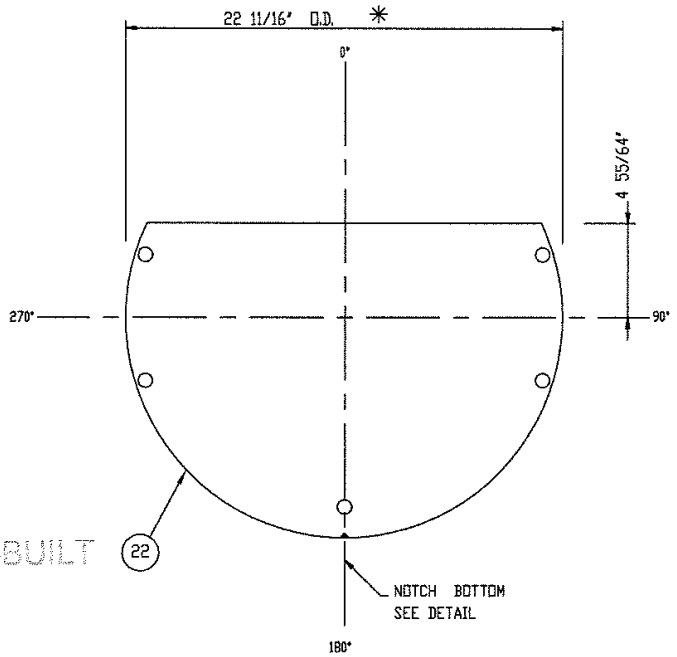
DWG. NO. X-7929-I
REV 0



VIEW ZZ OF BAFFLES

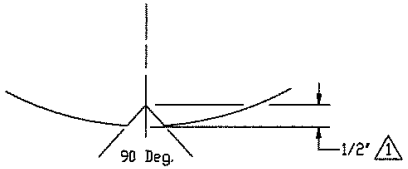
3-REQD. CUT A 1/4" THK

2-REQD. CUT A 1/2" THK



VIEW ZZ OF BAFFLES

△1 4-REQD. CUT B 1/4" THK



NOTCH DETAIL

CUSTOMER: MISSISSIPPI POWER
/ SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NOTES:

1) FOR JOB NOTES SEE DWG. X-7929-R
2) DRILL TUBE HOLES IN BAFFLES 25/32" DIA. & DEBURR.
3) DRILL TIE ROD HOLES 9/16" DIA.
SEE TUBE LAYOUT (DWG. X-7929-H) FOR LOCATION. △1
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 Ra.
7) SEE TUBE LAYOUT (DWG. X-7929-H) FOR BAFFLE CUT LOCATIONS. △1

NO.	DATE	REVISIONS
△		
△		
△		
△		
△		
△1	5/12/11	REVISED PER CUSTOMER MD/SG

BAFFLE DETAILS

DWN. BY D.MORRISON

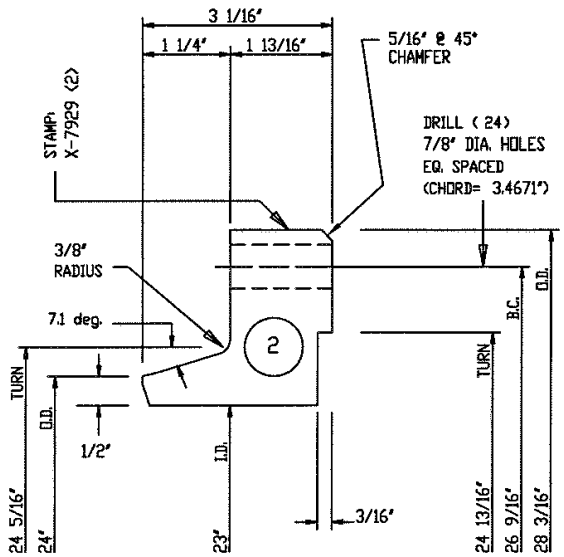
DATE 3-14-11

CKD. BY SM

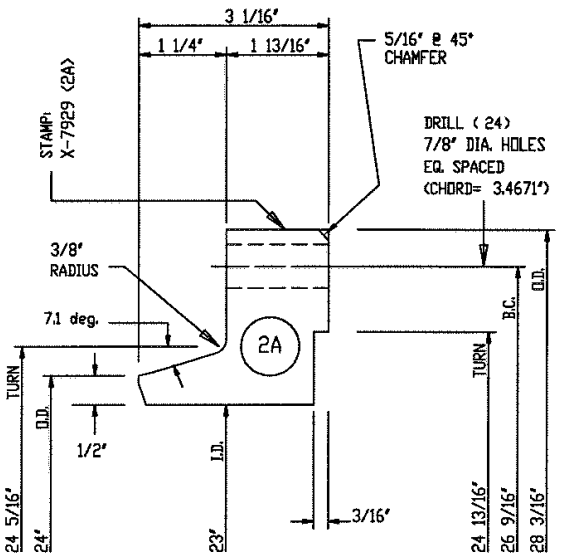
Energy Exchanger Co.
1844 No. Garnett Rd. - Tulsa, Okla. 74116

DWG. NO. X-7929-J

REV 1



#2 GIRTH FLANGE (ONE) REQ'D.



#2A GIRTH FLANGE (ONE) REQ'D.

CERTIFIED AS-BUILT

CUSTOMER: MISSISSIPPI POWER
/ SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NOTES:
1) SEE DWG. X-7929-R FOR JOB NOTES.
2) MACHINE ALL SURFACES TO 250 Ra
EXCEPT GASKET SURFACES MACHINE TO 125 - 250 Ra.

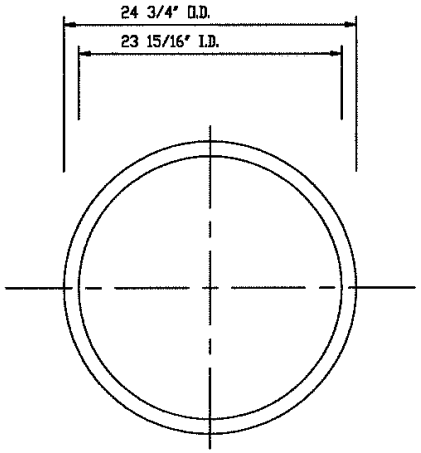
NO.	DATE	REVISIONS

GIRTH FLANGES

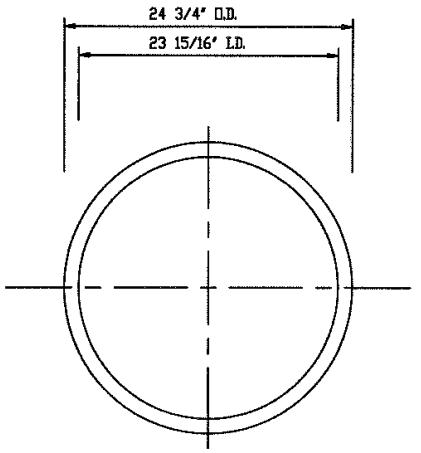
DWN. BY D.MORRISON
DATE 3-14-11
CKD. BY SM

Energy Exchanger Co.
1044 No. Garnett Rd. • Tulsa, Okla. 74116

DWG. NO. X-7929-K
REV 0



(1)-REQUIRED.
TOP CHANNEL COVER GASKET
1/8" THK 321 STN STL DJ FLEXIBLE GRAPHITE FILLED



(1)-REQUIRED.
BOTTOM CHANNEL COVER GASKET
1/8" THK 321 STN STL DJ FLEXIBLE GRAPHITE FILLED

CERTIFIED AS-BUILT

NOTES:

1) QUANTITIES SHOWN FOR ONE SET
(2)-SET 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) ALL JACKETED GASKETS TO HAVE
LAP OF GASKET NEAR SIDE.

CUSTOMER: MISSISSIPPI POWER
/ SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

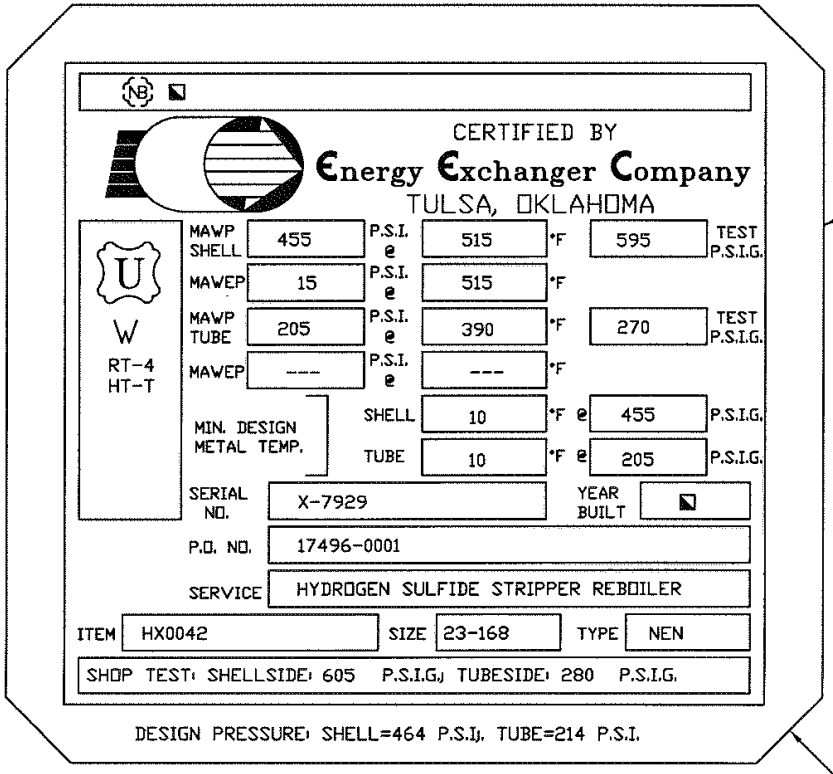
NO.	DATE	REVISIONS
1		
2		
3		
4		
5		
6		

GASKET DETAILS

DWN. BY D.MORRISON
DATE 3-14-11
CKD. BY

Energy Exchanger Co.
1944 No. Garnett Rd. • Tulsa, Okla. 74116

DWG. NO. X-7929-0
REV 0



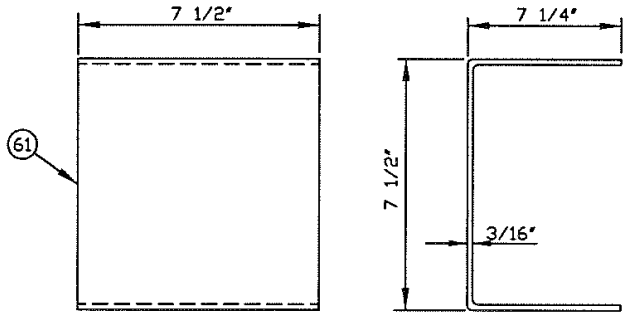
NAME PLATE DETAIL

ONE - REQ'D.

60

CLIP CORNERS & SEAL WELD TO NAME PLATE BRACKET

■ SHOP TO ASSIGN AT COMPLETION OF FABRICATION



NAME PLATE BRACKET DETAIL

ONE - REQ'D.

CERTIFIED AS-BUILT

CUSTOMER: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NO.	DATE	REVISIONS

NAME PLATE DETAILS

DWN. BY D.MORRISON
DATE 3-14-11
CKD. BY

Energy Exchanger Co.

DWG. NO. X-7929-Q1
REV 0

CLIP CORNERS & SEAL WELD
TO NAME PLATE BRACKET

CAUTION

PRESSURES AND TEMPERATURES SHOWN ON THE NAMEPLATE OF THIS HEAT EXCHANGER RELATE ONLY TO PRESSURE RETAINING CAPABILITY. CERTAIN COMPONENTS HAVE BEEN DESIGNED FOR SPECIFIC OPERATING CONDITIONS. DEVIATION FROM THESE CONDITIONS OR A CHANGE IN SERVICE REQUIRE A MECHANICAL DESIGN CHECK BE PERFORMED TO AVOID POSSIBLE DAMAGE TO THE HEAT EXCHANGER OR DANGER TO PERSONNEL.

CAUTION PLATE DETAIL △1
ONE - REQ'D.

WARNING

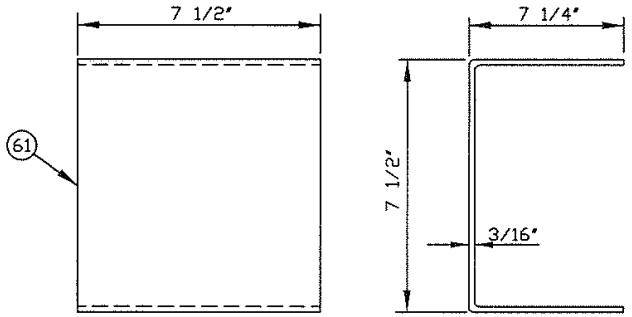
FIXED TUBESHEET HEAT EXCHANGER
INTRODUCE SHELL SIDE FIRST BEFORE INTRODUCING TUBE SIDE

STEAMOUT TUBE SIDE ALONE IS NOT ALLOWED FOR THIS UNIT. STEAMOUT SHELL SIDE FIRST, WHILE SHELL SIDE IS HOT STEAMOUT TUBE SIDE.

WARNING PLATE DETAIL △1
ONE - REQ'D.

CLIP CORNERS & SEAL WELD
TO NAME PLATE BRACKET

△1
(60) USE BACK SIDE OF EEC NAME PLATE. SPLIT IN HALF TO MAKE BOTH NAME PLATES (FIT BOTH ON SAME BRACKET)



CAUTION PLATE BRACKET DETAIL
ONE - REQ'D.

CERTIFIED AS-BUILT

CUSTOMER: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NO.	DATE	REVISIONS
△1	5/12/11	REV. PER CUSTOMER MD/SG

NAME PLATE DETAILS

DWN. BY D.MORRISON
DATE 3-14-11
CKD. BY SM
DWG. NO. X-7929-Q2
REV 1

Energy Exchanger Co.
1844 No. Garnett Rd. - Tulsa, Okla. 74116

Kemper County MM209937

FABRICATION REQUIREMENTS

1. ALL BOLT HOLES TO STRADDLE NATURAL CENTER LINES.
2. NOZZLES SHALL NOT PROTRUDE BEYOND THE INSIDE SURFACE OF THE CHANNEL OR SHELL.
3. CHECK SHELL FOR OUT-OF-ROUNDNESS. USE TWO DISCS EQUAL THE BAFFLE DIA. MOUNTED ON A SHAFT 18" APART.
4. FLANGE FLATNESS TOLERANCE AND SURFACE FINISH SHALL BE MEASURED AFTER THE FLANGE HAS BEEN WELDED & PWHT.
1 5. CHANNEL COVER, AND BODY FLANGE PERIPHERAL GASKET SURFACES SHALL HAVE A FLATNESS TOLERANCE OF 1/32" AND MEASURED WITH A DIAL GUAGE.
1 6. DELETED
7. ALL FLAME-CUT BEVEL WELDS SHALL BE GROUND TO BRIGHT METAL PRIOR TO WELDING.
8. MATCH MARKS REQUIRED ON CHANNEL COVER AND ALL TEMA FLGS. WITH A SCRIBED LINE 1/8" DEEP AT THE 90° AND 270° POSITIONS.
9. THE FOLLOWING PARTS SHALL BE STAMPED WITH MANUFACTURER'S SERIAL NUMBER & ITEM NUMBER: CHANNEL FLANGE, CHANNEL COVER.
10. TUBESHEET AND TUBE HOLES SHALL BE CLEANED AND DEGREASED IMMEDIATELY PRIOR TO ASSEMBLY WITH A CHLORIDE FREE SOLVENT.
11. PRIOR TO ASSEMBLY, ALL INTERNALS SHALL BE CLEAN AND FREE OF LOOSE SLAG, SCALE OR OTHER DEBRIS.
12. ANY WELD DEFECTS SHALL HAVE THE DEFECT REMOVED AND CONFIRMED IF ORIGINALLY RT, THEN RT REPAIR AND ALSO MT.
1
13. WELD JOINT SURFACES AND A MINIMUM OF 1" OF THE INTERNAL AND EXTERNAL SURFACES OF THE ADJACENT BASE METAL SHALL BE CLEAN AND FREE FROM PAINT, OIL, DIRT, SCALE, OXIDES, AND OTHER FORIEGN MATERIAL DETRIMENTAL TO THE INTEGRITY OF THE WELD.

M.T. REQUIREMENTS

1 1. DELETED
2. MT ALL LIFTING LUG WELDS
1 3. DELETED
4. TEMPORARY ATTACHMENT WELDS SHALL BE REMOVED, THE AREAS DRESSED, AND EXAMINED.
1 5. DELETED
1 6. DELETED
1 7. MT ALL CHANNEL SIDE WELDS AFTER PWHT.

HEAT TREAT REQUIREMENTS

1 TOP CHANNEL & BTTM CHANNEL:
- A) HEAT FROM 800 deg.F TO 1150 deg.F ±25 deg. F. AT 400 deg.F PER HOUR.
- B) HOLD AT 1150 deg.F ±25 deg. F. FOR 1.00 -HOUR (MIN).
- C) COOL FROM 1150 deg.F TO 800 deg.F AT 500 deg.F PER HOUR.
- D) FURTHER COOLING MAY BE IN STILL AIR.

ALL MACHINED CONTACT SURFACES AND THREADED CONNECTIONS SHALL BE SUITABLY PROTECTED TO PREVENT SCALING OR LOSS OF FINISH DURING PWHT.

R.T. REQUIREMENTS

1. TUBESIDE: SPOT RADIOGRAPHED.
   AS A MINIMUM, SPOT RADIOGRAPH SHALL BE AS FOLLOWS:
   - A) ONE SPOT AT EACH CATEGORY A AND B WELDED JOINT. (NOZZLE WELDS EXEMPT)
   - B) AT EACH START AND STOP OF WELDS MADE BY AUTOMATIC SUBMERGED-ARC PROCESS.
   - C) SPOTS SHALL BE AT LEAST 10" LG. OR FULL LENGTH IF WELD IS LESS THAN 10".
   - D) WELD POROSITY LIMITS FOR SPOT RADIOGRAPHS SHALL BE SAME AS LIMITS FOR FULL RADIOGRAPHED JOINTS.
   - E) RT EACH WELD PROCEDURE, WELDER/OPERATOR, & SHIFT.
2. SHELLSIDE : NO RADIOGRAPH
3. RT FILM SHALL BE FINE GRAIN, HD, HIGH CONTRAST FILM (KODAK TYPE AA OR EQUAL) FILM DENSITY OF 2.0-3.5 DETERMINED BY SPECIMEN OR DENSITOMETER.

1 4. DELETED
1 5. DELETED

HARDNESS REQUIREMENTS

1. WELD HARDNESS TESTING, SHALL BE IN ACCORDANCE WITH THE FOLLOWING:
   - A) THE WELD METAL & HAZ OF PRESSURE-RETAINING WELDS IN COMPONENTS
   - B) BRINELL HARDNESS LIMITS SHALL BE 200 MAX.
   - C) HARDNESS SHALL BE DETERMINED USING A 10mm DIA. BALL UNLESS OTHERWISE SPECIFIED.
1 D) DELETED
   - E) ONE READING IN THE WELD METAL OF EACH CIRC. SEAM AND ONE READING IN EACH HEAT AFFECTED ZONE.
   - F) ONE READING IN THE WELD METAL OF NOZZLE TO EXCHANGER WELDS AND ONE READING IN EACH HEAT AFFECTED ZONE IN 50% OF THE NOZZLES.
   - G) IF MORE THAN ONE WELDING PROCEDURE IS USED TO FABRICATE LONG. OR CIRC. WELDS, HARDNESS READINGS SHALL BE MADE OF WELDS DEPOSITED BY EACH PROCEDURE.
   - H) TESTING SHALL BE DONE ON ACCESSIBLE INSIDE SURFACES.

1 D

CERTIFIED AS-BUILT

HYDROTESTING REQUIREMENTS

1. HOLD FOR AT LEAST ONE HOUR. A HYDROTEST CHART IS REQ'D.
2. MINIMUM TEST WATER TEMP. = 50 deg.F.
3. PAINT OR OTHER COATINGS SHALL NOT BE APPLIED OVER WELDS BEFORE FINAL HYDROTEST.
1 4. LEAK TEST WELD PADS WITH 15 PSI AIR AND SOAP SOLUTION, OBSERVING WELDS FROM THE INSIDE AND OUTSIDE.
5. LEAKAGE AT MAIN FLANGES REQUIRES CUSTOMER NOTIFICATION IN WRITING. ALL CORRECTIVE ACTION SHALL BE SUSPENDED UNTIL APPROVAL IS RECEIVED BY THE CUSTOMER. THE REASON FOR THE LEAK SHALL BE DETERMINED, DOCUMENTED BY AN NCR AND REPAIRED TO THE SATISFACTION OF THE CUSTOMER.
6. IMMEDIATELY AFTER HYDRO, DRAIN AND DRY BY BLOWING WARM AIR NOT TO EXCEED 120°F.

SHIPPING REQUIREMENTS

1. PAINT ON THE SIDE OF THE EXCHANGER AND EACH CRATE: ITEM NO., P.O. NO., AND GROSS WEIGHT. IDENTIFY SPARE PARTS AS "SPARES" AND ITEM NUMBER.
2. CRATES SHALL HAVE A MINIMUM OF 2 STEEL STRAPS ON APPROX. 24" CENTERS. A PACKING LIST SHALL BE PLACED INSIDE AND ATTACHED TO THE OUTSIDE.
2 3. ALL NOZZLE GASKET SURFACES SHALL BE COATED WITH RUST VETO 342 PRIOR TO INSTALLING THE GASKETS AND SHALL BE PROTECTED BY METAL COVERS, PROVIDE A 1/4" N.P.T. WITH PLUG IN BOTTOM NOZZLE COVERS FOR DRAINING PURPOSES.
4. EXPOSED THREADS OF BOLTS SHALL BE PROTECTED WITH RUST VETO 342 RUST PREVENTATIVE TO PREVENT CORROSION DURING TESTING, SHIPPING, AND STORAGE. TAPPED HOLES SHALL BE PLUGGED WITH GREASE.
5. ATTACH A LARGE WEATHERPROOF TAG "CAUTION: THIS EQUIPMENT HAS BEEN TREATED WITH A RUST PREVENTATIVE AND NO PARTS SHOULD BE DISTURBED UNTIL READY TO BE PLACED IN SERVICE. IF PROTECTIVE FILM IS BROKEN, IT SHALL BE RESTORED FOR CONTINUED STORAGE."
6. MARK C-O-G (DRY) WITH A 3" CIRCLE ON HORZ. & VERTICLE CENTERLINES.
7) MARK ON TWO SIDES OF EXCHANGER 180° APART IN 3" LETTERS: "NO WELDING OR BURNING PERMITTED ON THIS EXCHANGER"
8) THE NORTH ORIENTATION SHALL BE CENTER PUNCHED AND MARKED IN A CONTRASTING COLOR ON THE OUTSIDE OF EXCHANGER, LOCATED APPROX. 12 INCHES ABOVE SUPPORT BASE PLATE. THE MARK SHALL BE A 6 INCHE LONG LINE AND NOTED AS "N".
2 9. NITROGEN PURGE REQUIRED FOR SHIPPING AND STORAGE. PAINT ON BOTH SIDES OF EXCHANGER WITH 4" HIGH LETTERS, "WARNING-NITROGEN PURGED, DANGER OF SUFFOCATION UPON OPENING."

CUSTOMER: MISSISSIPPI POWER
/ SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NO.	DATE	REVISIONS	
2	8-31-12	REV'D PER CUST.	DM/SM
1	8-10-11	REV'D PER CUST.	WE/SM

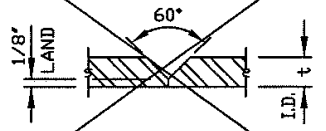
JOB NOTES

DWN. BY: D.MORRISON
DATE: 3/14/11
CKD. BY: SM

Energy Exchanger Co.
1044 No. Garnett Rd. • Tulsa, Okla. 74116

DWG. NO. X-7929-R
REV 2

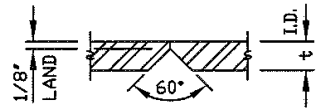
t=LESS THAN 7/16"
LOCATE LONG SEAM 15° ABOVE CL UNLESS OTHERWISE SPECIFIED.
ALL SEAMS BACK GOUGED & BACK WELDED



CHANNEL WELD PROC: -----
SHELL WELD PROC: -----

LONG OR CIRC WELD BEVEL
(CYL TO FLG, OR CYL)

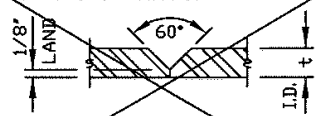
t=7/16" TO 5/8"
LOCATE LONG SEAM 15° ABOVE CL UNLESS OTHERWISE SPECIFIED.
ALL SEAMS BACK GOUGED & BACK WELDED



CHANNEL WELD PROC: A-62-H
SHELL WELD PROC: ---

LONG OR CIRC WELD BEVEL
(CYL TO FLG, OR CYL)

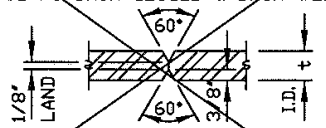
t=7/16" TO 5/8"
ALL SEAMS BACK GOUGED & BACK WELDED



CHANNEL HEAD WELD PROC: -----
SHELL HEAD WELD PROC: -----

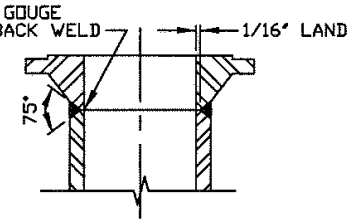
CIRC WELD BEVEL
(CYL TO HEAD)

t=OVER 5/8"
LOCATE LONG SEAM 15° ABOVE CL UNLESS OTHERWISE SPECIFIED.
ALL SEAMS BACK GOUGED & BACK WELDED



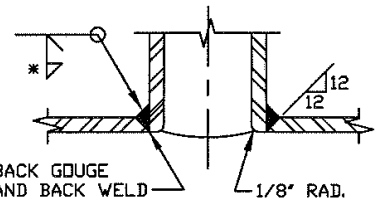
CHANNEL WELD PROC: -----
SHELL WELD PROC: -----

LONG OR CIRC WELD BEVEL
(CYL TO FLG, OR CYL)



CHANNEL WELD PROC: M-79-H, A-62-H
SHELL WELD PROC: M-5

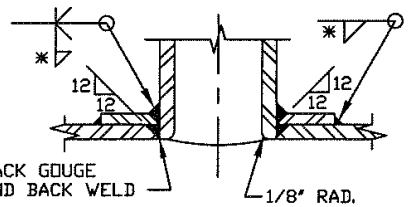
WELD-NECK FLANGE INSTALLATION



CHANNEL WELD PROC: M-76-H
SHELL WELD PROC: M-1

NOZZLE INSTALLATION WITHOUT PAD

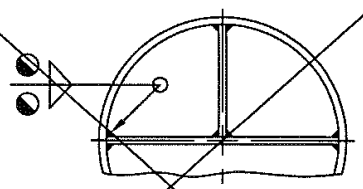
(1) 1/4" NPT IN EACH WELD PAD OR SEC. OF WELD PAD, PLUG W/ STIFF GREASE, UNLESS DETAILS SPECIFY OTHERWISE.



CHANNEL WELD PROC: -----
SHELL WELD PROC: M-1

NOZZLE INSTALLATION WITH PAD

WELD THE FOLLOWING ITEMS WITH PROC'S.
SUPPORT PAD TO SHELL: M-1
NAME PL. BRK'T. TO SHELL: M-1
IMP. PL. TO SHELL: M-1

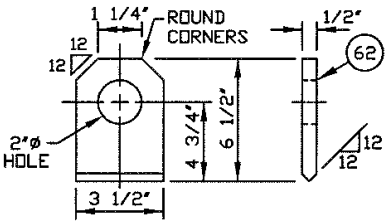


1/4" (MIN.) AT FRONT CHANNEL

PASS PLATE WELDS TO BE FULL PENETRATION FOR 2" (MIN) FROM FACE OF GASKET SURFACE.

WELD PROCEDURE: -----

PASS PLATE WELDS



FULL PEN WELD THEN SEAL WELD WITH 1/4" FILLET
WELD PROCEDURE: M-75-H

LIFTING LUG DETAIL

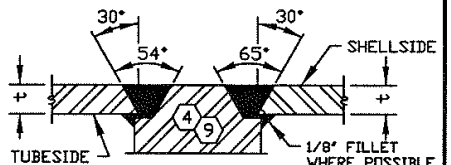
SHELLSIDE WELDS THAT MAY INTERFERE WITH BUNDLE INSTALLATION OR REMOVAL SHALL BE GROUND FLUSH.

1/4" MINIMUM FILLET WELDS FOR ALL NON PRESSURE ATTACHMENTS UNLESS NOTED OTHERWISE

* ALL FILLETS WELDS TO BE 3/8" UNLESS NOTED OTHERWISE

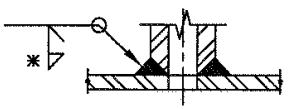
CHANNEL WELD PROC: -----
SHELL WELD PROC: -----

AUXILLARY NOZZLE INSTALLATION
(TO PIPE, CYLINDER OR HEAD)



CHANNEL WELD PROC: A-62-H
SHELL WELD PROC: M-6

CIRCUMFERENTIAL SEAM
(TUBESHEET TO CYL)



CHANNEL WELD PROC: M-76-H
SHELL WELD PROC: ---

SADDLE-ON NOZZLE INSTALLATION

CERTIFIED AS-BUILT

CUSTOMER: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NO.	DATE	REVISIONS

WELD & BEVEL DETAILS

DWN. BY: DM
DATE: 3/14/11
CKD. BY:

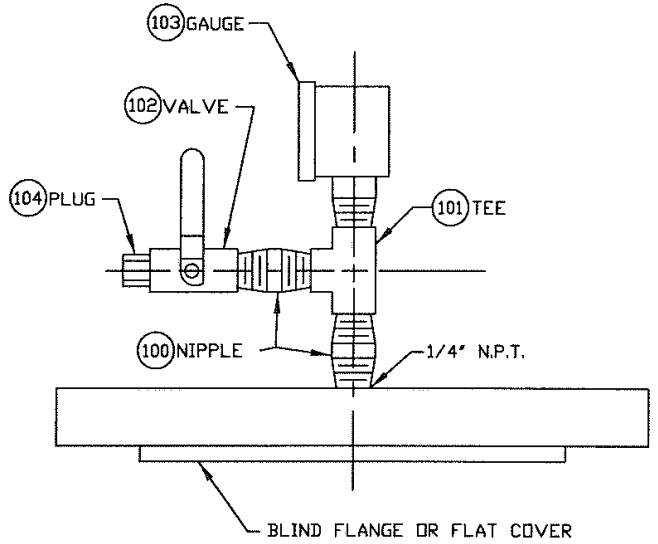
Energy Exchanger Co.
1844 No. Garnett Rd. • Tulsa, Okla.74116

DWG. NO. X-7929-S
REV 0

Kemper County MM209937

NOTES:

1) BOTH SIDES SHALL BE THOROUGHLY DRAINED AND DRIED AFTER HYDROTEST. REMOVE MOISTURE BY BLOWING HOT AIR (150°F, MAXIMUM).
2) A) SEAL ALL EXTERNAL OPENINGS WITH A 1/8" THK. RUBBER-GASKETED BLIND FLANGE OR FLAT COVER.
   B) INSTALL A CONNECTION WITH A VALVE AND PRESSURE GAUGE.
   C) PRESSURE TO 15 PSIG AND DEPRESSURIZE TWICE; REPRESSURE TO 15 PSIG WITH DRY NITROGEN.
3) STENCIL BY EACH NOZZLE: "CONTENTS UNDER N2 PRESSURE; DO NOT OPEN WITHOUT PURCHASER'S APPROVAL".
4) TACKWELD A PIECE OF PIPE TO EACH COVER EQUIPPED WITH THE FITTING AND GAUGE ASSEMBLY, FOR PROTECTION DURING SHIPMENT.



ONLY ONE BLIND FLANGE OR COVER SHALL BE TAPPED FOR CHANNEL SIDE, AND ONE FOR SHELL SIDE.

PROVIDE 1/4" N.P.T. WITH PLUG ON BOTTOM COVERS FOR DRAINING PURPOSES.

CUSTOMER: MISSISSIPPI POWER
/ SOUTHERN COMPANY SERVICES
P.O. NO: 17496-0001 REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER
ITEM NO: HX0042

NO.	DATE	REVISIONS

NITROGEN PURGE DETAILS

DWN. BY D.MORRISON
DATE 8/31/12
CKD. BY MD

Energy Exchanger Co.
3944 Mr. Bennett Rd. • Tulsa, Okla. 74116

DWG. NO. X-7929-X
REV 0

BILL OF MATERIAL

PART NO	ONE REQ'D., DESCRIPTION OF ONE	MATERIAL SPEC.	QTY ONE	TOT QTY	REV	NOTE	PO NO	PROMISED	
21	TUBES 3/4" O.D.X 0.0830" (MW) THK. X 14'-0" LG.	SA-179	462	462					*
	FORGED RING MATERIAL								
2	FLG 28 3/16" O.D.X 23" I.D.X 3 1/16" THK	SA-266-4N	1	1		1			*
2A	FLG 28 3/16" O.D.X 23" I.D.X 3 1/16" THK	SA-266-4N	1	1		1			*
	TUBESHEETS & COVERS								
4	TUBESHEET 24" O.D.X 3 3/8" THK	SA-516-70N	1	1		1			*
9	TUBESHEET 24" O.D.X 3 3/8" THK	SA-516-70N	1	1		1			*
1	COVER 28 3/16" O.D.X 1 3/4" THK	SA-516-70N	1	1		1			*
1A	COVER 28 3/16" O.D.X 1 3/4" THK	SA-516-70N	1	1		1			*
	BAFFLES								
22	BAFFLES 22 11/16" O.D.X 1/4" THK	SA-36	7	7					*
22A	FIRST & LAST BAFFLES 22 11/16" O.D.X 1/2" THK	SA-36	2	2					*
	HEADS								
	CYLINDERS								
12	SMLS.PIPE 24" ODX(0.5000" SchXH)X 1'-9" LG.	SA-333-6	1	1		1			*
15	SMLS.PIPE 24" ODX(0.5620" Sch30)X 13'-5 7/8" LG.	SA-106B	1	1					*
17	SMLS.PIPE 24" ODX(0.5000" SchXH)X 1'-7 1/8" LG.	SA-333-6	1	1		1			*

NOTES: MATERIAL SHALL NOT ORIGINATE IN EITHER CHINA OR NORTH KOREA.
1) MATERIAL HARDNESS SHALL NOT EXCEED 22 HRC.
2) MATERIAL HARDNESS SHALL NOT EXCEED 187 HB.

* DENOTES PRELIMINARY ORDER

CERTIFIED AS-BUILT

REQ No: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER

NO.	DATE	DESCRIPTION
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Energy Exchanger Co.
1844 No. Garnett Rd. • Tulsa, Okla.74116

CUST: MISSISSIPPI POWER c/o SOUTHERN COMPANY SERVICES
P.O.: 17496-0001 ITEM: HX0042

PB/M	DR: MD	CK: DN	DATE: 1/19/11	DWG. NO.	REV
FB/M	DR: DM	CK: SM	DATE: 3-14-11	X-7929-1BM	0

BILL OF MATERIAL

PART NO	ONE REQ'D., DESCRIPTION OF ONE	MATERIAL SPEC.	QTY ONE	TOT QTY	REV	NOTE	PO NO	PROMISED	
	ASME FLANGES								
71	ASME 6" - 300 # RF WN W/ (SchXH BORE)	SA-105	1	1					*
72	ASME 3" - 300 # RF WN W/ (SchXXH BORE)	SA-105	1	1					*
81	ASME 10" - 300 # RF WN W/ (SchXH BORE)	SA-105	1	1		2			*
87	ASME 6" - 300 # RF WN W/ (SchXH BORE)	SA-105	1	1		2			*
73	ASME 3/4" - 300 # RF LWN X 9" LG(0.750"BORE)	SA-105	1	1					*
74	ASME 3/4" - 300 # RF LWN X 9" LG(0.750"BORE)	SA-105	1	1					*
75	ASME 3/4" - 300 # RF LWN X 9" LG(0.750"BORE)	SA-105	1	1					*
82	ASME 2" - 300 # RF LWN X 9" LG(2.000"BORE)	SA-105	1	1		2			*
89	ASME 2" - 300 # RF LWN X 9" LG(2.000"BORE)	SA-105	1	1		2			*
71A	SMLS.PIPE 6 5/8" ODX(0.4320" SchXH)X 7 3/4" LG.	SA-106B	1	1					*
72A	SMLS.PIPE 3 1/2" ODX(0.6000" SchXXH)X 8 1/4" LG.	SA-106B	1	1					*
81A	SMLS.PIPE 10 3/4" ODX(0.5000" SchXH)X 7 3/4" LG.	SA-333-6	1	1					*
87A	SMLS.PIPE 6 5/8" ODX(0.4320" SchXH)X 7 3/4" LG.	SA-333-6	1	1					*
71B	WELD PAD 9 3/4" O.D. X 3/8" THK	SA-516-70	1	1					*
73D	ASME 3/4" - 300 # RF BLIND FLANGE	SA-105	1	1					*
74D	ASME 3/4" - 300 # RF BLIND FLANGE	SA-105	1	1					*
75D	ASME 3/4" - 300 # RF BLIND FLANGE	SA-105	1	1					*
82D	ASME 2" - 300 # RF BLIND FLANGE	SA-105	1	1		2			*
89D	ASME 2" - 300 # RF BLIND FLANGE	SA-105	1	1		2			*
	COUPLINGS								

SEE DWG. X-7929-1BM FOR MATERIAL NOTES.

* DENOTES PRELIMINARY ORDER

CERTIFIED AS-BUILT

REQ No: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER

NO.	DATE	DESCRIPTION
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Energy Exchanger Co.
1844 No. Garnett Rd. • Tulsa, Okla.74116

CUST: MISSISSIPPI POWER c/o SOUTHERN COMPANY SERVICES
P.O.: 17496-0001 ITEM: HX0042

PB/M	DR: MD	CK: DN	DATE: 1/19/11	DWG. NO.	REV
FB/M	DR: DM	CK: [signature]	DATE: 3/14/11	X-7929-2BM	0

BILL OF MATERIAL

PART NO	ONE REQ'D., DESCRIPTION OF ONE		MATERIAL SPEC.	QTY ONE	TOT QTY	REV	NOTE	PO NO	PROMISED	
	BOLTING & GASKETS									
40	LOT OF GASKETS PER DWG X-7929-0			2	2					
41	3/4" ROUND X 10-THREAD STUDS X 5 1/4" LG. 1&2		SA-193B7	24	24					
42	3/4" ROUND X 10-THREAD STUDS X 5 1/4" LG. 1A&2A		SA-193B7	24	24					
43	3/4" HEAVY HEX NUTS 10-THREAD		SA-194-2H	96	96					
44	5/8" ROUND X 11 THREAD STUDS X 3 1/8" LG	(3/4"-300# RF)	SA-193B7	12	12					
44A	5/8" HEAVY HEX NUTS	(3/4"-300# RF)	SA-194-2H	24	24					
45	5/8" ROUND X 11 THREAD STUDS X 3 5/8" LG	(2"-300# RF)	SA-193B7	16	16					
45A	5/8" HEAVY HEX NUTS	(2"-300# RF)	SA-194-2H	32	32					
47	GASKETS 0.175" THK 321 STN STL SP. WD. FLEXIBLE GRAPHITE FILLED									
	W/ 1/8" THK C'STL OUTER COMPRESSION RING FOR:	(3/4"-300# RF)		3	3					
		(2"-300# RF)		2	2					
	MISC. MATERIAL									
60	STD. NAME PLATE		STN.STL.	2	2					
61	STD. NAME PLATE BRK'T.		SA-516-70	2	2					
62	LIFTING LUGS 3 1/2" X 1/2" X 6 1/2" LG		SA-516-70	4	4					
23	FT. 1/2" O.D. TIE RODS		C'STL	72	72					
23A	FT. 3/4" O.D. SPACER TUBING		SA-214	72	72					
23B	1/2" TIE ROD HEX NUTS		C'STL	12	12					
22C	6 1/8" X 1/4" THK X 12" IMP. PLATE		SA-516-70	1	1	1				
63	DELETE					2				
64	DELETE					2				
	INSULATION SUPPORT MATERIAL									
65	PLATE 1 1/2" X 1/4" THK X 3" LG (CLIPS)		SA-36	8	8	2				
66	PLATE RING 27" O.D. X 25" I.D. X 1/4" THK		SA-36	2	2	2				
67	ANGLE 3" X 3" X 1/4" THK X 95" LG. (ROLLED LEG IN TO 24 1/8" I.D.)		SA-36	1	1	2				
70	NOZZLE SHIPPING COVERS PER SKETCH									
	SUPPORT MATERIAL									
120	PLATE 13" X 3/8" THK X 10 1/8" LG		SA-516-70	2	2					
121	PLATE 6" X 3/4" THK X 11" LG		SA-516-70	2	2					
122	PLATE 8 1/4" X 1/2" THK X 11" LG		SA-516-70	4	4					
125	5/8" DIA X 11 THD X 2" LG HEX HD BOLT		C'STL	1	1					
	NITROGEN PURGE MATERIAL									
100	1/4" PIPE NIPPLE X 2" LG. (THRD. OUTSIDE EACH END)		C. STL.	4	4	3				
101	1/4" STRAIGHT TEE (THRD. INSIDE EACH END)		C. STL.	2	2	3				
102	1/4" PIPE VALVE (INSIDE THRD.) (#5X713)		BRASS	2	2	3				
103	1/4" PRESSURE GAUGE (#5X939)(P570K-60LMX0-60 PSIG)			2	2	3				
104	1/4" PIPE PLUG		C. STL.	2	2	3				

SEE DWG. X-7929-1BM FOR MATERIAL NOTES.

* DENOTES PRELIMINARY ORDER

CERTIFIED AS-BUILT

REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER

NO.	DATE	DESCRIPTION	
4			
3	8-31-11	REV'D PER CUST.	DM/
2	8-10-11	REV'D PER CUST.	WE/MD
1	6-24-11	REV'D PER CUST.	WE/DN

Energy Exchanger Co.
1844 No. Garnett Rd. • Tulsa, Okla.74116

CUST: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O.: 17496-0001 ITEM: HX0042

PB/M	DR: ----	CK: ----	DATE: ----	DWG. NO.	REV
FB/M	DR: DM	CK: SM	DATE: 3/15/11	X-7929-3BM	3

X-7929 PACKING LIST

LINE NO	SPARE PARTS LIST	MATERIAL SPEC.	QTY ONE	TOT QTY	REV	NOTE	PO NO	PROMISED	
SP1	SPARE GASKETS PER DWG. X-7929-□		1 SET(S)	1 SET(S)					
SP2									
SP3									
SP4									
SP5									
SP6									
SP7									
SP8									
SP9									
SP10									

SPARE PARTS TO BE BOXED & TAGGED WITH P.O. NO., ITEM NO., SHIPPING WT. & 'SPARE GASKETS AND PARTS'

LINE NO	STACKING MATERIAL	MATERIAL SPEC.	QTY ONE	TOT QTY	REV	NOTE	PO NO	PROMISED	
S1									
S2									
S3									
S4									
S5									
S6									
S7									
S8									
S9									
S10									
S11									
S12									
S13									
S14									
S15									
S16									
S17									
S18									
S19									
S20									
S21									
S22									
S23									
S24									
S25									

* DENOTES PRELIMINARY ORDER

DO NOT ORDER FROM PACKING LIST

CERTIFIED AS-BUILT

REQ No.: MC202
SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER

NO.	DATE	DESCRIPTION
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Energy Exchanger Co.
1844 No. Garnett Rd. • Tulsa, Okla.74116

CUST: MISSISSIPPI POWER / SOUTHERN COMPANY SERVICES
P.O.: 17496-0001 ITEM: HX0042

PB/M	DR: ----	CK: ----	DATE: ----	DWG. NO.	REV
FB/M	DR: DM	CK: [signature]	DATE: 3/14/11	X-7929-PL	0

Energy Exchanger Company

Mike Duvall 8/15/12
CERTIFIED AS-BUILT

DATE: 1/19/2011
PAGE: 1 of 38

MECHANICAL CALCULATIONS

CUSTOMER:	MISSISSIPPI POWER c/o SOUTHERN COMPANY SERVICES
DESTINATION:	KEMPER COUNTY, MISSISSIPPI △1
P.O. No.:	17496-0001
ITEM No.:	HX0042
E.E.C. SERIAL No.:	X-7929
SERVICE:	HYDROGEN SULFIDE STRIPPER REBOILER
REQ No.:	MC202 △1

DESIGN DATA			
	SHELL SIDE	TUBE SIDE	△2
DESIGN PRESSURE	455 PSIG * / FV	205 PSIG *	
DESIGN TEMP.	515°F	390°F	
M.D.M.T.	10 °F	10 °F	
CORR. ALLOW.	1/8"	3/16"	△1
NO. PASSES	ONE	ONE	
M.A.W.P. (H&C)	455 PSIG	205 PSIG	
LIMITED BY	FIXED TUBESHEET	FIXED TUBESHEET	

NOTE: ALL LOADING CONDITIONS REFERENCED IN PARA. UG-22 HAVE BEEN ADDRESSED

△2 NOTE: SEE PG. 35 FOR ANCHOR BOLT CALCULATIONS.

