

## Manufacturer's Final Data Book Index for PO# 1083-BC-4006, Item# BL-E-301, HED SO# 4474

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BANTREL	JOB	VP NO.	RE				
VENDOR PRIN	1083	- BC-4106-6024	ī				
EQUIPMENT NUMBER		Bh-E-301					
CLIENT CROSS REF							
design details developed or	Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve the supplier from full compliance with contractual obligations.						
<ol> <li>Work may proceed.</li> <li>Revise and resubmit. Work may proceed subject to incorporation of changes indicated.</li> </ol>							
		t. Work SHALL NOT proceed.  . Work may proceed.	7121				

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Petroleum,	Petrochemical,	Power.	Food,	and	Industrial	on	Heat	Transfer	Equipmen

901 East Beecher Street Indianapolis, IN 46203 Mariness

Rick Windell | St. | REVIEW

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## Heat Exchanger Design, Inc.



Indianapolis, IN., 46205 Fax:(317)686-9100 **HEAT EXCHANGER SPECIFICATION SHEET** Page 1 Job No. 4474 Purchase Order No. 1083-BC-4006 Customer Cenovus Energy Address Proposal No. 616-12 Plant Location Rev 0 Date Service of Unit Natural Gas Heater (Turndown Case) Item No. BL-E-301 Size 90 x 65 x 6096mm SH4K1-20-00-24UV-2C3D 1 Parallel Type Horz. 1 Series Conn. In Surf/Unit (Gross/Eff) 8.30 / 8.27 m2 Surf/Shell (Gross/Eff) 8.30 / 8.27 m2 Shell/Unit PERFORMANCE OF ONE UNIT Shell Side Fluid Allocation Tube Side Ethylene Glycol (50 wt%) / H2O Fluid Name Natural Gas Fluid Quantity, Total 1981.50 1981.50 Vapor (In/Out) 1981.50 Liquid 897.750 897.750 Steam Water Noncondensables Temperature (In/Out) 150.00 100.00 5.00 35.00 990.40 Density kg/m3 1034.1 63.900 53.190 Viscosity mN-s/m2 0.3640 0.7100 0.0128 0.0130 Molecular Weight, Vapor 7.16 Molecular Weight, Noncondensables Specific Heat kJ/kg-C 3.7400 3.5400 2.8400 2.6700 Thermal Conductivity W/m-C 0.3904 0.3914 0.0381 0.0410 Lalent Heat kJ/kg 6981.50 Inlet Pressure kPa 997.332 Velocity m/s8.117e-2 2.95 Pressure Drop, Allow/Calc 70.000 70.000 0.199 0.999 Fouling Resistance (min) m2-K/W 0.000180 0.000180 Heat Exchanged MegaWatts 0.0454 MTD (Corrected) 104.8 C 52,43 W/m2-K Clean CONSTRUCTION OF ONE SHELL Transfer Rate, Service 108.81 W/m2-N 100.02 W/m2-K Sketch (Bundle/Nozzle Orientation) Shell Side Tube Side Design/Test Pressure kPaG 7650 / Code 9930 / Code Design Temperature C -28.8 / 178 -28.8 / 150 No Passes per Shell Corrosion Allowance 1.5 mm 1.5 (except tube) 1 @ 2" 600# RF Connections mm 1 @ 3" 900# RF @ 2" 600# RF @ 3" 900# RF Size & Out mm Rating intermediate Inner Pipe - (1) 2 1/2" Sch 40 pipe (73mm OD) Length 6.096m nom Tube Type Longitudinal Fin - (24) 12.7mm fins x 0.89mm thk x 6096mm ig Material SA-106B, C Sti Fins 4" Sch 40 SA-106B Pipe (114.3mm OD) Shell Shell Cover SA105/516 70 Weldment Channel or Bonnet SA-516-70/105 Weidmen! Channel Cover N/A Tubesheet-Stationary SA-516-70 Tubesheet-Floating N/A Floating Head Cover N/A Impingement Plate None Type NONE Baffles-Cross Baffles-Long N/A Seal Type Supports-Tube N/A U-Bend Type Tube-Tubesheet Joint Bypass Seal Arrangement Welded Expansion Joint N/R Bundle Entrance Rho-V2-Inlet Nozzle 17,30 kg/m-s2 0.00 Bundle Exit 0.00 kg/m-s2 Tube Side Gaskels-Shell Side Kammpro type Kammpro type -Floating Head Code Requirements ASME Section VIII, Div. 1 TEMA Class Weight/Shell 804.22 Filled with Water 921.2 Bundle 150,62 Remarks: 1. Lifting & Grounding lugs required. 2. Insulation is included in quote, but due to potential damage during shipment, HED strongly advises that insulation is installed on site, and cannot be responsible for damage to insulation during shipment. 3. Maximum length is 6500mm. 4. This is HED's standard separated head double pipe hairpin design with independent bolting. 5. Hydrolest at minimum 1 hour with chart. 6. Note that due to manufacturing restrictions on finned pipe inner pipe will be fabricated using return bend and straight pipes with two circumferential welds. Reprinted with Permission (v6 SP3)

 PERMISSIONS TO PROCEED BORS NOT CONSTITUTE OF APPROVAL OF DESIGN DETAILS, CALCULATURES, TEST METHODS ON MATERIALS DEVELOPED ON SELECT-DITY THE SUPPLIER
AND DOES NOT RELIEVE SUPPLIER FROM FULL COMPLANCE WITH CONTRACTUAL DELICATIONS.
work MAY PROCEED. With comment
2 REVISE AND RESUBBIT WORK MAY PROCEED SUBJECT TO INCORPORATION OF CHANGES INDICATED
3. REVISE AND RESUBMIT WORK SHALL NOT PROCEED.
4REVIEW NOT REQUIRED. WORK MAY PROCEED.
BY WIT NATE MUTCH 1424

P.O.Box 524

BANTREL	J08	M/R NO.	VPNO.	REV
VENDOR PRINT	1083	BC-4006	2000	7
EQUIPMENT . MUMBER .	BL	- E30		·
CLIENT . CROSS REF -				

# SECTION 1 Shipping Release Form

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Rick Windell 25 SEP 13



## Quality Surveillance Release Certificate TR-80-FRM-00-106-01

Cenovus Project Name:	Bear Lake Battery	PO Promised Delivery Date:	June 14, 2013
EP Company:	Bantrel	Purchase Order No.:	1083-BC-4006
EP QSC Name:	Sumeet Singla	Surveillance Date:	25Sep13
QSR Name:	Rick Windell	Report Date:	26Sep13
Supplier:	Heat Exchanger Design Inc	Report No.:	1083-BC-4006-QSR-002
Shop Order No.:	4474	Sub Supplier:	
Main Contact Name:	David Bradshaw / David Freedinger	Shop Order No.:	
Main Contact Tel:	317-686-9000	Main Contact Name:	
Main Contact e-mail:	dbradshaw@hed-inc.com / dwf@hed-inc.com	Main Contact Tel:	
Location:	901 East Beecher St Indianapolis, IN 46203	Main Contact e-mail:	
Inspection Agency Name & Job No.	Spectrol Group / 3089	Location:	

PO Item	Quantity	Description	Tag Item # as per PO
1	1 Ea.	Natural Gas Heater Double Pipe Heat Exchanger	BL-E-301
2	1 Lot	Start-up & Commissioning Spare Parts	BL-E-301

<b>Note: The Action</b>	<b>Items List pertain</b>	ning to this	<b>Purchase</b>	Order i	must be	attached to	this
document.							

Without exceptions     ■ Without exce	QSR Initials here →RW
$\hfill \square$ With the following authorized exceptions / deficiencies:	QSR Initials here $\rightarrow$

#### QUALITY SURVEILLANCE REPRESENTATIVE (QSR) ACKNOWLEDGES:

Signing this release is solely for the purpose of authorizing the supplier to ship the goods in accordance with the order. Such authorization shall not relieve the supplier of its obligations set out in the purchase order, including without limitation the warranty that the goods are free from defects.

Name & Signature of				
QSR or Cenovus	il remeel	Date	30Sep13	
Representative				

#### SUPPLIER'S CONFORMANCE STATEMENT:

We certify that the PO items listed, and the required QC / Shipping documentation meet or will meet the requirements at our costs all applicable Code, Standards, specification and other related documents as set forth in the purchase order document.

#### Agreed by

Supplier Rep Name:	DAVID FREEDINGER		Date	30 SEP 2013
Signature & Title	David Helderica	QC	MG	R

The accepted preliminary QC documentation, bill of lading, packing slip, and all related shipping documents must accompany the shipped goods and be added as a line item on the packing list.

#### Agreed By



## Quality Surveillance Release Certificate TR-80-FRM-00-106-01

Supplier Rep Name:	Date	
Signature & Title		

January 2013 Page 2 of 2 TR-80-FRM-00-106-01 Rev 1

# SECTION 2 ABSA CRN Form

Musulless D Rick Windell SCo REVIEW D

9410 - 20 Ave N.W. Edmonton, Alberta, Canada T6N 0A4 Tel: (780) 437-9100 / Fax: (780) 437-7787

November 12, 2013

**Attention:** David E. Bradshaw HEAT EXCHANGER DESIGN, INC.

**PO BOX 524** 

901 E BEECHER ST

INDIANAPOLIS, IN 46206-0524

The design submission, tracking number 2013-08343, originally received on November 12, 2013 was surveyed and accepted for registration as follows:

CRN: W2682.2 Accepted on: November 12, 2013

**Reg Type:** Revision To accepted Design **Drawing No. :** 4474 SHT. 1; Rev 1 As Noted

Description	MAWP	Design Temperature	MDMT
SS Internal Pressure	7653kPa	178 °C	-29 °C
SS External Pressure	103kPa	178 °C	-29 °C
TS Internal Pressure	9930kPa	150 °C	-29 °C
TS External Pressure	103kPa	150 °C	-29 °C

#### The registration is conditional on your compliance with the following notes:

- We have revised the T.S. MAWP from 9928 kPa to 9930 kPa, per client e-mail of October 23, 2013. Note that this acceptance letter supersedes the previous one issued on September 11, 2013.

An invoice covering survey and registration fees will be forwarded from our Revenue Accounts.

If you have any question don't hesitate to contact me by phone at (780) 433-0281 ext 3341 or fax (780) 437-8797 or e-mail DeLeon@absa.ca.

Sincerely,

DE LEON, JESUS, P. Eng.

## **SECTION 3**

## Manufacturer's Equipment Record Book Cover

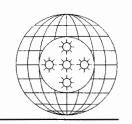
Alfahalells WITNESS D Rick Windell 25 SEP13

## Heat Exchanger Design, Inc.

P. O. Box 524

Indianapolis, IN 46206-0524 USA

Phone: (317)686-9000 • Fax: (317)686-9100



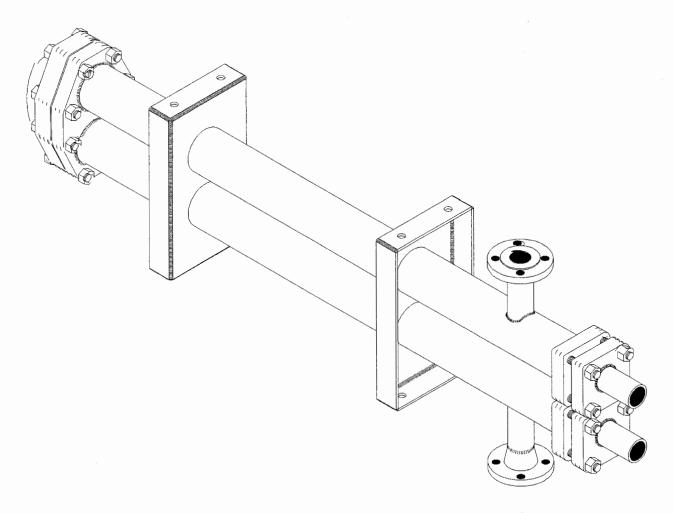
## Manufacturer's Equipment Record Book

Customer: Cenovus Energy, Inc.

Purchase Order #: 1083-BC-4006

Item #: BL-E-301

Sales Order #: 4474



Serving Rick Windell

Petroleum, Petrochemical, Power, Food, and Industrial on Heat Transfer Equipment

WITNESS

REVIEW



## **SECTION 4**

## **U-1 Manufacturer's Data Report**

Multiple WITNESS DE REVIEW REVIEW 25 SEA 13

### 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. Ma	Manufactured and certified by Heat Exchanger Design, Inc.  901 E. Beecher Street, Indianapolis, IN 46203  (Name and address of Manufacturer)																	
2. Ma	Manufactured for Cenovus Energy, Inc., c/o Bantrel Tower, 700, 6th Ave. S.W., Calgary, AB T2P 4C9, Canada (Name and address of Purchaser)																	
3. Lo	cation of installa	tion Un	knowr	l					(Name	ano aoo	ress of Pur	cnaser)						
										•	ne and addi	ress)						
4 Tv	Horizontal Hairpin Heat Exchanger 4474 W2682.2 4474 Rev.1 3532 2013												2013					
T. 13	(Horiz,, vert	, or sphere	) (Та	nk, separator,	kt. vessel,	, heat exh., e	etc.)	(Mfg's ser	ial No.)	(C	RN)		(Drav	ving No.)	(Na	ťl. Bd.	No.) (Ye	ar built)
		VIII Div			2010	, A11								•				
5. AS	ME Code, Sect	ion viii, Div	. '	Edition		enda (date)				Code (	Case No.		_	Special	Servi	ce 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 multi-chamber vessels.																		
6. Shell (a) No. of course(s): (b) Overall length (ft & in.): 20'-3.875" each leg-parallel legs w/common cover																		
	Cour	se(s)			Material		Thick	rness	+		t (Cat. A)		Circu	m, Joint (Cat. A	1, B 8	k C)	Heat Trea	tment
No.	Diameter, in.	Length (ft.	& in.)	Spec./C	rade or Ty	/pe	Nom.	Corr.	Туре	Full, Sp	ot, None	Eff.	Туре	Full, Spot, Nor	ie i	Eff.	Temp.	Time
(2)	4.026" ID	20'-3.8	75"	SA	-106Gr.E	3	.237"	.0625"	' S			100%					None	
									<b></b>						_			
	CA	-516Gr.7	ONT (1)	(" (D)						L							1	
7. He	eads: (a) SA								(b) -									
		(Ma	t'i Spec	No., Grade o	Туре) Н.	rTime & Te	emp				(Mat'l S	pec. No	., Grad	e or Type) H.T.	-Time	e & Ter	mp	
L	ocation (Top,	Thick	ness	Rad	lius	Elliptical	Conic	ai	Hemispl	herical	Flat	S	ide to P	ressure			Category /	٩
B	lottom, Ends)	Min.	Соп.	Crown	Knuckle	Ratio	Apex A	ıngle	Rac	lius	Diameter	Cor	vex	Concave	Туре	Full, S	Spot, None	Eff.
(a)	End	.44"	.0625	;"		2:1						Ye	s	Yes				
(b)																		
8. Ty	8. Type of jacket None Jacket closure —— (Describe as ogee & weld, bar, etc.)											Grade,		•				
									Jacket o	closure			Describ	e as ogee & w	eld, b	ar, etc.	.)	
If	bar, give dimer	isions							Jacket o	closure			Describ	e as ogee & w				sketch
	bar, give dimer			V nei	at may too		352	35	****	_	Min desire	(			lf i	bolted,	describe or	
lf 9. M	AWP1	110			at max. ten	·· F ·	352	35	2	_	Min. design	(		e as ogee & w	lf i	bolted,		
9. M	AWP 1	110 ternal)	(exte	rnal)		(inte	mai)	(extern	2	°F i		(			lf i	bolted,	describe or	
9. M	AWP 1	110 ternal)	(exte			(inte CS-66 and	mal) d remair	extern) (extern	2 nal) ms per	% I	0(f).	metal t			lf i	bolted,	describe or	
9. M. 10. In 11. H	AWP 1 (in:	o, studs &	(exte & nuts press.	exempt per	Fig. U	(inte CS-66 and (Indica	mal) d remair	extern) (extern	2 nal) ms per	% I		metal t			lf i	bolted,	describe or	
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9. M. 10. In	AWP 1 (in: npact test N  ydro., pneu., or s 12 and 13 to t ubesheet:	comb. test te complete	(extermits) press. d for tub A-106	mal) exempt per 1443 e sections. Gr.B	Fig. U	(inte CS-66 and (Indica Pro	mal) d remain te yes or n oof test OD	extern) (extern	2 nal) ms per compon	°F 1 UG-20 ent(s) in	0(f).	metal f	.062	-20	if i	polted, Fat	describe or 1110 / F	.V. psi
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9. M. 10. Ir. 11. H item: 12. T - 13.Tu Item: 14. S	AWP 1 (initial properties of the country of the cou	comb. test be complete S. stationary (More Spec. No.) Gr.B / SA pec. No., G be complete course(s): Length (f	(exter control (exter	rnal) exempt per  1443 e sections. Gr.B c. No)  Dia., i	Dia., ir	(inte CS-66 and (Indica Pro 3.938" n. (subject to 2.875" O.D., in. d vessels or	mal) d remain te yes or n oof test  OD press.)  Nom. thk  channels o	(externing iter to and the	2 ms per component of the component of t	oF UG-20 ent(s) in " long n. thk., ir 203" n. or gaus (ft & in.) Long	O(f).  npact tester  n.  Corr. Allow  uge  g Joint (Car, Spot, Non	Co , in	.062 Tr. Allow	-20 5"  /, in.  1) er  um, Joint (Cate Full, Spot, N	If I o	bolted, F at  Chment Chment Type  & C)  Eff.	Bolted (welded or  "U" (Straight or	bolted)  U)  eatment Time
9. M. 10. Ir. 11. H item: 12. T - 13.Tu Item: 14. S	AWP 1 (in: npact test N  lydro., pneu., or s 12 and 13 to to ubesheet:  Not Floating (Mat'l ubes: SA-106 Mat'l S s 14 - 18 incl. to hell (a) No. of c  Cou Diameter, in.	comb. test be complete S. stationary (More Spec. No.) Gr.B / SA pec. No., G be complete course(s): Length (f	(exter the content of	rnal) exempt per  1443 e sections. Gr.B c. No)  Dia., i	Dia., ir	(inte CS-66 and (Indica Pro 3.938" n. (subject to 2.875" O.D., in. d vessels or	mal) d remain te yes or n oof test  OD press.)  Nom. thk channels of	(externing iter to and the second for the second fo	2	oF IUG-20 ent(s) in " long n. thk., ir 203" n. or gaus (ft & in.) Long	npact tester  Corr. Allow  g Joint (Car. Spot, Non	Co in.	.062 T. Allow  Number	-20  5"  /., in.  1)  er  sum, Joint (Cat.	If I o	chment Type  & C)  Eff.	Bolted (welded or  "U" (Straight or	bolted)  U)  eatment Time
9. M. 10. Ir. 11. H item: 12. T  13. Tu ttem: 14. S	AWP 1 (initial properties of the state of th	comb. test be complete S. Stationary (M. Spec. No. ) Gr.B / S. pec. No., G be complete course(s):	(exter the content of	rnal) exempt per  1443 e sections. Gr.B c. No)  Dia., i	Dia., ir  Of jacketed  Material  c./Grade o	(inte CS-66 and (Indica Pro 3.938" n. (subject to 2.875" O.D., in. d vessels or	mal) d remain te yes or n oof test  OD o press.)  Nom. thk	(externing iter to and the	2	oF IUG-20 ent(s) in " long n. thk., ir 203" n. or gaus (ft & in.) Long	O(f).  npact tester  n.  Corr. Allow  uge  g Joint (Car , Spot, Non	Co in	.062 Tr. Allow  (Number	-20 -5" /, in.  1) er  um, Joint (Cat.	If I o	chment Type  & C)  Eff.	Bolted (welded or "U" (Straight or	bolted)  U)  eatment Time
9. M. 10. Ir. 11. H item: 12. T  13. Tu ttem: 14. S	AWP 1 (initial properties of the state of th	comb. test be complete S. Stationary (Mone Spec. No. ) Gr.B / S.A pec. No., G be complete course(s): Length (t	(exter it is not seen to be considered as it is not seen to be considered as it is not seen to be considered as it is in.)	rnal) exempt per  1443 e sections. Gr.B c. No)  Dia., i	Dia., ir  Of jacketed  Material  c./Grade o	(inte CS-66 and (Indica Pro 3.938" n. (subject to 2.875" O.D., in. d vessels or	mal) d remain te yes or n oof test  OD o press.)  Nom. thk  channels o	(externing iter to and the	2	oF IUG-20 ent(s) in " long n. thk., ir 203" n. or gaus (ft & in.) Long	npact tester  n.  Corr. Allow  uge  g Joint (Car	Co ., in.	.062 T. Allow  Circ  Typ	-20  5"  /., in.  1)  er  sum, Joint (Cat.	Attace Attace	chment Type  & C)  Eff	Bolted (welded or "U" (Straight or	bolted)  U)  eatment Time
9. M. 10. In 11. H item: 12. T 13. Tu tem: 14. S	AWP 1 (initial properties of the state of th	comb. test the complete S. Stationary (Mone Spec. No. ) Gr.B / SA pec. No., G be complete course(s): Length (Mone (Mone)	(exter it is not seen to be considered as it is not seen to be considered as it is not seen to be considered as it is in.)	exempt per  1443 e sections.  Gr.B c. No)  Dia., i  Gr.WPB Type ner chambers  Spe	Dia., ir  Of jacketed  Material  c./Grade o	(inte CS-66 and (Indica Pro 3.938" n. (subject to 2.875" O.D., in. d vessels or	mal) d remain te yes or n oof test  OD o press.)  Nom. thk  channels o	(externing iter to and the	2	oF IUG-20 ent(s) in " long n. thk., ir 203" n. or gaus (ft & in.) Long	O(f).  Inpact tester  Corr. Allow  Uge  G Joint (Call  Spot, Non  (Mat'l S	Co ., in.	.062 T. Allow  Circ  Typ   J. Grad	-20  5"  /., in.  1)  er  sum, Joint (Cat.	Attace Attace	chment Type  & C)  Eff	Bolted (welded or  "U" (Straight or  Temp.	bolted)  U)  eatment Time
9. M. 10. In 11. H item: 12. T  13. Tt Item: 14. S	AWP 1 (initial properties of the state of th	comb. test the complete S. Stationary (Mone Spec. No. ) Gr.B / SA pec. No., G be complete course(s): Length (Mone (Mone)	(exter the content of	exempt per  1443 e sections.  Gr.B c. No)  Dia., i  Gr.WPB Type ner chambers  Spe	Dia., ir Dia., ir  Of jacketed  Material  C./Grade o  Type) H.  Radius	(inte CS-66 and (Indica Pro 3.938"  n. (subject to 2.875"  O.D., in. d vessels or  TTime & Te Elli	mal) d remain te yes or n oof test  OD press.)  Nom. thk  channels of  Nom.	(externing iter to and the	2	oF IUG-20 ment(s) in long n. thk., ir long n. or gat s. (ft & in.) Long	O(f).  Inpact tester  Corr. Allow  Uge  G Joint (Call  Spot, Non  (Mat'l S	Co., in.	.062 T. Allow  Circ Typ  D. Grad Sid	-20  5"  I, in.  1)  er  um, Joint (Cat. e   Full, Spot, N	Attace Attace Attace	chment Type  & C)  Eff.  e & Ter	Bolted (welded or  "U" (Straight or  Temp.   Temp.  Category	bolted)  U)  eatment Time
9. M. 10. In 11. H item: 12. T  13. Tt Item: 14. S	AWP 1 (initial properties of the second seco	comb. test the complete Stationary (Marchaeles):  Spec. No., G be complete course(s):  Length (f  None (Marchaeles)	(exter the content of	mal) exempt per 1443 e sections. Gr.B c. No) Dia., i Gr.WPB Type ner chambers Spe	Dia., ir  Dia., ir  Material c./Grade o  Type) H.  Radius	(inte CS-66 and (Indica Pro 3.938"  n. (subject to 2.875"  O.D., in. d vessels or  TTime & Te Elli	mal) d remain te yes or n oof test  OD press.)  Nom. thk  channels of  Nom.	(externing iter to and the	2	oF I UG-20 lent(s) in " long n. thk., ir 203" n. or gat s. (ft & in.) Long e Full	O(f).  npact tester  n.  Corr. Allow  uge  g Joint (Car , Spot, Non  (Mat'l Scal Flat Dian	Co ., in.	.062 T. Allow Circ Typ G. Grad Sid Conve:	-20  5"  /, in.  1)  er  Eum, Joint (Cat.  e Full, Spot, N   e or Type) H.T.  e to Pressure  c Concave	Attace Attace Attace Typ	bolted, F at  chment chment Type & C) Eff e & Tel	Bolted  (welded or  "U"  (Straight or  Heat Tr  Temp.    Category of Spot, Non-	bolted)  U)  eatment Time A e Eff.
9. M. 10. In 11. H item: 12. T  13.Tu Hems 14. S	AWP 1 (initial properties of the second proper	comb. test be complete S. stationary (None Complete Spec. No.) Gr.B / S. pec. No., G be complete course(s): I Length (t  Thick Min.	(exter content of the	mal) exempt per  1443 e sections. Gr.B c. No)  Dia., i Gr.WPB Type ner chambers  Spe	Dia., ir  Dia., ir  Naterial c./Grade o  Type) H.  Radius	(inte CS-66 and (Indica Pro 3.938" n. (subject to 2.875" O.D., in. d vessels or  TTime & Te uckle	mal) d remain te yes or n oof test  OD o press.)  Nom. thk  channels of	(externing iter to and the	2	oF UG-20 ent(s) in "long n. thk., ir 203" n. or gaus (ft & in.)  Long e Full  mispheric Radius	O(f).  npact tester  n.  Corr. Allow  uge  g Joint (Car , Spot, Non  (Mat'l S cal File Diam	Co., in.	.062 T. Allow  Circ Typ  D. Grad Sid	-20  5"  I, in.  1)  er  um, Joint (Cat. e   Full, Spot, N	Attace Attace Attace Typ	chment Type  & C)  Eff.  e & Ter	Bolted (welded or  "U" (Straight or  Temp.   Temp.  Category	bolted)  U)  eatment Time