- DESIGNED TO ASME SEC VIII, DIV 1, 2007 ED, '09 AD.
- MATERIAL ARE IMPACT TEST EXEMPT PER UG-20(f)

△2 * 9 PSIG ADDED IN DESIGN TO ACCOUNT FOR STATIC HEAD WHEN ERECTED

REVISION LOG

DATE	PAGE	REV.	DESCRIPTION
3/8/2011	AS NOTED	1	REVISED CA TUBE SIDE & PER CUST. COMMENT
5/12/2011	AS NOTED	2	REVISED PER CUST. COMMENT
6/23/2011	AS NOTED	3	REV PER CUST. COMMENT & ADDED FV FOR STEAM OUT

W.O. No.: X-7929

SHELL SIDE

NOM. SIZE	PRESS.	TEMP.	C.A.	RT	H.T.	TEMA
24.000"	464.0psig *	515deg.F	0.1250"	NONE	0deg.F	R

ASME CODE SEC.VIII DIV.I UG-27 [CYLINDER]

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

SHELL CYLINDER

MATERIAL: SA-106B PRESS = 464.0 * psig TEMP = 515deg.F

O.D.	NOM. THK.	RW=0/PIPE=1	CORR.ALLOW	EFFICIENCY
24.0000"	0.5620"	1	0.1250"	1.00

ATM.STRS	DES.STRS	STRS/STRS	MAWP N-C	MAWP CORR.
17100.0psi	17100.0psi	1.000	712.422psig	529.087psig

P*(RO)
---------- = 0.32212" + CORR. ALLOW. = 0.44712" + MTOL. = 0.51099"
S*E+(.4*P)

****

* DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD

----- External Pressure Calculations -----

Ext Press Chart No.=	1
Ext Press Chart....=	CS-2
OD.....=	24.00000
T.....=	0.36675
L.....=	162.00000
Temp.....=	515.00000
Stress from MT.....=	17100.00000
Yield from MT.....=	28244.99805
2 x Stress.....=	34200.00000
B1 from Chart@Right=	0.00000
Yield= 2 x B1 x 0.9=	0.00000
S.....=	0.00000
DO/T.....=	65.43967
L/DO.....=	6.75000
A.....=	0.00033
B.....=	4341.26172
PA1.....=	0.00000
PA2.....=	0.00000
PA.....=	88.45321

TOP & BOTTOM CHANNELS

NOM. SIZE	PRESS.	TEMP.	C.A.	RT	H.T.	TEMA
24.000"	214.0psig *	390deg.F	0.1875" (1)	SPOT	1150deg.F	R

ASME CODE SEC.VIII DIV.I UG-27 [CYLINDER]

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

CHANNEL CYLINDERS

MATERIAL: SA-333-6 PRESS = 214.0psig * TEMP = 390deg.F

O.D.	NOM. THK.	RW=0/PIPE=1	CORR.ALLOW (1)	EFFICIENCY
24.0000"	0.5000"	1	0.1875"	0.85

ATM.STRS	DES.STRS	STRS/STRS	MAWP N-C	MAWP CORR.
17100.0psi	17100.0psi	1.000	537.764psig	305.357psig

$$\frac{P*(RO)}{S*E+(.4*P)} = 0.17564" + \text{CORR. ALLOW.} = 0.36314" + \text{MTOL.} = 0.41502"$$

****

* DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD

----- External Pressure Calculations -----

Ext Press Chart....=	1 CS-2
Actual Chart Used..=	1 CS-2
Material.....=	SA-516-70
OD.....=	24.00000
T.....=	0.25000
L.....=	25.00000
Temp.....=	250.00000
Stress from MT.....=	20000.00000
Yield from MT.....=	34200.00000
2 x Stress.....=	40000.00000
B1 from Chart@Right=	0.00000
Yield= 2 x B1 x 0.9=	0.00000
S.....=	0.00000
DO/T.....=	96.00000
L/DO.....=	1.04167
A.....=	0.00137
B.....=	13468.19434
PA1.....=	0.00000
PA2.....=	0.00000
PA.....=	187.05826

(3)

```
NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO= S1      6.00"    300 LB RF  WN
[INLET] SHELL SIDE
PRESSURE =  464.0psig *  TEMP =  515.0deg.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.     =   0.12500"            C.A.     =   0.12500"
I.D.     =  23.01650" ** (2)     I.D.     =   5.76100"
O.D.     =  24.00000"            O.D.     =   6.62500"
THK.     =   0.49175" **         THK.   XH=   0.43200"
T        =   0.36675" ** (2)     TN       =   0.30700"
TR       =   0.32212" **         TRN      =   0.08892"
ET       =   0.04463" **         ETN      =   0.21808"

MIN STD. WT. PIPE+C.A.=  0.37000"   TR+C.A.=  0.44712"
LIMITS=  12.02200"
fr1= 1.0000 fr2= 1.0000 fr3= 1.0000 fr4= 1.0000     F=   1.00000
Min weld sizes:NS=  0.0000" NP=  0.3039" PS=  0.2593" IF=  0.0000"

AREA REQD.              A =   1.93625in^2
EXCESS IN CYL.          A1=   0.26828in^2
EXCESS IN NOZ.(OUTSIDE) A2=   0.39991in^2  H =   0.91687"
AREA OF FILLETS           =   0.28125in^2
AREA AVAILABLE            =   0.94944in^2

NOZ. NECK WELD= 0.37500"  AREA=   0.14062in^2

PAD MATL.= SA-516-70     S=  19910.psi
PAD O.D.=   9.62500"    THK.=   0.37500"    AREA=   1.12500in^2
PAD TO CYL. WELD=   0.37500"    AREA=   0.14062in^2
ARC=   6.712"
PAD RET. DIM.=   9.625"  X    9.750"

< AREA REQD-AREA AVAILABLE >  =   -0.13819in^2

MAWP N-C=   628.0psig  LIMITED BY AR
MAWP COR=   480.0psig  LIMITED BY AR

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

(2) * DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD
** Please see UG-37, pipe thickness and ID based on nominal thickness less manufacturing
   undertolerances allowed by material specification.

EXTERNAL PRESSURE VERIFICATION:

NOZTYP[ 0.0] X-7929         6.00"- 300# RF  WN   PRESS= -15 TEMP= 515  INLET
<<<<<< CYLINDER >>>>  <<<<<< NOZZLE >>>>>>
      SA-106B              SA-106B
OPER STRS=17100.0000  OPER STRS=17100.0000  Area reqd.     A=  0.5447
ATM STRS =17100.0000  ATM STRS =17100.0000  Excess in cyl A1=  1.1150
C.A.     =   0.12500  C.A.     =   0.12500  Excess in noz A2=  0.5146 H= 0.9169
I.D.     =  23.01650  I.D.     =   5.76100  Excess in noz A3=  0.0000 H= 0.0000
O.D.     =  24.00000  O.D.     =   6.62500  Area fillets    =  0.2812
THK.     =   0.49175  THK.   XH=   0.43200  Area avail.     =  1.9108
T        =   0.36675  TN       =   0.30700  Noz neck weld   =  0.3750 A= 0.1406
TR       =   0.18125  TRN      =   0.02640  Pad weld        =  0.3750 A= 0.1406
ET       =   0.18550  ETN      =   0.28060  Internal weld   =  0.0000 A= 0.0000
PIPE F=1.0000 E1=1.0000  SHELL TOL=0.8750 (Min USED)  NOZ TOL=1.0000 (Nom USED)
MIN STD. WT. PIPE+C.A.=0.37000   TR[using abs(P)]+C.A.=0.13552   CHORD=  0.0000
LIMITS=  12.02200    fr1= 1.0000 fr2= 1.0000 fr3= 1.0000 fr4= 1.0000
Min weld sizes: NS= 0.0000 NP= 0.3039 PS= 0.2593 IF= 0.0000
PAD MATL.= SA-516-70    O.D.= 9.62500 THK.= 0.37500 AREA= 1.12500 S= 19910.
Area reqd-Area avail =<< -2.49109>>
```

```
NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO= S2      3.00"    300 LB RF  WN
[OUTLET] SHELL SIDE
PRESSURE =  464.0psig *  TEMP =  515.0deg.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.     =   0.12500"            C.A.     =   0.12500"
I.D.     =  23.01650" ** (2)     I.D.     =   2.30000"
O.D.     =  24.00000"            O.D.     =   3.50000"
THK.     =   0.49175" **         THK.  XXH=   0.60000"
T        =   0.36675" ** (2)     TN       =   0.47500"
TR       =   0.32212" **         TRN      =   0.04698"
ET       =   0.04463"            ETN      =   0.42802"

MIN STD. WT. PIPE+C.A.=  0.31400"   TR+C.A.=  0.44712"
LIMITS=   5.10000"
fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000     F=   1.00000
Min weld sizes:NS=  0.3536" NP=  0.0000" PS=  0.0000" IF=  0.0000"

AREA REQD.                A =   0.82140in^2
EXCESS IN CYL.            A1=   0.11381in^2
EXCESS IN NOZ.(OUTSIDE)   A2=   0.78489in^2  H =   0.91687"
AREA OF FILLETS             =   0.14062in^2
AREA AVAILABLE              =   1.03933in^2

NOZ. NECK WELD= 0.37500"  AREA=   0.14062in^2

< AREA REQD-AREA AVAILABLE >  =   -0.21793in^2

MAWP N-C=   806.0psig  LIMITED BY AR
MAWP COR=   523.0psig  LIMITED BY AR

 * DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD
(2) ** Please see UG-37, pipe thickness and ID based on nominal thickness less manufacturing
       undertolerances allowed by material specification.
```

EXTERNAL PRESSURE VERIFICATION:

```
NOZTYP[ 0.0] X-7929          3.00"- 300# RF  WN   PRESS= -15 TEMP= 515  OUTLET
<<<<<< CYLINDER >>>>  <<<<<< NOZZLE >>>>>>
      SA-106B                SA-106B
OPER STRS=17100.0000  OPER STRS=17100.0000  Area reqd.      A=  0.2311
ATM STRS =17100.0000  ATM STRS =17100.0000  Excess in cyl A1=  0.4730
C.A.     =   0.12500  C.A.     =   0.12500  Excess in noz A2=  0.8377 H= 0.9169
I.D.     =  23.01650  I.D.     =   2.30000  Excess in noz A3=  0.0000 H= 0.0000
O.D.     =  24.00000  O.D.     =   3.50000  Area fillets     =  0.1406
THK.     =   0.49175  THK.  XXH=   0.60000  Area avail.     =  1.4513
T        =   0.36675  TN       =   0.47500  Noz neck weld   =  0.3750 A= 0.1406
TR       =   0.18125  TRN      =   0.01820  Pad weld        =  0.0000 A= 0.0000
ET       =   0.18550  ETN      =   0.45680  Internal weld   =  0.0000 A= 0.0000
PIPE F=1.0000 E1=1.0000  SHELL TOL=0.8750 (Min USED)  NOZ TOL=1.0000 (Nom USED)
MIN STD. WT. PIPE+C.A.=0.31400   TR[using abs(P)]+C.A.=0.13552   CHORD=  0.0000
LIMITS=   5.10000    fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000
Min weld sizes: NS= 0.3536 NP= 0.0000 PS= 0.0000 IF= 0.0000
Area reqd-Area avail =<< -1.22021>>
```

```
NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO= T1      6.00"    300 LB RF  WN
[INLET] REAR CHANNEL or COVER
PRESSURE =  214.0psig *  TEMP =  390.0deg.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.     =   0.18750"             C.A.     =   0.18750"
I.D.     =  23.12500" **  (2)     I.D.     =   5.76100"
O.D.     =  24.00000"             O.D.     =   6.62500"
THK.     =   0.43750" **          THK.   XH=   0.43200"
T        =   0.25000" **  (2)     TN       =   0.24450"
TR       =   0.14943" **          TRN      =   0.04125"
ET       =   0.10057"             ETN      =   0.20325"

MIN STD. WT. PIPE+C.A.=  0.43250"   TR+C.A.=  0.33693"
LIMITS=  12.27200"
fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000     F=   1.00000
Min weld sizes:NS=  0.2420" NP=  0.0000" PS=  0.0000" IF=  0.0000"

AREA REQD.              A =   0.91689in^2
EXCESS IN CYL.          A1=   0.61711in^2
EXCESS IN NOZ.(OUTSIDE) A2=   0.24848in^2  H =   0.61125"
AREA OF FILLETS           =   0.14062in^2
AREA AVAILABLE            =   1.00621in^2

NOZ. NECK WELD= 0.37500"  AREA=   0.14062in^2

< AREA REQD-AREA AVAILABLE >  =   -0.08933in^2

MAWP N-C=   426.0psig  LIMITED BY AR
MAWP COR=   224.0psig  LIMITED BY AR.

 * DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD
** Please see UG-37, pipe thickness and ID based on nominal thickness less manufacturing (2)
   undertolerances allowed by material specification.



      EXTERNAL PRESSURE FOR STEAM OUT:

NOZTYP[11.0] X-7929         6.00"- 300# RF  WN   PRESS= -15 TEMP= 250  INLET
 <<<<<< CYLINDER >>>>  <<<<<< NOZZLE >>>>>>
      SA-106B               SA-106B
 OPER STRS=17100.0000  OPER STRS=17100.0000  Area reqd.     A=  0.2194
 ATM STRS =17100.0000  ATM STRS =17100.0000  Excess in cyl A1=  1.0953
 C.A.     =   0.18750  C.A.     =   0.18750  Excess in noz A2=  0.2654 H= 0.6113
 I.D.     =  23.12500  I.D.     =   5.76100  Excess in noz A3=  0.0000 H= 0.0000
 O.D.     =  24.00000  O.D.     =   6.62500  Area fillets    =  0.1406
 THK.     =   0.43750  THK.   XH=   0.43200  Area avail.     =  1.5013
 T        =   0.25000  TN       =   0.24450  Noz neck weld   =  0.3750 A= 0.1406
 TR       =   0.07150  TRN      =   0.02740  Pad weld        =  0.0000 A= 0.0000   (3)
 ET       =   0.17850  ETN      =   0.21710  Internal weld   =  0.0000 A= 0.0000
 PIPE F=1.0000 E1=1.0000  SHELL TOL=0.8750 (Min USED)  NOZ TOL=1.0000 (Nom USED)
 MIN STD. WT. PIPE+C.A.=0.43250   TR[using abs(P)]+C.A.=0.19802   CHORD=  0.0000
 LIMITS=  12.27200    fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000
 Min weld sizes: NS= 0.2420 NP= 0.0000 PS= 0.0000 IF= 0.0000
        Area reqd-Area avail =<< -1.28194>>
```

```
NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO= T2     10.00"    300 LB RF  WN
[OUTLET] FRONT CHANNEL SIDE
PRESSURE =  214.0psig *  TEMP =  390.0deg.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.     =   0.18750"             C.A.     =   0.18750"
I.D.     =  23.12500" ** (2)      I.D.     =   9.75000"
O.D.     =  24.00000"             O.D.     =  10.75000"
THK.     =   0.43750" **          THK.   XH=   0.50000"
T        =   0.25000" ** (2)      TN       =   0.31250"
TR       =   0.14943" **          TRN      =   0.06693"
ET       =   0.10057"             ETN      =   0.24557"

MIN STD. WT. PIPE+C.A.=  0.50688"   TR+C.A.=  0.33693"
LIMITS=  20.25000"
fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000     F=   1.00000
Min weld sizes:NS=  0.2475" NP=  0.0000" PS=  0.0000" IF=  0.0000"

AREA REQD.                A =   1.51295in^2
EXCESS IN CYL.            A1=   1.01830in^2
EXCESS IN NOZ.(OUTSIDE)   A2=   0.30696in^2  H =   0.62500"
AREA OF FILLETS             =   0.25000in^2
AREA AVAILABLE              =   1.57526in^2

NOZ. NECK WELD= 0.50000"  AREA=   0.25000in^2

< AREA REQD-AREA AVAILABLE >  =   -0.06231in^2

MAWP N-C=   393.0psig  LIMITED BY AR
MAWP COR=   218.0psig  LIMITED BY AR

* DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD
** Please see UG-37, pipe thickness and ID based on nominal thickness less manufacturing
   undertolerances allowed by material specification.
```

(2)

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      EXTERNAL PRESSURE FOR STEAM OUT:

NOZTYP[ 0.0] X-7929        10.00"- 300# RF  WN   PRESS= -15 TEMP= 250  OUTLET
<<<<<< CYLINDER >>>>  <<<<<< NOZZLE >>>>>>
      SA-106B               SA-106B
OPER STRS=17100.0000  OPER STRS=17100.0000  Area reqd.     A=  0.3989
ATM STRS =17100.0000  ATM STRS =17100.0000  Excess in cyl A1=  1.7334
C.A.     =   0.18750  C.A.     =   0.18750  Excess in noz A2=  0.3451 H= 0.6250
I.D.     =  23.12500  I.D.     =   9.75000  Excess in noz A3=  0.0000 H= 0.0000
O.D.     =  24.00000  O.D.     =  10.75000  Area fillets    =  0.2500
THK.     =   0.43750  THK.   XH=   0.50000  Area avail.    =  2.3285
T        =   0.25000  TN       =   0.31250  Noz neck weld  =  0.5000 A= 0.2500
TR       =   0.07880  TRN      =   0.03640  Pad weld       =  0.0000 A= 0.0000
ET       =   0.17120  ETN      =   0.27610  Internal weld  =  0.0000 A= 0.0000
PIPE F=1.0000 E1=1.0000  SHELL TOL=0.8750 (Min USED)  NOZ TOL=1.0000 (Nom USED)
MIN STD. WT. PIPE+C.A.=0.50688   TR[using abs(P)]+C.A.=0.19802   CHORD=  0.0000
LIMITS=  20.25000    fr1= 1.0000 fr2= 1.0000 fr3= 0.0000 fr4= 0.0000
Min weld sizes: NS= 0.2475 NP= 0.0000 PS= 0.0000 IF= 0.0000
Area reqd-Area avail =<< -1.92960>>
```

(3)

ASME SEC.VIII DIV.1 APPENDIX 2			Front Channel to cover flange
DESIGN CONDITIONS	GASKET and BOLTING CALCULATIONS		TABLE
Design Pres= 214.0 psig	Eff.Gsk OD= 24.6875"		No.Passes= 1
Neg. Pres= None	Eff.Gsk ID= 23.9375"		N= 0.375"
Design Temp= 390 deg.F	THK= 0.1250"	col.=2	b= 0.188
Flg Matl=SA-266-4	Gsk Matl=S.S. DJNAF		y= 9000psi
Bolt Matl=SA-193B7	Gsk Face=FLAT FACE	w= 0.0000"	m= 3.750
Corr Allow= 0.1875"	Wm2= 128891 #	Am =	5.1556in^2
Flange Desn Sfo 20000.0 psi	Hp = 22985 #	Ab =	7.2480in^2
Atm. Sfa 20000.0 psi	H = 99348 #	W =	155045 #
Bolting Desn Sb 25000.0 psi	Wm1= 122334 #	Wm1=	122334 #
Atm. Sa 25000.0 psi	Gasket Width Check	Nmin =	0.1318"

CONDITION	LOAD	x	LEVER ARM =	MOMENT	
	HD =	91834 #	hD= 1.35938"	MD=	124837 in#
Operating	HG =	22985 #	hG= 1.12500"	MG=	25858 in#
	HT =	7514 #	hT= 1.35938"	MT=	10214 in#
				Mo=	160911 in#
Gasket Seating	HG =	155045 #	hG= 1.12500"	mo=	174426 in#

Allow.Stress-STRESS CALCULATIONS-Operating		SHAPE CONSTANTS			
1.5 Sfo&2.5 Sno Long Hub,SH	25820.0 psi	K	= 1.2059	h/ho=	0.4625
Sfo Radial Flg,SR	3619.6 psi	T	= 1.8366	F =	0.8541
Sfo Tang Flg,ST	9205.3 psi	Z	= 5.4038	V =	0.3214
Sfo .5(SH+SR)or.5(SH+ST)	17512.7 psi	Y	=10.4756	f =	1.0000
J(APP.2-14)= 0.9607		U	=11.5116	e =	0.3160in^-1
Allow.Stress-STRESS CALCULATIONS-Gsk.Seating		g1/go= 1.5000		d =	9.452In^3
1.5 Sfa&2.5 Sna Long Hub,SH	27988.6 psi	ho = 2.7027"			
Sfa Radial Flg,SR	3923.6 psi				
Sfa Tang Flg,ST	9978.5 psi	OTHER STRESS FORMULA FACTORS			
Sfa .5(SH+SR)or.5(SH+ST)	18983.6 psi	t	1.6250"		
J(APP.2-14)= 0.9893		Alpha	1.5135		
		Beta	1.6847		
		Gamma	0.8241		
		Delta	0.4540		
		Lambda	1.2781		
		M	7250 #		
		m	7859 #		

O.D.	= 28.1875"	THK.	=	1.8125"	
I.D.	= 23.0000"	T-Adder	=	0.0000"	
GO	= 0.5000"	G1	=	0.6562"	
HUB O.D.	= 24.3125"	HUB LEN	=	1.2500"	
HUB ANG	= 7.1250deg	RIB LENGTH	=	0.0000"	
G(MEAN)	= 24.3125"	G(CALC)	=	24.3125"	
G(MIN.)	= 23.7500"	G(MAX.)	=	24.8125"	
B.C.	= 26.5625"	B.S.C.F.	=	1.0533	
No. BOLTS	= 24	BOLT DIAMETER	=	0.7500"	
R	= 1.1250"	E	=	0.8125"	
BOLT SPAC	= 3.4671"	TORQUE	=	96ft#	
MIN. SPAC	= 1.7500"	TEMA MAX. SPAC	=	3.7941"	
FLG TURN	= 0.1875"	FACING	=	RECESS	
BPRIME	= 0.0000"	BG1	=	0.0000"	
FLG RWT	= 181Lbs	FLG FWT	=	116Lbs	

* DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD

///// FRONT COVER CALCULATIONS /////

EXCHANGER TYPE....=	N E N	MATERIAL.....=	SA-516-70N
PRESSURE.....=	214.0 psig	CORROSION ALLOWANCE=	0.1875"
TURN LOW.....=	0.1875"	TURN HIGH.....=	0.2500"
S COVER STRESS...=	20000.0 psi	E.....=	1.0
Sb STRESS BOLTS..=	25000.0 psi	Ab.....=	7.2480 in^2
d.....=	24.3125"	C.....=	0.3000
W.....=	155045 #	Wm1.....=	122334 #
hG (ASME).....=	1.1250"	hG (TEMA).....=	0.0000"
G (TEMA).....=	24.3125"	E (MOD.) x (10)-6..=	27.7 psi
COVER THK SET HOLD=	[NO]		

[PER ASME SECT.VIII UG-34 USING Wm1 (OPERATING)]

$$THK = d \sqrt{\frac{C\,P}{S\,E} + \frac{1.9\,Wm1\,hG}{S\,E\,d^3}} = 1.5605"$$

[PER ASME SECT.VIII UG-34 USING W (GASKET SEATING)]

$$THK = d \sqrt{\frac{1.9\,W\,hG}{S\,E\,d^3}} = 0.8256"$$

[COV THK Min] CODE Operating	=	1.5605"	+	0.1875"	= 1.7480"
[COV THK Min] CODE Gasket Seating	=	0.8256"	+	0.1875"	= 1.0131"

ACTUAL COVER THICKNESS USED (SET HOLD[NO])= 1.7500"

* DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD

MAIN FLG IS FLANGE MARK # 2
COMP FLG IS FLANGE MARK # 0

/// INDIVIDUAL COMPONENTS ///

MAWP CORR. MAIN FLG	=	222.0	Limited by: J-Calc. Operating
MAWP CORR. COVER	=	214.0	
MAWP CORR. T.S.[STD DIA]	=	0.0	
MAWP N-C MAIN FLG	=	316.0	Limited by: Minimum bolting area Am.
MAWP N-C COVER	=	269.0	

ASME SEC.VIII DIV.1 UHX-13

(FTS) Configuration a

No or EPC=Elastic-Plastic Calcs SSC=Simply Supported Calcs			=SSC
MT Tubes	=SA-179	MT Tubesheets	=SA-516-70N
MT Channel	=SA-333-3	MT Shell	=SA-106B
Diameter (Do)	= 22.3736"	Pass Lane Area (AL)	= 0.000in^2
Perimeter of layout (CP)	= 0.0000"	Area enclosed by CP (AP)	= 0.000in^2
Tubesheet thickness (h)	= 3.3750"	Tubesheet thickness HOLD	= NO
Tube Pitch (p)	= 0.9375"	Pitch type = Triangle	(30 Deg)
Diameter of tube (dt)	= 0.7500"	Tube thickness (tt)	= 0.0830"
Exp length of tube (ltx)	= 0.0000"	Exp depth ratio (Rho)	= 0.9500
Groove channel side (hg)	= 0.0000"	Groove shell side	= 0.0000"
Channel I.D. (Dc)	= 23.0000"	Channel thickness (Tc)	= 0.5000"
Shell I.D. (Ds)	= 22.8760"	Shell thickness (Ts)	= 0.5620"
TS outside diameter (A)	= 24.0000"	Bolt circle (C)	= 0.0000"
G Channel side (Gc or G1)	= 0.0000"	G Shell side (Gs or G1)	= 0.0000"
Bolt load Chan side (Wc)	= 0.0#	Bolt load Sh side (Ws)	= 0.0#
1.8*Sqrt(Dc*Tc)	= 0.0000"	1.8*Sqrt(Ds*(Ts or Ts1))	= 0.0000"
Thickness at Top TS (tr)	= 3.3750"	Outer Tube Circle	= 22.3736"
hr Ch Op= 0.0000" Ch Atm=	0.0000"	Sh Op= 0.0000" Sh Atm	= 0.0000"
Tubes welded Backside TS	=NO	Hole Size in Tubesheet	= 0.0000"
Radial Differential Thermal Expansion Adjacent to Tubesheet			= NO

Design Press Chan (Pt)	= 214.0psig *	Design Press Shell (Ps)	= 464.0psig *
Design Temp Chan	= 390.0deg.	Design Temp Shell	= 515.0deg.
Corr Chan	= 0.18750"	Corr Shell	= 0.12500"
Corr Chan side TS (ct)	= 0.18750"	Corr Shell side TS (cs)	= 0.12500"

Number Tubes (Nt)	= 462.00	F-F Tubesheets (Lt)	= 167.8750"
Un-supported Tube Span (l)	= 31.25000"	Support Constant (k)	= 1.00000
Expansion Joint	= None	Exp Joint I.D.	= 0.00000"
Spring Rate Corr (Kj)	= 0.#	Spring Rate Un-Corr (Kjn)	= 0.#
MT Thickened Shl	=	Thk Thickened Shl (Ts1)	= 0.00000"
Len Thickened Shl (lll)	= 0.00000"	Len Thickened Shl (lll')	= 0.00000"

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

* DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD

ASME SEC.VIII DIV.1 UHX-13 Case 1

```
(FTS)  Configuration a
Tubesheet Thickness (h)    =   3.0625"
F-F Tubesheets (Lt)        = 167.5000"      F-F Inside Tubesheets (L)= 161.3750"
Exp length of tube (ltx)   =   2.9094"      Exp depth ratio (Rho)    =   0.9500"
Channel I.D. (Dc)          =  23.3750"      Channel thickness (Tc)   =   0.3125"
Shell I.D. (Ds)            =  23.1260"      Shell thickness (Ts)     =   0.4370"

Press Chan (Pt)            =    214.0psi    Press Shell (Ps)         =      0.0psi
Corr Chan                  =  0.18750"      Corr Shell               =  0.12500"
Corr Chan side TS (ct)     =  0.18750"      Corr Shell side TS (cs)  =  0.12500"
```

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi

```
Mu=  0.2000 d*=  0.6440"    P*=  0.9375"    Mu*=  0.3131 hg'=  0.0000"    hgs'=  0.0000"
W         =         0.0#        wj       =         0.0"        ao       = 11.18677998"
Rho s     = 1.033630729         Rho c    = 1.044759989         Chi s    = 0.480848223
Chi t     = 0.685226977         Ks       = 5411391.500Lb/In    Kt       = 29093.82812Lb/In
Ks,t      = 0.402592897         j        = 1.000000000         Beta s   = 0.566499650in^-1
Kappa s   = 233740.8281#        Lambda s = 4787501.000psi      Beta c   = 0.668145478in^-1
Kappa c   = 103594.0859#        Lambda c = 2599820.750psi      h/p      = 3.266666651
E*        = 8053920.000psi      v*       = 0.345361441         Xa       = 2.644720793
Zd        = 0.077879079         Zv       = 0.126476079         Zm       = 0.564917266
K         = 1.072694778         F        = 0.754432321         Phi      = 1.014984131
Q1        =-0.060214549         Qz1      = 1.718772292         Qz2      = 2.261739016
U         = 4.523478031         Gamma    =         0.0"        Omega s  =         0.0in^2
Omega c   =         0.0in^2     Omega s* =-3.534133911in^2     Omega c*=-2.125888348in^2
Delta s   = 0.000009630In^3/Lb  Delta c  = 0.000013390In^3/Lb  Gamma b  =         0.0
Ps'    =          0.0psi       Pt'    =   718.6097412psi     P Gamma  =         0.0psi
PW        =         0.0psi      Prim     =-16.44434357psi      Es,w     = 1.000000000
Pe        =-171.7923889psi      Q2       = 289.1478882#        Q3       =-0.087113529
Fm        = 0.094685681         Es,wl    =         0.0         lt       = 31.25000000"
Rt        = 0.237638906"        Ft       = 131.5020294         Ct       = 159.2741089
Fs        = 2.000000000         Stb      = 6166.893066psi      Ft,min   = 0.234580144
Sigmat,1 =-520.3059692psi       Sigmat,2 = 651.9843750psi      Ft,max   = 1.629235864
Sigma s,m= 512.9665527psi       Sigma s,b=-6095.613281psi      Sigma s  = 6608.580078psi
Sigma c,m= 3949.005859psi       Sigma c,b= 17655.07422psi      Sigma c  = 21604.08008psi
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         = 0.153976202       Phi      = 0.207153648       Q1       = 0.006652270
Qz1       = 1.925647497       Qz2      = 3.185766220       U        = 6.371532440
Omega s* = 0.071960613in^2    Omega c*= 0.824546218in^2    Prim     = 8.983849525psi
Pe        =-157.1120758psi    Q2       =-157.9668732#      Q3       = 0.022720801
                                                      Sigma    = |    -4809 psi  |
Sigma      |  -4159 psi  | <= 1.5S    29865 psi   [OK Per Simply Sup]
Tau        |  -1568 psi  | <= .8S     15928 psi   [OK                ]
Sigmat,max|    651 psi  | <  St      13384 psi   [OK                ]
Sigmat,min|   -520 psi  | <= Stb      6166 psi   [OK                ]
Sigma s    |   6608 psi  | <= Spss    56489 psi   [OK Per Simply Sup]
Sigma c    |  21604 psi  | <= Spsc    60020 psi   [OK Per Simply Sup]
Sigmas,m   |    512 psi  | <=SsEs,w   17100 psi   [OK                ] Step 10
```

ASME SEC.VIII DIV.1 UHX-13 Case 2

```
(FTS)  Configuration a
Tubesheet Thickness (h)    =   3.0625"
F-F Tubesheets (Lt)        = 167.5000"      F-F Inside Tubesheets (L)= 161.3750"
Exp length of tube (ltx)   =   2.9094"      Exp depth ratio (Rho)    =   0.9500"
Channel I.D. (Dc)          =  23.3750"      Channel thickness (Tc)   =   0.3125"
Shell I.D. (Ds)            =  23.1260"      Shell thickness (Ts)     =   0.4370"

Press Chan (Pt)            =      0.0psi    Press Shell (Ps)         =    464.0psi
Corr Chan                  =  0.18750"      Corr Shell               =  0.12500"
Corr Chan side TS (ct)     =  0.18750"      Corr Shell side TS (cs)  =  0.12500"
```

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi

```
Mu=  0.2000 d*=  0.6440"    P*=  0.9375"    Mu*=  0.3131 hg'=  0.0000"    hgs'=  0.0000"
W         =         0.0#        wj        =         0.0"        ao       = 11.18677998"
Rho s     = 1.033630729         Rho c     = 1.044759989         Chi s    = 0.480848223
Chi t     = 0.685226977         Ks        = 5411391.500Lb/In    Kt       = 29093.82812Lb/In
Ks,t      = 0.402592897         j         = 1.000000000         Beta s   = 0.566499650in^-1
Kappa s   = 233740.8281#        Lambda s  = 4787501.000psi      Beta c   = 0.668145478in^-1
Kappa c   = 103594.0859#        Lambda c  = 2599820.750psi      h/p      = 3.266666651
E*        = 8053920.000psi      v*        = 0.345361441         Xa       = 2.644720793
Zd        = 0.077879079         Zv        = 0.126476079         Zm       = 0.564917266
K         = 1.072694778         F         = 0.754432321         Phi      = 1.014984131
Q1        =-0.060214549         Qz1       = 1.718772292         Qz2      = 2.261739016
U         = 4.523478031         Gamma     =         0.0"        Omega s  =         0.0in^2
Omega c   =         0.0in^2     Omega s*  =-3.534133911in^2     Omega c* =-2.125888348in^2
Delta s   = 0.000009630In^3/Lb  Delta c   = 0.000013390In^3/Lb  Gamma b   =         0.0
Ps'    =  1027.633179psi      Pt'     =         0.0psi        P Gamma  =         0.0psi
PW        =         0.0psi      Prim      = 59.27386856psi      Es,w     = 1.000000000
Pe        = 254.0253296psi      Q2        =-1042.237671#        Q3       =-0.125785202
Fm        = 0.085965946         Es,w1     =         0.0         lt       = 31.25000000"
Rt        = 0.237638906"        Ft        = 131.5020294         Ct       = 159.2741089
Fs        = 2.000000000         Stb       = 6166.893066psi      Ft,min   = 0.336023808
Sigmat,1  = 674.0183105psi      Sigmat,2  =-786.8353882psi      Ft,max   = 1.511368990
Sigma s,m = 3472.952148psi      Sigma s,b = 22914.10742psi      Sigma s  = 26387.05859psi
Sigma c,m =         0.0psi      Sigma c,b =-5796.971680psi      Sigma c  = 5796.971680psi
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         = 0.153976202       Phi       = 0.207153648       Q1       = 0.006652270
Qz1       = 1.925647497       Qz2       = 3.185766220       U        = 6.371532440
Omega s*  = 0.071960613in^2   Omega c*= 0.824546218in^2   Prim     =-1.699990630psi
Pe        = 227.1429138psi    Q2        = 29.89166260#      Q3       = 0.008755420
                                                      Sigma    = |     6756 psi  |
Sigma      |   5584 psi  | <= 1.5S    29865 psi   [OK Per Simply Sup]
Tau        |   2319 psi  | <= .8S     15928 psi   [OK                ]
Sigmat,max |    786 psi  | <  St      13384 psi   [OK                ]
Sigmat,min |   -786 psi  | <= Stb      6166 psi   [OK                ]
Sigma s    |  26387 psi  | <= Spss    56489 psi   [OK Per Simply Sup]
Sigma c    |   5796 psi  | <= Spsc    60020 psi   [OK Per Simply Sup]
Sigmas,m   |   3472 psi  | <=SsEs,w   17100 psi   [OK                ] Step 10
```

ASME SEC.VIII DIV.1 UHX-13 Case 3

```
(FTS)  Configuration a
Tubesheet Thickness (h)    =   3.0625"
F-F Tubesheets (Lt)        = 167.5000"      F-F Inside Tubesheets (L)= 161.3750"
Exp length of tube (ltx)   =   2.9094"      Exp depth ratio (Rho)    =   0.9500"
Channel I.D. (Dc)          =  23.3750"      Channel thickness (Tc)   =   0.3125"
Shell I.D. (Ds)            =  23.1260"      Shell thickness (Ts)     =   0.4370"

Press Chan (Pt)            =    214.0psi    Press Shell (Ps)         =    464.0psi
Corr Chan                  =  0.18750"      Corr Shell               =  0.12500"
Corr Chan side TS (ct)     =  0.18750"      Corr Shell side TS (cs)  =  0.12500"
```

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi

```
Mu=  0.2000 d*=  0.6440"    P*=  0.9375"    Mu*=  0.3131 hg'=  0.0000"    hgs'=  0.0000"
W        =         0.0#        wj       =         0.0"        ao      = 11.18677998"
Rho s    = 1.033630729         Rho c    = 1.044759989         Chi s   = 0.480848223
Chi t    = 0.685226977         Ks       = 5411391.500Lb/In    Kt      = 29093.82812Lb/In
Ks,t     = 0.402592897         j        = 1.000000000         Beta s  = 0.566499650in^-1
Kappa s  = 233740.8281#        Lambda s = 4787501.000psi      Beta c  = 0.668145478in^-1
Kappa c  = 103594.0859#        Lambda c = 2599820.750psi      h/p     = 3.266666651
E*       = 8053920.000psi      v*       = 0.345361441         Xa      = 2.644720793
Zd       = 0.077879079         Zv       = 0.126476079         Zm      = 0.564917266
K        = 1.072694778         F        = 0.754432321         Phi     = 1.014984131
Q1       =-0.060214549         Qz1      = 1.718772292         Qz2     = 2.261739016
U        = 4.523478031         Gamma    =         0.0"        Omega s =         0.0in^2
Omega c  =         0.0in^2     Omega s* =-3.534133911in^2     Omega c*=-2.125888348in^2
Delta s  = 0.000009630In^3/Lb  Delta c  = 0.000013390In^3/Lb  Gamma b =         0.0
Ps'   =   1027.633179psi      Pt'   =   718.6097412psi      P Gamma =         0.0psi
PW       =         0.0psi      Prim     = 42.82952499psi      Es,w    = 1.000000000
Pe       = 82.23294067psi      Q2       =-753.0898438#        Q3      =-0.206573993
Fm       = 0.101863697         Es,w1    =         0.0         lt      = 31.25000000"
Rt       = 0.237638906"        Ft       = 131.5020294         Ct      = 159.2741089
Fs       = 2.000000000         Stb      = 6166.893066psi      Ft,min  = 0.547949255
Sigmat,1 = 153.7122803psi      Sigmat,2 =-134.8510742psi      Ft,max  = 1.265134096
Sigma s,m= 3985.918701psi      Sigma s,b= 16818.49219psi      Sigma s = 20804.41016psi
Sigma c,m= 3949.005859psi      Sigma c,b= 11858.10254psi      Sigma c = 15807.10840psi
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        = 0.153976202         Phi      = 0.207153648         Q1      = 0.006652270
Qz1      = 1.925647497         Qz2      = 3.185766220         U       = 6.371532440
Omega s* = 0.071960613in^2     Omega c*= 0.824546218in^2      Prim    = 7.283859253psi
Pe       = 70.03083801psi      Q2       =-128.0752106#        Q3      =-0.022575490
                                                        Sigma    = |     1956 psi  |
Sigma      |   2141 psi  | <= 1.5S    29865 psi   [OK Per Simply Sup]
Tau        |    750 psi  | <= .8S     15928 psi   [OK                ]
Sigmat,max|    153 psi  | <  St      13384 psi   [OK                ]
Sigmat,min|   -134 psi  | <= Stb      6166 psi   [OK                ]
Sigma s    |  20804 psi  | <= Spss    56489 psi   [OK Per Simply Sup]
Sigma c    |  15807 psi  | <= Spsc    60020 psi   [OK Per Simply Sup]
Sigmas,m   |   3985 psi  | <=SsEs,w   17100 psi   [OK                ] Step 10
```

ASME SEC.VIII DIV.1 UHX-13 Case 4

```
(FTS)  Configuration a
Tubesheet Thickness (h)    =   3.0625"
F-F Tubesheets (Lt)        = 167.5000"      F-F Inside Tubesheets (L)= 161.3750"
Exp length of tube (ltx)   =   2.9094"      Exp depth ratio (Rho)    =   0.9500"
Channel I.D. (Dc)          =  23.3750"      Channel thickness (Tc)   =   0.3125"
Shell I.D. (Ds)            =  23.1260"      Shell thickness (Ts)     =   0.4370"

Press Chan (Pt)            =      0.0psi    Press Shell (Ps)         =      0.0psi
Corr Chan                  =  0.18750"      Corr Shell               =  0.12500"
Corr Chan side TS (ct)     =  0.18750"      Corr Shell side TS (cs)  =  0.12500"
```

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi

```
Tt,m       = 393deg.F                                   At,m= 7.0860In/In
Ts,m       = 423deg.F                                   As,m= 7.1460In/In