If removable, bolts used (describe other fastening)

(16) 3/4"-10 x 5" long studs SA-193Gr.B7 / (16) nuts SA-194Gr.2H

16. MAWP	s. MAWP 1440 F.V. psi at max. temp. 302 302 °F Min. design metal temp20 °F at 1440 / F.V. psi.										
(internal) (external) (internal) (external)											
17. Impact test No, studs & nuts exempt per Fig. UCS-66 and remaining items per UG-20(f).  (Indicate yes or no and the component(s) impact tested)											
(indicate yes or no and the component(s) impact tested)  18. Hydro., pneu., or comb. test press. 1872 Proof test											
19. Nozzles, inspec				Floorites							
Purpose (inlet,		Diameter	Flange	Mate	erial	Nozzie 7	Thickness	Reinforcement	How Att	tached	Location
Outlet, Drain, etc.)	No.	or Size	Туре	Nozzie	Flange	Nom.	Corr.	Material	Nozzle	Flange	(Insp.Open)
Shell Inlet	(1)	2"	Cl.600 rfwn	SA-106Gr.B	SA-105	.343"	.0625"	Not Required	UW-16.1(c)	Fig.2-4(6)	Top
Shell Outlet	utlet (1) 2" Cl.600 rfwn SA-106Gr.B SA-105 .343" .0625" Not Required UW-16.1(c) Fig.2-4(6) Bottom							Bottom			
Tube Inlet	e Inlet (1) 3" Cl.900 rflwn SA-105 SA-105 .3125" .0625" Not Required UW-16.1(a) Integral End							End			
Tube Outlet	be Outlet (1) 3" Cl.900 rflwn SA-105 SA-105 .3125" .0625" Not Required UW-16.1(a) Integral End							End			
-	<del></del>										
-	=	=									
00 0 0		No				<u> </u>	Sado	lles		Welded to	
20. Supports: Skirt	-	(Yes or N		Legs _	Other	·			ached	(Where and	
21. Manufacturer's	Parti	•	•	(No.) d and signed by Commiss	(No.) sioned Inspectors hav	e been furr	Descri) nished for t	,	the report:	(Wilele aliu	now)
			nber, mfg's. name and	• •	,			•	•		
None											.,
22. Remarks: 1)	Reli	ef valvir	g to be supplied i	in customers piping	. 2) Tube nozzle	s bolted	to tube	fittings per line	15. 3) Sins	gle inner U	-pipe
				90° butt weld elbow						-	
				'-10 x 6" lg. studs S							
nozzles, 100	% E	Eff. for a	ll. 6) Shell return	cover head-to-flan	nge weld and inn	er U-pir	e welds	subjected to spe	ot RT.		
and employed be the pressure ver Manufacturer had employer makes	27 ed, he y ssel	olding a vi	Name Heat Excellent Excell	changer Design,Inc. (Manu CERTII red by The National Bo	FICATE OF SHO ard of Boiler and P P/AY 20 ASME Code, Sectivessure vessel description	nessure V  13  on VIII, Deribed in the	essel Ins and stat ivision 1. his Manuf	pectors and the Sta of <u>Lynn, MA.</u> ee that, to the best By signing this cel acturer's Data Rep	of my knowl	he of IN.  have insteaded and be er the Inspectore, neither	lief, the ctor nor his the Inspecto
Date 9/27	//3	Si	gned MA	Merfer	(	Commissi	ons N	BIOCEG(A,B)	12140	<b>Y</b>	
				Authorized Inspector)				at'l Board incl. end			e and No.)
***************************************				CERTIFICATE OF	FIELD ASSEME	SLY CO					
We certify that t				prrect and that the field	d assembly constru	ıction of a	ill parts of	this vessel confor		equirements	of ASME
U Certificate of	Auth	orization	No		Expires				20 _		
Date		Nar	ne	(Assembler)		Sia	ned _	(Repres	entative)		
			C	ERTIFICATE OF F	IELD ASSEMBI	Y INSP	ECTION	l			
I, the undersign		holding a		sued by The National					e State or Pr	ovince of	
		statemer	nts in this Manufactu	irer's Data Report with	the described pre	ssure ves	ssel and s	state that parts refe	erred to as da	ata items	
			, not ir	ncluded in the certifica	te of shop inspecti	on, have	been ins	pected by me and	to the best o	f my knowled	
				d assembled this press							
				t ofps							
				essel described in this						r nis employ	er snail
be liable in any	mar	nner for a	ny personal injury or	r property damage or a	a loss of any kind a	irising fro	m or con	nected with this in:	spection.		
Date Signed Commissions (Authorized Inspector) (Nat'l Board incl. endorsement, State, Province and No.)											

## **SECTION 5**

## **Nameplate Copies**

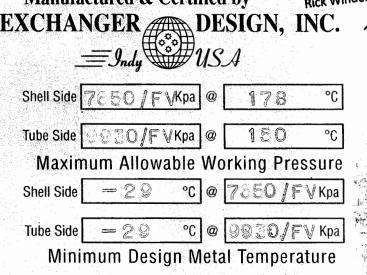
Muhilly St. REVIEW 2558113

	(18) 3532	
	Manufactured & Certified by	
L CAN A HE	AT EXCHANGER DESIGN, INC.	
	USA	
W- KT	Shell Side 1110 PSI @ 532 °F	
	Tube Side 1440 PSI @ 302 °F	
	Maximum Allowable Working Pressure	
Serial Number	Shell Side Fy PSI @ 352 °F	
+474	Tube Side FV PSI @ 302 °F	
<b>*</b>	Maximum Allowable External Working Pressure	
Hydro Test Pressure	Shell Side = ₽0 °F @ 1110 /F V PSI	
1443 /1872 Shell Side / Tube Side	Tube Side	
	Minimum Design Metal Temperature	
Customer: CENOVU	ENERGY INC	
P.O.#: 1083 - BC	-4008 CRN W2882,2	
Service: NATURAL	GAS HEATER	
Item: BL - E - 30	Year Built: 2013	
		[7
		NESS L
	Manufactured & Certified by Rick Windell AT EXCHANGER DESIGN, INC. 25 GEN 13 REV	
	#\@\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	
	=Indy₩#USA	

Serial Number

Hydro Test Pressure

Shell Side / Tube Side



## **SECTION 6**

## NDE Reports, Personnel Certifications & Procedures

Mumbell WITNESS D
Rick Windell 25 St 13



7515 Company Drive, Suite B Indianapolis, IN 46237 Phone: 247 990 9720

S-Surface

El-Elongated Indication

USI WO# 35869	Report Page of
Date: 6/24	1/13
Customer: Heat Ex	changer
901 E.	Beecher St.
Indols,	IN 46203
PO#:	5010/03-01
Location: Some a	s above
Description:	butt weld
1000/ Inon	- Snot Inch

Fax: 317-890							100% Ins		<i>D</i>	Spot Ins	p. 1/	
Serial # or Pi Customer W		<u>S.C</u>	),# ),# (	44	174 34-00	$\infty$	Insp.Spe RT Proce	edure:	ASM BT-1	hnique EV Rev.24		
Weld #	Film #	Acc.	Rei	Code	Remarks	Welder		nce Stand. used belo	<u> </u>	EVIII /K	7-1 Sup	. Rev. 14
C-1	0-6		<u> </u>	0000	remarks	weiger	1 10011.	uscu bolo	"			
							0		Positioned er of Pope		Source Pene Source Pene	<b>)</b>
· · · · · · · · · · · · · · · · · · ·							1			010		
		+		<b></b>	<del></del>		Material:			<u> </u>		
		1	-				Pipe Size:		14"	Wall Thk.	.500	<del>7</del> 2
		11		<del></del>			Process:	SMAW	X	GTAW X		<u>3</u>
	_	1					FCAW:	14	SAW	X	Other	
		-					Source	Isotope		2 Curies	45	
		11					Physical S		145	KVP/MA		•
		1	-				Exposure	Time:	1.5 m	SFD:	14"	
		<del>                                     </del>			<b></b>	M COMP	Film/Object	ct inches:	·····	conta		
		1				<del></del>	Geometric	Unsharpn			020	
		<del>  </del>			<del></del>		Marie Type	≥ / Size:		STMB	(1013)	
	<del></del>	+		0/1		TOW'	ـ ا	Material:	5/5	Placemen	t <i>F/</i>	<u> </u>
			1		-50	14	Shims	Material:		_ Thickness		_
			4	CON	PALC		NESS	Marker/# I	Belt	_ ρЬ≠	15	
		1	4	V		// ***	Film:	ABrand:	A6FI	4 Type:	<b>D7</b>	
		d			1- //a //	1 12	Z Z	Size:	4.5×10		Single	<del></del>
				111	Valley Y	II R	HEW /	Emulsion		_	70613 N	<del></del>
			KI	V #///	W 1_	MOX	Screens:		` ———			
		1 1	711	1	Nindell (	<u></u>	Julieens:	Front:	.01		.010	
		<del>  </del>	,-,	pick	Millo	<del></del>	1			Backing:		
		╂		1,,,,	<b></b>		Viewing	Single:		Double		<b>19</b> *-
	<del></del>	<del></del>		<b></b>	<b> </b>		Density (P			2.8-3.4		was in the second of the secon
		<b>↓</b>		<b></b>			Density (w	reld) min.m:	ax	2.8-3.		
		<u> </u>					1	•				Harden State of the State of th
P-Porosity		SI-Slag	Inclus	ion	I-Tungsten	Inclusion	I	77	(	1 1		Z Mentalestation and Comment
C-Crack		BT-Bur			CV-Root Cor		1 4	15c.	10.0	Halla.	n	
F-Incomplete	Fusion					-	1 '	211	gan 1	KY KEL	71	ACTOR DE LA COMPANSION
n -moompiete	Damatustic -	MT-Me	it into	ugn (	CX-Root Cor	ivexity	I	Radiograp	mer /	$I \cap II$	_	

## Radiograph Review Form

As directed by ASME Sec.V, Art 2, para. T-286, we the manufacturer shall evaluate and accept each radiograph to assure compliance with the requirements of the Code. This Review Form is completed while examining the radiographs and their associated reports for proper radiographic technique and the required markings. This Form will accompany the radiographs as supporting documentation.

Sales Order#	Weld Joint	
4474	C1	
Check List for Permanent Markings on Radiographs		
•		
Work Order Number		
Weld Joint Identification		
Manufacturer's Name (HED)		
Date of Radiograph		
Welder Identification		
Location Markers		
Penetrameter		
Check List for Radiographic Technique Data (Review Radiogra  Work Order Number	pine reader sheet,	
Location Marker Map (per T-2753) if required		
Number of Exposures		
X-ray Voltage or Isotope Type		
X-ray Focal Spot Size <i>or</i> Isotope Source Size		
Base Material Type		
Base Material / Weld Thickness		
Minimum Source-to- Object Distance		
Maximum Source Side of Object-to-Film Distance		
Film Manufacturer	101 000	WITNESS
Film Designation	Musikell Rick Windell	171110000
Number of Film per Cassette (Holder)	Pick Windeli	REVIEW
Single or Double Wall Exposure	WILK AAUGO	
Single or Double Wall Viewing	,	
Evaluation of Object Radiographed		

Date: 6-25-13

Accepted by: Quality Control, H.E.D., Inc.

Bick L Hussong



7515 Company Drive, Suite B Indianapolis, IN 46237

Phone: 317-890-9729

**El-Elongated Indication** 

USI WO#	363404	Repor	t Page /c	of /	
Date:	7/30/1	<b>'3</b> ,			
Customer:	Heat E	Kchanger			
		Beecher	St.		
	Indols	, IN 46	203		
PO#:		50108	8-0L		
Location:	Same	as abou	e,		
Description	1:	butt 1	Weld		
100% Insp	V	Spot I	nsp.		

Fax: 317-890-8	577				100% Insp Spot Insp.
Ordel Man Dise	- 4	5 1	# 411	אכן	Technique Data
Serial # or Piec Customer WO		<del>2.0</del>	# 77	934.000	Insp.Specification ASME V RT Procedure: RT-1 Rev. 24
Customer WO	π	1.0	<del>,                                    </del>	037-000	Acceptance Stand. RT-1 Rev. 24  ASME VIII/RT-1 Sup. Rev. 16
Weld#	Film#	Acc. R	ej. Code	Remarks	RT Tech. used below "B"
T4	0-1	$\Box \Box \Box$			
	1-2	<b>1</b>			Source the source
	2.0	$\overline{\mathbf{V}}$			
					Pene
		ļ			
					- В У п 日 Д ((( ))
		<del>                                     </del>			
		<del>                                     </del>			
					© D Source
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					Source
		<del>├</del>			Source
		+			
	<del> </del>	+-+	-		1 19/ 11/
		<del>                                     </del>			Source
				,	Pene
					Source Positioned
					in Center of Pope
		<del>  </del>			C/2
		+			Material:
		+			Pipe Size: 2,5" Wall Thk. , 203"  Process: SMAW X GTAW  GMAW X
	<b></b>	<del>                                     </del>			FCAW: SAW X Other
					Source Isotope Zr. 192 Curies 31
					Physical Size: 1/55 KVP/MA
					Exposure Time: 6 Sec. SFD: , 2.5"
		<b>↓↓</b> -			Film/Object Inches: Contact
		<del>                                     </del>			Geometric Unsharpness:
		<del>                                     </del>			Pene Type / Size:  Astorial:  So Pleasment
		<del>                                     </del>			Material: 5/5 Placement F/5 Shims: Material: 5/5 Thickness 090
			_ I		Marker/# Belt
		1/1/	1/		Film: Brand: AGFA Type: 04
		14 16	amele	WITNESS	Size: 4.5x10 Load: Single
		HICK	(Windell '		Emulsion(s) number: 2240630
		<del>  </del>	· windell	REVIEW	Seens: Front: ,010 Back: ,010
		<del>                                     </del>	DISA	19	Backing:
		+	4	1	Viewing Single: Double Double 2. / - 2. 3
		1			Density (Pen.) 2. / - 2. 3  Density (weld) min.max 2. / - 2. 3
					7.7
P-Porosity		SI-Slag II	nclusion	TI-Tungsten Inclusion	7 // //
C-Crack		BT-Burn		CV-Root Concavity	1 Drugg Hallem
IF-Incomplete Fe		MT-Melt	-	CX-Root Convexity	Radiographer
IP-incomplete P	enetration	UC-Unde		OX-Oxidation	1 1/5 d//// 1-1700
S-Surface		FA-Film	Artifact	SK-Shrinkage	275 Allam Lev. ILRT

## Radiograph Review Form

As directed by ASME Sec.V, Art 2, para. T-286, we the manufacturer shall evaluate and accept each radiograph to assure compliance with the requirements of the Code. This Review Form is completed while examining the radiographs and their associated reports for proper radiographic technique and the required markings. This Form will accompany the radiographs as supporting documentation.

Sales Order#	Weld Joint
4474	T4
No. 1 Line Co. Dominion of Malican and De Vicensel	
Check List for Permanent Markings on Radiographs	
Work Order Number	
Weld Joint Identification	
Manufacturer's Name (HED)	
Date of Radiograph	
Welder Identification	
Location Markers	
Penetrameter	
Check List for Radiographic Technique Data (Review Rad	adiographic Reader Sheet)
	adiographic Reader Sheet)
Work Order Number	adiographic Reader Sheet)
Work Order Number  Location Marker Map (per T-2753) if required	adiographic Reader Sheet)
Work Order Number Location Marker Map (per T-2753) if required Number of Exposures	adiographic Reader Sheet)
Work Order Number Location Marker Map (per T-2753) if required Number of Exposures X-ray Voltage or Isotope Type	adiographic Reader Sheet)
Work Order Number Location Marker Map (per T-2753) if required Number of Exposures X-ray Voltage or Isotope Type X-ray Focal Spot Size or Isotope Source Size	adiographic Reader Sheet)
Work Order Number Location Marker Map (per T-2753) if required Number of Exposures X-ray Voltage or Isotope Type X-ray Focal Spot Size or Isotope Source Size Base Material Type	adiographic Reader Sheet)
Work Order Number Location Marker Map (per T-2753) if required Number of Exposures X-ray Voltage or Isotope Type X-ray Focal Spot Size or Isotope Source Size Base Material Type Base Material / Weld Thickness	adiographic Reader Sheet)
Work Order Number Location Marker Map (per T-2753) if required Number of Exposures X-ray Voltage or Isotope Type X-ray Focal Spot Size or Isotope Source Size Base Material Type Base Material / Weld Thickness Minimum Source-to- Object Distance	adiographic Reader Sheet)
Work Order Number Location Marker Map (per T-2753) if required Number of Exposures X-ray Voltage or Isotope Type X-ray Focal Spot Size or Isotope Source Size Base Material Type Base Material / Weld Thickness Minimum Source-to- Object Distance Maximum Source Side of Object-to-Film Distance	adiographic Reader Sheet)
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Work Order Number Location Marker Map (per T-2753) if required Number of Exposures X-ray Voltage or Isotope Type X-ray Focal Spot Size or Isotope Source Size Base Material Type Base Material / Weld Thickness Minimum Source-to- Object Distance Maximum Source Side of Object-to-Film Distance Film Manufacturer Film Designation	



## Certification of NDT Qualification: BRYAN HALLAM

The education, training and experience of the individual named above has been reviewed, and found to meet or exceed the requirements of one or more of Acuren Inspections written practices QP-141 (NAS-410), QP-142 (SNT-TC-1A) and/or QP-145 (CP-189). The specific certification standard is identified in the comments column.

Certifications	· · · · · · · · · · · · · · · · · · ·		, , , , , , , , , , , , , , , , , , ,			
Method & Level	<b>Certified</b>	Expires	Exam Avg	Comments		
Radiological - Level II	7/7/2011	7/6/2014	91.44 %	X-Ray & Gamr	na SNT-TC-1A	
Magnetic Particle Testing - Level II	7/7/2011	7/7/2014	85.39 %	Fluorescent & Visible Yoke & Coil Methods SNT-TC-1A		
Penetrant Testing - Level II	11/9/2011	11/9/2014	95.22 %	Visible Only SI	NT-TC-1A	
Job History / NDT Experience		o de la compensación de la compe				
<u>Employer</u>	<u>Method</u>	/ Position		<u>From</u>	<u> To</u>	
Acuren Inspection	RT,MT,	PT - LII		11/1/1999	Present	
MQS Inspection	RT,MT,	PT - LII		9/1/1987	11/1/1999	
Technical Training						
Course Title	Location			Date	Hours	
MT	MQS Inspe	ection	12	2/4/1987	24	
PT	MQS Inspe	ection	12	2/4/1987	16	
RT	MQS Inspe	ction	5/	24/1991	80	
MT	US Inspect	ion	12	/27/2007	8	
PT	US Inspect	ion	12	/27/2007	16	
Formal Education	<u></u>					
Education		ocation			<u>Date</u>	
General/Diploma	(	Sibson Southern	1 H.S., IN		5/19/1986	

-	_		min
-ve	1-Ya	mination	Record

Examined By: David Klingstein

Last Exam Date Corrected Expiration 5/10/2013 Yes 5/10/2014

The individual named above has satisfactorily demonstrated the ability to read the Jaeger #J-1 letters, to read the Snellen test chart or equivalent for vision acuity of 20/30 or greater, and able to distinguish contrasting colors used in the methods.

The individual named above is certified in the indicated NDE Method(s) and Level(s). The certification(s) will expire on the date(s) listed above, or upon termination of employment.

Thereby certify that, to the best of my knowledge, the information listed above is true ... Tiffani Ivins Director of Quality L-III

Signature

Date

Mulandell 45 13 Review
Rick Windell 45 13 Page 1 of 1

Printed: 5/13/2013



### **NDE Procedure**

## Radiographic Examination (ASME Section V)

RT-1

	1,4,1-4
PERMISSIONS TO PROCEED DOES NOT CONSTITUTE ACCEPTANCE OR APPROVAL OF DESIGN BEGALS, CALCULATIONS, ANALYSES, TEST METMODS ON MATERIALS DEVELOPED OR SELECTED BY THE SUPPLIER AFID OF SELECTED BY THE SUPPLIER AFID OF SELECTION OF SUPPLIER FROM FULL COMPLIANCE WITH CONTRACTUAL OBLIGATIONS.	Revision 22
1. WORK MAY PROCEED.	
REVISE AND RESUBMIT WORK MAY PROCEED SUBJECT TO INCORPORATION OF CHANGES INDICATED.  REVISE AND RESUBMIT WORK SHALL NOT PROCEED.	3/12/2012
4. REVIEW NOT REQUIRED. WORK MAY PROCEED.  BY WT DATE MATCH 14, 2973	

Reviewed and Approved by:

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Gerald F. Wade ASNT Level III #13614 Thomas L. Payne QA Director - USA

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## Revision/Change Summary

Revision or			
Change	No.	Date	Description
	1.		Updated Section 2 to current code revisions.
			Added procedure RT-CAL-1 to list of references.
Revision	12	12/28/07	Revised Section 5.9, Densitometer.
		<u> </u>	Corrected Figure typo on page 12.
			Added Confidentiality Notice to cover page.
	1	ľ	Revised page numbers in TOC.
	1	Ì	Revised Section 2.0 References.
		1.	Added paragraphs 3.3, 3.4 and 3.5.
Revision	13	01/03/09	Changed paragraph 5.1 and renumbered remaining
	1		paragraphs in Section 5.0.
	1		Revised paragraphs 5.8 and 6.2.
	1		Revised paragraphs 7.5.2, 7.5.4 & 7.5.5.
			Revised paragraph 9.4.
		1	Added paragraph 11.3.
	T		Revised references 2.1 through 2.5.
			Deleted ASME - B31.8 as Reference 7 and renumbered
			remaining references.
Revision	14	10/07/09	Revised paragraph 4.1.
			Revised paragraph 5.6.1 deleting Fuji 150 as an acceptable
			film type.
			Revised paragraphs 5.10.1, 5.10.2 and 5.10.3.
			Revised a page number in the TOC.
	•		Revised paragraph 5.10.4 for the recording of densitometer
Revision	15	12/28/09	calibration readings.
	1		Added paragraph 11.4, Documentation of Personnel and
	1		Procedure Demonstrations.
			Replaced Table 1, IQI Selection.
Revision	16	06/15/10	Added a Note after paragraph 11.1.
		1	Revised paragraphs 11.2 b, g and h.
Revision	17	12/28/10	Revised the reference section.
			Added reference 2.7 to the reference section.
Revision	18	03/03/11	Renumbered references 2.8 and 2.9.
			Revised the reference section.
			Revised paragraph 7.2.1.4.
Revision	19	09/27/11	Revised paragraphs 7.3.1, 7.3.2 and 7.3.3.
	1		Revised paragraph 7.4.1.
			Revised paragraph 9.4.
Revision	20	11/30/11	Added reference 2.10
Revision	21	01/09/12	Revised paragraph 4.1 to show compliance with SNT-TC-1A.
	T		Added SI unit dimensions to the standard dimensions throughout the
Revision	22	03/12/12	procedure.
		L	Revised paragraphs 4.1 and 5.6.2.

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#### 1.0 SCOPE

- 1.1 This procedure describes the requirements to be implemented by Acuren examination personnel performing radiographic examinations using X-ray or Gamma sources.
- 1.2 This procedure may be used for the detection of discontinuities, in materials, equipment, components and welds as applicable to client specifications, and/or applicable codes.
- 1.3 The type and thickness of material, source to object distance, distance from the source side of the object to the film, and physical source size used is unlimited provided the geometric unsharpness requirements of the referencing Code section are satisfied (when applicable) and the density and IQI image requirements of this procedure are met.

#### 2.0 REFERENCES

- 2.1 ASME Section I Power Boilers, 2010 Edition w/2011 Addenda
- 2.2 ASME Section V Nondestructive Examination, 2010 Edition w/2011 Addenda
- 2.3 ASME Section VIII Pressure Vessels, Divisions I and 2, 2010 Edition w/2011 Addenda
- 2.4 ASME Section IX Welding and Brazing Qualifications, 2010 Edition w/2011 Addenda
- 2.5 ASME B31.1 Power Piping, 2010 Edition
- 2.6 ASME B31.3 Process Piping, 2010 Edition
- 2.7 ASME B16.34 Valves, Flanged, Threaded and Welding End, 2009 Edition
- 2.8 QCP-1, Written Practice for the Qualification and Certification of NDE Personnel
- 2.9 RT-CAL-1, Calibration of Densitometers for Radiographic Testing
- 2.10 API-650, Welded Steel Tanks for Oil Storage, 11th edition

#### 3.0 RESPONSIBILITY

- 3.1 The Quality Assurance Director is responsible for the preparation, review, approval and control of this procedure. The level III is responsible for the technical review and approval of this procedure.
- 3.2 Level III, II, and level I examiners are responsible for implementing the requirements of this procedure. Level III and II examiners are responsible for the supervision of level I examiners and trainees.
- 3.3 The QA Manager is responsible to monitor compliance with this procedure.