Mu=  0.2000 d*=  0.6440"    P*=  0.9375"    Mu*=  0.3131 hg'=  0.0000"    hgs'=  0.0000"
W          =         0.0#       wj       =         0.0"       ao       = 11.18677998"
Rho s      = 1.033630729        Rho c     = 1.044759989        Chi s    = 0.480848223
Chi t      = 0.685226977        Ks        = 5411391.500Lb/In   Kt       = 29093.82812Lb/In
Ks,t       = 0.402592897        j         = 1.000000000        Beta s   = 0.566499650in^-1
Kappa s    = 233740.8281#       Lambda s  = 4787501.000psi     Beta c   = 0.668145478in^-1
Kappa c    = 103594.0859#       Lambda c  = 2599820.750psi     h/p      = 3.266666651
E*         = 8053920.000psi     v*        = 0.345361441        Xa       = 2.644720793
Zd         = 0.077879079        Zv        = 0.126476079        Zm       = 0.564917266
K          = 1.072694778        F         = 0.754432321        Phi      = 1.014984131
Q1         =-0.060214549        Qz1       = 1.718772292        Qz2      = 2.261739016
U          = 4.523478031        Gamma     =-0.037723009"       Omega s  = 3.606094599in^2
Omega c    = 2.950434446in^2    Omega s*  =-3.534133911in^2     Omega c* =-2.125888348in^2
Delta s    = 0.000009630In^3/Lb Delta c   = 0.000013390In^3/Lb Gamma b   =         0.0
Ps'    =           0.0psi      Pt'    =           0.0psi      P Gamma  =-1289.701172psi
PW         =         0.0psi     Prim      =         0.0psi     Es,w     = 1.000000000
Pe         =-301.4211426psi     Q2        =         0.0#       Q3       =-0.060214549
Fm         = 0.100750893        Es,w1     =         0.0        lt       =         0.0"
Rt         =         0.0"       Ft        =         0.0        Ct       =         0.0
Fs         =         0.0        Stb       =         0.0psi     Ft,min   = 0.164018631
Sigmat,1 = 241.8973694psi       Sigmat,2 = 2523.736572psi     Ft,max   = 1.711220860
Sigma s,m=-3663.295166psi       Sigma s,b=-10264.39941psi     Sigma s  = 13927.69434psi
Sigma c,m=         0.0psi       Sigma c,b= 11476.28613psi     Sigma c  = 11476.28613psi
Thermal Expansion Acting on this Case (Yes)
Sigma      |  -7765 psi  | <= Sps     61430 psi   [OK              ]
Tau        |  -2752 psi  | <= .8S     15928 psi   [OK              ]
Sigmat,max|   2523 psi  | <= 2St     26769 psi   [OK              ]
Sigma s    |  13927 psi  | <= Spss    56489 psi   [OK              ]
Sigma c    |  11476 psi  | <= Spsc    60020 psi   [OK              ]
Sigmas,m   |  -3663 psi  | <=2Ss      34200 psi   [OK              ] Step 10
Sigmas,m   |  -3663 psi  | <=Ss,b     12939 psi   [OK              ] Step 10
```

ASME SEC.VIII DIV.1 UHX-13 Case 5

(FTS) Configuration a

Tubesheet Thickness (h)	= 3.0625"		
F-F Tubesheets (Lt)	= 167.5000"	F-F Inside Tubesheets (L)	= 161.3750"
Exp length of tube (ltx)	= 2.9094"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.3750"	Channel thickness (Tc)	= 0.3125"
Shell I.D. (Ds)	= 23.1260"	Shell thickness (Ts)	= 0.4370"
Press Chan (Pt)	= 214.0psi	Press Shell (Ps)	= 0.0psi
Corr Chan	= 0.18750"	Corr Shell	= 0.12500"
Corr Chan side TS (ct)	= 0.18750"	Corr Shell side TS (cs)	= 0.12500"

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi
Tt,m	= 393deg.F			At,m= 7.0860In/In			
Ts,m	= 423deg.F			As,m= 7.1460In/In			

Mu= 0.2000	d*= 0.6440"	P*= 0.9375"	Mu*= 0.3131	hg'= 0.0000"	hgs'= 0.0000"
W	= 0.0#	wj	= 0.0"	ao	= 11.18677998"
Rho s	= 1.033630729	Rho c	= 1.044759989	Chi s	= 0.480848223
Chi t	= 0.685226977	Ks	= 5411391.500Lb/In	Kt	= 29093.82812Lb/In
Ks,t	= 0.402592897	j	= 1.000000000	Beta s	= 0.566499650in^-1
Kappa s	= 233740.8281#	Lambda s	= 4787501.000psi	Beta c	= 0.668145478in^-1
Kappa c	= 103594.0859#	Lambda c	= 2599820.750psi	h/p	= 3.266666651
E*	= 8053920.000psi	v*	= 0.345361441	Xa	= 2.644720793
Zd	= 0.077879079	Zv	= 0.126476079	Zm	= 0.564917266
K	= 1.072694778	F	= 0.754432321	Phi	= 1.014984131
Q1	=-0.060214549	Qz1	= 1.718772292	Qz2	= 2.261739016
U	= 4.523478031	Gamma	=-0.037723009"	Omega s	= 3.606094599in^2
Omega c	= 2.950434446in^2	Omega s*	=-3.534133911in^2	Omega c*	=-2.125888348in^2
Delta s	= 0.000009630In^3/Lb	Delta c	= 0.000013390In^3/Lb	Gamma b	= 0.0
Ps'	= 0.0psi	Pt'	= 718.6097412psi	P Gamma	=-1289.701172psi
PW	= 0.0psi	Prim	=-16.44434357psi	Es,w	= 1.000000000
Pe	=-473.2135315psi	Q2	= 289.1478882#	Q3	=-0.069979779
Fm	= 0.098549023	Es,w1	= 0.0	lt	= 31.25000000"
Rt	= 0.237638906"	Ft	= 131.5020294	Ct	= 159.2741089
Fs	= 2.000000000	Stb	= 6166.893066psi	Ft,min	= 0.189634830
Sigmat,1	=-278.4085999psi	Sigmat,2	= 3175.720947psi	Ft,max	= 1.681457520
Sigma s,m	=-3150.328613psi	Sigma s,b	=-16360.01270psi	Sigma s	= 19510.34180psi
Sigma c,m	= 3949.005859psi	Sigma c,b	= 29131.36133psi	Sigma c	= 33080.36719psi

Thermal Expansion Acting on this Case (Yes)

Sigma	-11924 psi	<= Sps	61430 psi	[OK	]	
Tau	-4321 psi	<= .8S	15928 psi	[OK	]	
Sigmat,max	3175 psi	<= 2St	26769 psi	[OK	]	
Sigmat,min	-278 psi	<= Stb	6166 psi	[OK	]	
Sigma s	19510 psi	<= Spss	56489 psi	[OK	]	
Sigma c	33080 psi	<= Spsc	60020 psi	[OK	]	
Sigmas,m	-3150 psi	<=2Ss	34200 psi	[OK	]	Step 10
Sigmas,m	-3150 psi	<=Ss,b	12939 psi	[OK	]	Step 10

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(FTS) Configuration a

Tubesheet Thickness (h)	= 3.0625"		
F-F Tubesheets (Lt)	= 167.5000"	F-F Inside Tubesheets (L)	= 161.3750"
Exp length of tube (ltx)	= 2.9094"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.3750"	Channel thickness (Tc)	= 0.3125"
Shell I.D. (Ds)	= 23.1260"	Shell thickness (Ts)	= 0.4370"
Press Chan (Pt)	= 0.0psi	Press Shell (Ps)	= 464.0psi
Corr Chan	= 0.18750"	Corr Shell	= 0.12500"
Corr Chan side TS (ct)	= 0.18750"	Corr Shell side TS (cs)	= 0.12500"

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi
Tt,m	= 393deg.F			At,m= 7.0860In/In			
Ts,m	= 423deg.F			As,m= 7.1460In/In			

Mu= 0.2000	d*= 0.6440"	P*= 0.9375"	Mu*= 0.3131	hg'= 0.0000"	hgs'= 0.0000"
W	= 0.0#	wj	= 0.0"	ao	= 11.18677998"
Rho s	= 1.033630729	Rho c	= 1.044759989	Chi s	= 0.480848223
Chi t	= 0.685226977	Ks	= 5411391.500Lb/In	Kt	= 29093.82812Lb/In
Ks,t	= 0.402592897	j	= 1.000000000	Beta s	= 0.566499650in^-1
Kappa s	= 233740.8281#	Lambda s	= 4787501.000psi	Beta c	= 0.668145478in^-1
Kappa c	= 103594.0859#	Lambda c	= 2599820.750psi	h/p	= 3.266666651
E*	= 8053920.000psi	v*	= 0.345361441	Xa	= 2.644720793
Zd	= 0.077879079	Zv	= 0.126476079	Zm	= 0.564917266
K	= 1.072694778	F	= 0.754432321	Phi	= 1.014984131
Q1	=-0.060214549	Qz1	= 1.718772292	Qz2	= 2.261739016
U	= 4.523478031	Gamma	=-0.037723009"	Omega s	= 3.606094599in^2
Omega c	= 2.950434446in^2	Omega s*	=-3.534133911in^2	Omega c*	=-2.125888348in^2
Delta s	= 0.000009630In^3/Lb	Delta c	= 0.000013390In^3/Lb	Gamma b	= 0.0
Ps'	= 1027.633179psi	Pt'	= 0.0psi	P Gamma	=-1289.701172psi
PW	= 0.0psi	Prim	= 59.27386856psi	Es,w	= 1.000000000
Pe	=-47.39581299psi	Q2	=-1042.237671#	Q3	= 0.291221738
Fm	= 0.213436186	Es,w1	= 0.0	lt	= 0.0"
Rt	= 0.0"	Ft	= 0.0	Ct	= 0.0
Fs	= 0.0	Stb	= 0.0psi	Ft,min	=-0.757870197
Sigmat,1	= 915.9156494psi	Sigmat,2	= 1736.901245psi	Ft,max	= 2.782358408
Sigma s,m	=-190.3430939psi	Sigma s,b	= 12649.70801psi	Sigma s	= 12840.05078psi
Sigma c,m	= 0.0psi	Sigma c,b	= 5679.314941psi	Sigma c	= 5679.314941psi

Thermal Expansion Acting on this Case (Yes)

Sigma	-2586 psi	<= Sps	61430 psi	[OK	]	
Tau	-432 psi	<= .8S	15928 psi	[OK	]	
Sigmat,max	1736 psi	<= 2St	26769 psi	[OK	]	
Sigma s	12840 psi	<= Spss	56489 psi	[OK	]	
Sigma c	5679 psi	<= Spsc	60020 psi	[OK	]	
Sigmas,m	-190 psi	<=2Ss	34200 psi	[OK	]	Step 10
Sigmas,m	-190 psi	<=Ss,b	12939 psi	[OK	]	Step 10

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```
(FTS)  Configuration a
Tubesheet Thickness (h)    =   3.0625"
F-F Tubesheets (Lt)        = 167.5000"      F-F Inside Tubesheets (L)= 161.3750"
Exp length of tube (ltx)   =   2.9094"      Exp depth ratio (Rho)    =   0.9500"
Channel I.D. (Dc)          =  23.3750"      Channel thickness (Tc)   =   0.3125"
Shell I.D. (Ds)            =  23.1260"      Shell thickness (Ts)     =   0.4370"

Press Chan (Pt)            =    214.0psi    Press Shell (Ps)         =    464.0psi
Corr Chan                  =  0.18750"      Corr Shell               =  0.12500"
Corr Chan side TS (ct)     =  0.18750"      Corr Shell side TS (cs)  =  0.12500"
```

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi	V =.300	Sps =	61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi	Vt=.300		
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi	Vc=.300	Spsc=	60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi	Vs=.300	Spss=	56489psi

```
Tt,m       = 393deg.F                                   At,m= 7.0860In/In
Ts,m       = 423deg.F                                   As,m= 7.1460In/In

Mu=  0.2000 d*=  0.6440"     P*=  0.9375"     Mu*=  0.3131 hg'=  0.0000"     hgs'=  0.0000"
W          =          0.0#        wj       =          0.0"        ao       = 11.18677998"
Rho s      = 1.033630729          Rho c     = 1.044759989          Chi s    = 0.480848223
Chi t      = 0.685226977          Ks        = 5411391.500Lb/In     Kt       = 29093.82812Lb/In
Ks,t       = 0.402592897          j         = 1.000000000          Beta s   = 0.566499650in^-1
Kappa s    = 233740.8281#         Lambda s  = 4787501.000psi       Beta c   = 0.668145478in^-1
Kappa c    = 103594.0859#         Lambda c  = 2599820.750psi       h/p      = 3.266666651
E*         = 8053920.000psi       v*        = 0.345361441          Xa       = 2.644720793
Zd         = 0.077879079          Zv        = 0.126476079          Zm       = 0.564917266
K          = 1.072694778          F         = 0.754432321          Phi      = 1.014984131
Q1         =-0.060214549          Qz1       = 1.718772292          Qz2      = 2.261739016
U          = 4.523478031          Gamma     =-0.037723009"         Omega s  = 3.606094599in^2
Omega c    = 2.950434446in^2      Omega s*  =-3.534133911in^2       Omega c*=-2.125888348in^2
Delta s    = 0.000009630In^3/Lb   Delta c   = 0.000013390In^3/Lb   Gamma b  =          0.0
Ps'     =    1027.633179psi       Pt'     =    718.6097412psi      P Gamma  =-1289.701172psi
PW         =          0.0psi      Prim      = 42.82952499psi       Es,w     = 1.000000000
Pe         =-219.1882019psi       Q2        =-753.0898438#         Q3       =-0.005304800
Fm         = 0.113132007          Es,w1     =          0.0         lt       =          0.0"
Rt         =          0.0"        Ft        =          0.0         Ct       =          0.0
Fs         =          0.0         Stb       =          0.0psi      Ft,min   = 0.019979211
Sigmat,1 = 395.6096497psi         Sigmat,2 = 2388.885498psi        Ft,max   = 1.878579497
Sigma s,m= 322.6234741psi         Sigma s,b= 6554.093750psi        Sigma s  = 6876.717285psi
Sigma c,m= 3949.005859psi         Sigma c,b= 23334.38867psi        Sigma c  = 27283.39453psi
Thermal Expansion Acting on this Case (Yes)
```

Sigma	-6340 psi	<= Sps	61430 psi	[OK	]
Tau	-2001 psi	<= .8S	15928 psi	[OK	]
Sigmat,max	2388 psi	<= 2St	26769 psi	[OK	]
Sigma s	6876 psi	<= Spss	56489 psi	[OK	]
Sigma c	27283 psi	<= Spsc	60020 psi	[OK	]
Sigmas,m	322 psi	<=2Ss	34200 psi	[OK	] Step 10

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```
(FTS)  Configuration a
Tubesheet Thickness (h)    =   3.3750"
F-F Tubesheets (Lt)        = 167.8750"      F-F Inside Tubesheets (L)= 161.1250"
Exp length of tube (ltx)   =   3.2062"      Exp depth ratio (Rho)    =   0.9500"
Channel I.D. (Dc)          =  23.0000"      Channel thickness (Tc)   =   0.5000"
Shell I.D. (Ds)            =  22.8760"      Shell thickness (Ts)     =   0.5620"

Press Chan (Pt)            =    214.0psi    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 = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi

```
Mu=  0.2000 d*=  0.6440"    P*=  0.9375"    Mu*=  0.3131 hg'=  0.0000"    hgs'=  0.0000"
W        =         0.0#        wj       =         0.0"        ao      = 11.18677998"
Rho s    = 1.022456884         Rho c    = 1.027999163        Chi s   = 0.480848223
Chi t    = 0.685226977         Ks       = 6933094.500Lb/In   Kt      = 29138.97070Lb/In
Ks,t     = 0.515004396         j        = 1.000000000        Beta s  = 0.500872552in^-1
Kappa s  = 439568.7500#        Lambda s = 6464793.000psi     Beta c  = 0.530318439in^-1
Kappa c  = 336791.0938#        Lambda c = 5309300.000psi     h/p     = 3.599999905
E*       = 8053920.000psi      v*       = 0.345361441        Xa      = 2.459800720
Zd       = 0.095104538         Zv       = 0.136877611        Zm      = 0.596329451
K        = 1.072694778         F        = 1.110997796        Phi     = 1.494693637
Q1       =-0.096299022         Qz1      = 1.499606967        Qz2     = 1.454362631
U        = 2.908725262         Gamma    =         0.0"       Omega s =         0.0in^2
Omega c  =         0.0in^2     Omega s* =-4.407473087in^2    Omega c*=-3.754968882in^2
Delta s  = 0.000007330In^3/Lb  Delta c  = 0.000008100In^3/Lb Gamma b =         0.0
Ps'    =         0.0psi       Pt'    =   602.5858765psi    P Gamma =         0.0psi
PW       =         0.0psi      Prim     =-18.67723656psi     Es,w    = 1.000000000
Pe       =-178.8322906psi      Q2       = 424.8668518#       Q3      =-0.134267807
Fm       = 0.094128624         Es,w1    =         0.0        lt      = 31.25000000"
Rt       = 0.237638906"        Ft       = 131.5020294        Ct      = 159.2741089
Fs       = 2.000000000         Stb      = 6166.893066psi     Ft,min  = 0.468373537
Sigmat,1 =-307.6555481psi      Sigmat,2 = 511.4367981psi     Ft,max  = 1.404474497
Sigma s,m= 334.1159363psi      Sigma s,b=-3917.888428psi     Sigma s = 4252.004395psi
Sigma c,m= 2408.638184psi      Sigma c,b= 11152.63965psi     Sigma c = 13561.27734psi
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        = 0.153976202         Phi      = 0.207153648        Q1      =-0.005249350
Qz1      = 1.727735877         Qz2      = 2.448243618        U       = 4.896487236
Omega s* = 0.031910121in^2     Omega c*= 0.396531820in^2     Prim    = 3.320215225psi
Pe       =-160.9005890psi      Q2       =-75.52773285#       Q3      = 0.002252500
                                                        Sigma    = |    -4448 psi  |
Sigma      |  -3544 psi  | <= 1.5S    29865 psi   [OK Per Simply Sup]
Tau        |  -1481 psi  | <= .8S     15928 psi   [OK               ]
Sigmat,max|    511 psi  | <  St      13384 psi   [OK               ]
Sigmat,min|   -307 psi  | <= Stb      6166 psi   [OK               ]
Sigma s    |   4252 psi  | <= Spss    56489 psi   [OK Per Simply Sup]
Sigma c    |  13561 psi  | <= Spsc    60020 psi   [OK Per Simply Sup]
Sigmas,m   |    334 psi  | <=SsEs,w   17100 psi   [OK               ] Step 10
```

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(FTS) Configuration a

Tubesheet Thickness (h)	= 3.3750"		
F-F Tubesheets (Lt)	= 167.8750"	F-F Inside Tubesheets (L)	= 161.1250"
Exp length of tube (ltx)	= 3.2062"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.0000"	Channel thickness (Tc)	= 0.5000"
Shell I.D. (Ds)	= 22.8760"	Shell thickness (Ts)	= 0.5620"
Press Chan (Pt)	= 0.0psi	Press Shell (Ps)	= 464.0psi
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 = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi

Mu= 0.2000 d*= 0.6440" P*= 0.9375" Mu*= 0.3131 hg'= 0.0000" hgs'= 0.0000"

W	= 0.0#	wj	= 0.0"	ao	= 11.18677998"
Rho s	= 1.022456884	Rho c	= 1.027999163	Chi s	= 0.480848223
Chi t	= 0.685226977	Ks	= 6933094.500Lb/In	Kt	= 29138.97070Lb/In
Ks,t	= 0.515004396	j	= 1.000000000	Beta s	= 0.500872552in^-1
Kappa s	= 439568.7500#	Lambda s	= 6464793.000psi	Beta c	= 0.530318439in^-1
Kappa c	= 336791.0938#	Lambda c	= 5309300.000psi	h/p	= 3.599999905
E*	= 8053920.000psi	v*	= 0.345361441	Xa	= 2.459800720
Zd	= 0.095104538	Zv	= 0.136877611	Zm	= 0.596329451
K	= 1.072694778	F	= 1.110997796	Phi	= 1.494693637
Q1	=-0.096299022	Qz1	= 1.499606967	Qz2	= 1.454362631
U	= 2.908725262	Gamma	= 0.0"	Omega s	= 0.0in^2
Omega c	= 0.0in^2	Omega s*	=-4.407473087in^2	Omega c*	=-3.754968882in^2
Delta s	= 0.000007330In^3/Lb	Delta c	= 0.000008100In^3/Lb	Gamma b	= 0.0
Ps'	= 891.8553467psi	Pt'	= 0.0psi	P Gamma	= 0.0psi
PW	= 0.0psi	Prim	= 47.53353882psi	Es,w	= 1.000000000
Pe	= 270.4056702psi	Q2	=-1081.285522#	Q3	=-0.160205424
Fm	= 0.087062247	Es,wl	= 0.0	lt	= 31.25000000"
Rt	= 0.237638906"	Ft	= 131.5020294	Ct	= 159.2741089
Fs	= 2.000000000	Stb	= 6166.893066psi	Ft,min	= 0.525762796
Sigmat,1	= 396.0506287psi	Sigmat,2	=-680.5560303psi	Ft,max	= 1.339486599
Sigma s,m	= 2769.246582psi	Sigma s,b	= 16868.38086psi	Sigma s	= 19637.62695psi
Sigma c,m	= 0.0psi	Sigma c,b	=-4091.201172psi	Sigma c	= 4091.201172psi

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	= 0.153976202	Phi	= 0.207153648	Q1	=-0.005249350
Qz1	= 1.727735877	Qz2	= 2.448243618	U	= 4.896487236
Omega s*	= 0.031910121in^2	Omega c*	= 0.396531820in^2	Prim	=-0.579323113psi
Pe	= 239.3042755psi	Q2	= 13.17835045#	Q3	=-0.004369250

Sigma = | 6525 psi |

Sigma	4956 psi	<= 1.5S	29865 psi	[OK	Per Simply Sup]
Tau	2240 psi	<= .8S	15928 psi	[OK	]
Sigmat,max	680 psi	< St	13384 psi	[OK	]
Sigmat,min	-680 psi	<= Stb	6166 psi	[OK	]
Sigma s	19637 psi	<= Spss	56489 psi	[OK	Per Simply Sup]
Sigma c	4091 psi	<= Spsc	60020 psi	[OK	Per Simply Sup]
Sigmas,m	2769 psi	<=SsEs,w	17100 psi	[OK	] Step 10

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(FTS) Configuration a

Tubesheet Thickness (h)	= 3.3750"		
F-F Tubesheets (Lt)	= 167.8750"	F-F Inside Tubesheets (L)	= 161.1250"
Exp length of tube (ltx)	= 3.2062"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.0000"	Channel thickness (Tc)	= 0.5000"
Shell I.D. (Ds)	= 22.8760"	Shell thickness (Ts)	= 0.5620"
Press Chan (Pt)	= 214.0psi	Press Shell (Ps)	= 464.0psi
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 = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi

Mu= 0.2000 d*= 0.6440" P*= 0.9375" Mu*= 0.3131 hg'= 0.0000" hgs'= 0.0000"

W	= 0.0#	wj	= 0.0"	ao	= 11.18677998"
Rho s	= 1.022456884	Rho c	= 1.027999163	Chi s	= 0.480848223
Chi t	= 0.685226977	Ks	= 6933094.500Lb/In	Kt	= 29138.97070Lb/In
Ks,t	= 0.515004396	j	= 1.000000000	Beta s	= 0.500872552in^-1
Kappa s	= 439568.7500#	Lambda s	= 6464793.000psi	Beta c	= 0.530318439in^-1
Kappa c	= 336791.0938#	Lambda c	= 5309300.000psi	h/p	= 3.599999905
E*	= 8053920.000psi	v*	= 0.345361441	Xa	= 2.459800720
Zd	= 0.095104538	Zv	= 0.136877611	Zm	= 0.596329451
K	= 1.072694778	F	= 1.110997796	Phi	= 1.494693637
Q1	=-0.096299022	Qz1	= 1.499606967	Qz2	= 1.454362631
U	= 2.908725262	Gamma	= 0.0"	Omega s	= 0.0in^2
Omega c	= 0.0in^2	Omega s*	=-4.407473087in^2	Omega c*	=-3.754968882in^2
Delta s	= 0.000007330In^3/Lb	Delta c	= 0.000008100In^3/Lb	Gamma b	= 0.0
Ps'	= 891.8553467psi	Pt'	= 602.5858765psi	P Gamma	= 0.0psi
PW	= 0.0psi	Prim	= 28.85630417psi	Es,w	= 1.000000000
Pe	= 91.57337952psi	Q2	=-656.4186401#	Q3	=-0.210858613
Fm	= 0.105429307	Es,w1	= 0.0	lt	= 31.25000000"
Rt	= 0.237638906"	Ft	= 131.5020294	Ct	= 159.2741089
Fs	= 2.000000000	Stb	= 6166.893066psi	Ft,min	= 0.637837410
Sigmat,1	= 88.39507294psi	Sigmat,2	=-169.1192780psi	Ft,max	= 1.212572813
Sigma s,m	= 3103.362305psi	Sigma s,b	= 12950.49219psi	Sigma s	= 16053.85449psi
Sigma c,m	= 2408.638184psi	Sigma c,b	= 7061.438477psi	Sigma c	= 9470.076172psi

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	= 0.153976202	Phi	= 0.207153648	Q1	=-0.005249350
Qz1	= 1.727735877	Qz2	= 2.448243618	U	= 4.896487236
Omega s*	= 0.031910121in^2	Omega c*	= 0.396531820in^2	Prim	= 2.740892172psi
Pe	= 78.40368652psi	Q2	=-62.34938049#	Q3	=-0.017958470

Sigma = | 2076 psi |

Sigma	2032 psi	<= 1.5S	29865 psi	[OK Per Simply Sup]	
Tau	758 psi	<= .8S	15928 psi	[OK]	
Sigmat,max	169 psi	< St	13384 psi	[OK]	
Sigmat,min	-169 psi	<= Stb	6166 psi	[OK]	
Sigma s	16053 psi	<= Spss	56489 psi	[OK Per Simply Sup]	
Sigma c	9470 psi	<= Spsc	60020 psi	[OK Per Simply Sup]	
Sigmas,m	3103 psi	<=SsEs,w	17100 psi	[OK]	Step 10

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(FTS) Configuration a

Tubesheet Thickness (h)	= 3.3750"		
F-F Tubesheets (Lt)	= 167.8750"	F-F Inside Tubesheets (L)	= 161.1250"
Exp length of tube (ltx)	= 3.2062"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.0000"	Channel thickness (Tc)	= 0.5000"
Shell I.D. (Ds)	= 22.8760"	Shell thickness (Ts)	= 0.5620"
Press Chan (Pt)	= 0.0psi	Press Shell (Ps)	= 0.0psi
Corr Chan	= 0.00000"	Corr Shell	= 0.00000"
Corr Chan side TS (ct)	= 0.00000"	Corr Shell side TS (cs)	= 0.00000"

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi
Tt,m	= 393deg.F			At,m= 7.0860In/In			
Ts,m	= 423deg.F			As,m= 7.1460In/In			

Mu= 0.2000	d*= 0.6440"	P*= 0.9375"	Mu*= 0.3131	hg'= 0.0000"	hgs'= 0.0000"
W	= 0.0#	wj	= 0.0"	ao	= 11.18677998"
Rho s	= 1.022456884	Rho c	= 1.027999163	Chi s	= 0.480848223
Chi t	= 0.685226977	Ks	= 6933094.500Lb/In	Kt	= 29138.97070Lb/In
Ks,t	= 0.515004396	j	= 1.000000000	Beta s	= 0.500872552in^-1
Kappa s	= 439568.7500#	Lambda s	= 6464793.000psi	Beta c	= 0.530318439in^-1
Kappa c	= 336791.0938#	Lambda c	= 5309300.000psi	h/p	= 3.599999905
E*	= 8053920.000psi	v*	= 0.345361441	Xa	= 2.459800720
Zd	= 0.095104538	Zv	= 0.136877611	Zm	= 0.596329451
K	= 1.072694778	F	= 1.110997796	Phi	= 1.494693637
Q1	=-0.096299022	Qz1	= 1.499606967	Qz2	= 1.454362631
U	= 2.908725262	Gamma	=-0.037664570"	Omega s	= 4.439383030in^2
Omega c	= 4.151500702in^2	Omega s*	=-4.407473087in^2	Omega c*	=-3.754968882in^2
Delta s	= 0.000007330In^3/Lb	Delta c	= 0.000008100In^3/Lb	Gamma b	= 0.0
Ps'	= 0.0psi	Pt'	= 0.0psi	P Gamma	=-1289.701294psi
PW	= 0.0psi	Prim	= 0.0psi	Es,w	= 1.000000000
Pe	=-371.2440796psi	Q2	= 0.0#	Q3	=-0.096299022
Fm	= 0.104472697	Es,w1	= 0.0	lt	= 0.0"
Rt	= 0.0"	Ft	= 0.0	Ct	= 0.0
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.384364277
Sigmat,1	= 698.1790161psi	Sigmat,2	= 2723.963135psi	Ft,max	= 1.499606967
Sigma s,m	=-3527.060303psi	Sigma s,b	=-8983.994141psi	Sigma s	= 12511.05469psi
Sigma c,m	= 0.0psi	Sigma c,b	= 10794.48633psi	Sigma c	= 10794.48633psi

Thermal Expansion Acting on this Case (Yes)

Sigma	-8166 psi	<= Sps	61430 psi	[OK	]	
Tau	-3076 psi	<= .8S	15928 psi	[OK	]	
Sigmat,max	2723 psi	<= 2St	26769 psi	[OK	]	
Sigma s	12511 psi	<= Spss	56489 psi	[OK	]	
Sigma c	10794 psi	<= Spsc	60020 psi	[OK	]	
Sigmas,m	-3527 psi	<=2Ss	34200 psi	[OK	]	Step 10
Sigmas,m	-3527 psi	<=Ss,b	13400 psi	[OK	]	Step 10

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(FTS) Configuration a

Tubesheet Thickness (h)	= 3.3750"		
F-F Tubesheets (Lt)	= 167.8750"	F-F Inside Tubesheets (L)	= 161.1250"
Exp length of tube (ltx)	= 3.2062"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.0000"	Channel thickness (Tc)	= 0.5000"
Shell I.D. (Ds)	= 22.8760"	Shell thickness (Ts)	= 0.5620"
Press Chan (Pt)	= 214.0psi	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 = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi
Tt,m	= 393deg.F			At,m= 7.0860In/In			
Ts,m	= 423deg.F			As,m= 7.1460In/In			

Mu= 0.2000	d*= 0.6440"	P*= 0.9375"	Mu*= 0.3131	hg'= 0.0000"	hgs'= 0.0000"
W	= 0.0#	wj	= 0.0"	ao	= 11.18677998"
Rho s	= 1.022456884	Rho c	= 1.027999163	Chi s	= 0.480848223
Chi t	= 0.685226977	Ks	= 6933094.500Lb/In	Kt	= 29138.97070Lb/In
Ks,t	= 0.515004396	j	= 1.000000000	Beta s	= 0.500872552in^-1
Kappa s	= 439568.7500#	Lambda s	= 6464793.000psi	Beta c	= 0.530318439in^-1
Kappa c	= 336791.0938#	Lambda c	= 5309300.000psi	h/p	= 3.599999905
E*	= 8053920.000psi	v*	= 0.345361441	Xa	= 2.459800720
Zd	= 0.095104538	Zv	= 0.136877611	Zm	= 0.596329451
K	= 1.072694778	F	= 1.110997796	Phi	= 1.494693637
Q1	=-0.096299022	Qz1	= 1.499606967	Qz2	= 1.454362631
U	= 2.908725262	Gamma	=-0.037664570"	Omega s	= 4.439383030in^2
Omega c	= 4.151500702in^2	Omega s*	=-4.407473087in^2	Omega c*	=-3.754968882in^2
Delta s	= 0.000007330In^3/Lb	Delta c	= 0.000008100In^3/Lb	Gamma b	= 0.0
Ps'	= 0.0psi	Pt'	= 602.5858765psi	P Gamma	=-1289.701294psi
PW	= 0.0psi	Prim	=-18.67723656psi	Es,w	= 1.000000000
Pe	=-550.0763550psi	Q2	= 424.8668518#	Q3	=-0.108642846
Fm	= 0.101109803	Es,w1	= 0.0	lt	= 0.0"
Rt	= 0.0"	Ft	= 0.0	Ct	= 0.0
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.411676079
Sigmat,1	= 390.5234985psi	Sigmat,2	= 3235.399902psi	Ft,max	= 1.468678951
Sigma s,m	=-3192.944336psi	Sigma s,b	=-12901.88281psi	Sigma s	= 16094.82715psi
Sigma c,m	= 2408.638184psi	Sigma c,b	= 21947.12500psi	Sigma c	= 24355.76367psi

Thermal Expansion Acting on this Case (Yes)

Sigma	-11710 psi	<= Sps	61430 psi	[OK]	
Tau	-4558 psi	<= .8S	15928 psi	[OK]	
Sigmat,max	3235 psi	<= 2St	26769 psi	[OK]	
Sigma s	16094 psi	<= Spss	56489 psi	[OK]	
Sigma c	24355 psi	<= Spsc	60020 psi	[OK]	
Sigmas,m	-3192 psi	<=2Ss	34200 psi	[OK]	Step 10
Sigmas,m	-3192 psi	<=Ss,b	13400 psi	[OK]	Step 10

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(FTS) Configuration a

Tubesheet Thickness (h)	= 3.3750"		
F-F Tubesheets (Lt)	= 167.8750"	F-F Inside Tubesheets (L)	= 161.1250"
Exp length of tube (ltx)	= 3.2062"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.0000"	Channel thickness (Tc)	= 0.5000"
Shell I.D. (Ds)	= 22.8760"	Shell thickness (Ts)	= 0.5620"
Press Chan (Pt)	= 0.0psi	Press Shell (Ps)	= 464.0psi
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 = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi
Tt,m	= 393deg.F			At,m= 7.0860In/In			
Ts,m	= 423deg.F			As,m= 7.1460In/In			

Mu= 0.2000	d*= 0.6440"	P*= 0.9375"	Mu*= 0.3131	hg'= 0.0000"	hgs'= 0.0000"
W	= 0.0#	wj	= 0.0"	ao	= 11.18677998"
Rho s	= 1.022456884	Rho c	= 1.027999163	Chi s	= 0.480848223
Chi t	= 0.685226977	Ks	= 6933094.500Lb/In	Kt	= 29138.97070Lb/In
Ks,t	= 0.515004396	j	= 1.000000000	Beta s	= 0.500872552in^-1
Kappa s	= 439568.7500#	Lambda s	= 6464793.000psi	Beta c	= 0.530318439in^-1
Kappa c	= 336791.0938#	Lambda c	= 5309300.000psi	h/p	= 3.599999905
E*	= 8053920.000psi	v*	= 0.345361441	Xa	= 2.459800720
Zd	= 0.095104538	Zv	= 0.136877611	Zm	= 0.596329451
K	= 1.072694778	F	= 1.110997796	Phi	= 1.494693637
Q1	=-0.096299022	Qz1	= 1.499606967	Qz2	= 1.454362631
U	= 2.908725262	Gamma	=-0.037664570"	Omega s	= 4.439383030in^2
Omega c	= 4.151500702in^2	Omega s*	=-4.407473087in^2	Omega c*	=-3.754968882in^2
Delta s	= 0.000007330In^3/Lb	Delta c	= 0.000008100In^3/Lb	Gamma b	= 0.0
Ps'	= 891.8553467psi	Pt'	= 0.0psi	P Gamma	=-1289.701294psi
PW	= 0.0psi	Prim	= 47.53353882psi	Es,w	= 1.000000000
Pe	=-100.8383865psi	Q2	=-1081.285522#	Q3	= 0.075070783
Fm	= 0.151160136	Es,w1	= 0.0	lt	= 0.0"
Rt	= 0.0"	Ft	= 0.0	Ct	= 0.0
Fs	= 0.0	Stb	= 0.0psi	Ft,min	= 0.005193600
Sigmat,1	= 1094.229614psi	Sigmat,2	= 2043.406982psi	Ft,max	= 1.928981662
Sigma s,m	=-757.8136597psi	Sigma s,b	= 7884.387207psi	Sigma s	= 8642.201172psi
Sigma c,m	= 0.0psi	Sigma c,b	= 6703.284180psi	Sigma c	= 6703.284180psi

Thermal Expansion Acting on this Case (Yes)

Sigma	-3209 psi	<= Sps	61430 psi	[OK	]	
Tau	-835 psi	<= .8S	15928 psi	[OK	]	
Sigmat,max	2043 psi	<= 2St	26769 psi	[OK	]	
Sigma s	8642 psi	<= Spss	56489 psi	[OK	]	
Sigma c	6703 psi	<= Spsc	60020 psi	[OK	]	
Sigmas,m	-757 psi	<=2Ss	34200 psi	[OK	]	Step 10
Sigmas,m	-757 psi	<=Ss,b	13400 psi	[OK	]	Step 10

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(FTS) Configuration a

Tubesheet Thickness (h)	= 3.3750"		
F-F Tubesheets (Lt)	= 167.8750"	F-F Inside Tubesheets (L)	= 161.1250"
Exp length of tube (ltx)	= 3.2062"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.0000"	Channel thickness (Tc)	= 0.5000"
Shell I.D. (Ds)	= 22.8760"	Shell thickness (Ts)	= 0.5620"
Press Chan (Pt)	= 214.0psi	Press Shell (Ps)	= 464.0psi
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 = 515deg.F	S = 19910psi	Sy = 30715psi	E =26.9950psi		V =.300	Sps = 61430psi
Temp TBS	Tt= 515deg.F	St = 13384psi	Syt= 21005psi	Et =26.9950psi		Vt=.300	
Temp CH	Tc= 390deg.F	Sc = 17100psi	Syc= 30010psi	Ec =27.7400psi		Vc=.300	Spsc= 60020psi
Temp SH	Ts= 515deg.F	Ss = 17100psi	Sys= 28244psi	Es =26.9950psi		Vs=.300	Spss= 56489psi
Tt,m	= 393deg.F			At,m= 7.0860In/In			
Ts,m	= 423deg.F			As,m= 7.1460In/In			

Mu= 0.2000	d*= 0.6440"	P*= 0.9375"	Mu*= 0.3131	hg'= 0.0000"	hgs'= 0.0000"
W = 0.0#	wj = 0.0"	ao = 11.18677998"			
Rho s = 1.022456884	Rho c = 1.027999163	Chi s = 0.480848223			
Chi t = 0.685226977	Ks = 6933094.500Lb/In	Kt = 29138.97070Lb/In			
Ks,t = 0.515004396	j = 1.000000000	Beta s = 0.500872552in^-1			
Kappa s = 439568.7500#	Lambda s = 6464793.000psi	Beta c = 0.530318439in^-1			
Kappa c = 336791.0938#	Lambda c = 5309300.000psi	h/p = 3.599999905			
E* = 8053920.000psi	v* = 0.345361441	Xa = 2.459800720			
Zd = 0.095104538	Zv = 0.136877611	Zm = 0.596329451			
K = 1.072694778	F = 1.110997796	Phi = 1.494693637			
Q1 =-0.096299022	Qz1 = 1.499606967	Qz2 = 1.454362631			
U = 2.908725262	Gamma =-0.037664570"	Omega s = 4.439383030in^2			
Omega c = 4.151500702in^2	Omega s* =-4.407473087in^2	Omega c*=-3.754968882in^2			
Delta s = 0.000007330In^3/Lb	Delta c = 0.000008100In^3/Lb	Gamma b = 0.0			
Ps' = 891.8553467psi	Pt' = 602.5858765psi	P Gamma =-1289.701294psi			
PW = 0.0psi	Prim = 28.85630417psi	Es,w = 1.000000000			
Pe =-279.6706848psi	Q2 =-656.4186401#	Q3 =-0.058788441			
Fm = 0.114691973	Es,w1 = 0.0	lt = 0.0"			
Rt = 0.0"	Ft = 0.0	Ct = 0.0			
Fs = 0.0	Stb = 0.0psi	Ft,min = 0.301368862			
Sigmat,1 = 786.5740967psi	Sigmat,2 = 2554.843750psi	Ft,max = 1.593591332			
Sigma s,m=-423.6978149psi	Sigma s,b= 3966.498535psi	Sigma s = 4390.196289psi			
Sigma c,m= 2408.638184psi	Sigma c,b= 17855.92383psi	Sigma c = 20264.56250psi			

Thermal Expansion Acting on this Case (Yes)

Sigma	-6753 psi	<= Sps	61430 psi	[OK	]	
Tau	-2317 psi	<= .8S	15928 psi	[OK	]	
Sigmat,max	2554 psi	<= 2St	26769 psi	[OK	]	
Sigma s	4390 psi	<= Spss	56489 psi	[OK	]	
Sigma c	20264 psi	<= Spsc	60020 psi	[OK	]	
Sigmas,m	-423 psi	<=2Ss	34200 psi	[OK	]	Step 10
Sigmas,m	-423 psi	<=Ss,b	13400 psi	[OK	]	Step 10

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(FTS) Configuration a

Tubesheet Thickness (h)	= 3.0625"		
F-F Tubesheets (Lt)	= 167.5000"	F-F Inside Tubesheets (L)	= 161.3750"
Exp length of tube (ltx)	= 2.9094"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.3750"	Channel thickness (Tc)	= 0.3125"
Shell I.D. (Ds)	= 23.1260"	Shell thickness (Ts)	= 0.4370"
Press Chan (Pt)	= -15.0psi	Press Shell (Ps)	= 15.0psi (3)
Corr Chan	= 0.18750"	Corr Shell	= 0.12500"
Corr Chan side TS (ct)	= 0.18750"	Corr Shell side TS (cs)	= 0.12500"

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 250deg.F	S = 20000psi	Sy = 34200psi	E =28.3500psi		V =.300	Sps = 68400psi
Temp TBS	Tt= 250deg.F	St = 13400psi	Syt= 23400psi	Et =28.3500psi		Vt=.300	
Temp CH	Tc= 250deg.F	Sc = 17100psi	Syc= 31500psi	Ec =28.3500psi		Vc=.300	Spsc= 63000psi
Temp SH	Ts= 250deg.F	Ss = 17100psi	Sys= 31500psi	Es =28.3500psi		Vs=.300	Spss= 63000psi
Tt,m	= 250deg.F				At,m= 6.8000In/In		
Ts,m	= 250deg.F				As,m= 6.8000In/In		

Mu= 0.2000	d*= 0.6443"	P*= 0.9375"	Mu*= 0.3127	hg'= 0.0000"	hgs'= 0.0000"
W	= 0.0#	wj	= 0.0"	ao	= 11.18677998"
Rho s	= 1.033630729	Rho c	= 1.044759989	Chi s	= 0.480848223
Chi t	= 0.685226977	Ks	= 5683013.500Lb/In	Kt	= 30554.17773Lb/In
Ks,t	= 0.402592897	j	= 1.000000000	Beta s	= 0.566499650in^-1
Kappa s	= 245473.3281#	Lambda s	= 5027807.000psi	Beta c	= 0.668145478in^-1
Kappa c	= 105872.1016#	Lambda c	= 2656990.250psi	h/p	= 3.266666651
E*	= 8443892.000psi	v*	= 0.345594764	Xa	= 2.645718098
Zd	= 0.077794857	Zv	= 0.126402840	Zm	= 0.564671695
K	= 1.072694778	F	= 0.749756873	Phi	= 1.008868933
Q1	=-0.059816770	Qz1	= 1.720642805	Qz2	= 2.269223213
U	= 4.538446426	Gamma	= 0.0"	Omega s	= 3.606094599in^2
Omega c	= 2.950434446in^2	Omega s*	=-3.534133911in^2	Omega c*	=-2.125888348in^2
Delta s	= 0.000009170In^3/Lb	Delta c	= 0.000013110In^3/Lb	Gamma b	= 0.0
Ps'	= 33.22089767psi	Pt'	= -50.36984253psi	P Gamma	= 0.0psi
PW	= 0.0psi	Prim	= 3.078976870psi	Es,w	= 1.000000000
Pe	= 20.24587822psi	Q2	=-54.08768082#	Q3	=-0.102512218
Fm	= 0.091163047	Es,w1	= 0.0	lt	= 31.25000000"
Rt	= 0.237638906"	Ft	= 131.5020294	Ct	= 154.6441498
Fs	= 2.000000000	Stb	= 6725.438477psi	Ft,min	= 0.274353087
Sigmat,1	= 58.40435410psi	Sigmat,2	=-71.21263885psi	Ft,max	= 1.582814932
Sigma s,m	= 76.22334290psi	Sigma s,b	= 1169.741821psi	Sigma s	= 1245.965210psi
Sigma c,m	=-276.7994690psi	Sigma c,b	=-1411.112305psi	Sigma c	= 1687.911743psi

Thermal Expansion Acting on this Case (Yes)

Sigma	472 psi	<= Sps	68400 psi	[OK	]
Tau	184 psi	<= .8S	16000 psi	[OK	]
Sigmat,max	71 psi	<= 2St	26800 psi	[OK	]
Sigmat,min	-71 psi	<= Stb	6725 psi	[OK	]
Sigma s	1245 psi	<= Spss	63000 psi	[OK	]
Sigma c	1687 psi	<= Spsc	63000 psi	[OK	]
Sigmas,m	76 psi	<=2Ss	34200 psi	[OK	] Step 10

(FTS) Configuration a

Tubesheet Thickness (h)	= 3.0625"		
F-F Tubesheets (Lt)	= 167.5000"	F-F Inside Tubesheets (L)	= 161.3750"
Exp length of tube (ltx)	= 2.9094"	Exp depth ratio (Rho)	= 0.9500"
Channel I.D. (Dc)	= 23.3750"	Channel thickness (Tc)	= 0.3125"
Shell I.D. (Ds)	= 23.1260"	Shell thickness (Ts)	= 0.4370"
Press Chan (Pt)	= 15.0psi	Press Shell (Ps)	= -15.0psi
Corr Chan	= 0.18750"	Corr Shell	= 0.12500"
Corr Chan side TS (ct)	= 0.18750"	Corr Shell side TS (cs)	= 0.12500"

	Temp	Stress	Yield	Modulus x10^6	Coef x10^-6	Poisson Ratio	Prim Plus Stress
Temp TS	T = 250deg.F	S = 20000psi	Sy = 34200psi	E =28.3500psi		V =.300	Sps = 68400psi
Temp TBS	Tt= 250deg.F	St = 13400psi	Syt= 23400psi	Et =28.3500psi		Vt=.300	
Temp CH	Tc= 250deg.F	Sc = 17100psi	Syc= 31500psi	Ec =28.3500psi		Vc=.300	Spsc= 63000psi
Temp SH	Ts= 250deg.F	Ss = 17100psi	Sys= 31500psi	Es =28.3500psi		Vs=.300	Spss= 63000psi
Tt,m	= 250deg.F				At,m= 6.8000In/In		
Ts,m	= 250deg.F				As,m= 6.8000In/In		

Mu= 0.2000	d*= 0.6443"	P*= 0.9375"	Mu*= 0.3127	hg'= 0.0000"	hgs'= 0.0000"
W	= 0.0#	wj	= 0.0"	ao	= 11.18677998"
Rho s	= 1.033630729	Rho c	= 1.044759989	Chi s	= 0.480848223
Chi t	= 0.685226977	Ks	= 5683013.500Lb/In	Kt	= 30554.17773Lb/In
Ks,t	= 0.402592897	j	= 1.000000000	Beta s	= 0.566499650in^-1
Kappa s	= 245473.3281#	Lambda s	= 5027807.000psi	Beta c	= 0.668145478in^-1
Kappa c	= 105872.1016#	Lambda c	= 2656990.250psi	h/p	= 3.266666651
E*	= 8443892.000psi	v*	= 0.345594764	Xa	= 2.645718098
Zd	= 0.077794857	Zv	= 0.126402840	Zm	= 0.564671695
K	= 1.072694778	F	= 0.749756873	Phi	= 1.008868933
Q1	=-0.059816770	Qz1	= 1.720642805	Qz2	= 2.269223213
U	= 4.538446426	Gamma	= 0.0"	Omega s	= 3.606094599in^2
Omega c	= 2.950434446in^2	Omega s*	=-3.534133911in^2	Omega c*	=-2.125888348in^2
Delta s	= 0.000009170In^3/Lb	Delta c	= 0.000013110In^3/Lb	Gamma b	= 0.0
Ps'	= -33.22089767psi	Pt'	= 50.36984253psi	P Gamma	= 0.0psi
PW	= 0.0psi	Prim	=-3.078976870psi	Es,w	= 1.000000000
Pe	=-20.24587822psi	Q2	= 54.08768082#	Q3	=-0.102512218
Fm	= 0.091163047	Es,w1	= 0.0	lt	= 31.25000000"
Rt	= 0.237638906"	Ft	= 131.5020294	Ct	= 154.6441498
Fs	= 2.000000000	Stb	= 6725.438477psi	Ft,min	= 0.274353087
Sigmat,1	=-58.40435410psi	Sigmat,2	= 71.21263885psi	Ft,max	= 1.582814932
Sigma s,m	=-76.22334290psi	Sigma s,b	=-1169.741821psi	Sigma s	= 1245.965210psi
Sigma c,m	= 276.7994690psi	Sigma c,b	= 1411.112305psi	Sigma c	= 1687.911743psi

Thermal Expansion Acting on this Case (Yes)

Sigma	-472 psi	<= Sps	68400 psi	[OK	]	
Tau	-184 psi	<= .8S	16000 psi	[OK	]	
Sigmat,max	71 psi	<= 2St	26800 psi	[OK	]	
Sigmat,min	-58 psi	<= Stb	6725 psi	[OK	]	
Sigma s	1245 psi	<= Spss	63000 psi	[OK	]	
Sigma c	1687 psi	<= Spsc	63000 psi	[OK	]	
Sigmas,m	-76 psi	<=2Ss	34200 psi	[OK	]	Step 10
Sigmas,m	-76 psi	<=Ss,b	17030 psi	[OK	]	Step 10

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

Tube size.....=	0.75000"	Straight or U-Tube.=	Straight Tube
Internal Press...=	214.00000psig*	External press.....=	479.00000psig*
Temperature used.=	515.00000deg.	Tube Matl MT# 34...=	SA-179
Stress Oper.....=	13384.99902psi	Stress Atm.....=	13400.00000psi
Yield.....=	21005.00195psi	Inside Radius.....=	0.29200"
Joint Eff.....=	1.00000	Mill tol...= 0.00% =	0.00000"
Wall Thk. t.....=	0.08300"	Tube gauge.....=	
Mean Rad., R.....=	0.00000"	Tube Length.....=	168.00000"
Corrosion ID.....=	0.00000"	Corrosion OD.....=	0.00000"
Thinning factor..=	1.00000		
tr = PR/SE - .6P =	0.00471"	(tr*TF)+MT+CA.....=	0.00471"
MAWP Internal H/C=	3250.30688psig	MAWP Internal N/C..=	3253.94971psig
MAWP External H/C=	1928.78552psig	MAWP External N/C..=	2159.90234psig

* DESIGN PRESSURE HAS BEEN INCREASED BY 9 PSI DUE TO STATIC HEAD

Energy Exchanger Company

Customer :	SOUTHERN / MISS. POWER CO.	Item No.	HX 0042	W.O. :	X-7929
Subject :	Seismic and Wind Loading Factors	Date	5/11/2011	By :	DN/MD

Wind Loading

Given Data: From Customer Spec

Exposure Cat	C	
Occupancy Cat	III	
Importance Fact	1.150	
Kzt	1.000	
V	100.000	mph
qz = 0.00256KzKztKdV^2I		
Height of vessel	25.000	ft or less (2)
Alpha	9.5	Table 6-2
Zg	900	Table 6-2
Kz	0.945	Table 6-3
Kd	0.950	(Table 6-4)
qz =	26.437	
G	0.850	
Cf =	0.800	(Fig 6-21)
Wind Pressure	= qz*G*Cf	
	17.977	psf (2)

Seismic Loading

Given Data: From Customer Spec

Occupancy Cat:	III	
Design Cat:	B	
Reliability	1	
Importance Factor	1.25	
Site Class	C	
Ss	0.204	g
S1	0.087	g
R (Table 15.4.2)	3	
Fa	1.2	
Fv	1.7	
Sms	0.2448	g
Sm1	0.1479	g
Sds	0.1632	g
Sd1	0.0986	g
Cs = Sds/(R/I)	0.0680	
Min Cs =	0.0100	

SNOW LOADS

Pg	5	psf
CAT	C	
Ct	1.2	
I	1.1	
Pf = 0.7*Ct*I	6.6	psf
SNOW LOAD AREA	48	sf
ADDITIONAL WEIGHT	316.8	lbs

Input Echo, Leg & Lug Item 1, Description: X-7929 SUPPORTS

Design Internal Pressure		464.00	psig	← INCLUDES 9 PSI FOR STATIC HEAD
Design Temperature for Attachment	TEMP	515.00	F	
Vessel Outside Diameter	OD	24.000	in.	
Vessel Wall Thickness	Ts	0.4918	in.	
Vessel Corrosion Allowance	Cas	0.1250	in.	
Vessel Material		SA-106 B		
Vessel Material UNS Number		K03006		
Vessel Allowable Stress at Design	S	17100.00	psi	
Analysis Type:		Support Lug		
Tangent to Tangent Length of Vessel	TANTAN	13.469	ft.	
Height of Bottom Tangent Above Grade		0.370	ft.	
Empty Weight of Vessel	Wemp	9016.80	lb.	← WEIGHTS INCLUDE 316.8 LB
Operating Weight of Vessel (vertical load)	W	12016.80	lb.	FOR SNOW LOADING
Force Coefficient (Shape factor)	Cf	0.800		
Additional Area		0.00	in²	
User defined Wind Pressure		17.977	psf	(2)
Design Wind Code		ASCE 7-98/02/05/IBC 2003		
Type of Hill		None		
User Entered Seismic Zone Factor	Cs	0.068		
Additional Horizontal Force on Vessel	FF	0.00	lb.	
Location of Horizontal Force above Base Point	FH	0.00	ft.	
Support Lug with Full Reinforcing Rings?		No		
Number of Support Lugs	NLUG	2		
Location of Support Lugs above Base Point	LLUG	11.4635	ft.	(1)
Distance from Vessel OD to Lug Contact Point	DLUG	8.6250	in.	
Lug Support Force Bearing Width	WFB	4.0000	in.	
Support Lug Material		SA-516 70		
Support Lug Material UNS Number		K02700		
Support Lug Yield Stress	Ylug	30715.00	psi	
Radial Width of bottom Support Lug Plate	Wpl	10.6250	in.	
Effective Force Bearing Length	Lpl	6.0000	in.	
Thickness of bottom Support Lug Plate	Tpl	0.7500	in.	
Distance between Gussets	Dgp	5.0000	in.	
Mean Width of Gusset Plate	Wgp	6.3125	in.	
Height of Gusset Plate	Hgp	8.2500	in.	
Thickness of Gusset Plate	Tgp	0.5000	in.	
Perform WRC-107 (Loal Stress) Analysis on Lug		Yes		
Lug Pad Width (Circumferential direction)	wpad	10.000	in.	
Lug Pad Length (Longitudinal direction)	lpad	13.000	in.	
Lug Pad Thickness	tpad	0.375	in.	
Occasional Load Factor (AISC A5.2)	Occfac	1.00		

Results for support lugs, Description : X-7929 SUPPORTS

Vessel Wind Area, Af	: 6250.522 in²		
Vessel Wind load = P * Af * Cf	: 780.317 lb.		
Location of Centroid above Base Point	: 7.104 ft.		
Overturning Moment at Support Lug	Mlug	3562.	ft.lb.
Weight Load at the top of one Lug		6008.	lb.
Shear at top of one Lug		0.	lb.