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- 3.4 Technicians are responsible to comply with this procedure and to complete all required records/reports. At any time while performing work with this procedure, should it become evident that the requirements herein cannot be met, the technician is to immediately contact their supervisor or lead technician, as applicable, for resolution.
- 3.5 Technicians are to ensure that the item being inspected receives 100% inspection of all accessible areas within the inspection zone. Accessible areas are defined as those where all test parameters can be applied in accordance with the NDE procedure and the results properly viewed for interpretation/evaluation. In addition, inspection zone areas that are found to be inaccessible are to be recorded in the report.

#### 4.0 PERSONNEL QUALIFICATIONS

- 4.1 Unless otherwise specified by contract, PO or customer specifications, personnel performing Radiographic examinations shall be qualified and certified in accordance with reference 2.8, which complies with SNT-TC-1A and CP-189.
- 4.2 Personnel performing evaluations and/or reporting results in accordance with this procedure shall be certified Level II as a minimum.
- 4.3 Operator-helpers (radiographer's assistants) shall have completed radiation safety training and be in compliance with applicable regulatory requirements, and shall be responsible to the Level II or Level III technician.

#### 5.0 GENERAL REQUIREMENTS

- 5.1 Safety
- 5.1.1 Prior to beginning work, all personnel are to read, understand and follow the requirements of the applicable Job Hazard Analysis (JHA). In addition, personnel are to observe and follow all site specific safety requirements.
- 5.1.2 Should there be a question or a clarification needed to any safety requirement, the supervisor, lead technician or facility representative, as applicable, is to be contacted for resolution before beginning or resuming work.

#### 5.2 Image Quality Indicator (IQI)

The technique used shall produce sufficient sensitivity and contrast to display the IQI image and the specified hole or wire.

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IQI selection and the essential holes or wires shall be in accordance with Table 1.

#### 5.3 Backscatter Radiation

A lead letter "B" with a minimum dimension of 1/2 in. (12.7 mm) in height and 1/16 in. (1.58 mm) thickness shall be attached to the back of each film holder/cassette during each exposure to determine if backscatter radiation is exposing the film.

#### 5.4 Geometric Unsharpness

5.4.1 Geometric unsharpness of the radiograph shall be determined in accordance with:

Uq = Fd/D

Where:

Ug = geometric unsharpness

F = Source Size; the maximum projected dimension of radiating source (or effective focal spot) in the plane perpendicular to the distance D from the weld or object being radiographed, in.

D = Distance from source of radiation to weld or object being radiographed, in.

d = Distance from source side of weld or object being radiographed to the film, in.

Note: D and d shall be determined at the approximate center of the area of interest.

5.4.2 The unsharpness that can be expected for a given thickness, source-to-film distance and focal spot size is variable in effect to radiographic quality, type of film and filter/screens, radiation wavelength to material and thickness and also to darkroom procedure.

#### 5.5 Verification of Source Size

- 5.5.1 The equipment manufacturer's or supplier's publications, such as technical manuals, decay curves, or written statements documenting the actual or maximum source size or focal spot, shall be acceptable as source size verification.
- 5.5.2 The determination of the focal spot for X-ray machines at 420 kV and less may be made by the manufacturer's data, written statement documenting size, or the pinhole method.

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#### 5.6 Radiographic Film

- 5.6.1 Radiographic film Class I or II shall be used. Kodak AA, T, M, MX, DR; AGFA D7, D5, D4, D3; Fuji 100, 80 or 50 are acceptable.
- 5.6.2 To ensure complete coverage of the inspection area, radiographic film should be of sufficient length and width to allow 1.0 in. (25.4 mm) overlap beyond the location markers on consecutive circumferential/panoramic exposures, and 3/4 in. (19.95 mm) lateral coverage on both sides of the weld.

#### 5.7 Film Storage

Film shall be stored in a dry, clean area where the emulsion shall not be affected by heat, moisture or radiation.

- 5.8 Film Processing. The below applies to manual processing. For automatic processing, the equipment manufacturer's instructions shall be followed.
  - 1) Normal developing time is five to eight minutes at 68° F (20° C). When temperatures are higher or lower, developing time will be adjusted so that processing will consistently produce radiographs of desired quality.
  - Film shall be dried in a mechanical dryer or in an area that is free from dirt, oil, grease, etc.
  - 3) Developer, fixer and rinse water shall be changed on a regular basis or at any time when processed film shows chemical irregularities.
  - 4) The film processing area (darkroom/lab) and all accessories shall be kept clean at all times.

#### 5.9 Intensifying Screens

Lead foil screens shall be free of dirt, wrinkles, scratches, cracks and oxidation. Typically, the screen film combination front and back shall be 0.010 in. (0.25 mm) Pb screen/film/0.010in. (0.25 mm) Pb screen. Other thicknesses are acceptable, provided the requirements of Section 9.0 are met. Screens are optional at x-ray energies of 150 KV or less.

#### 5.10 **Densitometer**

5.10.1 Densitometers shall be calibrated at least every 90 days during use in accordance with reference 2.9.



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- 5.10.2 Periodic calibration verification checks shall be performed as described in reference 2.9 at the beginning of each shift, after 8 hr of continuous use, or after change of apertures, whichever comes first.
- 5.10.3 Step Wedge Comparison Films. Verification checks shall be performed annually per reference 2.9.
- 5.10.4 Densitometer calibration readings shall be recorded as required by reference 2.9.
- 5.11 Radiation Selection
- 5.11.1 This procedure shall be limited to the use of radioactive isotopes of Iridium 192 or Cobalt 60, Selenium 75, and X-ray machines of no greater than 420 kV.
- 5.11.2 Iridium 192 is normally used for performing radiography on steels with a thickness range of 3/16 in. (4.76 mm) to 3 in. (76.2 mm).
- 5.11.3 Cobalt 60 is normally used for performing radiography on steels with a thickness range of 1 1/2 in. (38.1 mm) to 7 in. (177.8 mm).
- 5.11.4 Selenium 75 is normally used for performing radiography on steels with a thickness range of .2 in. (5.08 mm) to 1.2 in. (30.48 mm).
- 5.11.5 The minimum or maximum thickness that can be radiographed for a given material is determined by demonstrating that the required sensitivity has been obtained.

#### 5.12 Direction of Radiation

The direction of the central beam of radiation shall be centered on the area of interest whenever practical.

#### 6.0 SURFACE PREPARATION

- 6.1 Where a surface condition which could mask a defect is detected by the radiographer prior to radiography, the surface condition shall be remedied before the exposure is made.
- 6.2 The weld ripples or weld surface irregularities on both the inside (where accessible) and outside, shall be removed by any suitable process to such a degree that the images of surface irregularities cannot mask or be confused with the image of any discontinuity on the resulting radiograph.

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The finished surface of all butt welded joints may be flush with the base material or may have reasonable uniform crowns, with reinforcement not to exceed that specified in customer code requirements.

- 6.3 When the weld cannot be discerned from the base material, suitable means of marking each side of the weld shall be used to assure complete coverage of the weld.
- 6.4 Where a surface condition has been demonstrated in the radiograph and the radiographic image is such that it could mask a rejectable discontinuity, one of the following shall be done:
  - a) The objectionable surface condition shall be treated so as to remedy the situation and the area radiographed again.
  - b) The radiographic examiner shall make a trace from the radiograph, place it on the surface in question, and determine if the radiographic indication results from a surface condition. If it is determined that the indication is a surface condition, then the radiographer shall indicate this on the tracing, sign and date the tracing, then file it with the radiograph. When two films are exposed simultaneously in the same cassette, then the indication shall be marked with the letter "S" on one of the two radiographs. The condition shall be noted on the radiographic report.

#### 7.0 EXAMINATION

#### 7.1 Radiograph Identification

The identification information on all radiographs shall be plainly and permanently produced, traceable to the contract, component, weld or weld seam or part numbers as appropriate, and shall not obscure any area of interest. The following information must be included as a minimum:

- 1) Contract-Component
- 2) Weld or weld seam number
- 3) Part number (traceable to drawings, contract number, or component)
- 4) Manufacturer's name or symbol
- 5) Date of radiograph
- 6) Location markers identifying the area of coverage.





- 7.2 Image Quality Indicators IQI's (penetrameters)
- 7.2.1 IQI (penetrameter) Selection Hole and Wire type

IQI's shall be either the hole-type or wire-type. Hole-type IQI's shall be manufactured and identified in accordance with the requirements or alternates allowed in SE-1025. Wire-type IQI's shall meet the requirements or alternates allowed in SE-747, except that the largest wire number or identity number may be omitted.

- 7.2.1.1 <u>Material</u>: IQI's shall be of the same alloy material group or grade or from an alloy material group or grade with less radiation absorption than the material being radiographed. (See Figure 1 for IQI Identification.)
  - Group 03 –all alloys of which magnesium is the predominant alloying constituent
  - Group 02 –all alloys of which aluminum is the predominant alloying constituent
  - Group 01 –all alloys of which titanium is the predominant alloying constituent
  - Group 1- all carbon steels, low alloy steels, stainless steels, manganesenickel-aluminum-bronze (Superston)
  - Group 2 –all aluminum-bronzes and all nickel-aluminum bronzes
  - Group 3 –nickel-chromium-iron alloy and 18% nickel maraging steel (Hastelloy D, Inconel X, Stellite Alloy No's 21 and S-816)
  - Group 4 –nickel, copper, nickel-copper series, or copper-nickel series of alloys, and all brasses (copper-zinc alloys, Hastelloy F and X)
  - Group 5 use on tin bronzes including gun-metal and valve bronze (Hastelloy alloys B and C, Stellite alloy No. 31, Stellite 3)





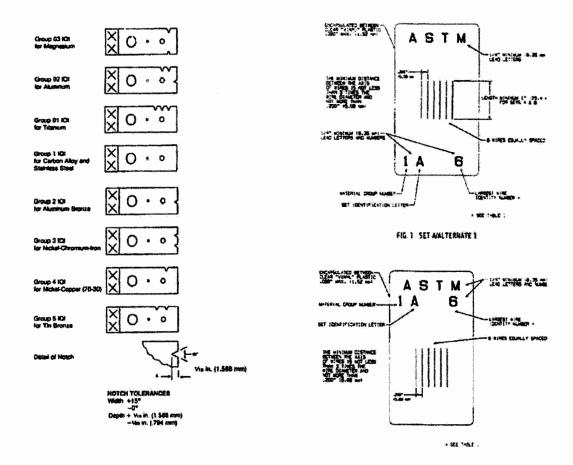


Figure 1 IQI Material Identification

- 7.2.1.2 <u>Dissimilar materials</u>: When the weld metal is of an alloy group or grade which has a radiation attenuation that differs from the base material, the IQI material selection shall be based on the weld metal. When the density limits cannot be met with one IQI, and the exceptional density area(s) is at the interface of the weld metal and the base metal, the material selection for the additional IQI(s) shall be based on the base material
- 7.2.1.3 <u>Size:</u> IQI selection is based on the nominal single wall thickness plus the estimated weld reinforcement, when present, not to exceed the maximum permitted by the referencing Code Section. The backing rings and strips are not considered part of the weld or reinforcement thickness in selection of IQIs. To select the designated IQI refer to Table 1.







7.2.1.4 Equivalent Hole Type Sensitivity. A thinner or thicker hole-type IQI than the designated IQI may be substituted, provided an equivalent or better IQI sensitivity, as listed in Table 2, is achieved and all other requirements for radiography are met. Equivalent IQI sensitivity is shown in any row which contains the designated IQI and hole. Better IQI sensitivity is shown in any row of Table 2 which is above the equivalent sensitivity row. If the designated IQI and hole are not represented on the table, the next thinner IQI row from Table 2 may be used to establish equivalent IQI sensitivity.