Distance from vessel center to Lug centroid [Rlug]:
= (OD / 2.0 + DLUG) / 12.0
= (24.0000 / 2.0 + 8.6250) / 12.0
= 1.72 ft.

Force on one Lug (compression side) [Flug]:
= (W/Nlug + Mlug/(Rlug * 2))
= (12016 /2 + 3562 /(1.72 * 2))
= 7044.68 lb.

Bearing Area [Ba]:
= Lpl * Wfb
= 6.000 * 4.000
= 24.00 in²

Bending Str. in bottom Plate (Unif. Load) Per Bednar p.156 [Spl2]:
= Betal * Flug/Ba * Wfb² / Tpl² per Roark & Young 5th Ed.
= 0.903 * 7044.7 /24.000 * 4.000² / 0.750²
= 7542.68 psi

Allowable Stress for Support Plate [Spa]:
= Min(0.66 * Ylug * Occfac, 0.75 * Ylug)
= Min(0.66 * 30715 * 1.00 , 23036.2)
= 20271.90 psi

Stress in Gusset Plate (Force / Gusset Plate Area) [Sgp]:
= (Flug/2) / (Wgp * Tgp)
= (7044 /2) / (6.313 *0.5000)
= 1115.99 psi

Gusset Plate Allowable Stress [Sga]:
= (1-(Klr)^2/(2*Cc^2))*Fy /
(5/3+3*(Klr)/(8*Cc)-(Klr^3)/(8*Cc^3)
= (1-(66.00)^2/(2 * 136.52 ^2)) * 30715 /
(5/3+3*(66.00)/(8* 136.52)-(66.00 ^3)/(8*136.52 ^3)
= 14791.67 psi

Maximum Compressive Stress in the Gussets per Bednar [SgpB]:
= Flug * (3*Dlug - Wpl) / (Tgp* Wpl**2 * (SIN(Alph_G))**2)
= 7044 *(3*8.625 -10.625)/(0.5000 *10.625 **2*(Sin(43.73))**2)
= 3983.52 psi

Gusset Plate Allowable Compressive Stress per Bednar [SgaB]:
= 18000./ (1.+ (1./18000)*(Hgp /SIN(Alph_G)/(.289*Tgp))**2)
= 18000/ (1+ (1/18000)*(8.250 /Sin(43.73)/(0.289*0.5000))**2)
= 13052.73 psi

Summary Of Results

Stress (psi)	Actual	Allowable	P/F
Bottom Plt. Str. (Unif. Load-Bednar) :	7542.68	20271.90	Ok
Gusset Plt. Str. (Force/Gusset Area) :	1115.99	14791.67	Ok
Gusset Plt. Max Comp. Str. (Bednar) :	3983.52	13052.73	Ok

Result of WRC-107 analysis on the Vessel-Support Lug Junction:
(Worst load case + Int. Pressure, ref. Pressure Vessel Design Manual, D. Moss)

Sustained (Wt) Forces/Moments for WRC107 Analysis :

Distance from Lug bottom to Lug centroid, b	:	3.463	in.
Force on lug in Sustained Condition, Flug_Sus	:	6008.40	lb.
Longitudinal Shear = Flug_Sus	:	6008.40	lb.
Long. Moment = Flug_Sus * DLUG + FF / Nlug * b	:	4318.54	ft.lb.

Occasional (Wind/Seismic) Forces/Moments for WRC107 Analysis :

Horizontal Live load max(Wind, Seismic), V	:	817.142	lb.
Force on lug in Occasional Condition, Flug_Occ	:	1036.28	lb.
Longitudinal Shear = Flug_Occ	:	1036.28	lb.
Long. Moment = Flug_Occ * DLUG + V / Nlug * b	:	862.74	ft.lb.

Parameter C11	C11	3.00	in.
Parameter C22	C22	6.60	in.
Pad Parameter C11P	C11P	10.00	in.
Pad Parameter C22P	C22P	13.00	in.
Thickness of Reinforcing Pad	tpad	0.38	in.

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	0.0	lb.
Circumferential Shear	VC	0.0	lb.
Longitudinal Shear	VL	6008.4	lb.
Circumferential Moment	MC	0.0	ft.lb.
Longitudinal Moment	ML	4318.5	ft.lb.
Torsional Moment	MT	0.0	ft.lb.

Dimensionless Parameters used : Gamma = 16.18

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.250	4C	2.501	(A,B)
N(PHI) / (P/Rm)	0.250	3C	1.857	(C,D)
M(PHI) / (P)	0.169	2C1	0.078	(A,B)
M(PHI) / (P)	0.169	1C	0.108	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.163	3A	0.522	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.184	1A	0.094	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.211	3B	1.811	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.198	1B	0.040	(A,B,C,D)
N(x) / (P/Rm)	0.212	3C	2.074	(A,B)
N(x) / (P/Rm)	0.212	4C	2.617	(C,D)
M(x) / (P)	0.219	1C1	0.089	(A,B)
M(x) / (P)	0.219	2C	0.056	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.163	4A	0.766	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.235	2A	0.047	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.211	4B	0.594	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.239	2B	0.054	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of	Stress Values at (psi)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0	0	0	0	0	0	0	0
Circ. Bend. P	0	0	0	0	0	0	0	0
Circ. Memb. MC	0	0	0	0	0	0	0	0
Circ. Bend. MC	0	0	0	0	0	0	0	0
Circ. Memb. ML	-3531	-3531	3531	3531	0	0	0	0
Circ. Bend. ML	-9592	9592	9592	-9592	0	0	0	0
Tot. Circ. Str.	-13123	6061	13123	-6061	0	0	0	0
Long. Memb. P	0	0	0	0	0	0	0	0
Long. Bend. P	0	0	0	0	0	0	0	0
Long. Memb. MC	0	0	0	0	0	0	0	0
Long. Bend. MC	0	0	0	0	0	0	0	0
Long. Memb. ML	-1755	-1755	1755	1755	0	0	0	0
Long. Bend. ML	-10666	10666	10666	-10666	0	0	0	0
Tot. Long. Str.	-12421	8911	12421	-8911	0	0	0	0
Shear VC	0	0	0	0	0	0	0	0
Shear VL	0	0	0	0	-613	-613	613	613
Shear MT	0	0	0	0	0	0	0	0
Tot. Shear	0	0	0	0	-613	-613	613	613
Str. Int.	13123	8911	13123	8911	1227	1227	1227	1227

Dimensionless Parameters used : Gamma = 32.22

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.554	4C	2.466	(A,B)
N(PHI) / (P/Rm)	0.554	3C	0.964	(C,D)
M(PHI) / (P)	0.465	2C1	0.008	(A,B)
M(PHI) / (P)	0.465	1C	0.061	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.462	3A	0.872	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.509	1A	0.062	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.504	3B	1.308	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.504	1B	0.006	(A,B,C,D)
N(x) / (P/Rm)	0.512	3C	0.964	(A,B)
N(x) / (P/Rm)	0.512	4C	2.466	(C,D)
M(x) / (P)	0.520	1C1	0.016	(A,B)
M(x) / (P)	0.520	2C	0.031	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.462	4A	3.177	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.586	2A	0.026	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.504	4B	0.783	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.542	2B	0.011	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad

Type of	Stress Values at (psi)							
Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0	0	0	0	0	0	0	0
Circ. Bend. P	0	0	0	0	0	0	0	0
Circ. Memb. MC	0	0	0	0	0	0	0	0
Circ. Bend. MC	0	0	0	0	0	0	0	0
Circ. Memb. ML	-2326	-2326	2326	2326	0	0	0	0
Circ. Bend. ML	-2426	2426	2426	-2426	0	0	0	0
Tot. Circ. Str.	-4753	100	4753	-100	0	0	0	0
Long. Memb. P	0	0	0	0	0	0	0	0
Long. Bend. P	0	0	0	0	0	0	0	0
Long. Memb. MC	0	0	0	0	0	0	0	0
Long. Bend. MC	0	0	0	0	0	0	0	0
Long. Memb. ML	-1612	-1612	1612	1612	0	0	0	0
Long. Bend. ML	-3978	3978	3978	-3978	0	0	0	0
Tot. Long. Str.	-5590	2366	5590	-2366	0	0	0	0
Shear VC	0	0	0	0	0	0	0	0
Shear VL	0	0	0	0	-630	-630	630	630
Shear MT	0	0	0	0	0	0	0	0
Tot. Shear	0	0	0	0	-630	-630	630	630
Str. Int.	5590	2366	5590	2366	1260	1260	1260	1260

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	0.0	lb.
Circumferential Shear	VC	0.0	lb.
Longitudinal Shear	VL	1036.3	lb.
Circumferential Moment	MC	0.0	ft.lb.
Longitudinal Moment	ML	862.7	ft.lb.
Torsional Moment	MT	0.0	ft.lb.

Dimensionless Parameters used : Gamma = 16.18
Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of Stress Load	Stress Values at (psi) Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0	0	0	0	0	0	0	0
Circ. Bend. P	0	0	0	0	0	0	0	0
Circ. Memb. MC	0	0	0	0	0	0	0	0
Circ. Bend. MC	0	0	0	0	0	0	0	0
Circ. Memb. ML	-705	-705	705	705	0	0	0	0
Circ. Bend. ML	-1916	1916	1916	-1916	0	0	0	0
Tot. Circ. Str.	-2621	1210	2621	-1210	0	0	0	0
Long. Memb. P	0	0	0	0	0	0	0	0
Long. Bend. P	0	0	0	0	0	0	0	0
Long. Memb. MC	0	0	0	0	0	0	0	0
Long. Bend. MC	0	0	0	0	0	0	0	0
Long. Memb. ML	-350	-350	350	350	0	0	0	0
Long. Bend. ML	-2130	2130	2130	-2130	0	0	0	0
Tot. Long. Str.	-2481	1780	2481	-1780	0	0	0	0
Shear VC	0	0	0	0	0	0	0	0
Shear VL	0	0	0	0	-105	-105	105	105
Shear MT	0	0	0	0	0	0	0	0
Tot. Shear	0	0	0	0	-105	-105	105	105
Str. Int.	2621	1780	2621	1780	211	211	211	211

Dimensionless Parameters used : Gamma = 32.22
Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad

Type of Stress Load	Stress Values at (psi) Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0	0	0	0	0	0	0	0
Circ. Bend. P	0	0	0	0	0	0	0	0
Circ. Memb. MC	0	0	0	0	0	0	0	0
Circ. Bend. MC	0	0	0	0	0	0	0	0
Circ. Memb. ML	-464	-464	464	464	0	0	0	0
Circ. Bend. ML	-484	484	484	-484	0	0	0	0
Tot. Circ. Str.	-949	20	949	-20	0	0	0	0
Long. Memb. P	0	0	0	0	0	0	0	0
Long. Bend. P	0	0	0	0	0	0	0	0
Long. Memb. MC	0	0	0	0	0	0	0	0
Long. Bend. MC	0	0	0	0	0	0	0	0
Long. Memb. ML	-322	-322	322	322	0	0	0	0
Long. Bend. ML	-794	794	794	-794	0	0	0	0
Tot. Long. Str.	-1116	472	1116	-472	0	0	0	0
Shear VC	0	0	0	0	0	0	0	0
Shear VL	0	0	0	0	-108	-108	108	108
Shear MT	0	0	0	0	0	0	0	0
Tot. Shear	0	0	0	0	-108	-108	108	108
Str. Int.	1116	472	1116	472	217	217	217	217

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (psi)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	7052	7516	7052	7516	7052	7516	7052	7516
Circ. Pm (OCC)	0	0	0	0	0	0	0	0
Circ. Pm(TOTAL)	7052	7516	7052	7516	7052	7516	7052	7516
Circ. Pl (SUS)	-3531	-3531	3531	3531	0	0	0	0
Circ. Pl (OCC)	-705	-705	705	705	0	0	0	0
Circ. Pl(TOTAL)	-4236	-4236	4236	4236	0	0	0	0
Circ. Q (SUS)	-9592	9592	9592	-9592	0	0	0	0
Circ. Q (OCC)	-1916	1916	1916	-1916	0	0	0	0
Circ. Q (TOTAL)	-11509	11509	11509	-11509	0	0	0	0
Long. Pm (SUS)	3526	3526	3526	3526	3526	3526	3526	3526
Long. Pm (OCC)	0	0	0	0	0	0	0	0
Long. Pm(TOTAL)	3526	3526	3526	3526	3526	3526	3526	3526
Long. Pl (SUS)	-1755	-1755	1755	1755	0	0	0	0
Long. Pl (OCC)	-350	-350	350	350	0	0	0	0
Long. Pl(TOTAL)	-2105	-2105	2105	2105	0	0	0	0
Long. Q (SUS)	-10666	10666	10666	-10666	0	0	0	0
Long. Q (OCC)	-2130	2130	2130	-2130	0	0	0	0
Long. Q (TOTAL)	-12797	12797	12797	-12797	0	0	0	0
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pm (OCC)	0	0	0	0	0	0	0	0
Shear Pm(TOTAL)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	0	0	0	0	-613	-613	613	613
Shear Pl (OCC)	0	0	0	0	-105	-105	105	105
Shear Pl(TOTAL)	0	0	0	0	-719	-719	719	719
Shear Q (SUS)	0	0	0	0	0	0	0	0
Shear Q (OCC)	0	0	0	0	0	0	0	0
Shear Q (TOTAL)	0	0	0	0	0	0	0	0
Pm (SUS)	7052	7516	7052	7516	7052	7516	7052	7516
Pm (SUS+OCC)	7052	7516	7052	7516	7052	7516	7052	7516
Pm+Pl (SUS)	3521	3985	10583	11047	7156	7608	7156	7608
Pm+Pl (SUS+OCC)	2815	3279	11288	11752	7193	7642	7193	7642
Pm+Pl+Q (Total)	11376	14788	22797	7408	7193	7642	7193	7642

Type of Stress Int.	Max. S.I. psi	S.I. Allowable psi	Result
Pm (SUS)	7516	17100	Passed
Pm (SUS+OCC)	7516	20520	Passed
Pm+Pl (SUS)	11047	25650	Passed
Pm+Pl (SUS+OCC)	11752	30780	Passed
Pm+Pl+Q (TOTAL)	22797	51300	Passed

WRC 107 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge

Type of Stress Int.	Stress Values at (psi)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	14489	14953	14489	14953	14489	14953	14489	14953
Circ. Pm (OCC)	0	0	0	0	0	0	0	0
Circ. Pm(TOTAL)	14489	14953	14489	14953	14489	14953	14489	14953
Circ. Pl (SUS)	-2326	-2326	2326	2326	0	0	0	0
Circ. Pl (OCC)	-464	-464	464	464	0	0	0	0
Circ. Pl(TOTAL)	-2791	-2791	2791	2791	0	0	0	0
Circ. Q (SUS)	-2426	2426	2426	-2426	0	0	0	0
Circ. Q (OCC)	-484	484	484	-484	0	0	0	0
Circ. Q (TOTAL)	-2911	2911	2911	-2911	0	0	0	0
Long. Pm (SUS)	7244	7244	7244	7244	7244	7244	7244	7244
Long. Pm (OCC)	0	0	0	0	0	0	0	0
Long. Pm(TOTAL)	7244	7244	7244	7244	7244	7244	7244	7244
Long. Pl (SUS)	-1612	-1612	1612	1612	0	0	0	0
Long. Pl (OCC)	-322	-322	322	322	0	0	0	0
Long. Pl(TOTAL)	-1934	-1934	1934	1934	0	0	0	0
Long. Q (SUS)	-3978	3978	3978	-3978	0	0	0	0
Long. Q (OCC)	-794	794	794	-794	0	0	0	0
Long. Q (TOTAL)	-4773	4773	4773	-4773	0	0	0	0
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pm (OCC)	0	0	0	0	0	0	0	0
Shear Pm(TOTAL)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	0	0	0	0	-630	-630	630	630
Shear Pl (OCC)	0	0	0	0	-108	-108	108	108
Shear Pl(TOTAL)	0	0	0	0	-738	-738	738	738
Shear Q (SUS)	0	0	0	0	0	0	0	0
Shear Q (OCC)	0	0	0	0	0	0	0	0
Shear Q (TOTAL)	0	0	0	0	0	0	0	0
Pm (SUS)	14489	14953	14489	14953	14489	14953	14489	14953
Pm (SUS+OCC)	14489	14953	14489	14953	14489	14953	14489	14953
Pm+Pl (SUS)	12163	12627	16815	17279	14544	15004	14544	15004
Pm+Pl (SUS+OCC)	11698	12162	17280	17744	14564	15023	14564	15023
Pm+Pl+Q (Total)	8786	15074	20192	14832	14564	15023	14564	15023

Type of Stress Int.	Max. S.I. psi	S.I. Allowable psi	Result
Pm (SUS)	14953	17100	Passed
Pm (SUS+OCC)	14953	20520	Passed
Pm+Pl (SUS)	17279	25650	Passed
Pm+Pl (SUS+OCC)	17744	30780	Passed
Pm+Pl+Q (TOTAL)	20192	51300	Passed

ANCHOR BOLTING CALC: (SHEAR ONLY)
BOLT MATERIAL: A325
BOLT DIAM: 1" (AREA=0.551IN^2) 4 BOLTS TOTAL (2 PER SUPPORT)
GREATEST COMBINED TRANSVERSE LOAD = 1077 LB (COMBINED WIND & SEISMIC)
STRESS IN BOLTS = 488.7 PSI < 11880 PSI ALLOW DESIGN IS ACCEPTABLE

Input Echo, Leg & Lug Item 2, Description: X-7929 FLL

Design Internal Pressure		0.00	psig
Design Temperature for Attachment	TEMP	100.00	F
Vessel Outside Diameter	OD	24.000	in.
Vessel Wall Thickness	Ts	0.4918	in.
Vessel Corrosion Allowance	Cas	0.1250	in.
Vessel Material		SA-106 B	
Vessel Material UNS Number		K03006	
Vessel Allowable Stress at Design	S	17100.00	psi
Analysis Type:		Lifting Lug	
Empty Weight of Vessel	Wemp	8700.00	lb.
Operating Weight of Vessel (vertical load)	W	11700.00	lb.
Force Coefficient (Shape factor)	Cf	0.800	
Additional Area		0.00	in²
User defined Wind Pressure		17.977	psf
Design Wind Code		ASCE 7-05	
Type of Hill		None	
User Entered Seismic Zone Factor	Cs	0.068	
Lifting Lug Material		SA-516 70	
Lifting Lug Material UNS Number		K02700	
Lifting Lug Yield Stress	YIELD	38000.00	psi
Lifting Lug Orientation to Vessel		Perpendicular	
Total Height of Lifting Lug	w	8.0000	in.
Thickness of Lifting Lug	t	0.5000	in.
Diameter of Hole in Lifting Lug	dh	2.0000	in.
Radius of Semi-Circular Arc of Lifting Lug	r	4.0000	in.
Height of Lug from bottom to Center of Hole	h	4.0000	in.
Offset from Vessel OD to Center of Hole	off	5.0000	in.
Minimum thickness of Fillet Weld around Lug	tw	0.3750	in.
Length of weld along side of Lifting Lug	wl	8.0000	in.
Length of Weld along Bottom of Lifting Lug	wb	0.5000	in.
Lift Orientation		Vertical	
Force Along Vessel Axis	Fax	8700.00	lb.
Force Normal to Vessel	Fn	8700.00	lb.
Force Tangential to Vessel	Ft	0.00	lb.
Impact Factor	Impfac	1.50	
Occasional Load Factor (AISC A5.2)	Occfac	1.12	

Results for lifting lugs, Description : X-7929 FLL

Vessel Wind Area, Af	: 8208.000 in²		
Vessel Wind load = P * Af * Cf	: 920.208 lb.		
Location of Centroid above Base Point	: 9.448 ft.		
Weld Group Inertia about the Circumferential Axis	ILC	35.190	in**4
Weld Group Centroid distance in the Long. Direction	YLL	4.248	in.
Dist. of Weld Group Centroid from Lug bottom	YLL_B	3.873	in.
Weld Group Inertia about the Longitudinal Axis	ILL	0.098	in**4
Weld Group Centroid Distance in the Circ. Direction	YLC	0.250	in.

Applying the Impact factor to the loads:

Fax = 8700.00 * 1.50 = 13050.00 lb.

Fn = 8700.00 * 1.50 = 13050.00 lb.

Primary Shear Stress in the Welds due to Shear Loads [Ssll]:

= Sqrt(Fax^2+Ft^2+Fn^2) / ((2*wl+wb) * tw)

= Sqrt(13050 ^2+0 ^2+13050 ^2) / ((2*8.0 +0.5) * 0.3750)

= 2982.71 psi

Shear Stress in the Welds due to Bending Loads [Sblf]:

= (Fn*(h-YLL_B)) *YLL/ILC + (Fax*off *YLL/ILC) + (Ft*off *YLC/ILL)

```
= (13050 *(4.000 -3.873 )) * 4.248 /35.190 +
  (13050 *5.000 * 4.248 /35.190 ) +
  (0 *5.000 * 0.250 /0.098 )
= 8076.74 psi
```

Total Shear Stress for Combined Loads [St]:

```
= Ssll + Sblf
= 2982.705 + 8076.736
= 11059.44 psi
```

Allowable Shear Stress for Combined Loads [Sta]:

```
= 0.4 * Yield * Occfac (AISC Shear All.)
= 0.4 * 38000 * 1.12
= 17100.00 psi
```

Shear Stress in Lug above Hole [Shs]:

```
= Sqrt( Fax^2 + Fn^2 + Ft^2 ) / Sha
= Sqrt( 13050 ^2 + 13050 ^2 + 0 ^2 ) / 3.000
= 6151.83 psi
```

Allowable Shear Stress in Lug above Hole [Sas]:

```
= 0.4 * Yield * Occfac
= 0.4 * 38000 * 1.12
= 17100.00 psi
```

Pin Hole Bearing Stress [Pbs]:

```
= Sqrt( Fax^2 + Fn^2 ) / ( t * dh )
= Sqrt( 13050 ^2 + 13050 ^2 ) / ( 0.500 * 2.000 )
= 18455.49 psi
```

Allowable Bearing Stress [Pba]:

```
= Min( 0.75 * Yield * Occfac, 0.9*Yield ) AISC Bearing All.
= Min( 0.75 * 38000 * 1.12 , 34200.0 )
= 32062.50 psi
```

Bending stress at the base of the lug [Fbs]:

```
= Ft*off / (w*t^(2) / 6) + Fax*off / (w^(2)*t / 6)
= 0 * 5.000 / (8.000 * 0.500 ^(2) / 6) +
  13050 * 5.000 / (8.000 ^(2) * 0.500 / 6)
= 12234.38  psi
```

Tensile stress at the base of the lug [Fa]:

```
= Fn / (w * t) = 13050 / (8.000 * 0.500 )
= 3262.50  psi
```

Total Combined Stress at the base of the lug:
= Fbs + Fa = 15496.9 psi

Lug Allowable Stress for Bending and Tension:

```
= Min( 0.66 * Yield * Occfac, 0.75*Yield )
= Min( 0.66 * 38000 * 1.12 , 28500.0 ) = 28215.0 psi
```

Note: Check the Shell Stresses using method such as WRC-107.

Summary Of Results

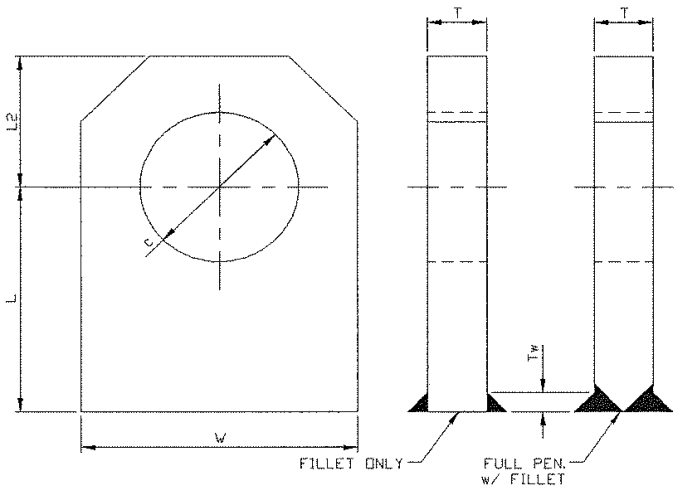
Stress (psi)	Actual	Allowable	P/F
Primary Shear Stress of Weld :	11059.44	17100.00	Ok
Shear Stress above Hole :	6151.83	17100.00	Ok
Pin Hole Bearing Stress :	18455.49	32062.50	Ok
Total Combined Stress at the lug base :	15496.88	28215.00	Ok

Energy Exchanger Company

Customer :	MISSISSIPPI POWER/SOUTHERN COMPANY SERVICES	Item No	HX0042	W.O. :	X-7929
Subject :	LIFTING LUG CALCULATION	Date	3/9/2011	By :	MD/DN

Note : Lugs are not designed for side loading. Do not side load lugs.

Material	SA-516-70	
Yield Strength	38000	psi
T =	1/2	in
Tw =	1/4	in
W=	3 1/2	in
L =	4 3/4	in
L2=	1 3/4	in
OAL =	6 1/2	in
C=	2	in
Analysis Type	Full Pen w/ Fillet (1)	
Impact Factor	1.500	
Occasional Load Factor	1.125	
Heaviest Lug Load	305	#
	(CHANNEL COVER)	
Weld Group Area (Aw)	2.651	in^2
Weld Group Inertia (Iw)	3.067	in^4
Shear Area (As)	0.375	in^2
Lug Inertia (I)	1.786	in^4



Allowable Loading

Shear Stress	17100	psi
0.4 * Yield * Occ Factor		
Bearing Stress	32062.5	psi
MIN(0.75*Yield*Occ Factor, 0.9*Yield)		
Combined	28215	psi
MIN(.66*Yield*Occ Factor, 0.75*Yield)		

Calculated Loads

Primary Shear in Welds	172.56	psi
Load*Impact/(Aw)		
Bending Shear Stress in Welds	298.30	psi
Load*Impact*(W+2*Tw)/2/(Iw)		
Total Combined Shear	470.86	psi
Shear in Lug Above Hole	813.33	psi
Load*Impact/(As)		
Pin Hole Bearing Stress	457.50	psi
Load*Impact/(T*C)		
Bending Stress @ Lug Base	2128.78	psi
Load*Impact*L/(W^2*T/6)		
Tensile @ Lug Base	261.43	psi
Load*Impact/(W*T)		
Total Combined Stress @ lug Base	2390.20	psi

SECTION 3

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

1. Manufactured and certified by ENERGY EXCHANGER COMPANY, 1844 NORTH GARNETT ROAD, TULSA, OK 74116 (Name and address of Manufacturer)
2. Manufactured for SOUTHERN COMPANY SERVICES, INC. 42 INVERNESS CENTER PARKWAY BIRMINGHAM, AL 35242 (Name and address of Purchaser)
3. Location of installation MISSISSIPPI POWER COMPANY, DEKALB, MS. (Name and address)
4. Type: VERT. (Horiz., vert., or sphere) HEAT EXCHANGER (Tank, separator, jkt. vessel, heat exh., etc.) X-7929 (Mfg's serial No.)
   N/A (CRN) X-7929-A REV. 6 (Drawing No.) 6066 (Nat'l Bd. No.) 2012 (Year built)
5. ASME Code, Section VIII, Div. 1 2007 EDITION, '09 ADD. (Edition and Addenda (date)) N/A (Code Case No.) [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) No. of course(s): 1 (b) Overall length (ft & in.): 13'-5 5/8"

Course(s)			Material	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B, & C)			Heat Treatment	
No.	Diameter, in.	Length (ft & in.)	Spec./Grade or Type	Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
1	24" O.D.	13'-5 5/8"	SA-106B	0.5620"	1/8"	S	NONE	1.0	7	NONE	1.0	N/A	N/A

7. Heads: (a) NA (Mat'l Spec. No., Grade or Type) (H.T. - Time & Temp.) (b) NA (Mat'l Spec. No., Grade or Type) (H.T. - Time & 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)														

If removable, bolts used (describe other fastening) NA (Mat'l Spec. No., Grade, size, No.)

8. Type of jacket NA Jacket closure NA (Describe as ogee & weld, bar, etc.)
   If bar, give dimensions NA If bolted, describe or sketch.
9. MAWP 455 (internal) 15 (external) psi at max. te 515 (internal) 515 (external) °F Min. design metal temp. 10 °F at 455 psi.
10. Impact test NO, EXEMPT PER UG-20(f) [Indicate yes or no and the component(s) impact tested] at test temperature of NA °F.
11. Hydro., ~~pneu., or comb.~~ Test press. 605 P.S.I.G. *(1)* Proof test NA

Items 12 and 13 to be completed for tube sections.

12. Tubesheet: SA-516-70N [Stationary (Mat'l Spec. No.)] 23 3/4" [Dia., in. (subject to press.)] 3 3/8" (Nom. thk., in.) 1/4" (Corr. Allow., in.) Welded [Attachment (welded or bolted)]
    NA [Floating (Mat'l Spec. No.)] NA (Dia., in.) NA (Nom. thk., in.) NA (Corr. Allow., in.) NA (Attachment)
13. Tubes: SA-179 (Mat'l Spec. No., Grade or Type) 3/4" (O.D., in.) 0.0830" (MW) THK. (Nom. thk., in. or gauge) 462 (Number) Straight [Type (Strait or U)]

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): 1/1 (b) Overall length (ft & in.): 1'-8 3/4" / 1'-6 7/8"

Course(s)			Material	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B, & C)			Heat Treatment	
No.	Diameter, in.	Length (ft & in.)	Spec./Grade or Type	Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
1	24" O.D.	1'-8 3/4"	SA-333-6	1/2"	3/16"	S	NONE	0.85	1 *(2)*	SPOT	0.85	1150° F.	1-HR.
1	24" O.D.	1'-6 7/8"	SA-333-6	1/2"	3/16"	S	NONE	0.85	1 *(2)*	SPOT	0.85	1150° F.	1-HR.

15. Heads: (a) SA-516-70N H.T.@ 1150 deg F. for 1 HR. (Mat'l Spec. No., Grade or Type) (H.T. - Time & Temp.) (b) SA-516-70N H.T.@ 1150 deg F. for 1 HR. (Mat'l Spec. No., Grade or Type) (H.T. - Time & 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)	END	1 3/4"	3/16						24 5/16"					
(b)	END	1 3/4"	3/16						24 5/16"					

If removable, bolts used (describe other fastening) a) SA-193B7;3/4" DIA; 24 b) SA-193B7; 3/4" DIA; 24 (Mat'l Spec. No., Grade, size, No.)

FORM U-1 (Back)

16. MAWP 205 (internal) NA (external) psi at max. temp. 390 (internal) NA (external) °F Min. design metal temp. 10 °F at 205 psi.

17. Impact test NO, EXEMPT PER UG-20(f), [indicate yes or no and the component(s) impact tested] at test temperature of NA °F.

18. Hydro., ~~pneu., or comb~~. Test press. 280 P.S.I.G. *(1)* Proof test NA

19. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Flange Type	Material		Nozzle Thickness		Reinforcement Material	How Attached		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
INLET	1	6"-300#	RF-WN	SA-106B	SA-105	0.4320"	1/8"	SA-516-70	WELDED	WELDED	SHELL
OUTLET	1	3"-300#	RF-WN	SA-106B	SA-105	0.6000"	1/8"	WELD	WELDED	WELDED	SHELL
BALANCE LINE	1	3/4"-300#	RF-LWN	SA-105	—	0.5700"	1/8"	WELD	WELDED	—	SHELL
VENT	1	3/4"-300#	RF-LWN	SA-105	—	0.5700"	1/8"	WELD	WELDED	—	TUBESHEET
DRAIN	1	3/4"-300#	RF-LWN	SA-105	—	0.5700"	1/8"	WELD	WELDED	—	TUBESHEET
OUTLET	1	10"-300#	RF-WN	SA-333-6	SA-105	0.5000"	3/16"	WELD	WELDED	WELDED	TOP CHAN.
VENT	1	2"-300#	RF-LWN	SA-105	—	0.6600"	3/16"	WELD	WELDED	—	TOP CHAN CVR
INLET	1	6"-300#	RF-WN	SA-333-6	SA-105	0.4320"	3/16"	WELD	WELDED	WELDED	BTTM CHAN.
DRAIN	1	2"-300#	RF-LWN	SA-105	—	0.6600"	3/16"	WELD	WELDED	—	BTTM CHAN CVR

20. Supports: Skirt NO (Yes or no) Lugs — (No.) Legs — (No.) Others 2-SADDLES (Describe) Attached WELDED TO SHELL (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, mfg's. name and identifying number)

22. Remarks: SERVICE: HYDROGEN SULFIDE STRIPPER REBOILER; P.O. NO: 17496-0001; ITEM NO.: HX0042; SIZE: 23-168; TYPE: NEN
TUBES DESIGNED W/ 0" C.A., SAFETY RELIEF DEVICES BY OTHERS
LINES 14-18 INCLUDES (2) 28 3/16" O.D. X 23" I.D. X 3 1/16" THK., SA-266-4N, RING
(1) FIELD TEST: SHELL SIDE=595 PSIG; TUBE SIDE=270 PSIG (2) Cylinder to tubesheet circumferential seams are Type 7 with .85 Efficiency

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 Authorization No. 12370 Expires SEPTEMBER 27 ,20 13

Date 8-24-12 Name ENERGY EXCHANGER COMPANY (Manufacturer) Signed Mark Wells (Representative)

CERTIFICATE OF SHOP INSPECTION

I, the undersigned, holding a valid commision issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of OKLAHOMA and employed by ONEBEACON AMERICA INSURANCE COMPANY of LYNN, MA have inspected the pressure vessel described in this Manufacturer's Data Report on 8.24.2012, 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 employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his 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 8.24.12 Signed (Authorized Inspector) Commissions N.B.# 12064 A OKLA.# 7 (Nat'l Board incl. endorsements, State, Province, and No.)

CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE

We certify that the statements on this report are correct and that 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 No.

U Certificate of Authorization No. _____ Expires _____ ,20 ____

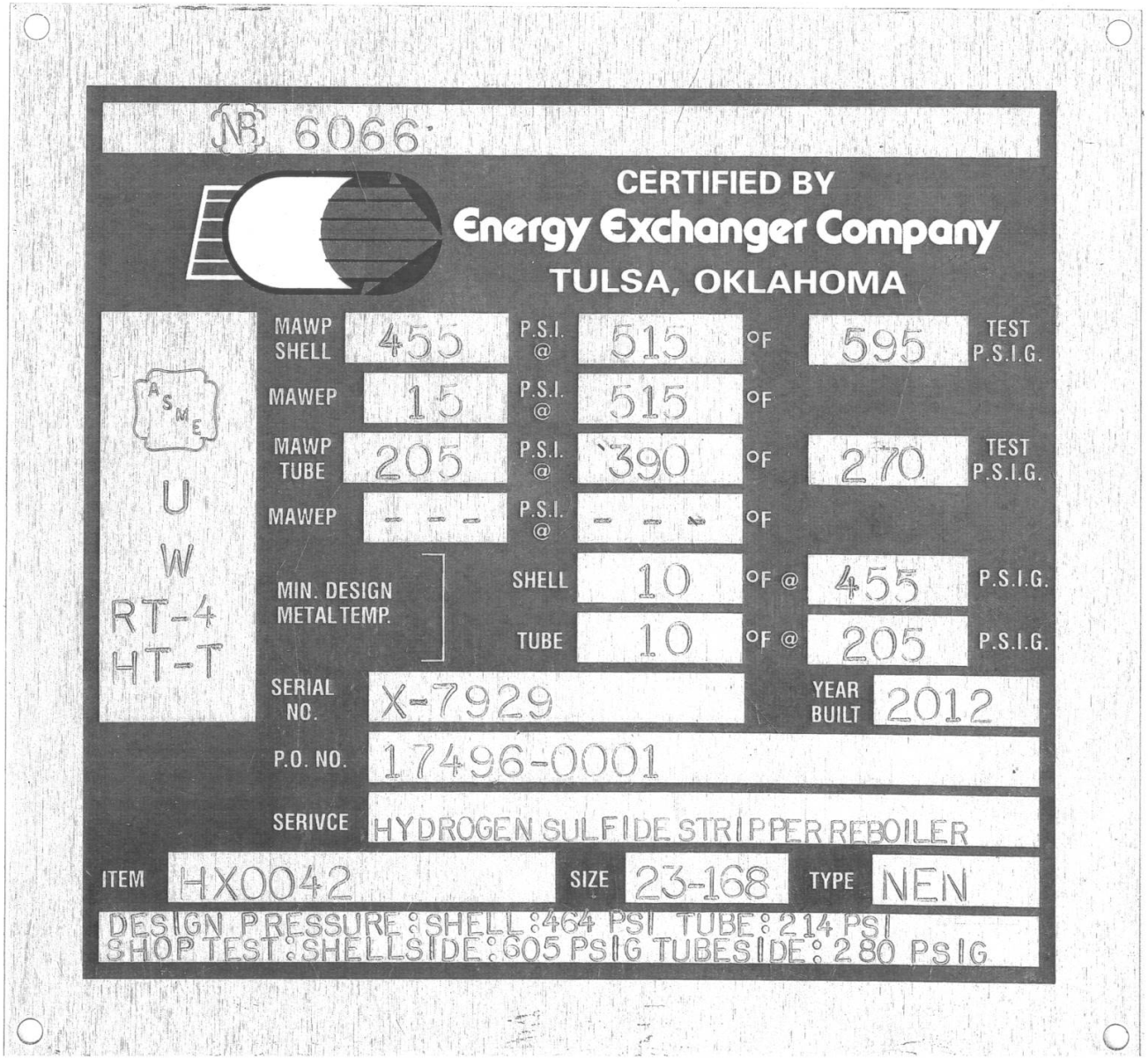
Date _____ Name _____ (Assembler) Signed _____ (Representative)

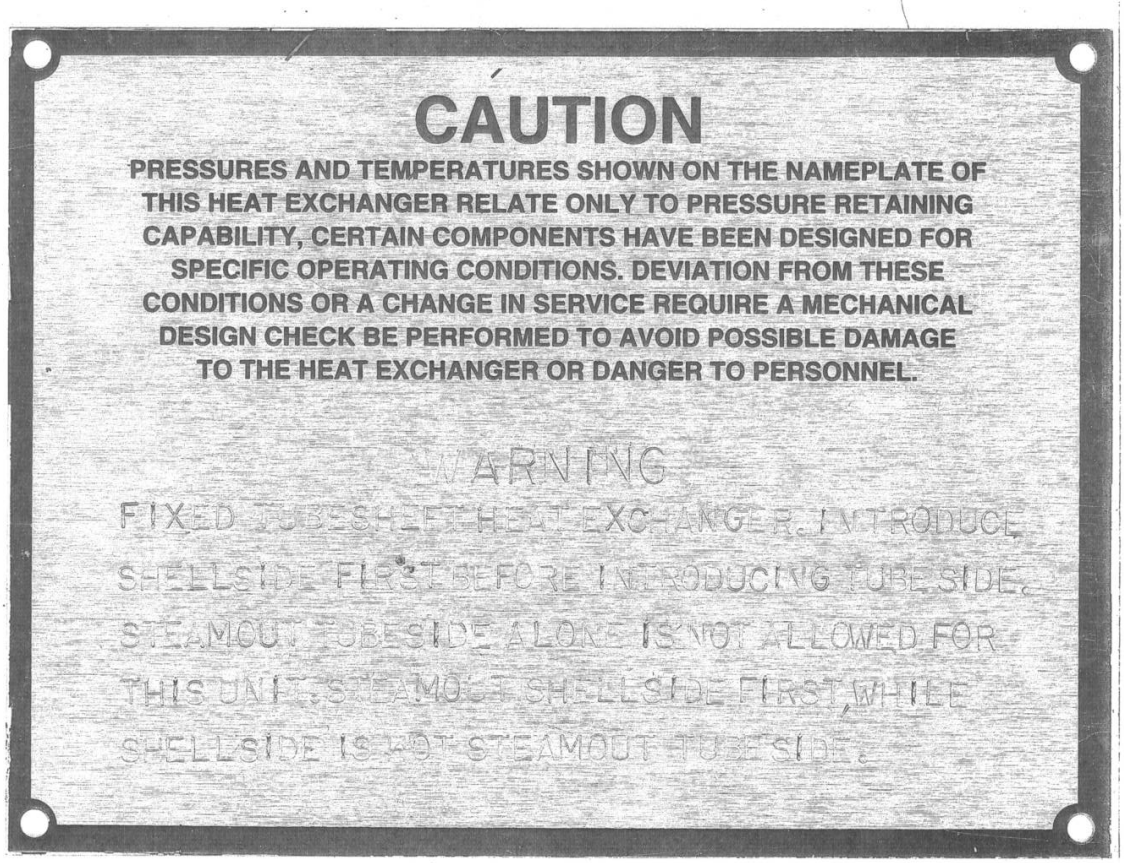
CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commision issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of _____ 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 ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. The described vessel was inspected and _____ psi.