	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			IQI		
	Source Side			Film Side		
Nominal Single-Wall Material Thickness Range, In. (mm)	Hole-Type Designation	Essential Hole	Wire-Type Essential Wire	Hole-Type Designation	Essential Hole	Wire-Type Essential Wire
Up to 0.25, Incl. (6.4)	12	27	-5	10	27	4
Over 0.25 through 0.375(6.4 through 9.5)	15	27	6	12	2 <i>T</i>	5
Over 0.375 through 0.50 (9.5 through 12.7)	17	27	7	15	27	6
Over 0.50 through 0.75 (12.7 through 19.0)	20	27	8	17	27	7
Over 0.75 through 1.00 (19.0 through 25.4)	25	27	9	20	27	8
Over 1.00 through 1.50 (25.4 through 38.1)	30	27	10	25	27	9
Over 1.50 through 2.00 (38.1 through 50.8)	35	27	11	30	27	10
Over 2.00 through 2.50 (50.8 through 63.5)	40	27	12	35	27	11
Over 2.50 through 4.00 (63.5 through 101.6)	50	27	13	40	27	12
Over 4.00 through 6.00 (101.6 through 152.4)	60	27	14	50	2 <i>T</i>	13
Over 6.00 through 8.00 (152.4 through 203.2)	80	27	16	60	27	14
Over 8.00 through 10.00 (203.2 through 254.0)	100	27	17	80	2 <i>T</i>	16
Over 10.00 through 12.00 (254.0 through 304.8)	120	27	18	100	27	17
Over 12.00 through 16.00 (304.8 through 406.4)	160	27	20	120	27	18
Over 16.00 through 20.00 (406.4 through 508.0)	200	27	21	160	2 <i>T</i>	20

Table 1 - IQI Selection (Identical with Table T-276, ASME Section V, Article 2)



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Hole-Type	Equivalent Hole-Type Designation		
Designation 2 <i>T</i> Hole	1.7 Hote	4 <i>T</i> Hole	
10	15	5	
12	17	7	
15	20	10	
17	25	12	
20	30	15	
25	35	17	
30	40	20	
35	50	25	
40	60	30	
50	70	35	
60	80	40	
80	120	60	
100	140	70	
120	160	80	
160	240	120	
200	280	140	

S	Set A			Set 8		
Wire Diameter, in.	(mm)	Wire Identity	Wire Diameter, is.	(mm)	Wire Identity	
0.0032	(80.0t	ì	0.010	(0,25)	6	
0.004	(0.01)	2	0.013	(0.331	7	
0.005	(0.13)	3	0.016	(0.41)	8	
0.0063	(0.16)	4	0.020	(0.51)	9	
300.0	10.20)	5	0.025	(0.64)	10	
0.010	(0,25)	6	0.032	(0.81)	11	
5	et C			iet D		
Wire Diameter, in.	tenni)	Wire Identity	Wire Diameter, in.	(mm)	Wire Identity	
0.032	(0.81)	11	0.100	(2.54)	16	
0.040	(1.02)	12	0.126	(3.20)	17	
0.050	11.27)	13	0.160	(4.06)	18	
0.063	(1.60)	14	0,200	t5.08)	19	
0.080	(2.03)	15	0.250	(6.35)	20	
0.100	(2.54)	16	0.320	(8.13)	21	

Table 2 - Equivalent Hole-Type IQI Sensitivity

Table 3 - Wire IQI Designation, Wire Diameter and Wire Identity

#### 7.3 Number of IQIs

- 7.3.1 One IQI shall be used for each radiograph with the exception of cylinders, vessels, spherical vessels, or flat components when more than one film holder is used for an exposure. Each exposure shall represent an area of essentially uniform radiographic density, through the area of interest and through the body of the designated IQI adjacent to the essential hole or adjacent to the essential wire of a wire-type IQI, so that the density change does not vary more than minus 15% or plus 30%, within the range of 1.8 (2.0 for gamma) to 4.0.
- 7.3.2 If the density through the area of interest varies by more than minus 15% or plus 30% from the density through the body of the designated IQI adjacent to the essential hole, or the area adjacent to the designated wire of a wire IQI, then an additional IQI shall be used for each exceptional area or areas and the radiograph retaken. When calculating the allowable variation in density, the calculation may be rounded to the nearest 0.1
- 7.3.3 When shims are used with hole IQI's, the plus 30% density restriction may be exceeded, and the minimum density requirements do not apply for the IQI, provided the required IQI sensitivity is displayed.
- 7.3.4 If the requirements of 7.3.2 above are not met by using more than one IQI, one shall be representative of the lightest area of interest and the other the darkest area of interest. The intervening densities on the radiograph shall be considered as having acceptable density.







#### 7.3.5 Special Cases

- 7.3.5.1 For cylindrical components where the source is placed on the axis of the component for a single exposure (Figure 2), at least three IQIs, spaced approximately 120 degrees apart, are required under the following conditions:
  - a) When the complete circumference is radiographed using one or more film holders, or
  - b) When a section or sections of the circumference, where the length between the ends of the outermost sections span 240 or more degrees, is radiographed using one or more film holders. Additional film locations may be required to obtain the necessary IQI spacing.
- 7.3.5.2 For cylindrical components where the source is placed on the axis of the components for a single exposure (Figure 2), at least three IQIs, with one placed at each end of the span of the circumference radiographed and one in the approximate center of the span are required under the following conditions:
  - a) When a section of the circumference, the length of which is greater than 120 degrees and less than 240 degrees, is radiographed using one film holder or;
  - b) When a section or sections of the circumference, where the length between the ends of the outermost sections span less than 240 degrees is radiographed using more than one film holder.
- 7.3.5.3 When performing radiography on vessels, where a circumferential weld with intersecting long seams are radiographed simultaneously, three equally spaced IQIs shall be placed on the girth seam and one on each longitudinal weld at the end of the section most remote from the junction with the circumferential weld being radiographed
- 7.3.5.4 For spherical components, where the source is placed at the center of the component for a single exposure (Figure 3), at least three IQIs, spaced approximately 120 degrees apart, are required under the following conditions:
  - a) When a complete circumference is radiographed using one or more film holders, or;
  - b) When a section or sections of a circumference, where the length between the ends of the outermost sections span 240 or more degrees, is radiographed using one or more film holders. Additional film locations may be required to obtain necessary IQI spacing.







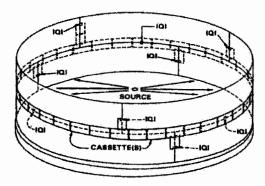


FIG. D-210-1 COMPLETE CIRCUMFERENCE CYLINDRICAL COMPONENT (T-277.2(b)(1)(a) & T-277.2(b)(3))

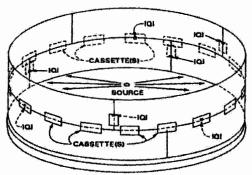


FIG. D-210-2 SECTION OF CIRCUMFERENCE 240 deg. OR MORE CYLINDRICAL COMPONENT (EXAMPLE IS ALTERNATE INTERVALS) [T-277.2(b)(1)(b) & T-277.2(b)(3)]

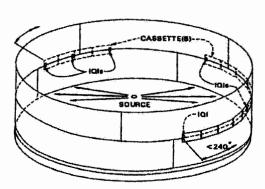


FIG. D-210-3 SECTION(S) OF CIRCUMFERENCE LESS THAN 240 deg. CYLINDRICAL COMPONENT (T-277.2(b)(2)(b))

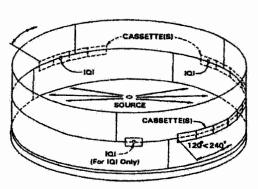


FIG. D-210-4 SECTION(S) OF CIRCUMFERENCE EQUAL TO OR MORE THAN 120 deg. AND LESS THAN 240 deg. CYLINDRICAL COMPONENT [T-277.2(b)(2)(b) OPTION]

Figure 2 Number of IQI – special Cases

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- 7.3.5.5 For spherical components, where the source is placed at the center of the component for a single exposure (Figure 3), at least three IQIs, with one placed at each end of the radiographed span of the circumference radiographed and one in the approximate center of the span, are required under the following conditions
  - a) When a section of a circumference, the length of which is greater than 120 degrees and less than 240 degrees, is radiographed using one film holder, or;
  - b) When a section or sections of a circumference, where the length between the ends of the outermost sections span less than 240 degrees is radiographed using more than one (1) film holder.

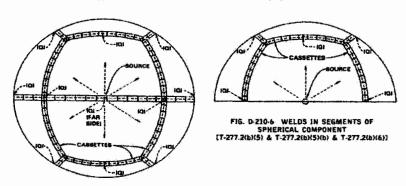


FIG. 0-210-5 COMPLETE CIRCUMFERENTIAL WELDS SPHERICAL COMPONENT [T-277.2(b)(4)(a) & T-277.2(b)(6)]

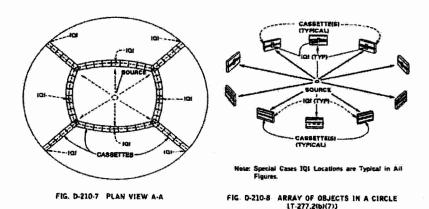


Figure 3 Number of IQI – Special Cases

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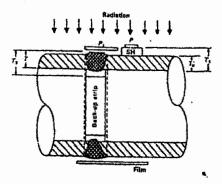


#### 7.4 Shims under IQI

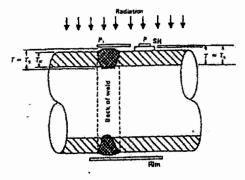
- 7.4.1 For welds, a shim of material radiographically similar to the weld metal shall be placed between the part and the IQI, if needed, so that the radiographic density throughout the area of interest is no more than minus 15% (lighter than) from the radiographic density through the designated IQI adjacent to the essential hole.
- 7.4.2 The shim dimension shall exceed the IQI dimension such that the outline of at least three sides of the IQI image shall be visible in the radiograph.
- 7.5 Placement of IQI(s)
- 7.5.1 Source Side IQI(s): The IQI shall be placed on the source side of the part being examined, (see Figures 4 and 5 for examples), except in the conditions described below.
- 7.5.2 Film Side IQI(s): Where inaccessibility prevents hand placing the IQI(s) on the source side, it shall be placed on the film side, in contact with the part being examined. A lead letter "F" shall be placed adjacent to or on the IQI(s), but shall not mask the essential hole where hole IQI(s) are used.
- 7.5.3 <u>IQI Location for Welds Hole IQIs:</u> The IQI(s) may be placed adjacent to or on the weld, The identification number(s) and lead letter "F", where used, shall not be in the area of interest, unless geometric configuration makes it otherwise impractical.
- 7.5.4 <u>IQI Location for Welds Wire IQIs:</u> The IQI(s) shall be placed on the weld so that the length of the wires is perpendicular to the length of the weld. The IQI identification and lead letter "F", where used, shall not be in the area of interest, unless geometric configuration makes it otherwise impractical.
- 7.5.5 <u>IQI Location for Materials Other Than Welds:</u> The IQI(s) with the IQI identification and lead letter "F", if used, may be placed in the area of interest.

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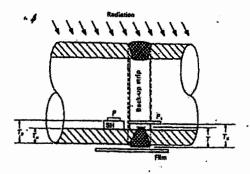




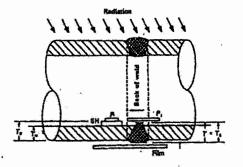
[a] Double-Wall Technique, Double-Wall Viewing, With Weld Reinforcement and Back-Up Strip



(b) Double-Wall Technique. Double-Wall Viewing. With Weld Reinforcement and No Back-Up Strip



(a) Double-Well Technique, Single-Wall Viewing, Back-Up Strip



(b) Dauble-Wall Technique, Single-Wall Viswing. Wall Reinforcement, No Back-Up Strip

#### GENERAL NOTE:

P and P<sub>1</sub> are suggested locations of penetrameters and are no intended to cover all geometric configurations or applications of production radiography.

#### LEGENO

- senetrament frais type
- P, m elterness penatrameter location
- 6H shim
- T = weld the traces upon which the panetrameter is based.

  T. is coming well this base.
- T<sub>a</sub> = nominal well thickness
- T<sub>1</sub> = total thickness including becking corp and/or minforcumen

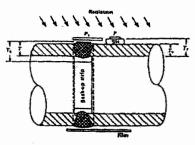
Figure 4
Side Views of Hole Type Penetrameter Placements

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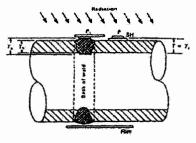
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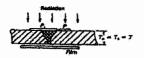




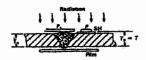
tel Double-Wall Technique, Double-Wall Viewing, With Weld Reinforcement and Back-Up, Strip



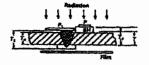
(b) Double-Wall Technique, Double-Wall Viewing, With Weld Reinforcement and No Back-Up Strip



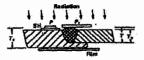
(a) Single Walt. No Reinforcement, No Back-Up Strip



(b) Single Wall, Wald Reinforcement, No Back-Up Strip



(c) Single Wall, Weld Reinforcement, Back-Up Strip



(d) Single Wall, Integral Backing Ring, Weld Reinforcement

GENERAL NOTE:

P and P<sub>1</sub> are suggested locations of penetrameters and are no intended to cover all geometric configurations or applications of production are reflected to a second configurations.