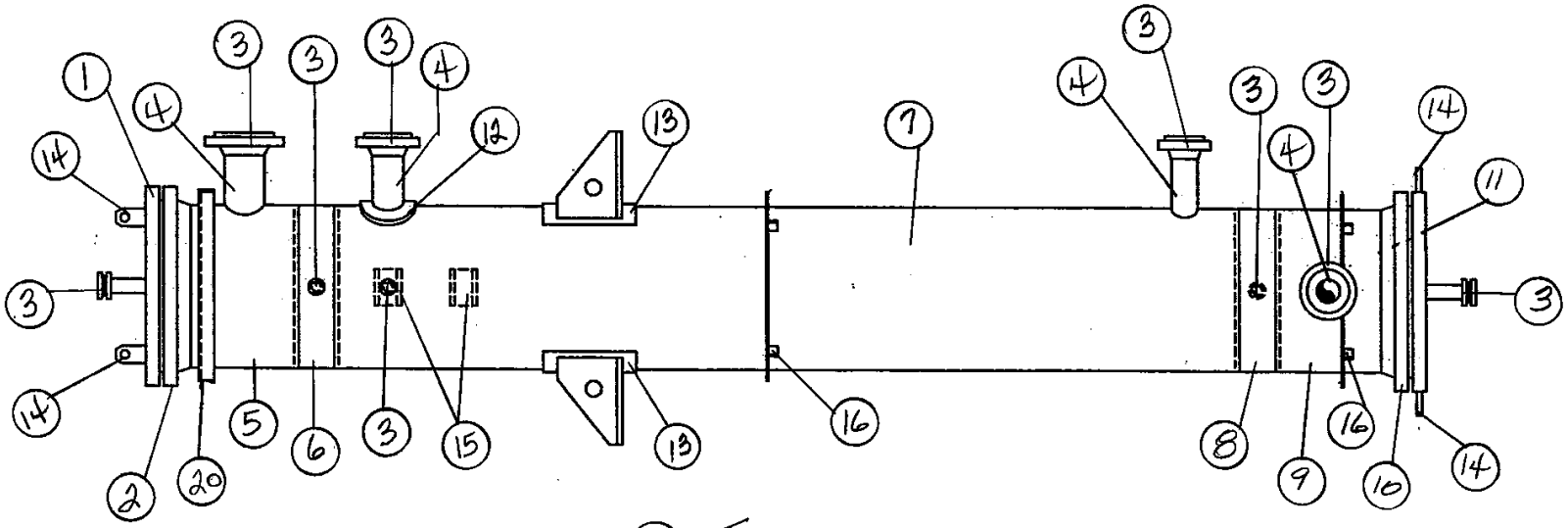
By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____ Signed _____ (Authorized Inspector) Commissions _____ (Nat'l Board incl. endorsements, State, Province, and No.)




CAUTION
PRESSURES AND TEMPERATURES SHOWN ON THE NAMEPLATE OF THIS HEAT EXCHANGER RELATE ONLY TO PRESSURE RETAINING CAPABILITY, CERTAIN COMPONENTS HAVE BEEN DESIGNED FOR SPECIFIC OPERATING CONDITIONS. DEVIATION FROM THESE CONDITIONS OR A CHANGE IN SERVICE REQUIRE A MECHANICAL DESIGN CHECK BE PERFORMED TO AVOID POSSIBLE DAMAGE TO THE HEAT EXCHANGER OR DANGER TO PERSONNEL.
WARNING
FIXED TUBESHEET HEAT EXCHANGER. INTRODUCE SHELLSIDE FIRST BEFORE INTRODUCING TUBESIDE. STEAMOUT TUBESIDE ALONE IS NOT ALLOWED FOR THIS UNIT. STEAMOUT SHELLSIDE FIRST, WHILE SHELLSIDE IS HOT STEAMOUT TUBESIDE.

SECTION 4



(17) TUBES
(18) STUDS
(19) NUTS

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh WB

X-7929

ENERGY EXCHANGER COMPANY

MATERIAL HEAT NUMBER INDEX

Project; Kemper County 1 - IGCC

CUSTOMER:	**Southern Co. (for) Mississippi Power Company**	**ITEM NO:**	**HX0042**	**PAGE:**	**1 of 3**
DESTINATION:	**DeKalb, Mississippi**	**SERVICE:**	**Hydrogen Sulfide Stripper Reboiler**	**DATE:**	**August 23, 2012**
P.O. No:	**17496-0001**	**DESCRIPTION:**	**1-23" x 168" NEN Exchanger**	**JOB NO:**	**X-7929**
Req. No:	**MC202**				

PART NO.	HEAT NO.	SLAB NO.	STEEL PRODUCER	GRADE	DESCRIPTION	PCS.	SIZE
1	822P34450	H032355	ArcelorMittal	SA-516-70N	**(#1 Channel Cover)**	1	28 3/16" OD x 1 3/4" thk.
2	110786		Nucor	SA-266-4N	**(#2 Channel Flange)**	1	28 3/16" OD x 23" ID x 3 1/16" thk.
3	W019		FCI	SA-105-N	**(Nozzle Flange V-1)**	1	2" 300# RF LWN x 9" lg.
3	3019785		Galperti	SA-105-N	**(Nozzle Flange V-1)**	1	2" 300# RF Blind
3	3000773		Galperti	SA-105-N	**(Nozzle Flange T-2)**	1	10" 300# RF WN Sch X-Hvy. Bore
3	A606AF		FVC	SA-105	**(Nozzle Flange V-2)**	1	3/4" 300# RF LWN x 9" lg.
3	79209		Galperti	SA-105-N	**(Nozzle Flange V-2)**	1	3/4" 300# RF Blind
3	102250N/02		Galperti	SA-105-N	**(Nozzle Flange S-1)**	1	6" 300# RF WN Sch X-Hvy. Bore
3	9721/02		Galperti	SA-105-N	**(Nozzle Flange S-2)**	1	3" 300# RF WN Sch XX-Hvy. Bore
3	A606AF		FVC	SA-105	**(Nozzle Flange S-3)**	1	3/4" 300# RF LWN x 9" lg.
3	79209		Galperti	SA-105-N	**(Nozzle Flange S-3)**	1	3/4" 300# RF Blind
3	A606AF		FVC	SA-105	**(Nozzle Flange D-2)**	1	3/4" 300# RF LWN x 9" lg.
3	79209		Galperti	SA-105-N	**(Nozzle Flange D-2)**	1	3/4" 300# RF Blind

I hereby certify that the above information is correct to the best of my knowledge and belief.

ENERGY EXCHANGER COMPANY

By: Lynda Patterson

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Kemper County MM209937

ENERGY EXCHANGER COMPANY
MATERIAL HEAT NUMBER INDEX

Project; Kemper County 1 - IGCC

CUSTOMER:	**Southern Co. (for) Mississippi Power Company**	**ITEM NO:**	**HX0042**	**PAGE:**	**2 of 3**
DESTINATION:	**DeKalb, Mississippi**	**SERVICE:**	**Hydrogen Sulfide Stripper Reboiler**	**DATE:**	**August 23, 2012**
P.O. No:	**17496-0001**	**DESCRIPTION:**	**1-23" x 168" NEN Exchanger**	**JOB NO:**	**X-7929**
Req. No:	**MC202**				

PART NO.	HEAT NO.	SLAB NO.	STEEL PRODUCER	GRADE	DESCRIPTION	PCS.	SIZE
3	102250N/02		Galperti	SA-105-N	**(Nozzle Flange T-1)**	1	6" 300# RF WN Sch X-Hvy. Bore
3	W019		FCI	SA-105-N	**(Nozzle Flange D-1)**	1	2" 300# RF LWN x 9" lg.
3	3019785		Galperti	SA-105-N	**(Nozzle Flange D-1)**	1	2" 300# RF Blind
4	83776		V&M	SA-333-6	**(Nozzle Pipe T-2)**	1	10" Sch X-Hvy. X 7 3/4" lg.
4	X22424		U.S.S.	SA-106-B	**(Nozzle Pipe S-1)**	1	6" Sch X-Hvy. X 7 3/4" lg.
4	HA0470		U.S.S.	SA-106-B	**(Nozzle Pipe S-2)**	1	3" Sch XX-Hvy. X 8 1/4" lg.
4	ZX0008		V&M Star	SA-333-6	**(Nozzle Pipe T-1)**	1	6" Sch X-Hvy. X 7 3/4" lg.
5	MA2181		U.S.S.	SA-333-6	**(Top Channel Cylinder)**	1	24" OD x 1/2" thk. x 1'-8 3/4" lg.
6	D52809	68347	LeTourneau	SA-516-70N	**(#4 Tubesheet)**	1	24" OD x 3 3/8" thk.
7	MA1922		U.S.S.	SA-106-B	**(Shell Cylinder)**	1	24" OD x .562" thk. x 13'-5 5/8" lg.
8	D52809	68347	LeTourneau	SA-516-70N	**(#9 Tubesheet)**	1	24" OD x 3 3/8" thk.
9	MA2181		U.S.S.	SA-333-6	**(Bottom Channel Cylinder)**	1	24" OD x 1/2" thk. x 1'-6 7/8" lg.
10	110786		Nucor	SA-266-4N	**(#2A Channel Flange)**	1	28 3/16" OD x 23" ID x 3 1/16" thk.

I hereby certify that the above information is correct to the best of my knowledge and belief.

ENERGY EXCHANGER COMPANY

By: Lynda Patterson

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

ENERGY EXCHANGER COMPANY
MATERIAL HEAT NUMBER INDEX

Project; Kemper County 1 - IGCC

CUSTOMER:	**Southern Co. (for) Mississippi Power Company**	**ITEM NO:**	**HX0042**	**PAGE:**	**3 of 3**
DESTINATION:	**DeKalb, Mississippi**	**SERVICE:**	**Hydrogen Sulfide Stripper Reboiler**	**DATE:**	**August 23, 2012**
P.O. No:	**17496-0001**	**DESCRIPTION:**	**1-23" x 168" NEN Exchanger**	**JOB NO:**	**X-7929**
Req. No:	**MC202**				

PART NO.	HEAT NO.	SLAB NO.	STEEL PRODUCER	GRADE	DESCRIPTION	PCS.	SIZE
11	822P34450	H032355	ArcelorMittal	SA-516-70N	**(#1A Channel Cover)**	1	28 3/16" OD x 1 3/4" thk.
12	1502825	09	Nucor	SA-516-70	**(Shell Weld Pad)**	1	9 3/4" OD x 3/8 thk.
13	A1S1804	02	Nucor	SA-516-70	**(Support Pads)**	2	13" x 3/8" thk. x 10 1/8" lg.
14	B1T7537	03	Nucor	SA-516-70	**(Lifting Lugs)**	4	3 1/2" x 1/2" thk. x 6 1/2" lg.
15	W0H543	0024	SSAB	SA-516-70	**(Name Plate Bracket)**	2	7 1/2" x 3/16" thk. x 22" lg.
16	3018892		CMC Steel	SA-36	**(Insulation Clips**	8	1 1/2" x 1/4" Thk. x 3" lg.
17	181070		Benteler	SA-179	**(Tubes)**	390	3/4"OD x .083" (min) x 14'-0" lg.
17	548853		Benteler	SA-179	**(Tube)**	72	3/4"OD x .083" (min) x 14'-0" lg.
18	10037360		Vulcan Thrd. Prod.	SA-193-B7	**(Studs)**	48	3/4" (10 Thd) x 5 1/4" lg.
19	SS161		Unytite	SA-194-2H	**(Nuts)**	96	3/4" (10 Thd)
20	L81828		ArcelorMittal	SA-36	**(Top Flashing)**	1	3" x 3" x 1/4" thk. x 95" lg.

I hereby certify that the above information is correct to the best of my knowledge and belief.

ENERGY EXCHANGER COMPANY

By: Lynda Patterson

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh WB

ArcelorMittal Burns Harbor Plate Part #1+11 20010

QUALITY ASSURANCE
REPORT OF TEST AND ANAYLSES

SHIPMENT NO.	DATE SHIPPED	CAR OR VEHICLE NO.	
803-16933	12-16-10	CSS-CHGO-BNSF LMIC 406516	PAGE 4

SOLD TO:
STEEL SERVICE CO
24412 AMAH PKWY
CLAREMORE OK 74017

SHIP TO:
STEEL SERVICE CO
C/O TULOMA STEVEDORING INC
TULSA PORT AUTHORITY OK
X-7929-1+1A

NOTE	SERIAL NUMBER	PAT NO.	HEAT NUMBER	NO. PCS.	SIZE AND QUANTITY THICKNESS	WIDTH OR DIA.	LENGTH	WEIGHT	YIELD POINT	TENSILE STRENGTH	ELONG	RED.
					INCHES	INCHES	INCHES	POUNDS	PSI	PSI	IN	% %

QUALITY STEEL MELTED & MANUFACTURED IN THE U. S. A.✓
PLATES - ASTM A516-06 GR 70 PVQ, ASME SA516 ✓
GR 70 PVQ 2010 EDITION, CH-V A20S5
PLT L 15/12 FTLBS AT -40F --- GAS
CUT 4 SIDES PLT NORMALIZED & COOLED
IN STILL AIR
NO WELD REPAIR WAS PERFORMED ON BELOW PLATE(S)
MFST - MFST MILL SERIAL# LIFT MAX 10 TON UNLDG
OH-CHAIN
CO# 31556 GH 816-3007J
PLATES HEAT TREATED - TEST SPECIMENS ATTACHED & YIELD STRENGTH @ .5% EUL

H032355	822P34450	1	2		96		480		26137	46300✓	74100✓2	33✓

N 1650 DEG F - 99 MIN

NAME: C.G.MARTIN
PO#: 6237
QUANTITY: 1
SIZE: 2 X 96 X 480 A516-70 NORM
HEAT #: 822P34450 H032355

Q-QUENCH TEMPERATURE T-TEMPER TEMPERATURE

CERTIFIED TRUE COPY TEST REPORT FROM
C.G. MARTIN CO., INC

CUST ID	22	WO#	79689
CUST	ENERGY EXCHANGER COMPANY		
P.O. #	1171		
ITEM #	2		
DESC	(2) 28-3/16" OD(F) X 1-3/4" THK(F)		
DATE	05/18/11	BY:	

SERIAL NUMBER	PAT NO	HEAT NUMBER	HARD BHN	BEND	THICKNESS	TYPE	SIZE	DIR	TEST TEMP F	CHARPY IMPACT ENERGY FT LBS 1	2	3	SHEAR(%) 1	2	3	LAT. EXP MILS 1	2	3
					INCHES													
H032355		822P34450			2.000	V	FULL L		-40	100	111	110						

HEAT NUMBER	CHEMICAL ANALYSIS C✓	Mn✓	P✓	S✓	Si✓	Cu✓	Ni✓	Cr✓	Mo✓	V✓	Ti✓	Al✓	B	Cb✓	N	Sn	MQUAD GRAIN SIZE
822P34450	.17	1.09	.015	.004	.335	.028	.02	.12	.077	.004	.002	.034	.0002	.002	.005	.005	

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.

D. W. ELWOOD PER WNK
SUPV. QUALITY ASSURANCE

BHPLTRPT.TIF

VERIFIED BY
MAY 24 2011
EEC QC DEPT
K. Patterson

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh WB

Part # 1 + 11

GLOBE X-RAY SERVICES, INC.

8441 South Union Tulsa, Ok. 74132

Report of Portable Hardness Test

Certification NO: 47524

Customer C G MARTIN Job or P.O.# WO# 079689

Address: TULSA, OK

Procedure: GXS VIII-B Rev.1-07

Test Instrument: KBI MIC-1040 Ser.# 34148

Probe: 10 kgf Ser.# 33766

Calibration Verification Block: 194 BRINELL BAR

NOTES: ALL RECORDS ARE AN AVERAGE OF 5 READINGS IN BRINELL

The material listed below have been tested and comply with the acceptance criteria of the above procedure. All hardness values stated below are measurements of the BRINELL scale.

Item# or Description	Weld	HAZ	HAZ	Base	Base
PL# 20010 822P34450 HO 32355				172 HBN	

_____ See attachment for additional results

Examination By: J WITHERS CWI Date: 5/18/11

This is not a laboratory report and test does not meet any ASTM Specifications. This is an indirect method of testing and results may vary with depth of surface preparation and location of test on weld. Not responsible for losses due results of examination.

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Part #2 of 10

OKLAHOMA FORGE, INC.

Certification of Analysis and Tests

INVOICE NUMBER 111-66965

Date: 6/20/11

Toll Free (866)909-5553
Local(918)446-5553 FAX (918)446-4150
e:Mail ~ sales@oklahomaforge.com
Web Site ~ www.oklahomaforge.com
P.O. Box 701500
Tulsa, Oklahoma 74170-1500

Sold To	Your Purchase Order	Sales Order
ENERGY EXCHANGER COMPANY 1844 N. GARNETT ROAD TULSA, OK 74116 USA	Number 1199 By JIM ELDER Dated 5/17/2011	Number 111-51903 Shipped Via DELIVERY Ship Date 6/20/2011

Item#	PART DESCRIPTION				Quantity
	Your Part Number	Shop Order Number	Shape	Dimensions	
	Part Name	Supplier	Heat Number	Material Specifications	
	Note	Chemical Analysis			
		Physical Properties		Charpy Impact (ft-lbs.)	

1 X-7926-4/9 | 111-51903-01 | DISC | 16.000"OD x 3.000"TH | 2
ARCELOMITTAL | 227N568 | SA266-10 GR4 NORMALIZED

C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other
.18	1.16	.014	.008	.23	.10	.09	.27	.027	.017	<.001	.021		.42	SN-.011; B-.0003

Yield Lb/Sqin	Tensile Strength Lb/Sqin	Elong%in 2in	Red of Area%	Brinell	Rckwl C	Bend Test	Grain Size	Type	Temp	Average	#1	#2	#3
49,600	75,500	34	68	146			FINE	CVN	-50F	114	127	137	80

2 X-7926-1/1A | 111-51903-02 | DISC | 21.125"OD x 1.625"TH | 2
ARCELOMITTAL | 227N568 | SA266-10 GR4 NORMALIZED

C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other
.18	1.16	.014	.008	.23	.10	.09	.27	.027	.017	<.001	.021		.42	SN-.011; B-.0003

Yield Lb/Sqin	Tensile Strength Lb/Sqin	Elong%in 2in	Red of Area%	Brinell	Rckwl C	Bend Test	Grain Size	Type	Temp	Average	#1	#2	#3
49,600	75,500	34	68	146			FINE	CVN	-50F	114	127	137	80

3 X-7930-4 | 111-51903-03 | DISC | 22.000"OD x 3.000"TH | 2
ARCELOMITTAL | 227N568 | SA266-10 GR4 NORMALIZED

C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other
.18	1.16	.014	.008	.23	.10	.09	.27	.027	.017	<.001	.021		.42	SN-.011; B-.0003

Yield Lb/Sqin	Tensile Strength Lb/Sqin	Elong%in 2in	Red of Area%	Brinell	Rckwl C	Bend Test	Grain Size	Type	Temp	Average	#1	#2	#3
49,600	75,500	34	68	146			FINE	CVN	-50F	114	127	137	80

4 X-7930-1 | 111-51903-04 | DISC | 27.875"OD x 3.250"TH | 2
ARCELOMITTAL | 227N568 | SA266-10 GR4 NORMALIZED

C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other
.18	1.16	.014	.008	.23	.10	.09	.27	.027	.017	<.001	.021		.42	SN-.011; B-.0003

Yield Lb/Sqin	Tensile Strength Lb/Sqin	Elong%in 2in	Red of Area%	Brinell	Rckwl C	Bend Test	Grain Size	Type	Temp	Average	#1	#2	#3
49,600	75,500	34	68	146			FINE	CVN	-50F	114	127	137	80

8 X-7930-2 | 111-51903-08 | RING | 27.875"OD x 20.500"ID x 4.188"TH | 2
NUCOR | 110786 | SA266-10 GR4 NORMALIZED

C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other
.17	1.17	.010	.002	.20	.10	.10	.19	.03	.016	.003	.024		.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
48,800	73,500	35	74	143			FINE	CVN	-50F	85	85	104	67

9 X-7929-2/2A | 111-51903-09 | RING | 28.188"OD x 23.000"ID x 3.063"TH | 2
NUCOR | 110786 | SA266-10 GR4 NORMALIZED

C	Mn	P	S	Si	Ni	Cr	Cu	Mo	V	Cb	Al	Pb	Ce	Other
.17	1.17	.010	.002	.20	.10	.10	.19	.03	.016	.003	.024		.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
48,800	73,500	35	74	143			FINE	CVN	-50F	85	85	104	67

Notes:

VERIFIED BY
JUN 27 2011
LEE OF DEPT

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 MANUFACTURED IN THE UNITED STATES OF AMERICA.

Anneal by heating to 1450-1550 degrees F for one hour/inch of thinnest section. Slow cool furnace to 700 degrees F then air cool to room temp.
Normalize by heating to 1650 degrees F, Hold at 1650 degrees F for one hour/inch of thinnest section and air cool.
Solution Anneal by heating to 2000-2050 degrees F and Water Quenching.

Reviewed / Accepted
I.Q.S. # 3

L Patterson

William Brenaugh WB

GALPERTI, INC.
160 Southbelt Industrial Drive
Houston, Texas 77047
PH. 713-433-0700 – FAX 713-433-5580
Email: galpmail@galperti-am.com

Noz T2

Part #3

TEST/CERTIFICATE EN 10204 — **3.1B**

INTERNAL JOB — **091939**

PROGRESSIVE SUPPLY
P. O. BOX 470748
TULSA OK 74145

This MTR applies to your PO# 1221

M.T.CERTIFICATE N.	DATE	YOUR P.O.	DATE
015325/B	08/06/2009	098352 X-7939-81	07/13/2009

ITEM	DESCRIPTION	QUANTITY	B/P	MATERIAL	HEAT N°		#
013/013	10" 300 WN RF XS A105 B1 F	10	B	ASTM A/SA105 03c	3000773		A
015/015	20" 300 WN RF XS A105 B1 F	2	B	ASTM A/SA105 03c	080474N/02		B
016/016	10" 300 WN RF 80 A105 B1 F	10	B	ASTM A/SA105 03c	840491/02		C
017/017	4" 300 WN RF 120 A105 B1 F	10	B	ASTM A/SA105 03c	3000972		D

CHEMICAL ANALYSIS

#		C %	MN %	SI %	P %	S %	CR %	NI %	MO %	CU %	V %	SN %	AL %	NB %	TI %	N %	CB%	B %	FL%
A		0.180	0.910	0.190	0.008	0.018	0.130	0.120	0.037	0.260	0.0001			0.002			0.002		0.39
A	C	0.170	0.930	0.210	0.011	0.015	0.120	0.130	0.047	0.270	0.0001			0.002			0.002		0.38
B		0.160	1.200	0.210	0.010	0.002	0.140	0.040	0.020	0.110	0.0200		0.020	0.0001	0.001		0.0001	0.0003	0.40
B	C	0.150	1.220	0.230	0.013	0.002	0.130	0.030	0.030	0.120	0.0150		0.030	0.0001	0.001		0.0001	0.0003	0.39
C		0.180	1.180	0.240	0.015	0.002	0.110	0.010	0.0001	0.020	0.0030		0.034	0.0001	0.021	0.007	0.0001		0.40
C	C	0.170	1.200	0.260	0.018	0.002	0.100	0.020	0.0001	0.030	0.0030		0.035	0.0001	0.021	0.007	0.0001		0.39
D		0.190	0.900	0.190	0.011	0.011	0.110	0.080	0.0230	0.220	0.0010			0.0020			0.0020		0.38
D	C	0.180	0.920	0.170	0.008	0.008	0.100	0.090	0.0330	0.230	0.0010			0.0020			0.0020		0.38

NOTES
FL=Carbon Equivalent Long Formula

C = CHECK ANALISYS

MECHANICAL PROPERTIES

#		TENSILE TYPE	⌀ DIAMETER mm.	AREA mmq.	LENGHT mm.	TEMP. F	TENSILE PSI	YIELD PSI	ELONG %	REDUCT. %	CHARPY TEST TYPE	TEMP.	VALUES	HB HARDNESS (AVERAGE)
A	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
A	O		12.50	122.70	50.00	68	78,133	46,654	30.0	70.0				150
B	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
B	O		12.50	122.70	50.00	68	77,785	47,188	31.0	67.3				159
C	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
C	O		12.50	122.70	50.00	68	78,183	47,036	26.6	66.8				153
D	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
D	O		12.50	122.70	50.00	68	78,172	47,015	27.6	69.3				158

NOTES
LINE 013 COUNTRY OF ORIGIN USA ✓

O = OBTAINED
S = STANDARD

#	HEAT TREATMENTS
A	Normalized at 900 dgr.C for 2 h.-Cooling from 900 dgr.C in still air
A	
B	Normalized at 900 dgr.C for 3 h.-Cooling from 900 dgr.C in still air
B	
C	Normalized at 900 dgr.C for 2 h.-Cooling from 900 dgr.C in still air
C	
D	Normalized at 900 dgr.C for 1.1/2 h.-Cooling from 900 dgr.C in still air
D	

GENERAL NOTES

ROUGHNESS
F -STOCK FINISH 125-250 microinch

STANDARD
- ASME B16.5

VERIFIED BY
JUN 16 2011
EEC QC DEPT

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

NOTES
Material I.A.W. Nace MR-0175-2002

TRADE MARK / LOGO	INT. INSPECT DATE	INT. INSPECTOR
Stamped on product	08/06/2009	.RUZICKA

INSPECTION AUTHORITY
Mion Ruzicka

GALPERTI, INC
An ISO 9001/2000 certified company.
Certification issued by:
Lloyds register quality assurance
Certificate No. UQA 0110391

FCI FORGED COMPONENTS INC.

14527 Smith Rd.
Humble, Texas 7739
TEL: (281) 441-4088
FAX: (281) 441-8899

REPORT NUMBER 48396
DATE 5/4/2011
FCI ORDER NUMBER 51488
Processed I.A.W. EN10204 3.1

Part #3

CUSTOMER ORDER NUMBER 119490
SOLD/SHIPPED TO PROGRESSIVE SUPPLY
P.O. BOX 470748
TULSA OK 74147 USA

This MTR applies to your PO# 1221

Item	Quantity	Description
6	12	2" X 300 X 9" LG RF LWN X-7429-82484 Noz. V1, D1

HEAT NUMBER: W019
MATERIAL TYPE: SA105N
Material Origin: USA ✓
Manufactured in USA ✓
I.A.W. ASME 2010 ED.

CHEMICAL ANALYSIS

C	.180 ✓
Mn	1.040 ✓
P	.0060 ✓
S	.0000 ✓
Si	.230 ✓
Cr	.140 ✓
Mo	.030 ✓
V	.014 ✓
Cu	.190 ✓
Ni	.070 ✓
Cb	.000 ✓
Sn	.013
As	.003
Sb	.001
Ti	.0010
Al	.026
B	.0000
C E	.40

PHYSICAL PROPERTIES

Yield PSI	48,600 ✓
Tensile PSI	71,800 ✓
Elongation	33 ✓
Reduction of Area	74 ✓
Hardness	137 HBW ✓

VERIFIED BY
JUN 16 2011
EEC QC DEPT
Y. Patterson

Heat Treatment	NORMALIZED ✓
Temperature	1650 °F
Time at Temperature	1/2 HR/IN THK MIN
Cooling Media	AIR

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by: Helen Fielder
Name: Helen Fielder Title: QA Representative

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh WB

Date printed: 5/4/2011 2:59:30 PM

Part #3

GALPERTI, INC.
160 Southbelt Industrial Drive
Houston, Texas 77047
PH. 713-433-0700 – FAX 713-433-6580
Email: galpmail@galperti-am.com

Noz. V1, D1

TEST/CERTIFICATE EN 10204: 3.1B

INTERNAL JOB: 111166

PROGRESSIVE SUPPLY
P. O. BOX 470748
TULSA OK 74145

This MTR applies to your PO# 1221

M.T.CERTIFICATE N.: 003083/B — DATE: 04/07/2011

YOUR P.O.: 11-9523 X-7929-82D+89D — DATE: 03/31/2011

ITEM	DESCRIPTION	QUANTITY	B/P	MATERIAL	HEAT N°	#
004/004	12" 600 WN RF 80 A105 B1 F	4	B	ASTM A/SA105 03c	102817N/02	A
005/005	8" 150 WN RF XS A105 B1 F	50	B	ASTM A/SA105 03c	100506N/02	B
006/006	2" 300 BL RF A105 B1 F	200	B	ASTM A/SA105 03c	3019785	C

CHEMICAL ANALYSIS

#		C %	MN %	SI %	P %	S %	CR %	NI %	MO %	CU %	V %	SN %	AL %	NB %	TI %	N %	CB%	FL%
A		0.170	1.170	0.190	0.008	0.002	0.080	0.080	0.030	0.150	0.017		0.026	0.002			0.002	0.40
A	C	0.160	1.190	0.210	0.005	0.002	0.090	0.070	0.040	0.160	0.012		0.037	0.002			0.002	0.40
B		0.170	1.150	0.260	0.011	0.001	0.110	0.070	0.040	0.200	0.016		0.028	0.003			0.003	0.41
B	C	0.160	1.130	0.280	0.014	0.001	0.100	0.060	0.050	0.210	0.011		0.048	0.003			0.003	0.39
C		0.190	1.050	0.230	0.006	0.017	0.050	0.090	0.020	0.190	0.003			0.001			0.001	0.39
C	C	0.180	1.070	0.250	0.009	0.020	0.060	0.100	0.010	0.180	0.003			0.001			0.001	0.39

NOTES
FL=Carbon Equivalent Long Formula

C = CHECK ANALISYS

MECHANICAL PROPERTIES

#		TENSILE TYPE	Ø DIAMETER mm.	AREA mmq.	LENGHT mm.	TEMP. F	TENSILE PSI	YIELD PSI	ELONG %	REDUCT. %	CHARPY TEST TYPE	TEMP.	VALUES	HB HARDNESS (AVERAGE)
A	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
A	O		12.50	122.70	50.00	68	77,523	50,416	28.1	66.0				162
B	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
B	O		12.50	122.70	50.00	68	77,993	49,943	30.0	68.0				152
C	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
C	O		12.50	122.70	50.00	68	77,474	49,259	27.0	70.0				155

NOTES

O = OBTAINED
S = STANDARD

#	HEAT TREATMENTS
A	Normalized at 900 dgr.C for 3 h.-Cooling from 900 dgr.C in still air
A	
B	Normalized at 900 dgr.C for 1.1/2 h.-Cooling from 900 dgr.C in still air
B	
C	Normalized at 900 dgr.C for 1 h.-Cooling from 900 dgr.C in still air
C	

GENERAL NOTES

ROUGHNESS
F =STOCK FINISH 125-250 microinch

VERIFIED BY
STANDARD
B1 ANSI B16.5

JUN 16 2011

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

NOTES
Material I.A.W. Nace MR-0175-2003 COUNTRY OF ORIGIN:USA ✓

EEC QC DEPT
K. Patterson

TRADE MARK / LOGO: Stamped on product

INT. INSPECT DATE: 04/07/2011

INT. INSPECTOR: D.RUZICKA

INSPECTION AUTHORITY

GALPERTI, INC
An ISO 9001/2008 certified company.
Certification issued by:
Lloyds register quality assurance
Certificate No. UQA 0110391

Part #2

GALPERTI, INC.
160 Southbelt Industrial Drive
Houston, Texas 77047
PH. 713-433-0700 – FAX 713-433-6580
Email: galpmail@galperti-am.com

Nz. S1 + T1

TEST/CERTIFICATE EN 10204: 3.1B

INTERNAL JOB: 110099

PROGRESSIVE SUPPLY
P. O. BOX 470748
TULSA OK 74145

This MTR applies to your PO# 1221

M.T.CERTIFICATE N.: 000532/B — DATE: 01/18/2011

YOUR P.O.: 11-9480 X-7929-71 + 87 — DATE: 01/10/2011

ITEM	DESCRIPTION	QUANTITY	B/P	MATERIAL	HEAT N°		#
002/002	16" 150 WN RF XS A105 B1 F	3	B	ASTM A/SA105 03c	10411W/02		A
004/004	10" 300 WN RF XS A105 B1 F	10	B	ASTM A/SA105 03c	3000773		B
006/006	2" 300 WN RF XXS A105 B1 F	15	B	ASTM A/SA105 03c	3016659		C
007/007	6" 300 WN RF XS A105 B1 F	50	B	ASTM A/SA105 03c	102250N/02		D

CHEMICAL ANALYSIS

#		C %	MN %	SI %	P %	S %	CR %	NI %	MO %	CU %	V %	SN %	AL %	NB %	TI %	N %	CO%	B %	FL%
A		0.170	1.200	0.250	0.009	0.007	0.090	0.110	0.040	0.160	0.022	0.010	0.027	0.0001	0.003	0.010	0.006	0.0003	0.41
A	C	0.160	1.220	0.270	0.012	0.010	0.100	0.120	0.030	0.170	0.017	0.010	0.036	0.0001	0.003	0.010	0.006	0.0003	0.41
B		0.180	0.910	0.190	0.008	0.018	0.130	0.120	0.037	0.260	0.0001			0.0020					0.39
B	C	0.170	0.930	0.210	0.011	0.015	0.120	0.130	0.047	0.270	0.0001			0.0020					0.38
C		0.190	1.040	0.220	0.008	0.019	0.090	0.070	0.020	0.230	0.0030		0.002	0.0010				0.0001	0.40
C	C	0.180	1.060	0.240	0.005	0.022	0.080	0.080	0.030	0.240	0.0030		0.010	0.0010				0.0001	0.40
* D		0.180	1.150	0.180	0.008	0.006	0.110	0.100	0.050	0.180	0.0170		0.025	0.0010					0.42
D	C	0.170	1.170	0.200	0.011	0.009	0.120	0.110	0.060	0.190	0.0120		0.028	0.0010					0.42

NOTES
FL=Carbon Equivalent Long Formula

C = CHECK ANALISYS

MECHANICAL PROPERTIES

#		TENSILE TYPE	Ø DIAMETER mm.	AREA mmq.	LENGHT mm.	TEMP. F	TENSILE PSI	YIELD PSI	ELONG %	REDUCT. %	CHARPY TEST TYPE	TEMP.	VALUES	HB HARDNESS (AVERAGE)
A	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
A	O		12.50	122.70	50.00	68	78,868	47,920	29.6	66.5				154
B	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
B	O		12.50	122.70	50.00	68	78,566	48,153	27.0	67.1				156
C	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
C	O		12.50	122.70	50.00	68	78,362	47,533	27.2	66.8				162
D	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
* D	O		12.50	122.70	50.00	68	78,457	46,889	29.9	69.6				151

NOTES

O = OBTAINED
S = STANDARD

#	HEAT TREATMENTS
A	Normalized at 900 dgr.C for 1.1/2 h.-Cooling from 900 dgr.C in still air
A	
B	Normalized at 900 dgr.C for 2 h.-Cooling from 900 dgr.C in still air
B	
C	Normalized at 900 dgr.C for 1 h.-Cooling from 900 dgr.C in still air
C	
D	Normalized at 900 dgr.C for 1.1/2 h.-Cooling from 900 dgr.C in still air
D	

GENERAL NOTES

ROUGHNESS
F =STOCK FINISH 125-250 microinch

VERIFIED BY
STANDARD
B31.1 ASME B16.34
JUN 16 2011

NOTES
Material I.A.W. Nace MR-0175-2003 COUNTRY OF ORIGIN: USA ✓

EEC QC DEPT
R. Patterson

TRADE MARK / LOGO
Stamped on product

INT. INSPECT DATE: 01/18/2011

INT. INSPECTOR: D.RUZICKA

INSPECTION AUTHORITY
Don Ruzicka

GALPERTI, INC
An ISO 9001/2008 certified company.
Certification issued by:
Lloyds register quality assurance
Certificate No. UQA 0110391

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh WB

04/08/2009 From: MATTSCO SUPPLY CO. To: ENERGY EXCHANGERS
Our# :31620 Line# :1 QTY: :6
To: :ENERGY EXCHANGERS
CPO# :4326

X-7929 - 730, 740, 750 Part #2

GALPERTI, INC.
160 Southbelt Industrial Drive
Houston, Texas 77047
PH. 713-433-0700 – FAX 713-433-6580
Email: galpmail@galperti-am.com

TEST/CERTIFICATE EN 10204: 3.1B
INTERNAL JOB: 083305

MATTSCO SUPPLY
P.O.BOX 2925
TULSA OK 74101

Noz. S3, V2, D2

M.T CERTIFICATE N.	DATE	YOUR P.O	DATE
011219/B	10/21/2008	946-S-09A	10/13/2008

ITEM	DESCRIPTION	QUANTITY	B/P	MATERIAL	HEAT N°		#
024/024	3" 600 WN RF 160 A105 B1 F	15	A	ASTM A/SA105 03c	252597		A
024/024	3" 600 WN RF 160 A105 B1 F	5	B	ASTM A/SA105 03c	3832/02		B
026/026	6" 150 BL RF A105 B1 F	20	B	ASTM A/SA105 03c	30469/02		C
027/027	0.75" 300 BL RF A105 B1 F	25	B	ASTM A/SA105 03c	79209		D

CHEMICAL ANALYSIS

#		C %	MN %	SI %	P %	S %	CR %	NI %	MO %	CU %	V %	SN %	AL %	NB %	TI %	N %	CB%	FL%
A		0.200	0.910	0.200	0.010	0.023	0.140	0.090	0.028	0.320	0.0001			0.002			0.002	0.41
A	C	0.190	0.930	0.180	0.013	0.020	0.150	0.100	0.018	0.330	0.0001			0.002			0.002	0.40
B		0.175	1.140	0.190	0.009	0.010	0.095	0.210	0.036	0.220	0.0010	0.014	0.020	0.001		0.009	0.001	0.42
B	C	0.165	1.160	0.170	0.012	0.013	0.105	0.220	0.046	0.230	0.0010	0.014	0.040	0.001		0.009	0.001	0.41
C		0.180	1.190	0.250	0.011	0.009	0.100	0.060	0.010	0.180	0.0230	0.009	0.025	0.002	0.021		0.002	0.42
C	C	0.170	1.210	0.230	0.014	0.012	0.110	0.070	0.020	0.190	0.0180	0.009	0.039	0.002	0.021		0.002	0.41
D		0.185	1.120	0.220	0.013	0.013	0.090	0.060	0.010	0.200	0.0240						0.001	0.41
D	C	0.195	1.140	0.240	0.010	0.010	0.100	0.070	0.020	0.190	0.0340						0.001	0.43

NOTES
FL=Carbon Equivalent Long Formula

C = CHECK ANALISYS

MECHANICAL PROPERTIES

#		TENSILE TYPE	Ø DIAMETER mm.	AREA mmq.	LENGHT mm.	TEMP. F	TENSILE PSI	YIELD PSI	ELONG %	REDUCT. %	CHARPY TEST TYPE	TEMP.	VALUES	HB HARDNESS (AVERAGE)
A	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
A	O		12.50	122.70	50.00	68	76,790	50,217	27.6	67.6				151
B	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
B	O		12.50	122.70	50.00	68	77,987	50,277	31.0	68.5				157
C	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
C	O		12.50	122.70	50.00	68	76,572	49,075	29.0	66.0				157
D	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
D	O		12.50	122.70	50.00	68	77,220	50,301	29.0	69.8				164

NOTES

O = OBTAINED
S = STANDARD

#	HEAT TREATMENTS
A	Normalized at 900 dgr.C for 1.1/2 h.-Cooling from 900 dgr.C in still air
A	
B	Normalized at 900 dgr.C for 1.1/2 h.-Cooling from 900 dgr.C in still air
B	
C	Normalized at 900 dgr.C for 1 h.-Cooling from 900 dgr.C in still air
C	
D	Normalized at 900 dgr.C for 1 h.-Cooling from 900 dgr.C in still air
D	

GENERAL NOTES

ROUGHNESS
F =STOCK FINISH 125-250 microinch

STANDARD
B1 = ASME B16.5

NOTES
Material I.A.W. Nace MR-0175-2002

TRADE MARK	INT. INSPECT DATE	INT. INSPECTOR
	10/21/2008	D.RUZICKA

INSPECTION AUTHORITY

CHECKED APR 15 2009

Reviewed / Accepted
I.Q.S. #3
William Brenaugh

04/08/2009 From: MATTSCO SUPPLY CO. To: ENERGY EXCHANGERS
Our# :31620 Line# :2 QTY: :6
To: :ENERGY EXCHANGERS
CPO# :4326

X-7929-73, 74, 75 Part #3

MATERIAL TEST REPORT

MTR # A183731

Forged Vessel Connections
2525 De Soto St. (77091)
P.O. Box 38421 (77238-8421)
Houston, Texas
A DIVISION OF AMERI-FORGE GROUP INC.

http://www.fvc.cc
QA@fvc.cc

TEL: (713) 688-9705 FAX: (713) 688-7954

Noz. 53, V2, D2

S.O. No: 8-02434 Date: 10/21/2008 REV #
Purchaser: Mattsco Supply Co. Distributor:
P.O. No.: 853-S-08 Distributor's Order No: Page 1

ITEM NO	QTY	DESCRIPTION	SPEC	HEAT #	HEAT TREAT
6	1	LWN,SA105, 300#,.75 x 9",RF&D J55433-0 J55433-1	SA105 2007 Edition, 2008a Adden	A606AF	As-Forged

(C + (Mn / 6)) + ((Cr + Mo + V) / 5) + ((Ni + Cu) / 15) = .442

CHEMICAL ANALYSIS AND MECHANICAL PROPERTIES

Heat #: A606AF 11789240

Chemical values below represent percentage of weight

C (Carbon)	Mn (Manganese)	P (Phosphorus)	S (Sulphur)	Si (Silicon)	Cr (Chromium)	Ni (Nickel)	Mo (Molybdenum)
.19	1.05 *CAS # 7349-96-5	.018 *CAS # 7723-14-0	.022	.26	.19 *CAS # 7440-47-3	.11 *CAS # 7440-02-0	.05 *CAS # 1313-27-5
Cu (Copper)	**Al (Aluminum)**	**V (Vanadium)**	**As (Arsenic)**	**Sb (Antimony)**	**Sn (Tin)**	**Co (Cobalt)**	**N (Nitrogen)**
.32 *CAS # 7440-50-8	.006	.002 *CAS # 7440-62-2			.013		
Ti (Titanium)	**Ta (Tantalum)**	**Cb (Columbium)**	**O (Oxygen)**	**H (Hydrogen)**			
		.013					

TENSILE (PSI)	YIELD (PSI)	ELONG (IN 2")	R.A. (%)	CHARPYS (FT - LBS)	TEMP ° F
82988	58388	28.0	66.0		

SHEAR %	LATERAL EXPANSION (MILS)	BHN
		< 187

COMMENTS
Test Bar: 187-187 BHN

FVC STANDARD MANUFACTURING PRACTICES:

1) FLANGE DIMENSIONS & BOLTING COMPLY - ASME B16.5
2) SELF-REINFORCING NOZZLES COMPLY WITH SPECIFICATION OF SECT. VIII DIV. 1 OR DIV.2 PER CUSTOMER DESIGN/FVC DESIGN.
3) MATERIAL SPECIFICATION COMPLIES WITH ASME SECT. II. PART A.
4) ALL FVC MATERIAL MANUFACTURED PER FINE GRAIN PRACTICE.
5) ALL FVC MATERIAL CERTIFIED PER EN 10204, 3.1.B UNLESS OTHERWISE SPECIFIED
6) CERTIFICATE OF INSURANCE AVAILABLE UPON REQUEST.

CHECKED APR 15 2009

L Patterson

EPCRA Supplier Notification:

* This product may contain one or more toxic chemicals subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act (Title III of the Superfund Amendments and Reauthorization Act of 1986) and 40 C.F.R. Part 372. Potentially reportable chemicals are indicated with an asterisk (*) under the chemical's name and percent-by-weight value, followed by a Chemical Abstract Service (CAS) registry number for that chemical. It is your responsibility alone to determine whether your facility is required to submit a Toxic Release Inventory Report under EPCRA Section 313.