LEGENO:

P = penetrimeter from typel

F, = attempts penetrimeter location

I a weld thickness upon which the penetrameter is based

To a secol thickores including backing strip and/or reinforce

Figure 5
Side Views of Hole Type Penetrameter Placements

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- 7.5.6 Alternative Locations for IQI(s): When configuration or size prevents placing the IQI(s) as described above, it may be placed on a separate block or like part/product).
- 7.5.6.1 The IQI on the source side of the separate block shall be placed no closer to the film than the source side of the part being radiographed.
- 7.5.6.2 The separate block shall be placed as close as possible to the part being radiographed.
- 7.5.6.3 The block dimensions shall exceed the IQI dimensions such that the outline of at least three sides of the IQI image shall be visible on the radiograph.
- 7.6 Location Markers
- 7.6.1 The film shall be placed in intimate contact with the weld, if possible. In no instance is the part to film distance to exceed 1/4 in. (6.35 mm).
- 7.6.2 The image of the location markers for the coordination of the part with the film shall appear on the film, without interfering with the interpretation, with such an arrangement that it is evident that complete coverage was obtained. These marker positions shall be marked on the part, and the position of the markers shall be maintained on the part during radiography.
- 7.6.3 Location markers which are to appear as radiographic images on the film, shall be placed on the part, (Figure 6), not on the exposure holder/cassette. Their locations shall be permanently marked on the surface of the part being radiographed when permitted, or on a map, in a manner permitting the area of interest on a radiograph to be accurately traceable to its location on the part, for the required retention period of the radiograph. Evidence shall also be provided on the radiograph that the required coverage of the region being examined has been obtained. Location markers shall be placed as follows.

#### 7.6.3.1 Single-Wall Viewing

- a) Source Side Markers. Location Markers shall be placed on the source side when radiographing the following:
  - flat components of longitudinal joints in cylindrical or conical components;

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- curved or spherical components whose concave side is toward the source and when the source to material distance is less than the inside radius of the component;
- curved or spherical components whose convex side is toward the source.

#### b) Film Side Markers.

- Location markers shall be placed on the film side when radiographing curved or spherical components whose concave side is toward the source and when the source to material distance is greater than the inside radius.
- 2) As an alternative to source side placement in 7.6.3.1 a), location markers may be placed on the film side when the radiograph shows coverage beyond the location markers to the extent demonstrated by (e) on Figure 6, and when this alternate is documented in the examination report.

#### c) Either Side Markers.

Locations markers may be placed on either the source side or film side when radiographing curved or spherical components whose concave side is toward the source and the source to material distance equals the inside radius of the component.

#### 7.6.3.2 Double-Wall Viewing

For double-wall viewing, at least one location marker shall be placed on the outside surface adjacent to the weld (or on the material in the area of interest) for each radiograph.

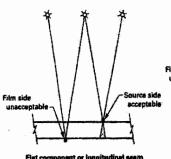
#### 7.6.3.3 Mapping the Placement of Location Markers

When inaccessibility or other limitations prevent the placement of markers as stipulated above, a dimensioned map of the actual marker placement shall accompany the radiographs and shall show that full coverage has been obtained.

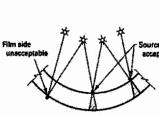




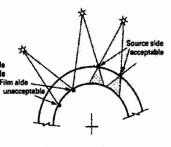




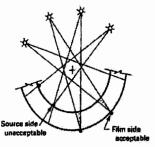
Fist component or longitudinal seem [See T-276.1[s](1]] [See sketch [e] for elternate] (a)



Curved components with rediction source to film distance less than redius of component [See T-275.1(a)[2]]



Curved components with convex surfac towards radiation source (See T-275, 1(a)(3))



Curved components with radiation source to film distance greater than radies of curvature (See T-275.1(b)(1)) (d)

LEGEND: Radiation source — 🔆

Location marker -- \*
Component center -- +

beyond film side location marker

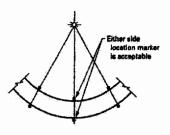
t = component thickness

My = film side location marker interval

D = source to component distance

(See T-275.1(b)(2))

(e)



Curved components with radiation source at center curvature (See T-275.1(c))

#### Figure 6 Location Marker Sketches

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#### 8.0 RADIOGRAPHIC TECHNIQUE

- 8.1 A single-wall exposure technique shall be used for radiography whenever practical. When it is not practical to use a single-wall technique, a doublewall technique shall be used.
- 8.2 <u>Single-Wall Technique:</u> In the single-wall technique, the radiation passes through only one wall of the material or weld, which is viewed for acceptance on the radiograph, An adequate number of exposures shall be made to demonstrate that the required coverage has been obtained.

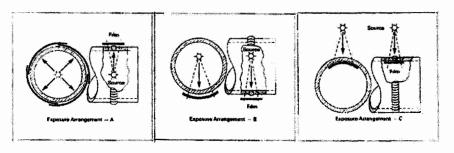


Figure 7
Single Wall Radiographic Techniques

- 8.3 <u>Double-Wall Technique:</u> When it is not practical to use a single-wall technique, one of the following double-wall techniques shall be used.
- 8.3.1 <u>Single-Wall Viewing:</u> For materials, and for welds in components, a technique may be used in which the radiation passes through two walls and only the weld (material) on the film side wall is viewed for acceptance. An adequate number of exposures shall be made to demonstrate that the required coverage is met for circumferential welds (materials). A minimum of three exposures taken at 120 degrees to each other shall be made.
- 8.3.2 <u>Double-Wall Viewing:</u> For materials and for welds in components 3-1/2 in. (88.9 mm) or less in nominal outside diameter, a technique may be used in which the radiation passes through two walls and the weld (material) in both walls is viewed for acceptance on the same radiograph. For double-wall viewing, a source side IQI shall be used. Care should be exercised to ensure that the required geometric unsharpness is not exceeded. If the geometric unsharpness requirement cannot be met, then single-wall viewing shall be used.

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- a) For welds, the radiation beam may be offset from the plane of the weld at an angle sufficient to separate the images of the source side and film side portions of the weld so that there is no overlap of the areas to be interpreted. When complete coverage is required, a minimum of two exposures taken 90 degrees to each other shall be made for each joint.
- b) As an alternative, the weld may be radiographed with the radiation beam positioned so that the images of both walls are superimposed. When complete coverage is required, a minimum of three exposures taken at either 60 degrees or 120 degrees to each other shall be made for each joint.
- Additional exposures shall be made if the required radiographic coverage cannot be obtained using the minimum number of exposures indicated in (a) or (b) above.

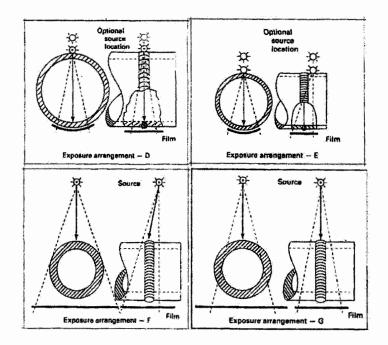


Figure 8

Double Wall Radlographic Techniques

ΔW



#### 9.0 EVALUATION

9.1 Facilities for Viewing of Radiographs: Viewing facilities shall provide subdued background lighting of an intensity that will not cause troublesome reflections, shadows, or glare on the radiograph. Equipment used to view radiographs for interpretation shall provide a variable light source sufficient for the essential IQI hole or wire to be visible for the specified density range. The viewing conditions shall be such that light from around the outer edge of the radiograph or coming through low-density portions of the radiograph does not interfere with interpretation.

#### 9.2 Quality of Radiographs

All radiographs shall be essentially free from mechanical, chemical, or other blemishes to the extent that they do not mask, and are not confused with the image of any discontinuity in the area of interest of the object being radiographed. Such blemishes include, but are not limited to fogging, streaks, water marks, chemical stains, scratches, finger marks, dirt, static marks, smudges, tear, poor detail due to poor film to screen contact, and false indications due to defective screens.

A radiograph showing one or more of the above conditions in the area of interest shall be discarded and the area radiographed again.

#### 9.3 Radiographic Density

- 9.3.1 The transmitted film density through the radiographic image of the body of the appropriate hole penetrameter or adjacent to the designated wire of a wire penetrameter and the area of interest shall be a minimum 2.0 for gamma ray and 1.8 for X-ray. For composite viewing of multiple film exposures, each film of the composite set shall have a minimum density of 1.3. The maximum density shall be 4.0 for either single or composite viewing.
- 9.3.2 A tolerance of 0.05 density is allowed for variations between densitometer readings.
- 9.3.3 If the density of the radiograph anywhere through the area of interest varies by more than minus 15% or plus 30% from the density through the body of the hole penetrameter or adjacent to the designated wire of a wire penetrameter, within the minimum/maximum allowable density ranges specified, then an additional penetrameter shall be used for each exceptional area or areas and the radiograph retaken.

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NOTE: When calculating the allowable variation in density, the calculation may be rounded to the nearest 0.1 within the range specified.

9.3.4 When shims are used the plus 30% density restriction above may be exceeded, provided the required penetrameter sensitivity is displayed and the density limitations are not exceeded.

#### 9.4 IQI/Penetrameter Sensitivity

Radiography shall be performed with a technique of sufficient sensitivity to display the designated hole IQI image and the essential hole, or the essential wire of a wire IQI. The radiograph shall also display the identifying numbers and letters. If the designated hole-type IQI image and essential hole or essential wire of a wire type IQI do not show on any film in a multiple film technique, but do show in composite film viewing, interpretation shall be permitted only by composite viewing.

#### 9.5 Excessive Backscatter

If a light image of the letter "B" appears on any radiograph of a darker background, protection from scatter radiation shall be considered insufficient and the radiograph shall be considered unacceptable. A dark image of the "B" on a lighter background is not cause for rejection.

#### 9.6 Geometric Unsharpness Limitations

9.6.1 For ASME B-31.3 Code examinations, the geometric unsharpness of the radiograph shall not exceed the following:

Material Thickness in. (mm)	Maximum Allowable Ug
Under 2 (50.8)	0.020 (0.51)
2 (50.8) through 3 (76.2)	0.030 (0.76)
Over 3 (76.2) through 4 (10	1.6) 0.040 (1.02)
Greater than 4 (101.6)	0.070 (1.78)

Note: Material thickness is the thickness on which the IQI is based.

9.6.2 For all other examinations, the above are to be used as guidelines for geometric unsharpness, but not rejection unless the geometric unsharpness exceeds 0.07 in. (1.78 mm).

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#### 10.0 STANDARDS OF ACCEPTANCE

- 10.1 Level II or Level III personnel shall be responsible for the review, interpretation and evaluation, and acceptance of the completed radiographs. When required, level II or level III personnel shall also determine the acceptability of the material, component, part or weld under examination in terms of the applicable acceptance criteria for the referenced Code, Standard, project or costumer specification.
- 10.2 Supplement 1 Radiographic Acceptance Standards. Shall be used with this procedure to determine acceptability when one of the codes or standards listed in Section 2.0, is referenced.
- 10.3 The acceptance standard used to determine acceptability shall be properly documented on the Radiographic Examination Report.

#### 11.0 RECORDS

11.1 The record of the radiographic examination is to be reported on a Radiographic Examination Report, an example is shown as Exhibit 1.

Note: The required radiographic technique documentation shall be completed prior to the evaluation.

- 11.2 The information reported is to include, but is not limited to the following:
  - a) Job/contract number/identification
  - b) Location marker placement and, if used, a dimensional map
  - c) Number of radiographs (exposures)
  - d) X-ray voltage or isotope type used
  - e) X-ray machine focal spot size or isotope physical source size
  - Base material type and thickness, weld thickness, weld reinforcement thickness, as applicable
  - g) Source-to-object distance
  - h) Distance from source side of object to film
  - i) Film manufacturer and type/designation
  - j) Number of film in each film holder/cassette
  - k) Single or double wall exposure
  - I) Single or double wall viewing
  - m) Procedure and/or Code references, examination results
  - n) Date of examination, name and qualification of examiners

Any drawings, component identification, or additional details will be provided to the customer's representative, along with the examination report.