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Quality Assurance

GALPERTI, INC.
160 Southbelt Industrial Drive
Houston, Texas 77047
PH. 713-433-0700 – FAX 713-433-5560
Email: galpmail@galperti-am.com

Nor 32

Part #2

TEST/CERTIFICATE	EN 10204	INTERNAL JOB
3.1B		091351

PROGRESSIVE SUPPLY
P. O. BOX 470748
TULSA OK 74145

This MTR applies to your PO# 1221

M.T.CERTIFICATE N.	DATE	YOUR P.O.	DATE
014577/B	07/06/2009	098331 Y.17924-12	05/15/2009

ITEM	DESCRIPTION	QUANTITY	B/P	MATERIAL	HEAT N°		#
016/016	3" 300 WN RF XXS A105 B1 F	10	B	ASTM A/SA105 03c	9721/02		A
018/018	3" 300 WN RF 160 A105 B1 F	25	B	ASTM A/SA105 03c	9721/02		B

CHEMICAL ANALYSIS

#		C %	MN %	SI %	P %	S %	CR %	NI %	MO %	CU %	V %	SN %	AL %	NB %	TI %	N %	CB%		FL%
A		0.170	1.170	0.214	0.010	0.016	0.130	0.185	0.050	0.180	0.001		0.020	0.002	0.001	0.009	0.002		0.42
A	C	0.160	1.150	0.234	0.013	0.019	0.120	0.175	0.060	0.190	0.001		0.030	0.002	0.001	0.009	0.002		0.41

NOTES
FL=Carbon Equivalent Long Formula

C = CHECK ANALISYS

MECHANICAL PROPERTIES

#		TENSILE TYPE	Ø DIAMETER mm.	AREA mmq.	LENGHT mm.	TEMP. F	TENSILE PSI	YIELD PSI	ELONG %	REDUCT. %	CHARPY TEST TYPE	TEMP.	VALUES	HB HARDNESS (AVERAGE)
A	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
A	O		12.50	122.70	50.00	68	78,586	47,781	28.5	66.4				159
B	S		12.50	122.70	50.00	68	70,000	36,000	22.0	30.0				187
B	O		12.50	122.70	50.00	68	78,487	47,214	29.0	68.0				154

NOTES
LINE 016 COUNTRY OF ORIGIN ITALY ✓

O = OBTAINED
S = STANDARD

#	HEAT TREATMENTS
A A	Normalized at 900 dgr.C for 1.1/2 h.-Cooling from 900 dgr.C in still air
B B	Normalized at 900 dgr.C for 1.1/2 h.-Cooling from 900 dgr.C in still air

VERIFIED BY
JUN 16 2011

GENERAL NOTES
ROUGHNESS
F =STOCK FINISH 125-250 microinch

STANDARD
B1 = ASME B16.5

NOTES
Material I.A.W. Nace MR-0175-2002

EEC QC DEPT
K. Patterson

Reviewed / Accepted
I.Q.S. #3
William Brenaugh

TRADE MARK / LOGO	INT. INSPECT DATE	INT. INSPECTOR
Stamped on product	07/06/2009	D.RUZICKA

INSPECTION AUTHORITY
Dan Ruzicka

GALPERTI, INC
An ISO 9001/2000 certified company
Certification issued by:
Lloyds register quality assurance
Certificate No. UQA 0110391

1221

V&M VALLOUREC & MANNESMANN TUBES
V & M do BRASIL S.A.
BARREIRO PLANT - Belo Horizonte - MG - Brazil
CEP: 30161-970 - P.O BOX: 1453

EcoTube

INSPECTION CERTIFICATE

(According to EN 10204 / DIN 50049 3.1.B)

N°.: 0050229660

She 1 / 2

Customer: VALLOUREC TUBES CANADA INC
Customer Order: VM1678
Inspection: V & M do BRASIL S.A.
Vessel: DS FREEWAY

Country: Canadá

Work Order: 180400 / 000030
Material Number: 376816

Customer Material Number:

DIMENSION: 10.3/4" X 0.500" GRADE: GR 6 /GR 1 /
METALURGICAL STANDARD: ASTM A 333 01.01.2005 # DIMENSIONAL STANDARD: ASTM A 333 01.01.2005
IN ACCORDANCE ALSO TO THE STANDARDS: ASME SA-333 / 2004 #
PRODUCT: SEAMLESS STEEL PIPE, HOT FINISHED , BEVELED ENDS 37,5 DEG. # NORMALIZED # SUPERFICIAL PROTECTION: LACQUER #
TOLERANCES: OUTSIDE DIAMETER: - 0.0315 " / + 0.0945 " WALL THICKNESS: - 0.0625 " / + 0.1125 "
CUT LENGTH: RANDOM 18.00 FT - 22.00 FT #
STANDARD MARKING: 175171/30 VMB ASTM A/ASME SA-333 6 1 S HF SCH 060 LT -50 F 10.3/4" X 0.500"
SHIPPING MARKING: MADE IN BRAZIL * VM1678 / P.O I-1891 * EDGEN * EDMONTON VIA HOUSTON

X-7929 - 81A Noz. T2

Batch	Heat N.	Inspection Lot	Pieces
0006268359	83776	030001159262	30
TOTAL			30

THE PRODUCT IS SATISFACTORY IN THE FOLLOWING TESTS / INSPECTIONS: DIMENSIONAL # VISUAL # FLATTENING TEST # HYDROSTATIC TEST: 2.000,0 PSI 5 s #

CHEMICAL COMPOSITION(%): CEq according: C+Mn/6+(Cr+Mo+V)/5 +(Ni+Cu)/15 DI according: Unit: Pcm:

	C	Mn	P	S	Si	Ni	Cr	Mo	Al	Cu	Sn	V	Nb	B	Ti	Pb	As	Zr	Bi	W	O	N	H	Ca	Zn	Sb	CEq	FB
Required: Min		0.40			0.10																						0.400	
Max	0.22	1.06	0.025	0.025																								
Heat N./ Batch:																											0.277	
83776/0006268359	0.11	0.92	0.010	0.003	0.17	0.02	0.05	0.01		0.010		0.000															0.277	
Check1	0.11	0.92	0.011	0.002	0.17	0.03	0.05	0.01		0.004		0.000															0.271	
Check2	0.11	0.91	0.010	0.002	0.17	0.03	0.05	0.01		0.004		0.000																

MECHANICAL TESTS S.Direction: Longitudinal Temperature: Room Temperature Gage Length: L0=2"

Tensile	Area(Sq.in)	Ys(PSI)	Ts(PSI)	E(%)	R.A.()	Ys/Ts
Required: Min.:		34835	60235	35		
Max.:						

VERIFIED BY
JUL 11 2011
EEC QC DEPT
L. Jatterson

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

Part #4

VALLOUREC & MANNESMANN TUBES

EcoTube

INSPECTION CERTIFICATE (According to BN 10204 / DIN 50049 3.1.B) | N°.: 0050229660 | She 2 / 2

Heat N./ Batch					
83776 / 0006268359	0.5	49930	66622	45	

Hardness — HV

	Min.:	Max.:
Required:		
Heat N./ Batch		
83776 / 0006268359		246

Impact — 134

According: CHARPY 10X55X10 V NOTCH — Direction: Longitudinal — Temperature: -50 °F

Heat N./ Batch	Absorbed Energy Required Min: 10 Ft.lb			Average Min: 13 Ft.lb	Shear Area Required Min:			Average Min:	Lateral Expansion Required Min:			Average Min:
	1	2	3	Average	1	2	3	Average	1	2	3	Average
83776 / 0006268359	176	178	167	174								

Remarks:
MATERIAL IN ACCORDANCE TO ITEM A-2 NACE MR 0175/ISO 15156-2/2003

Part #4

Reviewed / Accepted
I.Q.S. # 3
Brenaugh

We hereby certify that this product has been manufactured and examined in accordance with all requirements of the standards and specifications and all the results are found to be satisfactory. This testimonial and certificate respectively is recorded by a computer system and is valid without signature. Alteration or use for others products are regarded as falsification of documents and will be subject to criminal jurisdiction

QUALITY CONTROL DEPARTMENT
FAX:(55-31) 3328-2617
e-mail:jmssilva@vmtubes.com.br

DATE 05.07.20

DR. JULIO MÁRCIO SILVEIRA E SILVA - CREA/MG 34582/D
TECHNICAL RESPONSIBLE

Eco Tubes: The tubes from V&M do BRASIL are manufactured with steel which uses charcoal as a source of energy in its production. This coal comes from more than 100.000 ha of forest planted by V&M Florestal.With the acquisition of 15,8 ton(s) of steel tubes from V&M do BRASIL, your company contributed to the reduction of the greenhouse effect, avoiding the accumulation of 28,4 ton(s) of Carbon D [illegible] the atmosphere

UNITED STATES STEEL

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

DATE: 02/04/11
TIME: 11:04:35
SERIAL NO: F0062922

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER	VEHICLE I.D
DR00486 01		D1721000	

SOLD TO ADDRESS

PROGRESSIVE SUPPLY, INC.
7615 E. 42 ND. PL.
TULSA, OK. 74145

MAIL TO ADDRESS

This MTR applies to your
PO# 10109 NOZ. S1

VENDOR

USS TUBULAR PRODUCTS
USS FAIRFIELD WORKS
P.O. BOX 599
FAIRFIELD ALABAMA 35064

SPECIFICATION AND GRADE

PIPE CARBON SMLS STD PIPE API 5L-*44TH ED DTD OCT 2007 AND ISO 3183:2007 MOD PSL-2 GRADE B AND GRADE X42 R N OR Q AND ANNEX C & E ASTM A53-*07 ASTM A106-*08 GRADE B QUAD STENCIL ASME SA53-*2010 EDITION GRADE B ASME SA106-*2010 EDITION GRADE B/C BLK REG MILL COAT PE BEV 30 DEG MEETING ALL THE APPLICABLE REQUIREMENTS OF NACE STANDARD MR-01-75 *:2003/COR.1:2005 AND MR0103-2007

(2 pcs.) STOCK X-7929-71A

MATERIAL COND: AS-ROLLED

O.D.: 6.625 (168.275) in (mm)

WALL: 0.432 (10.972) in (mm)

PRODUCT IDENTIFICATION	TEST TYPE/ ORIENTATION	TEST COND.	GAUGE WIDTH	YIELD PSI	EXT % .50	TENSILE PSI	Y/T	ELONG % (IN 2")	HARDNESS SCALE: HRB	MIN HYDRO PSI	DWELL(SEC)
			IN	MIN: 42,100		MIN: 70,000	MAX:	MIN:	MIN:	4110	5
				MAX: 71,800		MAX: 110,200		29.0	MAX: 99.5		
X22424 *NOTE A	STRIP/L/B	AR	1.5	49,800	.50	75,500	0.66	38.3	85.4	4110	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 - THERMOMECHANICAL ROLLED; B - BODY; W - WELD

PRODUCT IDENTIFICATION	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	AL	N	V	B	TI	CB	CO	SN	AS	SB	C.E.* MAX .43
X22424	HEAT	19	111	005	007	22	03	01	02	01	032	005	00	0001	001	000		00	00	003	.38
X22424	PROD	21	106	006	005	21	03	02	03	02	032	007	00	0003	002	005		007	00	00	.40
X22424	PROD	20	114	007	008	23	03	01	03	01	030	006	00	0000	001	000		003	00	00	.41
		** END OF DATA THIS SHEET **																			

*C.E. IS BASED ON THE FOLLOWING EQUATION(S): C.E. = C + MN/6 + (CR+MO+ V)/5 + (CU+NI)/15 <= 0.43

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT.

VERIFIED BY
APR 14 2011
EEC QC DEPT
L Patterson

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Part #4

UNITED STATES STEEL

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

DATE: 02/04/11
TIME: 11:04:35
SERIAL NO: F0062922

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER
DR00486 01		D1721000

MATERIAL COND: AS-ROLLED

O.D.: 6.625(168.275) In (mm)

WALL: 0.432 (10.972) In (mm)

PRODUCT IDENTIFICATION	FLAT	BEND	GRAIN SIZE	MIN COLLAPSE	CHARPY V-NOTCH IMPACT TESTING												
					DIR	TEST LOC.	TEMP	SIZE	TEST COND.	FT-LBS 1	FT-LBS 2	FT-LBS 3	FT-LBS AVG	% SHEAR 1	% SHEAR 2	% SHEAR 3	% SHEAR AVG
							DEG F			12	12	12	15				
X22424	OK			** END OF DATA THIS SHEET **	T	B	+ 32	3/4	AR	27	26	20	24	10	10	10	10

LEGEND L - LONGITUDINAL T - TRANSVERSE B - BODY W - WELD HAZ - HEAT AFFECTED ZONE

TESTING / INSPECTION INFORMATION

TEST / INSPECTION	YES	RESULTS / COMMENTS
FULL LENGTH VISUAL	X	
FULL LENGTH EMI	X	OD ____ OD/ID ____X L ____ L/T __X 10.0/10.0% NOTCH
FULL LENGTH MPI		
FULL LENGTH UT		ID ____ OD/ID ____ L ____ L/T ____
END AREA INSPECTION (PLAIN END)	X	MPI __X UT ____
SPECIAL END AREA (SEA) INSP		MPI ____ UT ____
FULL LENGTH DRIFT		DRIFT MANDREL SIZE:

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.
*NOTE A SEE ATTACHED REPORT FOR TENSILE RESULTS.

** 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: J. MAJKRZAK - MANAGER, Q.A.

DATE 02/04/11

**

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Part #4

UNITED STATES STEEL

TUBULAR PRODUCTS
TENSILE TEST REPORT

DATE: 02/04/11
TIME: 11:04:51
PAGE: 1

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER	HEAT	SERIAL NUMBER: F0062922
DR00486 01		D1721000		

SOLD TO ADDRESS
PROGRESSIVE SUPPLY, INC.
7615 E. 42 ND. PL.
TULSA, OK. 74145

MAIL TO ADDRESS

VENDOR
USS TUBULAR PRODUCTS
USS FAIRFIELD WORKS
P.O. BOX 599
FAIRFIELD ALABAMA 35064

HEAT	PIPE/ LOT	TYPE/ DIR/ LOC	TEST COND	YIELD	EXT%	TENSILE	Y/T	ELONG %	REDUC AREA
X22424	2013	STRIP/L/B	AR	49,800	0.50	75,500	0.66	38.3	
X22424	2012	STRIP/L/B	AR	51,000	0.50	75,500	0.68	40.0	
X22424	2011	STRIP/L/B	AR	51,500	0.50	76,000	0.68	43.0	

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

Part # 4

UNITED STATES STEEL

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

DATE: 07/29/10
TIME: 04:06:33
SERIAL NO: L0032746

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER	VEHICLE I.D
DR48625 01	R82202	D1092000	LT8296

SOLD TO ADDRESS
PROGRESSIVE SUPPLY, INC.
7615 E. 42 ND. PL.
TULSA, OK. 74145

MAIL TO ADDRESS
This MTR applies to your
PO# 1221

VENDOR
USS TUBULAR PRODUCTS
2199 EAST 28TH ST.
LORAIN, OH 44055

SPECIFICATION AND GRADE

PIPE CARBON SMLS STD PIPE API 5L-*44TH ED DTD OCT 2007 AND ISO 3183:2007 MOD PSL-1 GRADE B AND GRADE X42 R N OR Q ASTM A53-*07 ASTM A106-*08 GRADE B QUAD STENCIL ASME SA53-*2007 EDITION ASME SA106-*2007 EDITION GRADE B BLK REG MILL COAT PE BEV 30 DEG MEETING ALL THE APPLICABLE REQUIREMENTS OF NACE STANDARD MR-01-75 *:2003/COR.1:2005 AND MR0103-2007

X-7439-731 Noz. 32

MATERIAL COND: AS ROLLED

O.D.: 3.500 (88.900) in (mm)

WALL: 0.600 (15.240) in (mm)

PRODUCT IDENTIFICATION	TENSILE TEST TYPE/ ORIENTATION	TEST COND.	GAUGE WIDTH	YIELD PSI	EXT %	TENSILE PSI	Y/T	ELONG % (IN 2")	HARDNESS SCALE: HRB	MIN HYDRO PSI	DWELL(SEC)
			IN	MIN: 42100	.50	MIN: 70000	MAX:	MIN:	MIN:	2970	5
				MAX:		MAX:		27.0	MAX: 99.0		
HA0461	STRIP/L/B	AR	0.750	48300	.50	79000	0.61	36.3	B 81.8	2970	5
HA0470	STRIP/L/B	AR	0.750	47900	.50	81000	0.59	37.8	B 83.5	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 - THERMOMECHANICAL ROLLED; B - BODY; W - WELD

PRODUCT IDENTIFICATION	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	AL	N	V	B	TI	CB	CO	C.E.*
																		MAX .50
HA0461	HEAT		22 98	012	003	24	15	11	16	02	028		00	0000	001	002		.44
HA0461	PROD		23 99	017	002	24	14	11	17	01	035		00	0003	004	009		.45
HA0461	PROD		23 99	017	003	24	14	11	17	01	036		00	0004	004	010		.45
HA0470	HEAT		23 98	010	004	21	16	12	17	01	026		00	0000	001	002		.45
HA0470	PROD		23 99	014	004	22	15	11	18	01	035		00	0004	004	009		.45
HA0470	PROD		23 99	014	003	22	15	11	18	01	032		00	0003	004	009		.45
			** END OF DATA THIS SHEET **															

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

VERIFIED BY
JUL 11 2011
EEC QC DEPT
L. Patterson

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT.

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Act #4

UNITED STATES STEEL

TUBULAR PRODUCTS

CERTIFIED TEST REPORT

(IN ACCORDANCE WITH ISO 10474/EN10204/DIN50049 "type 3.1")

DATE: 07/29/10
TIME: 04:06:33
SERIAL NO: L0032746

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER	
DR48625 01	R82202	D1092000	0017106

MATERIAL COND: AS ROLLED

O.D.: 3.500 (88.900) in (mm)

WALL: 0.600 (15.240) in (mm)

PRODUCT IDENTIFICATION	FLAT	BEND	GRAIN SIZE	MIN COLLAPSE	CHARPY V-NOTCH IMPACT TESTING												
					DIR	TEST LOC.	TEMP	SIZE	TEST COND.	FT-LBS				% SHEAR			
							DEG			1	2	3	AVG	1	2	3	AVG
HA0461	OK																
HA0470	OK		**	END OF DATA THIS SHEET **													

LEGEND L - LONGITUDINAL T - TRANSVERSE B - BODY W - WELD HAZ - HEAT AFFECTED ZONE

TESTING / INSPECTION INFORMATION

TEST / INSPECTION	YES	RESULTS / COMMENTS
FULL LENGTH VISUAL	X	
FULL LENGTH EMI		OD ____ OD/ID ____ L ____ L/T ____
FULL LENGTH MPI		
FULL LENGTH UT		ID ____ OD/ID ____ L ____ L/T ____
END AREA INSPECTION (PLAIN END)		MPI ____ UT ____
SPECIAL END AREA (SEA) INSP		MPI ____ UT ____
FULL LENGTH DRIFT		DRIFT MANDREL SIZE:

ADDITIONAL NOTES/COMMENTS

MELTED AND MANUFACTURED IN THE USA. 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.
PRODUCT WAS HOT ROLLED AND HOT FINISHED
ALL MELTING AND MANUFACTURING TOOK PLACE IN THE USA
PIPE ALSO MEET THE REQUIREMENTS OF ASTM A106 GRADE C & ASME SA106 GRADE C

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: R. HARRIS - MANAGER, Q.A.

DATE 07/29/10

Reviewed / Accepted
I.Q.S. # 3
William Branaugh

Part #4

This MTR applies to your

PO# 1224

8603 Sheldon Road
Houston, TX 77049

V&M STAR

Seamless Tubular Products

Thursday, December 23, 2010
CERTIFIED TEST REPORT - HOUSTON FACILITY

SLN: ZX0008 X-7929-87A

PRODUCT DESCRIPTION:

OD: 6.625 WALL 0.432 LBS / FT 28.60 PEB DRL LP

SEAMLESS NORMALIZED

GRADE: ASTM / ASME A/SA333 GR. 1 & 6 - 05/2007 Noz T1

CUSTOMER:	VMS MILL ORDER NO:
PROGRESSIVE SUPPLY, INC.	91075
CUSTOMER ORDER NUMBER:	**VMS W/O NO:**
903834	D00585
CUSTOMER SPEC:	**VMS LOT NO:**
	10-7018

COMMENTS:
Melted and Manufactured In the U.S.A. ✓
This material meets requirements of:
ASTM A53B-07
ASTM A106B/C-06
ASME SA53B-2007
ASME SA106B/C-2007
DIN EN 10204/2004 Type 3.1
Satisfies NACE MR0175
NO WELD REPAIR
FREE OF MERCURY

MECHANICAL PROPERTIES: LONGITUDINAL

SPECIMEN CROSS SECTION			STRENGTH KSI		ELONGATION	
WIDTH (IN)	THICK (IN)	AREA (SQIN)	YIELD	TENSILE	GAGE LENGTH	% ELONG
0.985	0.438	0.4333	48.9	73.2	2	40.0
1.011	0.435	0.4418	47.5	74.2	2	39.0

SUPPLEMENTAL REQUIREMENTS:

	YES	NO	REMARKS
HARDNESS	☑	☐	BHW 153 ✓
FLATTENING	☑	☐	PASSED
NACE TEST	☐	☑	
GRAIN SIZE	☐	☑	
OTHER	☐	☑	
COLLAPSE 8D MIN	☐	☑	

Inspection: EMI SR4 Q/T: AF ☑ 1700 TF ☐

HYDROSTATIC TEST (psi): 3000.5 SEC HOLD DRIFT PLUG SIZE: INCHES

CHEMICAL ANALYSIS: 61M

	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Nb	V	Al	Ca	B	Ti	N	CE
HEAT	0.22	0.68	0.009	0.005	0.23	0.19	0.07	0.09	0.02	0.008	0.001	0.004	0.034	0.0019	0.0001	0.002	0.0077	0.37
PRODUCT # 1	0.22	0.67	0.009	0.005	0.23	0.19	0.07	0.10	0.02	0.007	0.001	0.004	0.033	0.0019	0.0001	0.002	0.0087	0.38
PRODUCT # 2	0.22	0.66	0.009	0.005	0.23	0.19	0.07	0.10	0.02	0.008	0.001	0.004	0.031	0.0019	0.0001	0.002	0.0088	0.37
PRODUCT # 3																		
PRODUCT # 4																		

CHARPY IMPACT TESTING

DIRECTION		LONG
SIZE		3/4
NOTCH TYPE		A
TEMP (°F)	1	-55 ✓
	2	
	3	

	PC #	FT-LBS	SHEAR
1	1	35	20
	2	37	20
	3	33	20
	AVG.	35 ✓	20
2	1	0	0
	2	0	0
	3	0	0
	AVG.	0	0
3	1	0	0
	2	0	0
	3	0	0
	AVG.	0	0

This material has been produced and tested in accordance with the requirements of applicable specifications unless otherwise listed below. We hereby certify that the above test results are representative of those contained in the records of the company. Any modification to this certification as provided by V & M Star without the expressed written consent of V & M Star negates the validity of this test report. V & M Star is not responsible for the inability of this material to meet specific applications.

SIGNED: [signature]

DATE: 7/4/11

VERIFIED BY

JUL 11 2011

EEC QC DEPT

[signature]

*The following clause is a condition of this contract and must be passed on verbatim in each subsequent sale: 'These commodities, technology, or software, were exported from the United States in accordance with the export administration regulation. Diversion contrary to U.S. law is prohibited.' Buyer acknowledges his understanding that the sanction of denial of trading privileges in USA exports may be imposed for violation of this export.

SWORN AND SUBSCRIBED TO BEFORE
THIS _____ DAY _____

_____
NOTARY PUBLIC
MY COMMISSION EXPIRES _____

THIS CERTIFICATE IS NOTORIZED ONLY WHEN REQUESTED

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh WB

Unit # 4

1224

UNITED STATES STEEL

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

DATE: 03/01/11
TIME: 11:09:40
SERIAL NO: L0035164

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER	VEHICLE I.D
DR00362 05		019928	

VENDOR
USS TUBULAR PRODUCTS
2199 EAST 28TH ST.
LORAIN, OH 44055

X 7929 - 12 & 17

SPECIFICATION AND GRADE

PIPE CARBON SMLS LINE PIPE ASTM A106-*08 ASME SA106-*2010 EDITION GRADE B/C SPECIAL OD TOLERANCE TO T&Y/USS 003 REV 10 DTD 9/22/09 API 5L-*44TH ED DTD OCT 2007 AND ISO 3183:2007 MOD PSL-2 GRADE X42 Q BLK REG MILL COAT PE BEV 30 DEG MEETING ALL THE APPLICABLE REQUIREMENTS OF NACE STANDARD MR-01-75 *:2003/COR.1:2005 AND MR0103-2007

MATERIAL COND: QUENCH AND TEMPER

O.D.: 24.000 (609.600) in (mm)

WALL: 0.500 (12.700) in (mm)

PRODUCT IDENTIFICATION	TENSILE TEST TYPE/ ORIENTATION	TEST COND.	GAUGE WIDTH	YIELD PSI	EXT % .50	TENSILE PSI	Y/T	ELONG % (IN 2")	HARDNESS SCALE: HRB	MIN HYDRO PSI	DWELL(SEC)
			IN	MIN: 52200 MAX: 71800		MIN: 70000 MAX: 110200	MAX: 0.93	MIN: 30.0	MIN: MAX: 99.0	1960	5
MA2181 S504QA	STRIP/L/B	QT	1.500	56000	.50	86500	0.65	43.3	B 92.8	1960	5
MA2181 S504QA	STRIP/L/B	QT	1.500	67500	.50	85500	0.79	43.4			
		**	END OF DATA THIS	SHEET	**						

LEGEND: L - LONGITUDINAL, U - UPSET; T - TRANSVERSE, NM - NORMALIZED; QT - QUENCH & TEMPERED, SR - STRESS RELIEVED; AR - AS ROLLED, TR - THERMOMECHANICAL ROLLED; B - BODY; W - WELD

PRODUCT IDENTIFICATION	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	AL	N	V	B	TI	CB	CO	C.E.* MAX .43
MA2181	HEAT	14	102	009	002	22	09	06	09	08	025		024	0003	002	002		.36
MA2181 S504QA	PROD	15	102	010	006	28	13	07	10	10	039		030	0005	004	010		.38
MA2181 S504QA	PROD	14	105	010	005	26	12	07	10	10	037		028	0005	003	009		.37
			**	END	OF	DATA	THIS	SHEET	**									

VERIFIED BY
JUL 11 2011
EEC QC DEPT

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

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT.

L. Patterson

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh WB

Job # 5469

UNITED STATES STEEL

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

DATE: 03/01/11
TIME: 11:09:40
SERIAL NO: L0035164

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER
DR00362 05		019928

MATERIAL COND: QUENCH AND TEMPER

O.D.: 24.000(609.600) In (mm)

WALL: 0.500 (12.700) In (mm)

PRODUCT IDENTIFICATION	FLAT	BEND	GRAIN SIZE	MIN COLLAPSE	CHARPY V-NOTCH IMPACT TESTING											
					DIR	TEST LOC.	TEMP	SIZE	TEST COND.	FT-LBS 1	FT-LBS 2	FT-LBS 3	FT-LBS AVG	% SHEAR 1	% SHEAR 2	% SHEAR 3	% SHEAR AVG
					DEG F												
MA2181 S504QA	OK				T	B	+ 32	2/3	QT	162	170	164	165	100	100	100	100
MA2181 S504QA					L	B	- 50	FULL	QT	177	163	175	171	100	100	100	100
			**	END OF DATA THIS SHEET **													

LEGEND L - LONGITUDINAL T - TRANSVERSE B - BODY W - WELD HAZ - HEAT AFFECTED ZONE

TESTING / INSPECTION INFORMATION

TEST / INSPECTION	YES	RESULTS / COMMENTS
FULL LENGTH VISUAL	X	
FULL LENGTH EMI	X	OD X ODID L X L/T 10.0% NOTCH
FULL LENGTH MPI		
FULL LENGTH UT	X	ID X ODID L X L/T 10.0% NOTCH
END AREA INSPECTION (PLAIN END)	X	MPI X UT
SPECIAL END AREA (SEA) INSP		MPI UT
FULL LENGTH DRIFT		DRIFT MANDREL SIZE:

ADDITIONAL NOTES/COMMENTS

MELTED AND MANUFACTURED IN THE USA. 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.
MINIMUM TEMPERING TEMPERATURE 1050 DEG F.
MATERIAL ALSO MEETS THE REQUIREMENTS OF A53/SA53 GRADE B. THIS MULTIPLE CERTIFIED PRODUCT, (ASTM A53/AND OR A106 GRADE B, AND/OR ASTM A333 GRADE 6, AND API 5L X52Q) HAS HIGHER YIELD STRENGTH PROPERTIES THAN MATERIAL ORDERED AS ASTM A53 AND/OR A106 GRADE B AND/OR ASTM A333 GRADE 6

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: R. HARRIS - MANAGER, Q.A.

DATE 03/01/11

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Part # 5149

UNITED STATES STEEL

TUBULAR PRODUCTS
SUPPLEMENTAL STATEMENT SHEET

DATE: 03/01/11
TIME: 11:09:40

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER	HEAT	SERIAL NUMBER: L0035164
DR00362 05		019928	MA2181	

MAIL TO ADDRESS

VENDOR
USS TUBULAR PRODUCTS
2199 EAST 28TH ST.
LORAIN, OH 44055

PIPE ALSO MEETS THE CHEMICAL AND MECHANICAL PROPERTIES FOR ASTM/ASME A/SA333 GRADE 6 EXCEPT MARKINGS

Part #549

LeTourneau STEEL PRODUCTS

20119

LONGVIEW, TEXAS, U.S.A.
ISO 9001:2008 Registered Quality System
Material Test Report

REPORT OF CHEMICAL AND PHYSICAL TESTS OF STEEL PLATE

DATE: 03/10/11 PAGE: 1 of 1

SOLD TO: C.G. Martin Company, Inc.
P O Box 9345
Tulsa OK 74157

SALES ORDER NO.: 191857
PURCHASE ORDER NO.: 6229

GRADE: ASTM A/ASME SA516 Grade 70, Normalized
SIZE: 3.75" x 94" x 205"
HEAT NO.: D52809 ROLL NO.: 68347 X-7929-4+9

LADLE ANALYSIS

C ✓	MN ✓	S ✓	P ✓	SI ✓	CR ✓	NI ✓	MO ✓	AL ✓	V ✓	CU ✓	NB ✓	B	TI ✓
0.1900	1.0600	0.0070	0.0120	0.3000	0.1700	0.1500	0.0600	0.0390	0.0020	0.2500	0.0030	0.0000	0.0020

PHYSICAL ANALYSIS

HEAT TREAT TEMP	TIME HRS/MINS	YIELD POINT (psi)	TENSILE STRENGTH (psi)	2" GAGE %ELONG	%RA	HARDNESS LOW/HIGH	CHARPY TEST INFO TEMP	TYPE	FT/LBS	LAT EXP	% SHEAR
Normalized (B) 1650F	2:45	47800 ✓	76300 ✓	31.0 ✓	59.0 ✓	143 - 149 BHN ✓					

ELECTRIC FURNACE MELTED.
ASTM 516-GRADE 70/60, 2010 EDITION. ASME SA516-GRADE 70/60, 2007 EDITION, 2009b ADDENDA.
MATERIAL IS MERCURY FREE, FULLY KILLED AND DEOXIDIZED.
MATERIAL TEST REPORT PREPARED IN ACCORDANCE WITH EN 10204 3.1. 2004 EDITION.

MATERIAL WAS MELTED AND MANUFACTURED IN THE U.S.A. ✓
IN ACCORDANCE WITH THE RECORDS OF LeTOURNEAU TECHNOLOGIES, INC., I CERTIFY THE ABOVE INFORMATION IS CORRECT.

JoAnne Allgood
JO ANNE ALLGOOD
TECHNICAL SERVICES DEPARTMENT

VERIFIED BY
MAY 24 2011
EEC QC DEPT
K. Patterson

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

DUPLICATE ORIGINAL TEST REPORT FROM C.G. MARTIN CO., INC.

CUST ID	22	WO#	79689
CUST	ENERGY EXCHANGER COMPANY		
P.O. #	1171		
ITEM #	1		
DESC	(2) 24" OD(F) X 3-3/8" THK(F)		
DATE	05/18/11	BY:	

Part # 6 of 8

UNITED STATES STEEL

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

DATE: 11/13/10
TIME: 04:04:23
SERIAL NO: L0033912

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER	VEHICLE I.D
DR49989 06	R82808	6047	LT8124

SOLD TO ADDRESS

PROGRESSIVE SUPPLY, INC.
7615 E. 42 ND. PL.
TULSA, OK. 74145

MAIL TO ADDRESS

This MTR applies to your
PO# 1221

VENDOR

USS TUBULAR PRODUCTS
2199 EAST 28TH ST.
LORAIN, OH 44055

SPECIFICATION AND GRADE

PIPE CARBON SMLS STD PIPE API 5L-*44TH ED DTD OCT 2007 AND ISO 3183:2007 MOD PSL-1 GRADE B AND GRADE X42 R N OR Q ASTM A53-*07 ASTM A106-*08 GRADE B QUAD STENCIL SPECIAL OD TOLERANCE ASME SA53-*2010 EDITION ASME SA106-*2010 EDITION GRADE B BLK REG MILL COAT PE BEV 30 DEG MEETING ALL THE APPLICABLE REQUIREMENTS OF NACE STANDARD MR-01-75 *:2003/COR.1:2005 AND MR0103-2007

X-7929-15

MATERIAL COND: AS ROLLED

O.D.: 24.000 (609.600) in (mm)

WALL: 0.562 (14.274) in (mm)

PRODUCT IDENTIFICATION	TENSILE TEST TYPE/ ORIENTATION	TEST COND.	GAUGE WIDTH	YIELD PSI	EXT %	TENSILE PSI	Y/T	ELONG % (IN 2 ")	HARDNESS SCALE: HRB	MIN HYDRO PSI	DWELL(SEC)
			IN	MIN: 42100 MAX:		MIN: 70000 MAX:	MAX:	MIN: 30.0	MIN: MAX: 99.0	1780	5
MA1922	STRIP/L/B	AR	1.500	52000	.50	73000	0.71	47.0	B 75.6	1780	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 - THERMOMECHANICAL ROLLED, B - BODY, W - WELD

PRODUCT IDENTIFICATION	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	AL	N	V	B	TI	CB	CO	C.E.*
																		MAX .50
MA1922	HEAT	20	106	008	005	12	11	05	07	02	026		03	0001	001	002		.41
MA1922	PROD	21	102	009	006	11	11	05	07	02	023		03	0003	001	002		.42
MA1922	PROD	18	102	009	006	11	11	05	07	02	023		03	0002	001	001		.39
			** END OF DATA THIS SHEET **															

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

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT.

VERIFIED BY
JUL 11 2011
EEC QC DEPT
T. Patterson

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

Set # 1

UNITED STATES STEEL

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

DATE: 11/13/10
TIME: 04:04:23
SERIAL NO: L0033912

MILL ORDER/ITEM NO	SHIPPERS NO.	P.O. NUMBER	
DR49989 06	R82808	6047	0018741

MATERIAL COND: AS ROLLED

O.D.: 24.000 (609.600) in (mm)

WALL: 0.562 (14.274) in (mm)

PRODUCT IDENTIFICATION	FLAT	BEND	GRAIN SIZE	MIN COLLAPSE	CHARPY V-NOTCH IMPACT TESTING													
					DIR	TEST LOC.	TEMP	SIZE	TEST COND.	FT-LBS				% SHEAR				
							DEG			1	2	3	AVG	1	2	3	AVG
MA1922	OK			** END OF DATA THIS SHEET **														

LEGEND L - LONGITUDINAL T - TRANSVERSE B - BODY W - WELD HAZ - HEAT AFFECTED ZONE

TESTING / INSPECTION INFORMATION

TEST / INSPECTION	YES	RESULTS / COMMENTS
FULL LENGTH VISUAL	X	
FULL LENGTH EMI	X	OD X OD/ID ____ L X UT ____ 10.0% NOTCH
FULL LENGTH MPI		
FULL LENGTH UT		ID ____ OD/ID ____ L ____ UT ____
END AREA INSPECTION (PLAIN END)		MPI ____ UT ____
SPECIAL END AREA (SEA) INSP		MPI ____ UT ____
FULL LENGTH DRIFT		DRIFT MANDREL SIZE:

ADDITIONAL NOTES/COMMENTS

MELTED AND MANUFACTURED IN THE USA. 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.
PRODUCT WAS HOT ROLLED AND HOT FINISHED
PIPE ALSO MEET THE REQUIREMENTS OF ASTM A106 GRADE C & ASME SA106 GRADE C

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: R. HARRIS - MANAGER, Q.A.

DATE 11/13/10

Reviewed / Accepted
I.O.S. #3

Part #1

321

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

Mill Test Report

Page 3

NUCOR It's our Nature.

Issuing Date : 05/01/2011 B/L No. : 292311 Load No. : 294273 Our Order No. : 90537/10 Cust. Order No. : MUS-233263

Vehicle No: TTPX 82223

Specification : 0.3750" x 96.000" x 480.000"
ASTM A516 70-10/ASME SA516 70 PVQ 2010 Normalized Test
Coupons at 1650 F

Sold To : METALS USA - SOUTHCENTRAL
2800 N 43RD STREET EAST
MUSKOGEE,OK 74403

Ship To : METALS USA - PLATES AND SHAPES
TRACK 747
MUSKOGEE,OK 74401

Marking : X-7929. 71B

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	CEQ	PCM
1502825	0.19	1.02	0.013	0.002	0.19	0.21	0.07	0.10	0.01	0.025	0.005	0.002	0.002		0.0016	0.0002	0.009	0.40	0.26

	Tensile Test							Charpy Impacts										
Plate Serial No	Pieces	Tons	Dir.	(psi) Yield	(psi) Tensile	Elongation % in 2"	Elongation % in 8"		Dir.	1	(%) shear	2	(%) shear	3	(%) shear	Ave.	(%) shear	Size	Temp	Min Ave.
1502825-08	5	12.25	T	53,500	79,600		24.4													
1502825-09	5	12.25	T	51,000	76,100		24.8													
1502825-10	5	12.25	T	51,800	78,300		25.8													
1502825-08	5	12.25	T	55,800	76,400		25.8	N												
1502825-09	5	12.25	T	60,600	72,800		25.0	N												
1502825-10	5	12.25	T	49,800	75,800		24.9	N												

Part #19

VERIFIED BY
JUN 20 2011
EEC QC DEPT

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

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.

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 (#008063) by SRI Quality System Registrar (#0985-09). PED 97/23/EC 7/2 Annex 1, Para. 4.3 Compliant. DIN 50049 3.1.B/EN 10204 3.1B(2004), DIN EN 10204 3.1(2005) compliant. For ABS grades only. Quality Assurance certificate 09-MMPQA-546

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

T. A. Depretis, Metallurgist

05/12/2011 12:52:48 PM

NUCOR
NUCOR STEEL TUSCALOOSA, INC.

MILL TEST CERTIFICATE

1700 HOLT RD N.E.
Tuscaloosa, AL 35404-1000
800-827-8872

NU 331

Load Number	Tally	Mill Order Number	P.O. Number	Part Number	Certificate Number	Date
387479	00000000412159	N-106041-003	MUS-233438		L328209-1	06/06/2011 17:48

Grade

Customer:

Order Description:
A516 70, 0.3750 IN x 96.000 IN x 480.000 IN

Quality Plan Description:
A51670 NORM: ASTM A516-70-06/ASME SA516-70-06 09 add NORMTEST

Sold TO:
METALS USA MUSKOGEE OK

Ship TO:
Metals USA Muskogee OK

X-7929-120

Shipped Item	Heat/Slab Number	Certified By	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Cb	V	Al	Ti	N2	B	Ca	Sn	CEV
1E3293E	A1S1804-03 ***	A1S1804	0.23	1.08	0.009	0.006	0.19	0.18	0.08	0.09	0.023	0.001	0.002	0.038	0.001	0.007	0.0001	0.0031	0.011	0.45
* 1E3292B	A1S1804-02 ***	A1S1804	0.23	1.08	0.009	0.006	0.19	0.18	0.08	0.09	0.023	0.001	0.002	0.038	0.001	0.007	0.0001	0.0031	0.011	0.45

Shipped Item	Certified By	Heat Number	Yield ksi	Tensile ksi	Y/T %	ELONGATION % 2"	ELONGATION % 8"	Bend OK?	Hard HB	Charpy Impacts (ft-lbf) Size mm	1	2	3	Avg	Shear % 1	2	3	Avg	Test Temp
1E3293E	S1E3293BTT	A1S1804 ***	50.6	72.7	69.6	33.0													
1E3293E	S1E3293FTT	A1S1804 ***	49.2	77.5	63.5	32.8													
1E3293E	S1E3293MTT	A1S1804 ***	49.5	72.9	67.9	34.0													
1E3293E	S1E3293NBT	A1S1804 ***	53.8	75.4	71.4	36.0													
1E3293E	S1E3293NFT	A1S1804 ***	54.0	75.7	71.3	36.2													
1E3293E	S1E3293NMT	A1S1804 ***	52.8	75.5	69.9	34.8													
1E3292B	S1E3292BTT	A1S1804 ***	50.6	72.6	69.7	33.1													
1E3292B	S1E3292FTT	A1S1804 ***	55.1	77.7	70.9	33.8													
1E3292B	S1E3292MTT	A1S1804 ***	49.7	72.0	69.0	33.2													
1E3292B	S1E3292NBT	A1S1804 ***	53.3	75.7	70.4	34.6													
1E3292B	S1E3292NFT	A1S1804 ***	51.9	75.2	69.0	37.3													
1E3292B	S1E3292NMT	A1S1804 ***	51.0	74.8	68.2	34.7													

VERIFIED BY
SEP 20 2011
EEC QC DEPT
L. Patterson

Items: 2 PCS: 8 Weight: 39205 LBS

Mercury has not come in contact with this product during the manufacturing process not has any mercury been used by the manufacturing process. Certified in accordance with EN 10204 3.1. No weld repair has been performed on this material. 1650 F FOR 60 MIN PER INCH OF THICKNESS NACE MR0175 ANNEX 2.1.2 COMPLIANT Manufactured to a fully killed fine grain practice. ** Produced from Coil **
ISO 9001:2008 Registered, PED Certified

"***" indicates Heats melted and Manufactured in the U.S.A.

We hereby certify that the product described above passed all of the tests required by the specifications.

April Pitts - QA Engineer

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

Part #13

NUCOR
NUCOR STEEL TUSCALOOSA, INC.

MILL TEST CERTIFICATE

1700 HOLT RD N.E.
Tuscaloosa, AL 35404-1000
800-827-8872

STOCK LIFTING LUGS

Load Number	Tally	Mill Order Number	P.O. Number	Part Number	Certificate Number	Date
389976	00000000417856	N-106993-003	32981		L333877-1	07/23/2011 04:48

Grade

Customer:

Order Description:
A516 70, 0.5000 IN x 96.000 IN x 480.000 IN
Quality Plan Description:
A/SA516-70: ASTM A516-70-10/ASME SA516-70 2009 ADDENDA

Sold TO:
STEEL SERVICE COMPANY CLAREMORE OK
Ship TO:
STEEL SERVICE COMPANY Catoosa OK

1/2" x 3 1/2" x 8 3/4" LG.

Shipped Item	Heat/Slab Number	Certified By	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Cb	V	Al	Ti	N2	B	Ca	Sn	CEV
1G1767D	B1T7537-03 ***	B1T7537	0.23	1.11	0.010	0.007	0.20	0.20	0.07	0.07	0.011	0.000	0.002	0.037	0.001	0.007	0.0001	0.0031	0.007	0.45
1G1767E	B1T7537-03 ***	B1T7537	0.23	1.11	0.010	0.007	0.20	0.20	0.07	0.07	0.011	0.000	0.002	0.037	0.001	0.007	0.0001	0.0031	0.007	0.45

Shipped Item	Certified By	Heat Number	Yield ksi	Tensile ksi	Y/T %	ELONGATION % 2"	8"	Bend OK?	Hard HB	Charpy Impacts (ft-lbf) Size mm	1	2	3	Avg	Shear % 1	2	3	Avg	Test Temp
1G1767D	S1G1767BTT	B1T7537 ***	54.5	72.7	75.0	33.7													
1G1767D	S1G1767FTT	B1T7537 ***	55.5	76.3	72.7	34.2													
1G1767D	S1G1767MTT	B1T7537 ***	52.5	72.7	72.2	33.4													
1G1767E	S1G1767BTT	B1T7537 ***	54.5	72.7	75.0	33.7													
1G1767E	S1G1767FTT	B1T7537 ***	55.5	76.3	72.7	34.2													
1G1767E	S1G1767MTT	B1T7537 ***	52.5	72.7	72.2	33.4													

X-7929-62 Cut to 6 1/2" lg.

Name PIONEER
PO# 767386
Count 1
Size 1/2 X 96 X 240 A516-70
Heat# B1T7537-03

PIONEER STEEL INC.
DATE 2.21.12 QTY. 100
PO# 1874
PART# STOCK
BY

Items: 2 PCS: 6 Weight: 39205 LBS

Mercury has not come in contact with this product during the manufacturing process not has any mercury been used by the manufacturing process. Certified in accordance with EN 10204 3.1. No weld repair has been performed on this material. Manufactured to a fully killed fine grain practice. ** Produced from Coil **
ISO 9001:2008 Registered, PED Certified

*** Indicates Heats melted and Manufactured in the U.S.A.

We hereby certify that the product described above passed all of the tests required by the specifications.

April Pitts

April Pitts - QA Engineer

VERIFIED BY
2 3 2012
EEC QC DEPT
L. Patterson

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Cut #14

SSAB

Test Certificate

Form TC1: Revision 1: Date 31 Oct 2000

13609 Industrial Road, Houston, TX 77015

Customer: METALS USA PLATES & SHAPES SOU P.O. BOX 3528 101 EAST ILLINOIS ENID OK 73702	Customer P.O. No.: MUS-231893	Mill Order No.: 41-277716-01	Shipping Manifest : HT864418
	Product Description: ASTM A516-70(06)/ASME SA516-70(09A) STOCK NB BRACKETS	Ship Date: 07 Sep 10 Cert Date: 07 Sep 10	Cert No: 031110772 (Page 1 of 1)
	Size: 0.188 X 96.00 X 480.0 (IN)	X-7929-61	

Tested Pieces				Tensiles					Charpy Impact Tests								
Heat Id	Piece Id	Piece Dimensions	Tst Loc	YS (PSI)	UTS (PSI)	%RA	Elong % 2in	Tst Dir	Average Hardness	Abs. Energy(FTLB) 1 2 3 Avg	% Shear 1 2 3 Avg	Tst Tmp	Tst Dir	Tst Siz (mm)	BDWTT Tmp %Shr
W0B789	0051	0.187 X 96.00 (T.L.C)	L	58000	75000		27	T							
			C	59000	75000		26	T							
			T	61000	74000		25	T							
W0H543	0024	0.187 X 96.00 (T.L.C)	L	55000	70000		28	T							
			C	56000	71000		27	T							
			T	54000	70000		31	T							

Heat Id	Chemical Analysis C	Mn	P	S	Si	Tot Al	Sol Al	Cu	Ni	Cr	Mo	Cb	V	Ti	CEV	ORGN
W0B789	.19	1.11	.014	.005	.20	.019	.017	.28	.14	.12	.05	.003	.006	.012	.44	USA
* W0H543	.19	1.10	.009	.003	.21	.030	.029	.26	.14	.09	.05	.003	.005	.014	.42	USA

MERCURY IS NOT A METALLURGICAL COMPONENT OF THE STEEL AND NO MERCURY WAS INTENTIONALLY ADDED
DURING THE MANUFACTURE OF THIS PRODUCT
KILLED STEEL, PRODUCED TO A FINE GRAIN PRACTICE
CEV (IIW) = C + MN/6 + (CR+MO+V)/5 + (NI+CU)/15
MATERIAL MARKED WITH AN ASTERISK IS PRODUCED FROM COIL
MTR DIN EN10204:2004 TYPE 3.1 COMPLIANT
100% MELTED AND MANUFACTURED IN THE USA.
PRODUCTS SHIPPED:
* W0B789 0051 PCES: 6, WGT: 14741 * W0H543 0024 PCES: 12, WGT: 29482

ENERGY EXCHANGER
PO#1462
SO#203277

HT#W0H543 SL#0024
ITEM#1 65PCS

VERIFIED BY
SEP 19 2011
EEC QC DEPT

Cust Part # :

WE HEREBY CERTIFY THAT THIS MATERIAL WAS TESTED IN ACCORDANCE WITH, AND MEETS THE REQUIREMENTS OF, THE APPROPRIATE SPECIFICATION

Jason Thomas
SENIOR METALLURGIST

Reviewed / Accepted
I.Q.S. # 3

Last # 15

We hereby certify that the test results presented here

We hereby certify that the test results presented here
are accurate and conform to the reported grade specification

Daniel J. Schacht
Daniel J. Schacht
Quality Assurance Manager

CMC STEEL TEXAS
1 STEEL MILL DRIVE
SEGUIN TX 78155-7510

CERTIFIED MILL TEST REPORT

For additional copies call
830-372-8771

STOCK X-7929-G-5

HEAT NO.:3018892 SECTION: FLAT 1/4x1-1/2 20'0" A36/52950 GRADE: ASTM A36-08/A529-05 Gr 50 ROLL DATE: 09/03/2010 MELT DATE: 08/24/2010	S O L D T O	Steel Service Co - OK 24412 Amah Pkwy Claremore OK US 74019-4304 9183416322 9183416390	S H I P T O	Steel Service Co - OK 24412 Amah Pkwy Claremore OK US 74019-4304 9183416322 9183416390	Delivery#: 80441928 BOL#: 70155381 CUST PO#: 33419 CUST P/N: DLVRY LBS / HEAT: 9216.000 LB DLVRY PCS / HEAT: 362 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.19%				
Mn	0.67%				
P	0.013%				
S	0.040%				
Si	0.17%				
Cu	0.30%				
Cr	0.12%				
Ni	0.09%				
Mo	0.023%				
V	0.009%				
Cb	0.001%				
Sn	0.013%				
Al	0.002%				
Carbon Eq A529	0.39%				
Yield Strength test 1	52.5ksi				
Tensile Strength test 1	72.5ksi				
Elongation test 1	26%				
Elongation Gage Lgth test 1	8IN				

THIS MATERIAL IS FULLY KILLED, 100% MELTED AND MANUFACTURED IN THE USA, WITH NO WELD REPAIR OR MERCURY CONTAMINATION IN THE PROCESS.

REMARKS :
MEETS THE REQUIREMENTS OF ASME SA36-2008A

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

01/28/2011 14:51:32

CHECKED FEB 2 4 2011
L Patterson

Lot # 16

Benteler Stahl/Rohr GmbH
Postfach 13 40
33043 Paderborn
Deutschland
Tel.: +49.5254.81-0 Fax: +49.5254.13666

BENTELER
Stahl/Rohr

ABNAHMEPRÜFZEUGNIS EN 10204-3.1

INSPECTION CERTIFICATE EN 10204-3.1
CERTIFICAT DE RECEPTION EN 10204-3.1
EN 10204:2005-01

Benteler Stahl/Rohr GmbH - Postfach 1340 - 33043 Paderborn - Deutschland

Webco Industries, Inc.
9101 West 21st Street
SAND SPRINGS, OK 74063
USA

Dokument-Nr.: **Document No.:** No. du document:	41-488044/001/P	Prüf-Nr.: **Inspection No.:** No. du certificat:	Blatt: 1 / 6 **Page:** Page:
Kunden-Bestell-Nr.: **Purchase Order No.:** No. de commande du client:	BST 08-7130 / Webco 10013785	Hersteller: **Manufacturer:** Producteur:	Warmrohrwerk/Zieherei ISO/TS 16949 (ISO 9001) DNV CERT-11674A-2003 PED 97/23/EC TÜV CERT 07-202-5635 WZ-0606/07
Benteler Auftrags-Nr.: **Benteler Order No.:** No. de commande Benteler:	1530657	Herstellerzeichen: **Manufacturer's brand:** Marque du producteur:	
Versandanzeigen-Nr.: **Dispatch Note No.:** No. d'avis d'expédition:	4128151	Stempel des Abnahmebeauftragten: **Stamp of the inspection representative:** Timbre du contrôleur:	WA
Produkt: **Product:** Produit:	NAHTLOSE STAHLROHRE SEAMLESS STEEL TUBES TUBES D' ACIER SANS SOUDURE	Stahlerschmelzungsverfahren: **Steelmaking process:** Procédé d'élaboration de l'acier:	ELEKTROSTAHL ELECTRIC FURNACE FOUR ELECTRIQUE

Lieferbedingungen: **Terms of delivery:** Conditions de livraison:	ASTM-A 179-1990a, ASME SA-179, ASME Section II Part A Edition 2007 X 7929
Maße - Toleranzen: **Dimensions-tolerances:** Dimensions-tolérances:	ASME SA-450-CD, ASME Section II Part A Edition 2007, ASTM-A 450-2004a-CD (390 pcs.)
Stahlsorte: **Steel grade:** Nuance d'acier:	A 179, SA 179
Lieferzustand: **Delivery condition:** État de livraison:	Normalized CHECKED FEB 2 2 2010
Produktkennzeichnung: **Product marking:** Marquage du produit:	see attachment product marking

Pos. **Item** Poste	Stück **Number** Nombre	Maße **Dimensions** Dimensions	Länge **Length** Longueur feet	Gewicht **Weight** Poids lbs	Schmelzen-Nr. **Heat No.** No. de coulée	Prüfdruck **Test pressure** Pression d'épreuve	Rohr-Nr.-Gruppe **Tube number group** Série de no. des tubes	Vielfachlängen **Multiple lengths** Longueurs multiples
0001	318	0.750" O.D. * 0.083" MW 29 FT 1 "	9247,90	5851	181070 ←	(390 pcs)		
0002	385	0.750" O.D. * 0.083" MW 30 FT 1 "	11581,59	7291	181070			
0003	244	0.750" O.D. * 0.083" MW 31 FT 3 "	7625,00	4815	181070			

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

Benteler Stahl/Rohr GmbH
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33043 Paderborn
Deutschland
Tel.: +49.5254.81-0 Fax: +49.5254.13666

BENTELER
Stahl/Rohr

ABNAHMEPRÜFZEUGNIS EN 10204-3.1

INSPECTION CERTIFICATE EN 10204-3.1
CERTIFICAT DE RECEPTION EN 10204-3.1

Dokument-Nr.: **Document No.:** No. du document: 41-488044/001/P

Prüf-Nr.: **Inspection No.:** No. du certificat:

Pos. Item Poste	Stück Number Nombre	Maße Dimensions Dimensions	Länge Length Longueur feet	Gewicht Weight Poids lbs	Schmelzen-Nr. Heat No. No. de coulée	Prüfdruck Test pressure Pression d'épreuve	Rohr-Nr.-Gruppe Tube number group Série de no. des tubes	Vielfachlängen Multiple lengths Longueurs multiples
0004	153	0.750" O.D. * 0.083" MW 37 FT 1 "	5673,75	3583	181069			
0005	187	0.750" O.D. * 0.083" MW 38 FT 1 "	7121,10	4497	181069			
0006	262	0.750" O.D. * 0.083" MW 40 FT 2 "	10523,03	6706	181073			
0007	427	0.750" O.D. * 0.083" MW 41 FT 1 "	17542,36	11158	181073			
0008	472	0.750" O.D. * 0.083" MW 42 FT 1 "	19863,39	12606	181073			
0009	491	0.750" O.D. * 0.083" MW 43 FT 1 "	21152,70	13395	548853			
0010	195	0.750" O.D. * 0.083" MW 44 FT 1 "	8595,87	5423	548853			
0011	139	0.750" O.D. * 0.083" MW 45 FT 1 "	6266,40	4001	548853			
0012	140	0.750" O.D. * 0.083" MW 46 FT 1 "	6451,58	4123	548853			
0013	231	0.750" O.D. * 0.083" MW 51 FT 6 "	11896,39	7571	549318			

72 pcs

Schmelzenanalyse [%] / Heat analysis [%] / Analyse sur coulée [%]

Pos. Item Poste	Schmelzen-Nr. Heat No. No. de coulée	C	Si	Mn	P	S
0001	181070	0,100	0,160	0,48	0,008	0,003
0002	181070	0,100	0,160	0,48	0,008	0,003
0003	181070	0,100	0,160	0,48	0,008	0,003
0004	181069	0,100	0,160	0,48	0,008	0,003
0005	181069	0,100	0,160	0,48	0,008	0,003
0006	181073	0,100	0,170	0,47	0,010	0,003
0007	181073	0,100	0,170	0,47	0,010	0,003
0008	181073	0,100	0,170	0,47	0,010	0,003
0009	548853	0,100	0,160	0,47	0,007	0,002
0010	548853	0,100	0,160	0,47	0,007	0,002
0011	548853	0,100	0,160	0,47	0,007	0,002
0012	548853	0,100	0,160	0,47	0,007	0,002

Part #117

Reviewed / Accepted
I.Q.S. #3
William Bronaugh

Benteler Stahl/Rohr GmbH
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BENTELER
Stahl/Rohr

ABNAHMEPRÜFZEUGNIS EN 10204-3.1
INSPECTION CERTIFICATE EN 10204-3.1
CERTIFICAT DE RECEPTION EN 10204-3.1

Dokument-Nr.: / **Document No.:** / No. du document: 41-488044/001/P

Prüf-Nr.: / **Inspection No.:** / No. du certificat:

Schmelzenanalyse [%] / **Heat analysis [%]** / Analyse sur coulée [%]

Pos. / **Item** / Poste	Schmelzen-Nr. / **Heat No.** / No. de coulée	C	SI	MN	P	S
0013	549318	0,100	0,150	0,46	0,013	0,003

Prüfergebnisse / **Test results** / Résultats des essais

Die Rohre sind auf Dichtheit geprüft durch: / **The tubes have been submitted to a leak tightness test by:** / Les tubes ont passé un contrôle d'étanchéité par:	Hydrostatic test: eddy current testing instead of hydrostatic test	PASSED
Die Rohre wurden zerstörungsfrei geprüft: / **The tubes are non destructive tested:** / Les tubes ont passé un essai non destructif:	ET-test: acc. to ASME SA-450, ASTM-A 450; acc. to ASTM-E 309; imperfections	PASSED

Augensichtkontrolle: / **Visual inspection:** / Examen visuel:	PASSED	Aufweitversuch: / **Drift expanding/flare test:** / Essai d'évasement:	PASSED	Maßkontrolle: / **Dimensions examination:** / Vérification des dimensions:	PASSED
Ringfaltversuch: / **Flattening test:** / Essai d'aplatissement:	PASSED				

Ergebnisse der mechanischen Prüfung / **Results of mechanical testing** / Résultats des essais mécaniques

Die Probennahme erfolgte an Vielfachlängen.
The sampling was carried out on multiple lengths.
L'echantillonage etait realise aux longueurs multiples.

Härteprüfung / **Hardness test** / Essai de dureté

Pos. / **Item** / Poste	Proben-Nr. / **Specimen No.** / No. de l'éprouv.	Schmelzen-Nr. / **Heat No.** / No. de coulée	Härte / **Hardness** / Dureté	HRC	HB	HV	HRB	HBW
Anforderungen / **Requirements** / Exigences							MAX 72	
0001	000001	181070					064	
0001	000002	181070					065	

Part # 17

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

Benteler Stahl/Rohr GmbH
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BENTELER
Stahl/Rohr

ABNAHMEPRÜFZEUGNIS EN 10204-3.1
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Dokument-Nr.: 41-488044/001/P
Document No.:
No. du document:

Prüf-Nr.:
Inspection No.:
No. du certificat:

Härteprüfung / **Hardness test** / Essai de dureté

Pos. **Item** Poste	Proben-Nr. **Specimen No.** No. de l'éprouv.	Schmelzen-Nr. **Heat No.** No. de coulée	Härte **Hardness** Dureté				
Anforderungen **Requirements** Exigences			HRC	HB	HV	HRB MAX 72	HBW
0001	000003	181070				065	
0001	000004	181070				063	
0002	000001	181070				064	
0002	000002	181070				065	
0002	000003	181070				065	
0002	000004	181070				063	
0003	000001	181070				064	
0003	000002	181070				065	
0003	000003	181070				065	
0003	000004	181070				063	
0004	000001	181069				064	
0004	000002	181069				064	
0005	000001	181069				064	
0005	000002	181069				065	
0006	000001	181073				063	
0006	000002	181073				064	
0006	000003	181073				063	
0006	000004	181073				063	
0007	000001	181073				063	
0007	000002	181073				063	
0007	000003	181073				064	
0007	000004	181073				063	
0008	000001	181073				063	

Part #17

Reviewed / Accepted
~~I.Q.S. # 3~~
William Brenaugh WB

Benteler Stahl/Rohr GmbH
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BENTELER
Stahl/Rohr

ABNAHMEPRÜFZEUGNIS EN 10204-3.1
INSPECTION CERTIFICATE EN 10204-3.1
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Inspection No.:
No. du certificat:

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Page:
Page:

Härteprüfung / **Hardness test** / Essai de dureté

Pos. **Item** Poste	Proben-Nr. **Specimen No.** No. de l'éprouv.	Schmelzen-Nr. **Heat No.** No. de coulée	Härte **Hardness** Dureté				
Anforderungen **Requirements** Exigences			HRC	HB	HV	HRB MAX 72	HBW
0008	000002	181073				064	
0008	000003	181073				064	
0008	000004	181073				065	
0008	000005	181073				063	
0008	000006	181073				063	
0009	000001	548853				064	
0009	000002	548853				065	
0009	000003	548853				065	
0009	000004	548853				064	
0010	000001	548853				064	
0010	000002	548853				065	
0011	000001	548853				064	
0011	000002	548853				065	
0012	000001	548853				064	
0012	000002	548853				065	
0013	000001	549318				065	
0013	000002	549318				064	

Vermerk / **Remark** / Remarque

Certificate remarks: Steel and tubes manufactured by Benteler Stahl / Rohr ✓

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Kemper County MM209937

Benteler Stahl/Rohr GmbH
Postfach 13 40
33043 Paderborn
Deutschland
Tel.: +49.5254.81-0 Fax: +49.5254.13666

BENTELER
Stahl/Rohr

ABNAHMEPRÜFZEUGNIS EN 10204-3.1
INSPECTION CERTIFICATE EN 10204-3.1
CERTIFICAT DE RECEPTION EN 10204-3.1

Dokument-Nr.: 41-488044/001/P
Document No.:
No. du document:

Prüf-Nr.:
Inspection No.:
No. du certificat:

Blatt: 6 / 6
Page:
Page:

Beiblatt Produktkennzeichnung / **Attachment product marking** / Supplément marquage du produit

Pos. / **Item** / Poste	Produktkennzeichnung / **Produktkennzeichnung** / Marquage du produit
0001, 0002, 0003, 0004, 0005, 0006, 0007, 0008, 0011, 0012	
	FS: BENTELER A179-SA179 HEAT-NO. DIMENSIONS TUBES-LENGTH FEET 2008 WA MADE IN GERMANY
0009, 0010	
	FS: BENTELER A179-SA179 HEAT-NO. DIMENSIONS TUBES-LENGTH FEET 2108 WA MADE IN GERMANY
0013	FS: BENTELER A179-SA179 HEAT-NO. DIMENSIONS TUBES-LENGTH FEET 2408 WA MADE IN GERMANY

AEZ = Ätzlinienbeschriftung, Etching ink marking, Gravure à l'encre FK = Farbkennzeichnung, colour marking, marquage par couleur FS = Farbschablonierung, paint stencilling, marquage par peinture FSD = Farbstrahldrucker, Colour jet printer, Imprimante à jet d'encre de c LS = Längsschablonierung, longitudinal stencilling, marquage longitudinal par peinture PKE = Etikettenkennzeichnung, tag marking, marquage sur étiquette PS = Prägestempel, die stamp, marquage par poinçonnage TS = Tintenstrahlkennzeichnung, ink jet spray marking, imprimante à jet d'encre

Verkäufer(in) / **Salesman/ woman in charge** / Personne chargée : Mr Buerger, Tel.: 05254/81-4266, Fax: 4299

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh 6/12

Paderborn Schloß Neuhaus, 24.06.2008, TEL.: 05254.81-1767 FAX: 05254.81-1752

Abnahmebeauftragter
Inspection representative
Contrôleur
ALWIN PANKRATZ / TEM

Es wird bestätigt, daß die gelieferten Erzeugnisse den techn. Lieferbedingungen des Auftrages entsprechen.Dieses Dokument wurde mittels EDV erstellt und ist ohne Unterschrift rechtsgültig.
We certify that the supplied products comply with the order specification.This document was prepared by means of electronic data processing and is valid without signature.
Nous attestons que les produits livrés sont conformes aux stipulations de la commande.Ce document a été établi par traitement électronique de l'information et est valide sans signature.

Pole #17

DATE: 01/12/12

W. M. HEITGRAS COMPANY
P.O. BOX 2044
1316 N. OSAGE DRIVE
TULSA, OKLAHOMA 74101
(918) 583-3131

part #18

CERTIFIED MATERIAL TEST REPORT

ENERGY EXCHANGERS
1844 N. GARNETT RD.
TULSA OK 74116

LOT # 10037360
HEAT # 10037360
STOCK # B7S075C525
3/4-10 X 5-1/4 ASTM A-193 B-7
CUS PO# 1744
ORDER # 28168

X-7929-41+42

SPECIFICATIONS:

ASTM A193 B7 ALL THREAD ROD

VENDOR: VULCAN THREADED PRODUCTS, INC. QTY SOLD 40

-- CHEMICAL COMPOSITION --

C %	MN %	P %	S %	SI %	NI %	CR %
00.4000	00.8400	00.0090	00.0250	00.2500	00.0600	00.9200

MO %	CU %	CO %	V %	AL %	FE %	TA %
00.2100	00.1200		00.0030	00.0270		

TI %	ZN %	SE %	CB %	W %	N %	SN %
						00.0080

-- CHARPY IMPACT --

FIRST: 0 SECOND: 0 THIRD: 0 AVERAGE: 0

-- MECHANICAL PROPERTIES --

TENSILE STRENGTH: 132,200 Psi
YIELD : 121,500
ELON : 22.00
RA : 65.00

HARDNESS : 28 HRC
PROOF STRESS: 0 Psi

COMMENTS:

MELTED & MFG IN THE USA
TEMPERING TEMP 1415 F
META SI/RI/CI

VERIFIED BY

EEC QC DEPT

L. Patterson

W.M. HEITGRAS COMPANY

QUALITY CONTROL MANAGER

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

INSPECTION CERTIFICATE

Customer	Specification	Size	Lot No.	Date
	ASTM A-194 GRADE 2H HEAVY HEX NUT	3/4-10 UNC	SS161	May 09,'11

UNYTITE, INC.
One Unytite Drive
Peru, Illinois 61354
815-224-2221 — FAX# 815-224-3434

Mechanical properties tested in accordance to ASTM F606/F606M, ASTM A370, ASTM E18

X-7424-43

Chemical Composition STOCK (%)

Mill Maker	Material Size	Heat No. / Spec.	C	Si	Mn	P	S	Cu	Ni	Cr	Mo
			MIN	MAX.	MAX.	MAX	MAX.				
GERDAU AMER. CARBON			0.40	0.40	1.00	0.040	0.050	-	-	-	-
ISTEEL (NO STEEL		M664330	0.45	0.72	0.72	0.015	0.020	0.28	0.10	0.16	0.01

Shape & Dimension Inspection	ANSI B18.2.2 GOOD
Thread Precision Inspection	ANSI B1.1 CLASS 2B GOOD
Appearance Inspection	GOOD

Mechanical Property Inspection

Item	Proof Load	Cone stripping	Hardness	After Heat Treatment Hardness	Absorbed Energy
Spec.	58,450 lbf	-	24 -38 HrC	MIN. 99 HrB-HB	J-kgf-m-ftlbf
	n	n		5 Piece Average After Heat Treatment	
	5	-	28.9 29.1 27.6 28.1 28.6	105.4	
Results	Results	Results	28.5		
	GOOD	-		Hardness Treatment 1000 After 24 Hr.X °F(°C)	at °F(°C)

Heat Treatment

T:MIN. 850 F

Q: FORGING Q (W.Q.).

T:1202 F/45M. (W.C.)

Q: Quenching
T: Tempering
ST: Solution Treatment

Remarks:

" 2H U "

Production Quantity
46,735 pcs.

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

OFFICIAL SEAL
JEAN MARGHERIO
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES:10/18/13

05-10-11

Material used for the nut was melted and manufactured in the USA. The nut was manufactured in the USA to the above specification.

Chief of Quality Assurance Section

We hereby certify that the material described has been manufactured and inspected satisfactorily with the requirement of the above specification.

JUN - 6 2011
VERIFIED BY
EEC QC DEPT

Part # 19

MATERIAL CERTIFICATION REPORT

ArcelorMittal

ArcelorMittal LaPlace
138 HWY 3217
LaPlace LOUISIANA 70068
Telephone (985) 652-4900

STEEL SERVICE COMPANY
24412 AMAH PARKWAY
74019 Claremore

STEEL SERVICE COMPANY
CLAREMORE, OK
6725 AMAH PARKWAY
74019 Claremore

X-7929-67

Tested in Accordance With: ASTM A6

Invoice NO.
Product Equal Angl
Heat NO. L81828
Length 20'00"

Date 01/30/2012
Cust 40006655
Grade A3652950
Size 3"X3"X1/4"X4.900

PO: 35234
Ref. 80387026
Pieces 53

CHEMICAL ANALYSIS	
C	0.15
Mn	0.85
P	0.019
S	0.031
Si	0.14
Cu	0.32
Ni	0.13
Cr	0.17
Mo	0.036
Cb	0.015
V	0.000
B	
Al	
Sn	0.013
N	
Ti	

Ci	5.8
CE	0.36

MECHANICAL PROPERTIES	TEST 1 IMPERIAL	TEST 1 METRIC	TEST 2 IMPERIAL	TEST 2 METRIC	TEST 3 IMPERIAL	TEST 3 METRIC
YIELD STRENGTH	57,500 PSI	396 MPa	55,500 PSI	383 MPa		
TENSILE STRENGTH	78,400 PSI	541 MPa	78,200 PSI	539 MPa		
ELONGATION	25 %	25 %	23 %	23 %		
GAUGE LENGTH	8 IN	203 mm	8 IN	203 mm		
BEND TEST DIAMETER						
BEND TEST RESULTS						
SPECIMEN AREA						
REDUCTION OF AREA						
IMPACT STRENGTH						

IMPACT STRENGTH	IMPERIAL	METRIC	INTERNAL CLEANLINESS		GRAIN SIZE	
AVERAGE			SEVERITY		HARDNESS	
TEST TEMP			FREQUENCY		GRAIN PRACTICE	
ORIENTATION			RATING		REDUCTION RATIO	

A36-08,A52950-05,CSA50W,44W,A70936-09a,AASHTO M270 Grade 36
ASME SA36-2008A, A57250-07, A70950-10.

VERIFIED BY
EEG QC DEPT

I hereby certify that the material test results presented here are from the reported heat and are correct. All tests were performed in accordance to the specification reported above. All steel is electric furnace melted (billets), manufactured, processed, and tested in the U.S.A with satisfactory results, and is free of Mercury contamination in the process. No weld repair was performed on this heat.

Signed Mark Edwards
MARK EDWARDS, QUALITY ASSURANCE SUPERVISOR

Notarized upon request:
Sworn to and subscribed before me in and for ST. John Parish on this 30th day of January, 2012

Michael E. Soileau, #81887, Notary Public

Direct any questions or necessary clarifications concerning this report to the Sales Department 1-800-535-7692 (USA)

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Part # 20

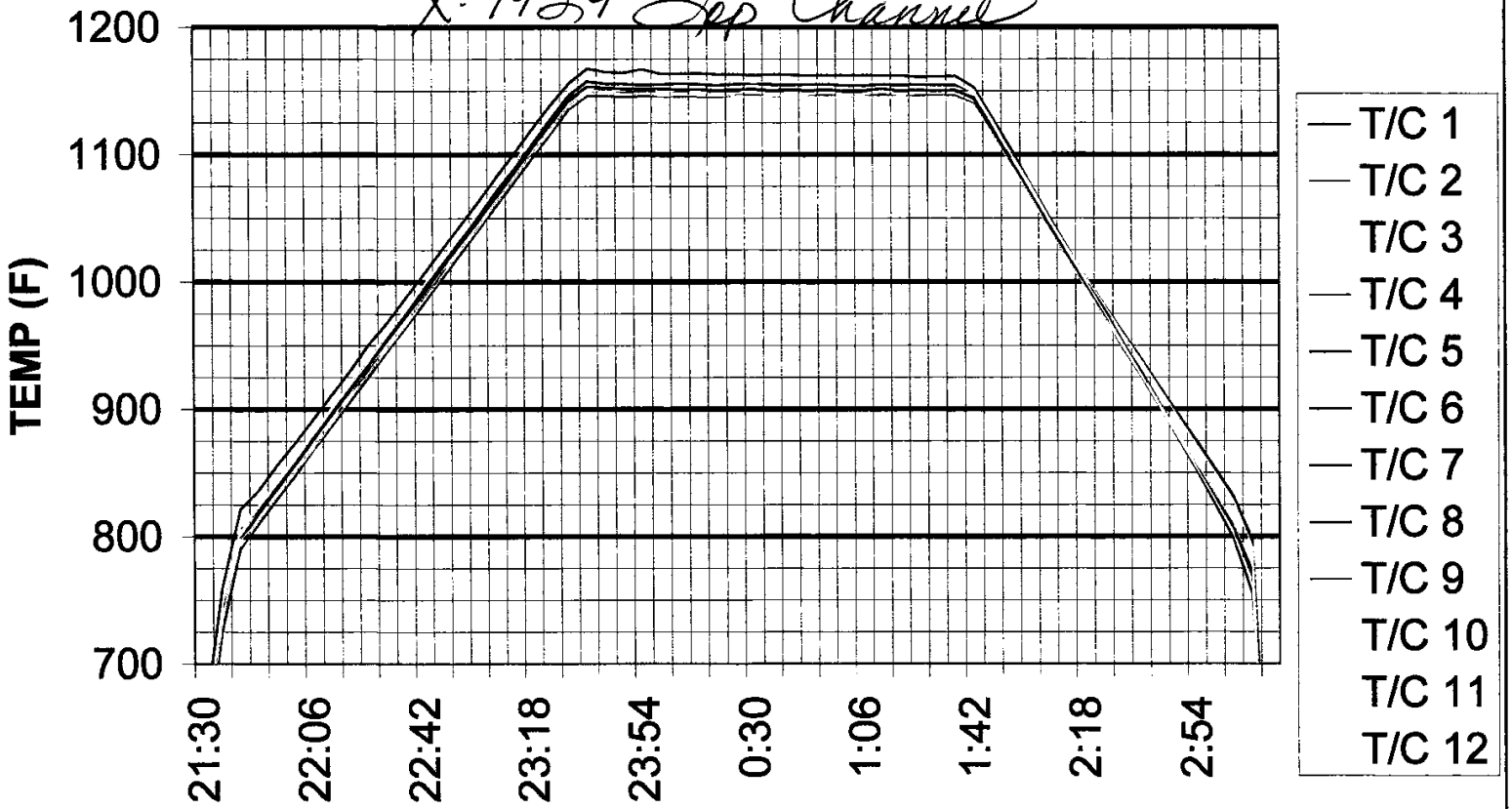
SECTION 5

ENERGY EXCHANGER
JOB# 55364
P.O.# PX 9621

8-15-12

BODYCOTE THERMAL PROCESSING FCE# 2001

X-7939 Top Channel



CALIBRATION DATE 8-10-12
CALIBRATION DUE DATE 11-10-12

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

SIGNED BY JOHN WINKLE
John Winkle

Kemper County MM209937

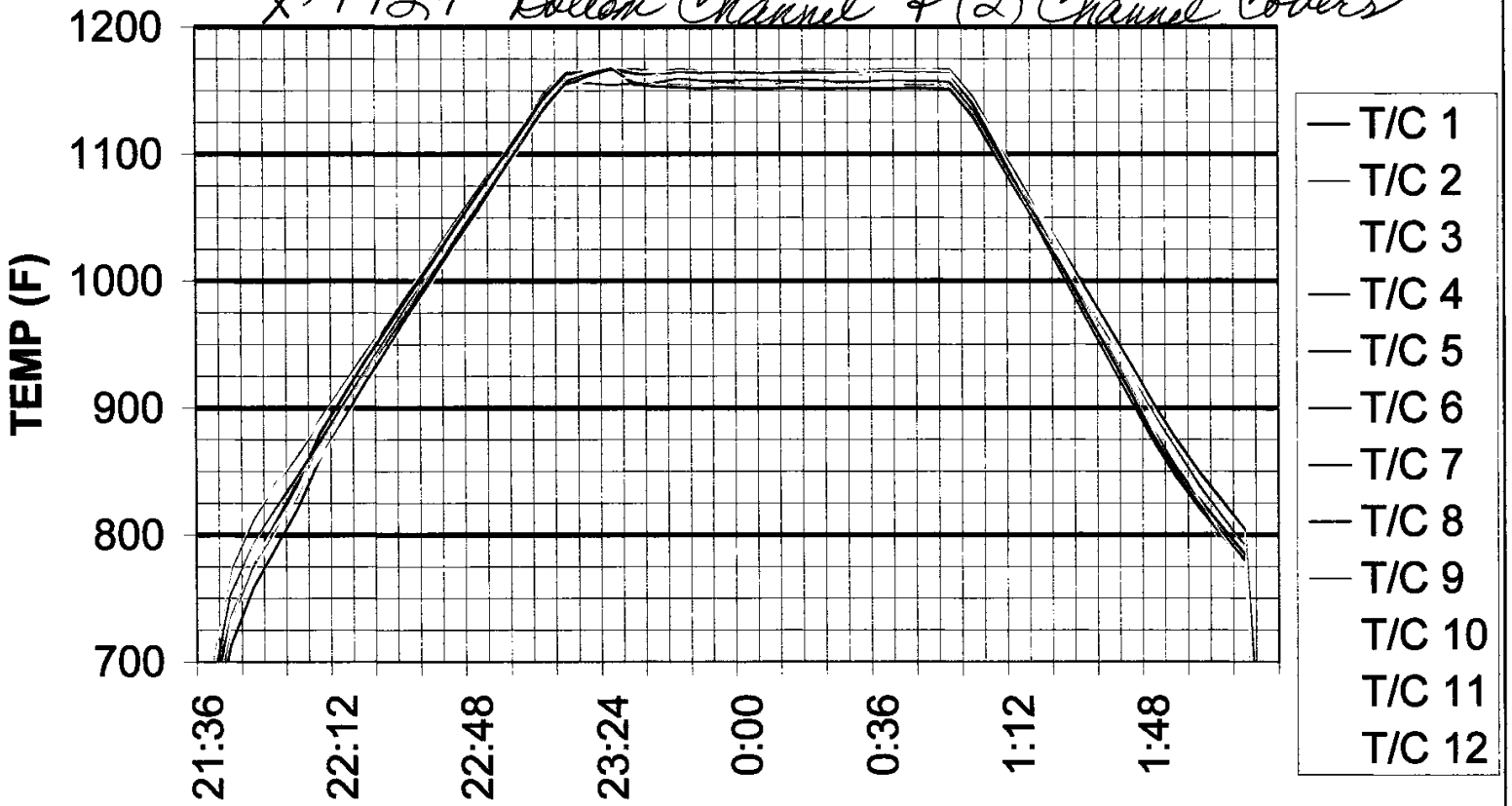
ENERGY EXCHANGER
JOB# 55344
P.O.# PX 9620

8-14-12

8/14/12

BODYCOTE THERMAL PROCESSING FCE# 2001

X-7929 Bottom Channel + (2) Channel Covers

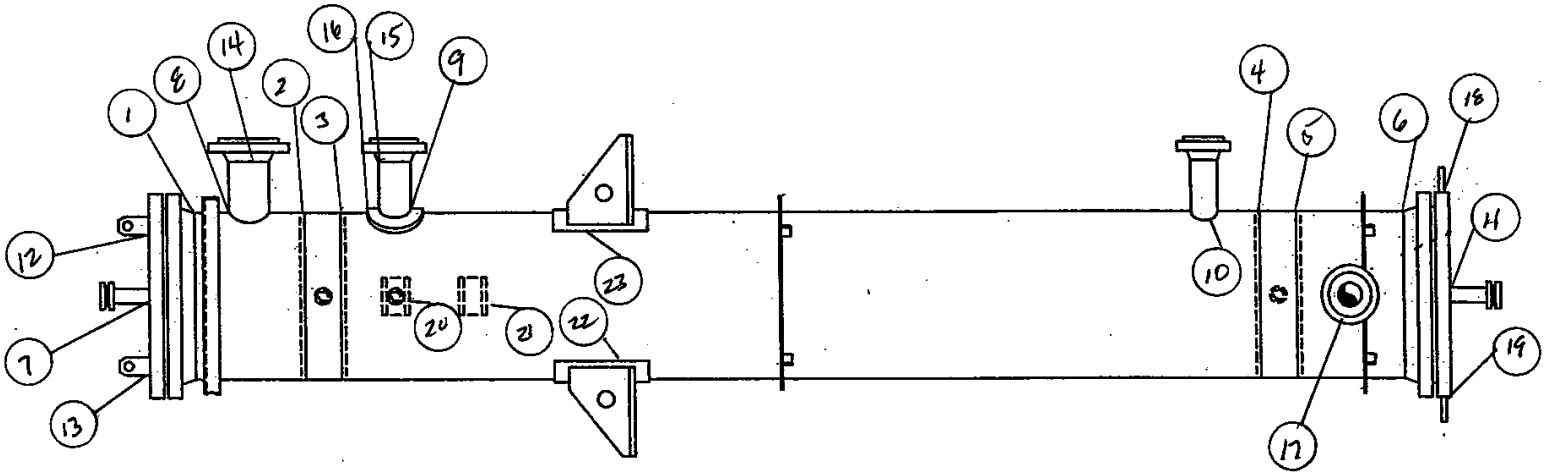


CALIBRATION DATE 8-10-12
CALIBRATION DUE DATE 11-10-12

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

SIGNED BY JOHN WINKLE
John Winkle

Kemper County MM209937



Reviewed / Accepted
I.Q.S. # 3
William Brenaugh

X-7929 NDE/WELD MAP

ENERGY EXCHANGER COMPANY

CUSTOMER: Southern Company **P.O.#:** 17496 - 0001
TAG: HX 0042 **ENERGY JOB #** X-7929

NDE / WELD INDEX

Part #	Consumable	WPS	Weld Stamp	NDE Procedure	NDE Technician
1	L-56	A-62-H	W	MT RT	MW / BC
2	L-56	A-62-H	VQ	MT	
3	E-7018-1	M-6	K	MT	
4	E-7018-1	M-6	K	MT	
5	L-56	A-62-H	VQ	MT	
6	L-56	A-62-H	W	MT RT	
7	E-7018-1	M-79-H	Z	MT	
8		M-76-H	G	MT	
9		M-1	S	MT	
10		M-1	R	MT	
11		M-79-H	D	MT	
12		M-75-H	Z	MT	
13		M-75-H	Z	MT	
14		M-6	O	MT	
15		M-5	L	MT	
16		M-1	S	MT	
17		M-1	S	MT	
18		M-75-H	S	MT	
19		M-75-H	S	MT	
20		M-1	S	MT	
21		M-1	S	MT	
22		M-1	S	MT	
23	—	M-1	S	MT	—

Reviewed / Accepted
I.Q.S. # 3
William Branaugh

ENERGY EXCHANGER COMPANY

JOB # X-7929

P.O.# 17496-0001

PART IDENTIFICATION CHANNEL B/S SPOT UW 51

TYPE OF MATERIAL SA-333-6 MATERIAL THICKNESS 24 1/2

SPECIFICATION NO: Q.C. WELDMENT CODE/STANDARD: ASME SEC. VIII, DIV. 1, A-

FILM IDENTIFICATION	ACCEPTABLE	REJECTED	FILM ARTIFACTS	SURFACE INDICATIONS	POROSITY	SLAG INCLUSIONS	CRACKS	INCOMPLETE FUSION	INADEQUATE PENETRATION	UNDERCUT	BURN THROUGH	REMARKS
Top CH R1												
1-2	✓				✓							
BOTTOM CH R1												
1-2	✓											

RADIOGRAPHIC DATA

1. RT DATE 7-31-12

2. MATERIAL EXAMINED:
   - (✓) WELDMENT
   - ( ) CASTING
   - ( ) OTHER _____

3. METHODS:
   - (✓) SINGLE EXPOSURE
   - ( ) MULTIPLE EXPOSURE
   - ( ) DOUBLE WALL TECHNIQUE
   - (✓) SINGLE WALL TECHNIQUE
   - ( ) DOUBLE WALL VIEWING
   - (✓) SINGLE WALL VIEWING
   - (✓) SINGLE FILM LOADING
   - ( ) DOUBLE FILM LOADING

4. IQI (PENETRAMETER) DATA:
   - DESIGNATION B
   - SENSITIVITY LEVEL 2/6
   - LOCATION (FS) (SS)

5. FILM DATA:
   - FILM TYPE 80
   - FILM DENSITY MAX. 3.5
   - FILM DENSITY MIN. 2.0

6. SOURCE DATA:
   - ISOTOPE ~~TM~~ IR192 SIZE, 1x1
   - CURIES 60 E.T. 1'46
   - S.O.D. 12 S.S.O.F. 1/2

RADIOGRAPHER R. Stahl RT-II

INTERPRETER B. W. III 193332 DATE REVIEWED 8-1-12

CUSTOMER INSPECTOR _____ DATE REVIEWED _____

Reviewed / Accepted
I.Q.S. # 3
William Brenaugh WB

readersheet(A99).doc

ENERGY EXCHANGER COMPANY

JOB # X-7929

P.O.# 17496-0001 APWHT

PART IDENTIFICATION Top / Bottom CH SPOT UW-51

TYPE OF MATERIAL SA-333 6 MATERIAL THICKNESS 24 1/2

SPECIFICATION NO: Q.C. WELDMENT CODE/STANDARD: ASME SEC. VIII, DIV. 1, A-

FILM IDENTIFICATION	ACCEPTABLE	REJECTED	FILM ARTIFACTS	SURFACE INDICATIONS	POROSITY	SLAG INCLUSIONS	CRACKS	INCOMPLETE FUSION	INADEQUATE PENETRATION	UNDERCUT	BURN THROUGH	REMARKS
T/CH R1												
1-2	✓											
B/CH R1												
1-2	✓											

RADIOGRAPHIC DATA

1. RT DATE 8-17-12

2. MATERIAL EXAMINED:
   - (+) WELDMENT
   - ( ) CASTING
   - ( ) OTHER _____

3. METHODS:
   - (+) SINGLE EXPOSURE
   - ( ) MULTIPLE EXPOSURE
   - ( ) DOUBLE WALL TECHNIQUE
   - (+) SINGLE WALL TECHNIQUE
   - ( ) DOUBLE WALL VIEWING
   - (+) SINGLE WALL VIEWING
   - (+) SINGLE FILM LOADING
   - ( ) DOUBLE FILM LOADING

4. IQI (PENETRAMETER) DATA:
   - DESIGNATION _____
   - SENSITIVITY LEVEL 2-2T
   - LOCATION (FS) ~~(SS)~~

5. FILM DATA:
   - FILM TYPE 80
   - FILM DENSITY MAX. 3.5
   - FILM DENSITY MIN. 2.0

6. SOURCE DATA:
   - ISOTOPE Ir192 SIZE 2x3
   - CURIES 100 E.T. 24
   - S.O.D. 12 S.S.O.F. 48

RADIOGRAPHER Dean Lowe

INTERPRETER Brown III 193332 DATE REVIEWED 8-18-12

CUSTOMER INSPECTOR _____ DATE REVIEWED _____

Reviewed / Accepted
I.Q.S. # 3
William Brown III

readersheet(A99).doc

IRISNDT

Ultrasonic Inspection Report

JOB # X-7929 Page 1 of 1
PO # Date 03/26/12

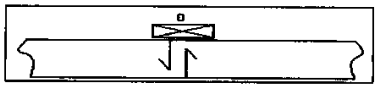
Client:	Energy Exchanger	Item Inspected:	Blind Overlay	IRISNDT#	136232
Location:	Tulsa, OK				
Code:	ASME Sec. V ART. 4				
	SA578	Heat Treatment:			

Procedure:	4.0 U.T.	Surface Condition:		As Welded				Material:	c/s
UT Equipment:	EPOCH XT	IRISNDT#		101371412				Cal Date:	2/1/2012
Calibration Block:	IIW	Probes:	Angle:(degrees)	0					
Test Piece:	ASME 3/4" Basic		Frequency:(mhz)	2.5					
Distance/Amp Cal:			Crystal Size:(inches)	1"					
Transfer Loss Cal:	Direct Comparison	Scan Gain:	+6dB	Couplant:	UT-X		Batch #		IRIS
Ref. Flaw Size:		Primary Reference Level:					80% FSH		
Scan Method:	Contact TOF	Lamination:	X	Thickness:	.		Shear Wave:		

Scope: UT Inspection Performed On Blind Overlay

Results:

X-7929 #1 - Accept
X-7929 #1A - Accept



UT Revealed No Rejectable Indications
All Welds Are Acceptable Per Code

Unit: 455	Miles:	Hrs.:	Consumables:	Technician: Mark Rake	(print)
In.	Out:			Technician: ***Mark Rake***	(sign)
In:	Out:			SNT-TC -1A Level: II cert# 522	
				I am in full agreement with report contents:	
				Client Representative:	

Reviewed / Accepted
I.Q.S. # 3
William Branaugh

Tulsa, Oklahoma
1115 West 41st Street
Phone: 918-446-8773 **Fax: 918-446-8777**

IRISNDT2529

Energy Exchanger Company
1844 N. Garnett Rd. • Tulsa, OK 74116 • www.energyexchanger.com
office (918) 437-3000
fax (918) 437-7144
info@energyexchanger.com

DATE: 8-22-12

CERTIFICATION OF EXAMINATION
BY
MAGNETIC PARTICLE (DRY POWDER METHOD)
(Procedure MT-1 Rev. 6)

P.O. # 17496-0001

TAG # HX0042

ENERGY JOB # X-7929

MT OF THE FOLLOWING:
LIFTING LUG WELDS
BACK CUTS
ALL INT + EXT WELDS BEFORE + AFTER PWHT
ALL TEMP ATTACHMENTS AND ARC STRIKES

This certification is made to document that all Magnetic Particle Examinations have been performed on X-7929 **in accordance with the requirements of ASME Section VIII, Division I, Appendix VI, ASME Section V, Article 7, customer specifications and Energy Exchanger Company drawings.**

TEST INSTRUMENT: ESC-Y400 / ESC MS-27D

PARTICLE TYPE & COLOR: DRY / GRAY **Lot:** 1774E

MATERIAL AND THICKNESS: SA-516-70 x .562

LIGHTING: 100 FT CANDLES MIN. @ SURFACE

ENERGY EXCHANGER COMPANY

Brent Wilson
Quality Control Manager
ASNT NDT Level III, #193332
CWI # 10082731

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Energy Exchanger Company

BRINELL HARDNESS REPORT

JOB NO: X-7929

COMPONENT	LOCATION	WELD METAL	BHN HEAT AFFECTED ZONE	BHN PLATE	WELD PROCEDURE NUMBER
TOP CHANNEL	R1	191	180		A-62-H
	R2	189	178		A-62-H
	T2	192	186		M-76-H
	V2	188	177		M-76-H
SHELL	R1	185	179		M-6
	R2	193	184		M-6
	S1	189	184		M-1
	S2	194	183		M-1
BOTTOM CHANNEL	R1	175	178		A-62-H
	R2	179	188		A-62-H
	T1	180	180		M-76-H
	D2	192	186		M-76-H

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

SECTION 6

Energy Exchanger Company
1844 N. Garnett Rd. • Tulsa, OK 74116 • www.energyexchanger.com
office (918) 437-3000
fax (918) 437-7144
info@energyexchanger.com

DATE: 8-21-12

CERTIFICATE OF WELD/SUPPORT PAD AIR TEST

P.O. NO: 17496-0001

TAG NO: HX 0042

ENERGY JOB NO: X-7929

This is to certify all weld/support pads on the above referenced equipment were air tested @ 15 P.S.I. and found to be satisfactory.

ENERGY EXCHANGER COMPANY

Brent Wilson
Quality Control Manager

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

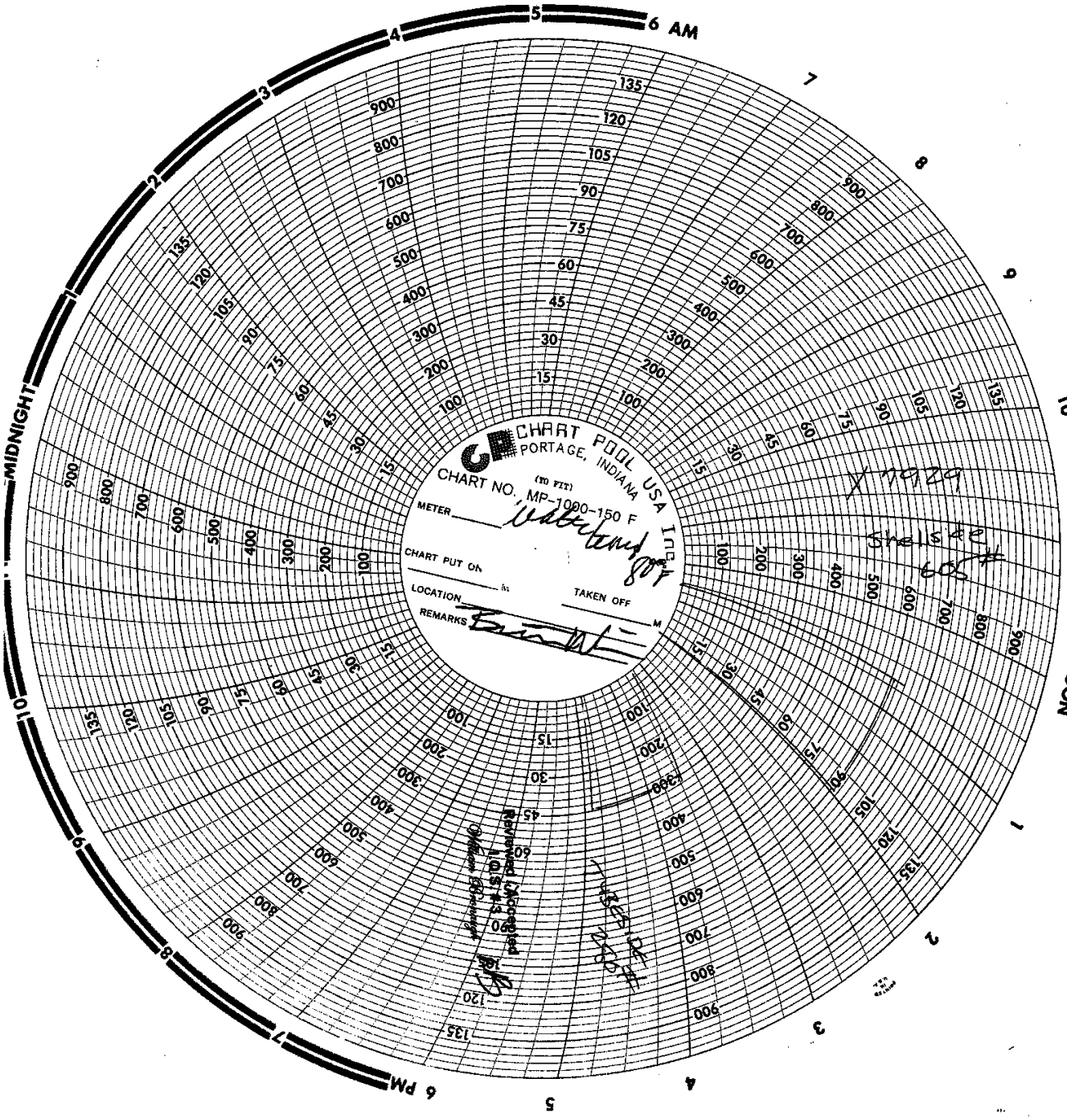


CHART POOL USA Inc.
PORTAGE, INDIANA
CHART NO. MP-1000-150 F
(10 PEN)
METER
CHART PUT ON
LOCATION
REMARKS
TAKEN OFF
MIDNIGHT
6 AM
NOON
6 PM

Energy Exchanger Company
1844 N. Garnett Rd. • Tulsa, OK 74116 • www.energyexchanger.com
office (918) 437-3000
fax (918) 437-7144
info@energyexchanger.com

DATE: 8-24-12

CERTIFICATE OF HYDROSTATIC TEST

P.O.# 17496-0001

TAG# HX0042

ENERGY JOB # X-7929

This is to certify the above referenced equipment was hydro tested at the following pressures:

605 **PSIG SHELL SIDE**

280 **PSIG TUBE SIDE**

ENERGY EXCHANGER COMPANY

Brent Wilson
Quality Control Manager

/lt

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

Energy Exchanger Company
1844 N. Garnett Rd. • Tulsa, OK 74116 • www.energyexchanger.com

office (918) 437-3000
fax (918) 437-7144
info@energyexchanger.com

Date: 8-30-12

CERTIFICATE OF NITROGEN PURGE

P.O. NO: 17496-0001

TAG NO: HK0042

ENERGY JOB NO: X-7929

This is to certify the above referenced equipment was purged with 15 PSI dry nitrogen after hydro test.

ENERGY EXCHANGER COMPANY

Brent Wilson
Quality Control Manager

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh

ENERGY EXCHANGER COMPANY

PAINT CHECK LIST

Contractor: EATON INDUSTRIAL COATINGS

Unit Serial No: X-7929 Customer Specification No: _____

Paint Required: 3-4 mils AMERON D-9 Primer; _____ mils _____ Intermediate;

1-2 mils AMERON 892 Finish

Testex PRESS-O-FILM™ HT X-Coarse 1.8 (C+XC)/2

Satisfactory Date

1. Paint Shelf Life
   A. Materials in accordance with Project Specifications & Drawings — MC 8/27/12
2. Notify Energy Exchanger Company
3. Weather Conditions:
   83 temperature; 71% humidity; 80 substate, 71 dew point,
   EEC verify _____ — MC 8/27/12
4. Surface Prep:
   (Req'd) SSPC-SP- 10 1-2 mils; (Actual) SSPC-SP- 10 1.8 mils
5. Surface Contamination — WL 8/27/12
6. Surface Imperfections
7. Paint Contractor Re-check above
8. Storage, Mixing, Application
9. Masked Surfaces
10. Check Compressed Air for Contamination
11. Wet Film Thickness:
    (Req'd) _____ (Actual) _____ — MC 8/29/12
12. Dry Film Thickness:
    SHELL (Req'd) 3-4 (Actual) 4
    SUPPORTS " 4-6 " 6 2nd COAT — W. 8/29/12
13. Tie Down/Shipping Preparation

TEMP 80
S.TEMP 80
HUMIDITY 65%
DEWPOINT 68

Reviewed / Accepted
I.Q.S. # 3
William Bronaugh WB

SECTION 7

SPL-7929

ENERGY EXCHANGER COMPANY

SPARE PARTS LISTS

CUSTOMER: Southern Company Services (for) Mississippi Power							EEC QUOTE: 11-7309			
DESTINATION: DeKalb, Mississippi				P.O. No.: 17496-0001			EEC JOB NO.: X-7929			9/13/2012
		SPARE GASKETS								
TAG NO.	EEC JOB NUMBER	QTY. SETS	NO. GASKETS PER SET	EEC DWG. NUMBER	UNIT $ PRICE *	SHIPMENT				
HX0042	X-7929	**	2	X-7929-O	$750.00	2-3 Weeks				

* 1) PRICES ARE F.C.A. ENERGY SHOPS, TULSA, OK.
* 2) SHIPPING TERMS ARE PREPAY AND CHARGE.
* 3) PRICE ARE VALID FOR TWELVE (12) MONTHS.
* 4) UNIT PRICES ARE PER SET OF SPARE GASKETS.

** 1) ENERGY EXCHANGER COMPANY RECOMMENDS ONE SET OF SPARE GASKETS PER EXCHANGER PER YEAR OF OPERATION.

Energy Exchanger Company

Installation, Operation and Maintenance Manual for SHELL AND TUBE HEAT EXCHANGERS

A Member of the
Tubular Exchanger
Manufacturers Association

Energy Industrial Park/1844 North Garnett/Tulsa, Oklahoma 74116-1698
918 437-3000 / FAX 918 437-7144

FOREWORD

Included in this manual are Tables and Figures which are reprinted in their entirety from the Standards of the Tubular Exchanger Manufacturers Association Seventh Edition (1988). Pages containing such material contain a citation to that publication.

Additionally, there are extensive extracts of text reprinted from the 7th Edition TEMA Standards. Pages containing such excerpts contain a footnote to that effect.

The information in this publication is based on the collective experience of industry engineers and technicians. While the information is intended to be comprehensive and thorough, it is subject to change based on particular applications, field experience and technological developments. The Tubular Exchanger Manufacturers Association expressly disclaims any warranty of fitness for a particular application, as well as any claims for compensatory, consequential or other damages arising out of or related to the use of this publication.

TABLE OF CONTENTS

GENERAL INSTRUCTIONS FOR INSTALLATION, OPERATION AND MAINTENANCE OF SHELL AND TUBE HEAT EXCHANGERS

SAFETY CONSIDERATIONS

LIFTING DEVICES

When eyebolts, lugs, clips or other devices are installed by the manufacturer, it is intended that these lifting devices are to lift only the empty components to which they are attached and not the assembled heat exchanger, unless explicitly specified otherwise.

Proper rigging must be used in lifting assembled heat exchangers. Exchangers are usually much heavier than pressure vessels of comparable dimensions; therefore, weights should be carefully evaluated. Where available, determinations should include reference to manufacturers drawings, added components, bill of lading, etc. Special care must be exercised in handling exchangers with expansion joints.

ROUTINE PRECAUTIONARY PROCEDURES

A heat exchanger is a multi-chamber pressure vessel designed at specific limits of pressure, temperature and fluid flow conditions as shown on the exchanger specification sheet and heat exchanger nameplate(s). The process system, which includes the heat exchanger, must be safeguarded so that the heat exchanger design conditions and operating limits are not exceeded. All operating and maintenance personnel should be made aware of specific limitations including pressures and temperatures, flow rates, start-up/shut-down procedures and cleaning procedures.

Do not remove channel covers, shell covers, floating head covers, bonnets or connecting piping until all pressure has been relieved and both shell and tube sides are completely drained. Exceptions are permissible when design permits independent pressure testing of shell or tube sides.

Plugged tubes and double tubesheets, unless vented, may remain pressurized after shell and tube sides are depressurized. Caution may be exercised in loosening of tube plugs or opening of vents to avoid sudden release of pressure or harmful fluids.

Many heat exchangers circulate fluids which are toxic, lethal or flammable and dangerous to the human system. These fluids could cause problems if bolted or threaded joints are not maintained in leak-tight condition under operating or no-flow ambient conditions. Proper precautions, such as effective draining and purging, must be taken in handling and decontamination when exchangers are opened for any reason. It is essential that the user advise maintenance or repair personnel, including outside contractors, when toxic, lethal, or flammable conditions exist.

When heat exchangers are cleaned, it is important that full characteristics of the circulating fluids, fouling material, and the cleaning agent be known and care exercised in handling them. Use eye protection, a respirator, or other appropriate protective devices.

Do not blow out heat exchangers with air when the process fluids or the cleaning fluids being handled are flammable or reactive.

SECTION 1
HEAT EXCHANGER NOMENCLATURE

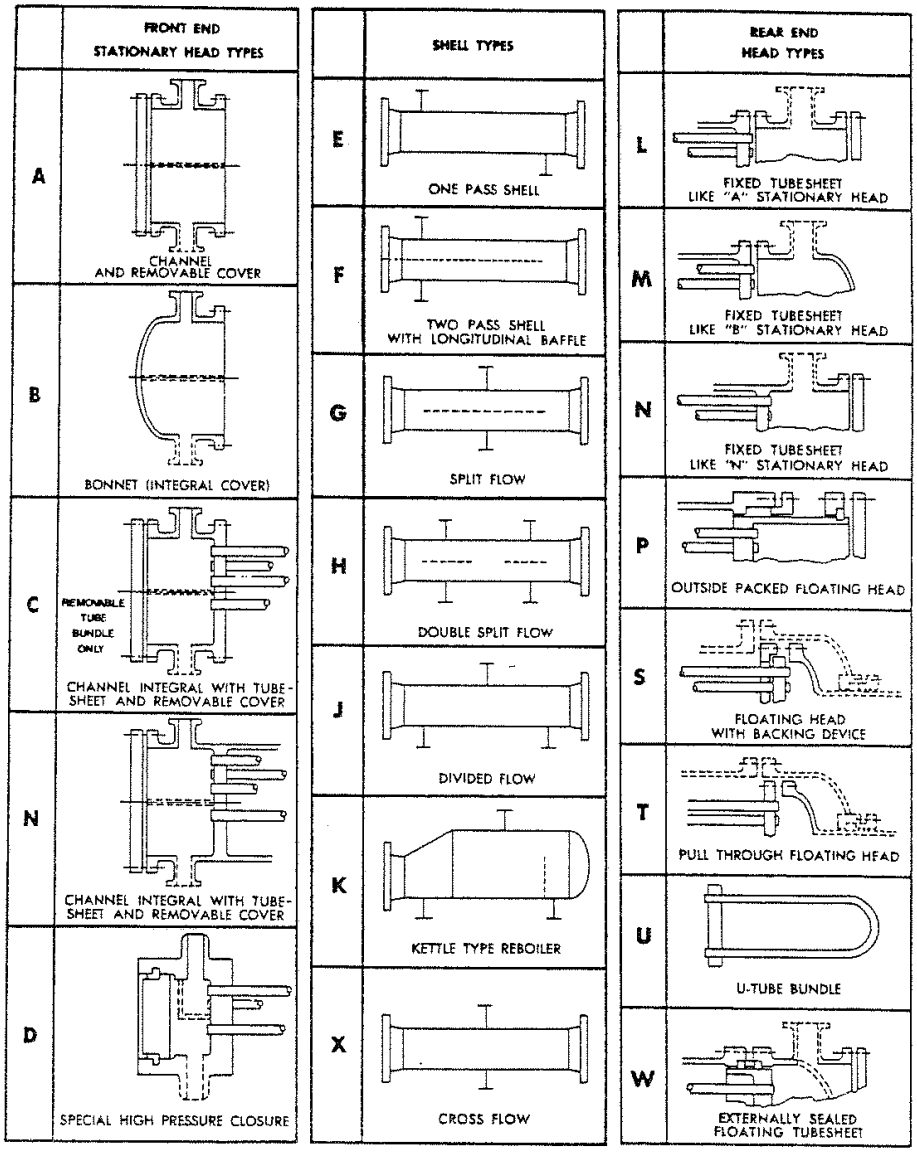
N-1 TYPE DESIGNATION-RECOMMENDED PRACTICE

It is recommended that heat exchanger type be designated by letters as described below.

N-1.1 TYPE

Type designation shall be by letters describing stationary head, shell (omitted for bundles only), and rear head, in that order, as indicated in Figure N-1.1.

Figure N-1.1



N-2 **NOMENCLATURE OF HEAT EXCHANGER COMPONENTS**

For the purpose of establishing standard terminology, Figure N-2 illustrates various types of heat exchangers. Typical parts and connections, for illustrative purposes only, are numbered for identification in Table N-2. (See Note)

Table N-2

1. Stationary Head — Channel
2. Stationary Head — Bonnet
3. Stationary Head Flange — Channel or Bonnet
4. Channel Cover
5. Stationary Head Nozzle
6. Stationary Tubesheet
7. Tubes
8. Shell
9. Shell Cover
10. Shell Flange — Stationary Head End
11. Shell Flange — Rear Head End
12. Shell Nozzle
13. Shell Cover Flange
14. Expansion Joint
15. Floating Tubesheet
16. Floating Head Cover
17. Floating Head Flange
18. Floating Head Backing Device
19. Split Shear Ring
20. Slip-on Backing Flange
21. Floating Head Cover — External
22. Floating Tubesheet Skirt
23. Packing Box
24. Packing
25. Packing Gland
26. Lantern Ring
27. Tierods and Spacers
28. Transverse Baffles or Support Plates
29. Impingement Plate
30. Longitudinal Baffle
31. Pass Partition
32. Vent Connection
33. Drain Connection
34. Instrument Connection
35. Support Saddle
36. Lifting Lug
37. Support Bracket
38. Weir
39. Liquid Level Connection

NOTE: Manufacturers may identify corresponding parts using numbers differing from the above.

Figure N-2

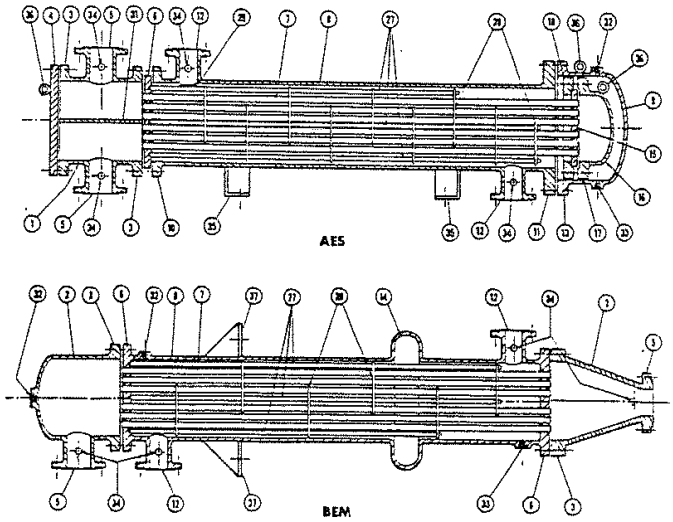
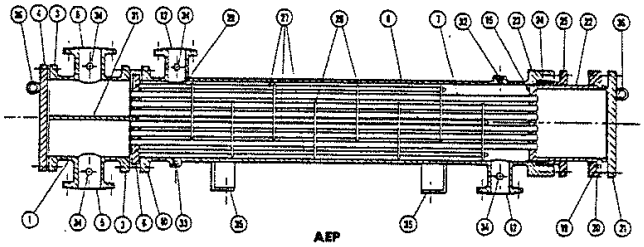
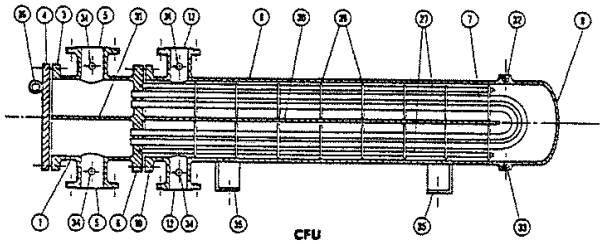


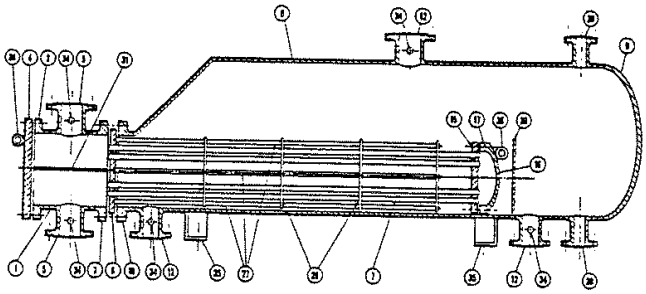
Figure N-2 (Continued)



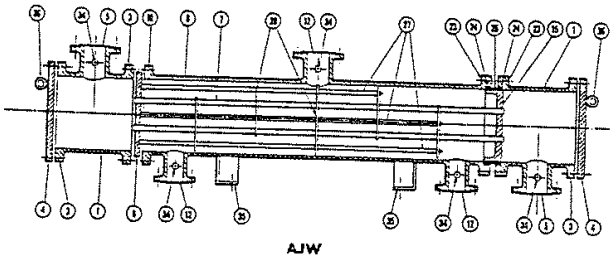
AEP



CFU



AKT



AJW

SECTION 2
HEAT EXCHANGER IDENTIFICATION AND DEFINITIONS

D-2.1 EXCHANGER IDENTIFICATION

D-2.11 COMPLETE EXCHANGER

Manufacturers normally assign a serial number which is unique and permanently identifies each exchanger. Inquiries to the manufacturer should reference this number when it is shown on the nameplate and manufacturer's drawings. Additional useful information normally shown includes size, type, and item number.

D-2.12 EXCHANGER PARTS

Exchanger parts should be identified by the exchanger serial number and by the name and part number corresponding to those shown in Section 1, Table N-2, or as shown on the manufacturer's drawings.

D-2.2 DEFINITIONS

D-2.21 EXCHANGER UNIT

One or more exchangers designed for a specific service.

D-2.22 ITEM NUMBER

The purchaser's identification number for an exchanger unit.

D-2.23 NORMAL OPERATING CONDITIONS

The thermal and hydraulic performance requirements generally specified for designing the heat exchanger.

D-2.24 UPSET CONDITIONS

A departure from specified operating conditions.

D-2.25 PULSATING FLUID CONDITIONS

Conditions of flow generally characterized by rapid fluctuations in pressure and flow rate resulting from sources outside of the heat exchanger such as: pumps, compressors, blowers, etc.

D-2.26 START-UP CONDITIONS

The conditions of operation which exist from the time that flow of either or both process streams is initiated to the time that steady-state operating conditions are achieved.

D-2.27 SHUT-DOWN CONDITIONS

The conditions of operation which exist from the time of steady-state operating conditions to the time that flow of both process streams has ceased.

D-2.28 CODE

All references to Code herein mean the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Pressure Vessels.

SECTION 3
INSTALLATION OF HEAT EXCHANGERS

E-3 INSTALLATION

E-3.1 INSTALLATION PLANNING

E-3.11 CLEARANCE FOR DISMANTLING

For straight tube exchangers fitted with removable bundles, provide sufficient clearance at the stationary head end to permit removal of the bundle from the shell and provide adequate space beyond the rear head end to permit removal of the shell cover and/or floating head cover.

For fixed tubesheet exchangers, provide sufficient clearance at one end to permit withdrawal and replacement of the tubes and enough space beyond the head at the opposite end to permit removal of the bonnet or channel cover.

For U-tube heat exchangers, provide sufficient clearance at the stationary head end to permit withdrawal of the tube bundle, or at the opposite end to permit removal of the shell.

E-3.12 FOUNDATIONS

Foundations must be adequate so that exchangers will not settle and impose excessive strains on the exchanger. Foundation bolts should be set to allow for setting inaccuracies. In concrete footings, pipe sleeves at least one size larger than bolt diameter slipped over the bolt and cast in place are best for this purpose, as they allow the bolt center to be adjusted after the foundation has set.

E-3.13 PIPING

E-3.131 THERMAL EXPANSION

It is essential that adequate provisions be made in the connecting piping to allow for thermal expansion without imposing unspecified piping loads on the exchanger. This is particularly important for single pass internal floating head designs, outside packed floating heads, and fixed tubesheet types with shell expansion joints. Unless precautions are taken, leakage or damage may result.

E-3.132 PULSATION AND VIBRATION

In all installations, care must be taken to eliminate or minimize transmission of fluid pulsations and mechanical vibrations to the heat exchangers.

E-3.14 CLEANING

Convenient means should be provided for cleaning the unit as suggested under "Maintenance." (Section 5)

E-3.15 LEVELING

Exchangers must be installed so that pipe connections are made without forcing, disassembling or loosening of flanged assemblies.

E-3.16 STACKED HEAT EXCHANGERS

The manufacturer normally stacks exchangers prior to completion of fabrication to insure proper alignment of interconnecting nozzles. Shims separating the intermediate shell supports are normally used. Therefore, it is important that shims, if used, match the thicknesses and locations used by the manufacturer.

E-3.17 CONNECTION PROTECTORS

Remove shipping covers and plugs immediately prior to installation. Before connecting to piping, inspect all openings in the heat exchanger for foreign material. The entire system should be clean and free of foreign objects before starting operation. Do not expose heat exchanger internals to moisture or harmful contaminants.

E-3.18 PIPE CONNECTIONS

Pipe connections must be in accordance with the manufacturer's dimensional outline drawing.

E-3.19 FOUNDATION BOLTS

Foundation bolts should be loosened at one end of unit to allow free expansion of shells. Slotted holes in supports are provided for this purpose.

E-3.20 If the heat exchanger is equipped with a bellows type expansion joint, the expansion joint must be adequately protected during shipping and setting. Shipping supports must be removed in accordance with instructions.

E-3.3 HEAT EXCHANGER STORAGE

Heat exchangers normally are not protected for storage. If storage is necessary, a covered location at uniform temperature is preferable and provisions must be made to protect the heat exchanger interior from moisture, freezing, or harmful contaminants.

SECTION 4
OPERATION OF HEAT EXCHANGERS

E-4. OPERATION

E-4.1 PERFORMANCE OF HEAT EXCHANGERS

Satisfactory performance and service life can be expected only from heat exchangers which are properly installed, operated in accordance with design conditions, and receive preventive maintenance and cleaning on an appropriate schedule. These requirements are the responsibility of the user.

E-4.11 PERFORMANCE FAILURES

The failure of heat exchanger equipment to perform satisfactorily may be caused by one or more factors, such as:

(1) Excessive fouling.
(2) Air or gas binding resulting from improper piping installation or lack of suitable vents.
(3) Operating conditions differing from design conditions.
(4) Maldistribution of flow in the unit.
(5) Excessive clearances between the baffles and shell and/or tubes, due to corrosion.
(6) Improper thermal design.
(7) Flooding resulting from inadequate drainage of condensate.

E-4.2 OPERATION OF HEAT EXCHANGERS

E-4.21 OPERATING PROCEDURES — NORMAL

Before placing any exchanger in operation, reference should be made to the exchanger drawings, specification sheet(s), and name plate(s) for any special instructions. Local safety and health regulations must be considered. Improper start-up or shut-down sequences, particularly of fixed tubesheet units, may cause leaking of tube-to-tubesheet and/or bolted flanged joints.

E-4.22 START-UP OPERATION

Most exchangers with removable tube bundles may be placed in service by first establishing circulation of the cold medium, followed by the gradual introduction of the hot medium. During start-up all vent valves should be opened and left open until all passages have been purged of air and are completely filled with fluid. For fixed tubesheet exchangers, fluids must be introduced in a manner to minimize differential expansion between the shell and tubes. (Refer E-4.24)

E-4.23 SHUT-DOWN OPERATION

For exchangers with removable bundles, the units may be shut down by first gradually stopping the flow of the hot medium and then stopping the flow of the cold medium. If it is necessary to stop the flow of cold medium, the circulation of hot medium through the exchanger should also be stopped. For fixed tubesheet exchangers the unit must be shut down in a manner to minimize differential expansion between shell and tubes, (Refer E-4.24). When shutting down the system, all units should be drained completely when there is the possibility of freezing or corrosion damage. To guard against water hammer, condensate should be drained from steam heaters and similar apparatus during start-up or shut-down. To reduce water retention after drainage, the tube side of water cooled exchangers should be blown out with air.

E-4.24 START-UP AND SHUT-DOWN PROCEDURES FOR FIXED TUBESHEET EXCHANGERS

When start-up and shut-down instructions are furnished, they must be followed. When specific instructions are not supplied, the recommended procedure is to start, or stop, the circulation of both shell and tube side fluids gradually and at the same time.

E-4.3 OPERATING LIMITATIONS

E-4.31 NORMAL OPERATING CONDITIONS

Equipment must not be operated at conditions more severe than those specified on the heat exchanger specification sheet, and/or name plates. A change in service or deviation from the specified operating conditions may require that a mechanical design check be made in order to avoid possible damage to the heat exchanger.

E-4.32 SUPPLEMENTAL NAME PLATE DATA

The manufacturer may supply supplemental data where it is pertinent to the operation or testing of the exchanger. This may include information pertaining to differential design and test pressure conditions, restrictions on operating conditions for fixed tubesheet type exchangers, or other restrictive conditions applicable to the design and/or operation of the unit or its components. Such information may be noted on the standard name plate or on a supplemental plate attached to the exchanger at the name plate location.

E-4.33 FLOW RATE

Heat exchangers are not to be operated at flow rates greater than those shown on the heat exchanger specification sheet. Excessive flow rates can cause vibration and/or erosion and severely damage the heat exchanger.

E-4.34 HYDRAULIC HAMMER

Exchangers should not be subjected to pulsating, slugging, or unstable flow conditions which may impair performance or result in destructive hydraulic hammer. Adequate condensate drainage is essential for steam heaters and similar apparatus.

E-4.35 TEMPERATURE SHOCKS

Exchangers normally should not be subjected to abrupt temperature fluctuations. Hot fluid must not be suddenly introduced when the unit is cold, nor cold fluid when the unit is hot.

E-4.36 FLUID TEMPERATURE LIMITS

E-4.361 Heat exchangers are not to be operated at fluid temperatures more severe than those shown on the heat exchanger specification sheet.

E-4.362 For fixed tubesheet exchangers fluid inlet temperatures may be severely limited when there is no fluid on the opposite side. Operation with fluid circulation on one side only should be avoided, unless specifically provided for in the design of the heat exchanger.

E-4.4 BOLTED JOINTS

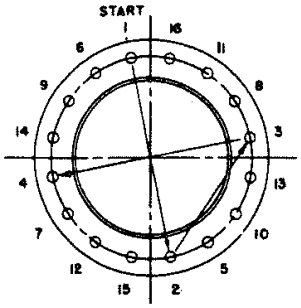
E-4.41 RECOMMENDATIONS FOR RETIGHTENING

Heat exchangers are pressure tested before leaving the manufacturer's shop in accordance with ASME Code requirements. However, normal yielding of gasket joints may occur in the interval between testing in the manufacturer's shop and installation at the job site. Therefore, all external bolted joints may require retightening after installation and, if necessary, after the exchanger has reached operating temperature.

E-4.42 RECOMMENDED BOLT TIGHTENING PROCEDURE

It is important that all bolted joints be tightened uniformly and in a diametrically staggered pattern as illustrated in Figure E-4.42 except for special high pressure closures when the instructions of the manufacturer should be followed.

Figure E-4.42



E-5. MAINTENANCE

E-5.1 INSPECTION OF UNIT

At regular intervals and as frequently as experience indicates, an examination should be made of the interior and exterior condition of the unit. Neglect in keeping all tubes clean may result in complete stoppage of flow through some tubes which could cause severe thermal strains, leaking tube joints, or structural damage to other components. Sacrificial anodes, when provided, should be inspected to determine whether they should be cleaned or replaced.

E-5.11 INDICATIONS OF FOULING

Exchangers subject to fouling or scaling should be cleaned periodically. A light sludge or scale coating on the tube greatly reduces its efficiency. A marked increase in pressure drop and/or reduction in performance usually indicates cleaning is necessary. The unit should first be checked for air or vapor binding to confirm that this is not the cause for the reduction in performance. Since the difficulty of cleaning increases rapidly as the scale thickness or deposit increases, the intervals between cleanings should not be excessive.

E-5.12 PREVENTIVE MAINTENANCE

Additional important reasons for inspections include:

(1) Corrosion and erosion may weaken various parts of an exchanger and may eventually cause mechanical failure, or impaired performance.

(2) Determination of fouling and corrosion rates for prediction of service life and scheduling down-time.

(3) Implementation of preventive maintenance procedures which reduce rates of fouling and general deterioration, or eliminate leaks.

E-5.13 ACCESS TO TUBES

Before disassembly, the user must assure himself that the unit has been depressurized, vented and drained, neutralized and/or purged of hazardous materials.

To inspect the inside of the tubes and also make them accessible for cleaning, the following procedures should be used:

(1) Stationary Head End

(a) Type A, C, & D, remove cover only.
(b) Type B, remove bonnet.

(2) Rear Head End

(a) Type L, N, & P, remove cover only.
(b) Type M, remove bonnet.
(c) Type S & T, remove shell cover and floating head cover.
(d) Type W, remove channel cover or bonnet.

E-5.14 LOCATING LEAKS IN TUBES

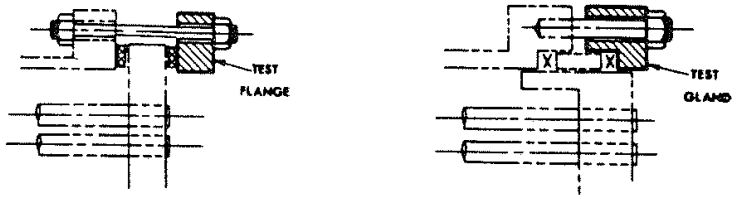
The following procedures may be used to locate perforated or split tubes and leaking joints between tubes and tubesheets. In most cases, the entire front face of each tubesheet will be accessible for inspection. The point where water escapes indicates a defective tube or tube-to-tubesheet joint.

(1) Units with removable channel cover:
Remove channel cover and apply hydraulic pressure in the shell.

(2) Units with bonnet type head:
(a) On fixed tubesheet units where tubesheets are an integral part of the shell, remove bonnet and apply hydraulic pressure in the shell.
(b) On fixed tubesheet units where tubesheets are not an integral part of the shell and on units with removable bundles, remove bonnet, re-bolt tubesheet to shell or install test flange or gland, whichever is applicable, and apply hydraulic pressure in the shell.
See Figure E-5.14-1 for typical test flange and test gland.

CAUTION: Bolting directly to the edges of the tubesheets may result in overstress unless it was considered in the design of the tubesheets.

Figure E-5.14-1

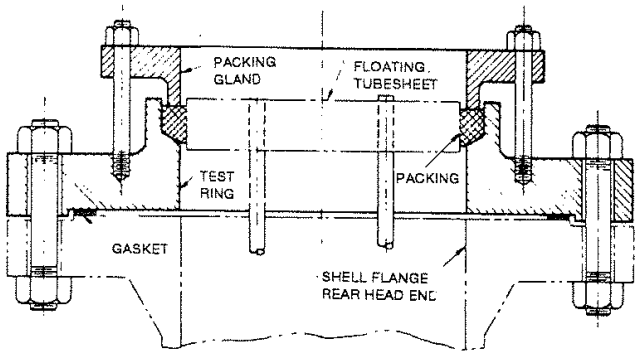


(3) Units with type S or T floating head:
Remove channel cover or bonnet, shell cover and floating head cover. Install test ring and bolt in place with gasket and packing. Apply hydraulic pressure in the shell. A typical test ring is shown in Figure E-5.14-2. When a test ring is not available it is possible to locate leaks in the floating head end by removing the shell cover and applying hydraulic pressure in the tubes. Leaking tube joints may then be located by sighting through the tube lanes.

NOTE: Care must be exercised when testing partially assembled exchangers to prevent over extension of expansion joints or overloading of tubes and/or tube-to-tubesheet joints.

Hydrostatic test should be performed so that the temperature of the metal is at least 30°F above the minimum design metal temperature, MDMT.

Figure E-5.14-2



E-5.2 TUBE BUNDLE REMOVAL

Bundles must be withdrawn from the stationary end as noted on the drawing. All parts such as glands, retainer rings, split shear rings and closure packing must be removed before attempting to remove bundle. Threaded eyebolts may be attached to the stationary tubesheet when tapped holes have been provided for this purpose. When eyebolt tappings are not provided, rods may be passed through two or more tubes and attached to a steel bearing plate over the floating tubesheet. Provide a protective spacer between the bearing plate and tubesheet to protect the tube ends.

E-5.21 HANDLING TUBE BUNDLES

Tube bundles should not be handled with hooks or other devices which might damage the tubes. Bundles should be supported on cradles or skids. Horizontal tube bundles should be lifted by means of suitable slings. Baffles can be bent and damaged by dragging a bundle over a rough surface. All gasket and packing contact surfaces should be protected from accidental damage since these areas are generally difficult to repair.

E-5.3 CLEANING TUBE BUNDLES

E-5.31 CLEANING METHODS

The heat transfer surfaces of heat exchangers should be kept reasonably clean to assure satisfactory performance. Convenient means for cleaning should be made available.

Heat exchangers may be cleaned by either chemical or mechanical methods. The method selected must be the choice of the operator of the plant and will depend on the type of deposit and the facilities available in the plant. Following are several cleaning procedures that may be considered:

(1) Circulating hot wash oil or light distillate through tubes or shell at high velocity may effectively remove sludge or similar soft deposits.

(2) Some salt deposits may be washed out by circulating hot fresh water.

(3) Commercial cleaning compounds are available for removing sludge or scale provided hot wash oil or water is not available or does not give satisfactory results.

(4) High pressure water jet cleaning.

(5) Scrapers, rotating wire brushes, and other mechanical means for removing hard scale, coke, or other deposits.

(6) Employ services of a qualified organization that provides cleaning services. These organizations will check the nature of the deposits to be removed, furnish proper solvents and/or acid solutions containing inhibitors, and provide equipment and personnel for a complete cleaning job.

E-5.32 CLEANING PRECAUTIONS

(1) Tubes should not be cleaned by blowing steam through individual tubes since this heats the tube and may result in severe expansion strain, deformation of the tube, or loosening of the tube-to-tube sheet joint.

(2) When mechanically cleaning a tube bundle, care should be exercised to avoid damaging the tubes.

(3) Cleaning compounds must be compatible with the metallurgy of the exchanger.

(4) Cleaning procedures, especially those which circulate hot fluids through the tubes, can cause significant temperature differentials between the shell and tubes. Such cleaning procedures can cause damage to fixed tubesheet heat exchangers and should be avoided unless specifically provided for in the design of the heat exchanger.

E-5.4 GASKET REPLACEMENT

Gasket and gasket surfaces should be thoroughly cleaned and should be free of scratches and other defects. Gaskets should be properly positioned before attempting to retighten bolts. It is recommended that when a heat exchanger is dismantled for any cause, it be reassembled with new gaskets. This will tend to prevent future leaks and/or damage to the gasket seating surfaces of the heat exchanger. Composition gaskets become dried out and brittle so that they do not always provide an effective seal when reused. Metal or metal jacketed gaskets, when compressed initially, flow to match their contact surfaces. In so doing they are work hardened and, if reused, may provide an imperfect seal or result in deformation and damage to the gasket contact surfaces of the exchanger.

Bolted joints and flanges are designed for use with the particular type of gasket specified. Substitution of a gasket of different construction or improper dimensions may result in leakage and damage to gasket surfaces. Therefore, any gasket substitutions should be of compatible design.

Any leakage at a gasketed joint should be rectified and not permitted to persist as it may result in damage to the gasket surfaces.

When metal jacketed filled type gaskets are used with a tongue and groove joint without a nubbin, the gasket should be installed so that the tongue bears on the seamless side of the gasket jacket. When a nubbin is used, the nubbin should bear on the seamless side.

E-5.5 SPARE AND REPLACEMENT PARTS

The procurement of spare or replacement parts from the manufacturer will be facilitated if the correct name for the part, as shown in Section 1, Table N-2, of this manual is given, together with the serial number, type, size, and other information from the nameplate. Replacement parts should be purchased from the original manufacturer.

E-5.6 EXPANDED TUBE JOINTS

E-5.61 TUBE HOLE FINISH

Tube hole finish affects the mechanical strength and leak tightness of an expanded tube-to-tubesheet joint. In general:

(1) A rough tube hole provides more mechanical strength than a smooth tube hole. This is influenced by a complex relationship of modulus of elasticity, yield strength, and hardness of the materials being used.

(2) A smooth tube hole does not provide the mechanical strength that a rough tube hole does, but it can provide a pressure tight joint at a lower level of tube wall reduction.

(3) Very light wall tubes require a smoother tube hole finish than heavier wall tubes.

(4) Significant longitudinal scratches can provide leak paths through an expanded tube-to-tubesheet joint and should therefore be removed.

E-5.62 TUBE WALL REDUCTION

The optimum tube wall reduction for an expanded tube-to-tubesheet joint depends on a number of factors, some of which are:

(1) Tube hole finish.

(2) The presence or absence of the tube hole serrations (grooves).

(3) The tube hole size and tolerance.

(4) Tubesheet ligament width and its relation to tube diameter and thickness.

(5) Tube wall thickness.

(6) Tube hardness and change in hardness during cold working.

(7) Tube O.D. tolerance.

(8) Type of expander used.

(9) Type of torque control or final tube thickness control.

(10) Function of tube joint, i.e., strength in resistance to pulling out, minimum cold work for corrosion purposes, freedom from leaks, ease of replacement, etc.

(11) Length of expanded joint.

(12) Compatibility of tube and tubesheet materials.

E-5.63 TUBE EXPANDING

A suitable tube expander should be used to tighten a leaking tube joint. Care should be taken to insure that tubes are not over expanded. Do not re-expand tubes which are not leaking. Do not expand tubes beyond 1/8" from the back face of the tubesheet.

E-5.64 TYPICAL COMPUTATION OF TUBE WALL REDUCTION

EXAMPLE OF DETERMINING THE EXPANDED TUBE INSIDE DIAMETER FOR A SPECIFIED AMOUNT OF WALL REDUCTION

GIVEN:	TUBE DIAMETER	= 0.750
	TUBE HOLE DIAMETER	= 0.760
	TUBE WALL THICKNESS	= 0.065
	SPECIFIED WALL REDUCTION	= 5%
SOLUTION:	WALL REDUCTION	= 0.065 x 0.05 = 0.00325
	FINAL WALL THICKNESS	= 0.065 – 0.00325 = 0.06175
	FINAL EXPANDED TUBE I.D.	= 0.760 – 2(0.06175) = 0.6365

CAUTION: *THE USE OF NOMINAL DIMENSIONS, WITHOUT ATTENTION TO PERMISSIBLE TOLERANCES CAN LEAD TO INCORRECT CONCLUSIONS.*

EXPANDING PROCEDURES SHOULD BE BASED ON MEASURED DIMENSIONS, NOT NOMINAL DIMENSIONS.

E-5.65 PLUGGING TUBES IN TUBE BUNDLES

In U-tube heat exchangers, and other exchangers of special design, it may not be feasible to remove and replace defective tubes. Defective tubes may be plugged using commercially available tapered plugs with ferrules or tapered only plugs which may or may not be seal welded. Excessive tube plugging may result in reduced thermal performance, higher pressure drop, and/or mechanical damage.

E-5.7 WELDED TUBE JOINTS

Welding procedure and testing techniques for either seal welded or strength welded tube joints normally are by agreement between manufacturer and purchaser and therefore should be considered prior to repairs to welded tube joints or tube replacements.

E-5.8 END FLANGES AND BOLTING

The purpose of this section is to alert the users, and provide basic data for consideration in assembly and maintenance of bolted flanged joints. Controlling the torque applied in tightening threaded bolts is the most economical and commonly used method for the control of initial tension. There are several factors which affect the relationship between torque and tension of threaded bolts. A few of the factors are the type of lubricant and/or plating, if any, used on the threads and the materials from which the bolt and nut are manufactured.

In assembling gasketed joints it is essential that the gasket first be seated uniformly by initial tightening of studs using a staggered quarterly pattern. After the gasket is seated, torquing may be completed stepwise to the final desired value, following a staggered or sequential pattern.

The following may be used as references and aids when assembling bolted flanged joints:

1. Recommended assembly and maintenance of flanged joints as shown in the Crane Company Catalog #60, Engineering Data Section.

2. Torque Control, Sixth Edition, Sturtevant Company.

3. ASME Code, Appendix S.

E-5.9 SPECIAL HIGH PRESSURE CLOSURES

The instructions of the heat exchanger manufacturer should be followed when provided.

E-5.10 REPAIRS, ALTERATION, RERATING, AND REPLACEMENT PARTS.

In order to maintain the Code integrity of the vessel, any repairs by welding, subsequent heat treating, alterations, replacement pressure parts, or rerating must be done in accordance with the National Board Inspection Code.

Potentially toxic or harmful contaminants must be neutralized prior to repairs.

Following repair by welding, post weld heat treatment may be a requirement for preservation of resistance to corrosion.