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- 11.3 Unless otherwise specified, all RT records and reports shall be maintained for a minimum of three (3) years.
- 11.4 Documentation of Personnel and Procedure Demonstrations
- 11.4.1 Personnel or procedure demonstrations performed in compliance with the requirements of reference 2.2 Article 1 shall be documented as specified by the referencing Code section.
- 11.4.2 When documentation requirements for personnel or procedure demonstrations performed in accordance with reference 2.2 Article 1 are not specified by the referencing Code section, the following information shall be recorded as a minimum:
  - a) Name of the organization responsible for preparation and approval of the examination procedure
  - b) Examination method applied
  - c) Procedure number and designation
  - d) Number and date of most recent revision
  - e) Date of the demonstration
  - f) Name and certification level (if applicable) of personnel performing the demonstration





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MARKERS: # OR SPACING		1	8		٥	1					
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X-Ray		DCEDUR		INTERME	PATE		Or	NAL [	REPAIR	☐ BEFORE PWHT	AUTO MANUAL AFTER PWHT
X-Ray STAGE OF MANUFACE C-CRACK SL-SIAG	CP-CLI P-POR	USTER P	OROSTY	ET	P-NCC	MPLE	TE P	ENETRATION USION	EU-EXTE	RNAL UNDERCUT	
X-Ray STAGE OF MANUFAC C-CRACK SL-SLAG T-TUNGSTEN	CP-CLI P-POR	USTERP	OROSTY AS POCK	ET	P-NCC	MPLE	TE P	ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	AFTER PWHT SU - SURFACE HL - IP DUE TO HIGHILOW
X-Ray STAGE OF MANUFACE C-CRACK SL-SIAG	CP-CLI P-POR	USTER POSITY.G.	OROSTY AS POCK	ET	P-NCC F-INCC EP-EXC	MPU ESSI	TE P	ENETRATION USION ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	AFTER PWHT SU - SURFACE HL - IP DUE TO HIGHILOW ST - SURN THROUGH
X-Ray STAGE OF MANUFAC C-GRACK SL-SLAG T-TUNGSTEN	CP-CLI P-POR	USTER POSITY.G.	OROSTY AS POCK	ET	P-NCC F-INCC EP-EXC	MPU ESSI	TE P	ENETRATION USION ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	AFTER PWHT SU - SURFACE HL - IP DUE TO HIGHILOW ST - SURN THROUGH
X-Ray STAGE OF MANUFAC C-GRACK SL-SLAG T-TUNGSTEN	CP-CLI P-POR	USTER POSITY.G.	OROSTY AS POCK	ET	P-NCC F-INCC EP-EXC	MPU ESSI	TE P	ENETRATION USION ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	AFTER PWHT SU - SURFACE HL - IP DUE TO HIGHILOW ST - SURN THROUGH
X-Ray STAGE OF MANUFAC C-GRACK SL-SLAG T-TUNGSTEN	CP-CLI P-POR	USTER POSITY.G.	OROSTY AS POCK	ET	P-NCC F-INCC EP-EXC	MPU ESSI	TE P	ENETRATION USION ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	AFTER PWHT SU - SURFACE HL - IP DUE TO HIGHILOW ST - SURN THROUGH
X-Ray STAGE OF MANUFAC C-GRACK SL-SLAG T-TUNGSTEN	CP-CLI P-POR	USTER POSITY.G.	OROSTY AS POCK	ET	P-NCC F-INCC EP-EXC	MPU ESSI	TE P	ENETRATION USION ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	AFTER PWHT SU - SURFACE HL - IP DUE TO HIGHILOW ST - SURN THROUGH
X-Ray STAGE OF MANUFAC C-CRACK SL-SLAG T-TUNGSTEN	CP-CLI P-POR	USTER POSITY.G.	OROSTY AS POCK	ET	P-NCC F-INCC EP-EXC	MPU ESSI	TE P	ENETRATION USION ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	ATTER PWHT SU - SURFACE HL - IP DUE TO HIGHLOW ST - SURN THROUGH
X-Ray STAGE OF MANUFAC C-CRACK SL-SLAG T-TUNGSTEN	CP-CLI P-POR	USTER POSITY.G.	OROSTY AS POCK	ET	P-NCC F-INCC EP-EXC	MPU ESSI	TE P	ENETRATION USION ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	AFTER PWHT SU - SURFACE HL - IP DUE TO HIGHILOW ST - SURN THROUGH
X-Ray STAGE OF MANUFAC C-GRACK SL-SLAG T-TUNGSTEN	CP-CLI P-POR	USTER POSITY.G.	OROSTY AS POCK	ET	P-NCC F-INCC EP-EXC	MPU ESSI	TE P	ENETRATION USION ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	ATTER PWHT SU - SURFACE HL - IP DUE TO HIGHLOW ST - SURN THROUGH
X-Ray STAGE OF MANUFAC C-CRACK SI-STAG SI-STAG T-TUNGSTEN WELD	CTURE  CP - CLI P - POR HB - HO	USTER POSITY G	OROS TY AS POCK EAD DEN PEN	SETY WELD	P-NCC F-INCC EP-EXC	MPU ESSI	TE P	ENETRATION USION ENETRATION	EU - EXTE IU - INTER IC - INTER	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	ATTER PWHT SU - SURFACE HL - IP DUE TO HIGHLOW ST - SURN THROUGH
X-Rey STAGE OF MANUFAC C-CRACK SI-STAG T-TUNGSTEN YELD  ADDITIONAL P	CP-CLI P-PDR-HD	USTER POSITY G	OROSTY AS POCK	SETY WELD	P-NCC F-INCC EP-EXC	MPU ESSI	TE PI	ENETRATION USION ENETRATION	EU - EXTE IU - INTE IU - INTE CATIONS	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	ATTER PWHT SU - SURFACE HL - IP DUE TO HIGHLOW ST - SURN THROUGH
X-Ray STAGE OF MANUFAC C-CRACK SI-STAGE T-TUNGSTEN WELD  ADDITIONAL P/	CP-CUP-P-POR-HB-HO	USTER POSITY G	OROSTY AS POSTY AS POSTY EAD DEN PEN	SETY WELD	P-NCC F-INCC EP-EXC	RE Puri	P Den	ENETRATION USION LIST INDICATE TO THE PROPERTY OF THE PROPERTY	EU - EXTE IU - INTE IU - INTE CATIONS	RNAL UNDERCUT HAL UNDERCUT HAL CONGAVITY	AFTER PWHT SU. SURFACE MIP DUE TO HIGHLOW ST. SURN THROUGH D-GTHER ID-REMARKS
X-Ray STAGE OF MANUFAC C - CRACK S SLAG T - TUMOSTEN WELD  AUDITIONAL P/ # OF FILM AND SIZE	CP-CUP-P-POR-HB-HO	USTER P OSITY G U OW B VEW	OROSTY AS POSTY AS POSTY EAD DEN PEN	STY WELD	P-NCC F-INCC EP-EXC	MPU MPU ESSI RE	P Diam	ENETRATION USION LIST INDI	EU - EXTE IU - INTE IC - INTE EATIONS	RIVAL UNDERCUT NAL UNDERCUT NAL CONGAUTY WELDER	U SURFACE SU SURFACE SU SURFACE SU SURFACE SU SURFACE
X-Ray STAGE OF MANUFAC C-CRACK SI-STAGE T-TUNGSTEN YELD	CTURE  CP-CU P-PCR HB-HO	USTER P OSITY G U OW B VEW	DEN PEN COMMENT	SSTY WELD	P-NCEF-HCC	RE Puri	P Diam	ENETRATION USION LIST INDI LIST INDI  LIST INDI  ILM GRANDITYPE  No	EU - EXTE IU - INTE IC - INTE EATIONS	RIVAL UNDERCUT NAL UNDERCUT NAL CONGAUTY WELDER	TOTAL # OF WELDS

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### **NDE Supplement**

## Radiographic Acceptance Criteria

PERMISSIONS TO PROCEED DOES NOT CONSTITUTE ACCEPTANCE OR APPROVAL OF DESIGN DETAILS, CALCULATIONS, AMALYSES, TEST APPROVAL OF DESIGN OF STATE OF STATE BY THE SUPPLIER	RT-1
METHORS OR MATERIALS DELIEVE SUPPLIER FROM FULL AND DES NOT RELIEVE SUPPLIER FROM FULL COMPLIANCE WITH CONTRACTUAL OBLIGATIONS.	Revision 15
WORK MAY PROCEED.     REVISE AND RESUBINIT, WORK MAY PROCEED SUBJECT TO INCORPORATION OF CHANGES INDICATED.     REVISE AND RESUBINIT, WORK SHALL NOT PROCEED.	5/18/2012
AREWEW NOT REQUIRED, WORK MAY PROCEED.  BY WT DATE MAYCH 14, 2973	

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Reviewed and Approved by:

Gerald F. Wade ASNT Level III #13614 Thomas L. Payne QA Director - USA

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Mundel SG REVIEW 255KP13 HW36



#### Revision/Change Summary

Revision or	T.,	*	
Change	No.	Date	Description
Revision	10	05-13-08	Updated references in Table of Contents for compliance with latest editions of the codes.  Replaced first page of Table 341.3.2 in Attachment 3.  Attachment 5 was reformatted in API 1104 & was replaced in its entirety herein.  Attachment 5 paragraphs 9.3.7.2, 9.3.7.3 and 9.3.9.3 were changed.
Revision	11	02-28-11	Added Confidentiality Notice to cover page. Revised the code listing in the TOC. Added item 8.0 ASME B31.5 to the TOC. Added a Note following the TOC. Added paragraph 4.3 addressing the gap requirements for socket-type weld joints. Added section 8.0 ASME B31.5 Acceptance Citeria to the text. Corrected typo in Attachment 1 Revised several Notes to Table 341.3.2 and added gap requirements for RT of socket type weld joints in Attachment 3.
Revision	12	03-04-11	Added item 9.0 ASME B16.34 and Attachment 6 to the TOC. Added item 9.0 to the text.  Added section 9.0 ASME B16.34 (Appendix I) Acceptance Citeria as Attachment 6.
Revision	13	09-27-11	Updated the TOC, revised to latest code editions. Revised paragraphs 1.2, 2.3 & 3.1.1. Replaced Attachments 1 & 2 in their entirety. Revised Attachments 3 & 4.
Revision	14	11-30-11	Added paragraph 10.0 to the TOC. Corrected typo in paragrah 8.1. Added paragraph 10.0.
Revision	15	05-18-12	Added paragraph 11.0 to the TOC. Revised several page numbers in the TOC. Added paragraph 11.0.



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#### RADIOGRAPHIC ACCEPTANCE

When Acuren personnel perform radiographic interpretation, it shall be done in accordance with one of the following criteria:

- 1.0 ASME SECTION VIII DIVISION 1, UW-51 ACCEPTANCE CRITERIA (Full Radiography of Welded Joints)
  - 1.1 Any indication characterized as a crack or zone of incomplete fusion or penetration is not acceptable, nor are any of the following:
  - 1.2 Any other elongated indication on the radiograph which has length greater than:
    - (a) ¼ in. (6 mm) for t up to ¾ in. (19 mm)
    - (b) 1/3t for t from \(^3\) in. (19 mm) to 2-1/4 in. (57 mm)
    - (c)  $\frac{3}{4}$  in. (19 mm) for t over 2-1/4 in. (57 mm)

#### Where:

t = the thickness of the weld excluding any allowable reinforcement. For a butt weld joining members having different thicknesses at the weld, "t" is the thinner of these thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in "t".

- 1.3 Any group of aligned indications that have an aggregate length greater than "t" in a length of 12t, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group.
- 1.4 Rounded indications in excess of that specified by the acceptance the porosity of the standards given in Attachment 1.
- 1.5 Any imperfections believed to be non-relevant shall be regarded as a discontinuity and shall be re-evaluated by the same method or by another nondestructive method to determine the relevance of the indication.
- 1.6 Indications shown on the radiographs of welds and characterized as imperfections are unacceptable under the following conditions and shall be repaired as provided in UW-38, and the repair radiographed to UW-51 or, at the option of the Manufacturer, ultrasonically examined in accordance with the method described in Appendix 12 and the standards specified in this paragraph, provided the defect has been confirmed by the ultrasonic examination to the satisfaction of the Authorized Inspector prior to making the repair. For material thicknesses in excess of 1" (25mm), the concurrence of the user shall be obtained. This ultrasonic examination shall be noted under remarks on the Manufacturer's Data Report Form.

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- 2.0 <u>ASME SECTION VIII Division 1, UW-52 ACCEPTANCE CRITERIA (Spot Examination of Welded Joints)</u>
  - 2.1 The minimum length of spot radiograph shall be 6 in. Spot radiographs may be retained or be discarded by the Manufacturer after acceptance of the vessel by the Inspector. The acceptability of welds examined by spot radiography shall be judged by the following standards.
  - 2.2 Welds in which indications are characterized as cracks or zones of incomplete fusion or penetration shall be unacceptable.
  - Welds in which indications are characterized as slag inclusions or cavities shall be unacceptable if the length of any such indication is greater than 2/3t where "t" is the thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, "t" is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in "t". If several indications within the above limitations exist in line, the welds shall be judged acceptable if the sum of the longest dimensions of all such indications is not more than "t" in a length of 6t (or proportionately for radiographs shorter than 6t) and if the longest indications considered are separated by at least 3L of acceptable weld metal where "L" is the length of the longest indication. The maximum length of acceptable indications shall be ¾ in. (19 mm). Any such indications shorter than ¼ in. (6 mm) shall be acceptable for any plate thickness.
  - 2.4 Rounded indications are not a factor in the acceptability of welds not required to be fully radiographed.

#### 3.0 ASME B31.1 ACCEPTANCE CRITERIA

- 3.1 Any type of crack or zone of incomplete fusion or penetration is not acceptable, nor are any of the following:
  - 3.1.1 Any elongated indication which has a length greater than:
    - (a)  $\frac{1}{4}$  in. (6 mm) for t up to  $\frac{3}{4}$  in. (19 mm) inclusive;
    - (b) 1/3t for t from \( \frac{1}{2} \) in. (19 mm) to 2-1/4 in. (57 mm) inclusive;
    - (c) ¼ in. (19 mm) for t over 2-1/4 in. (57 mm)

"t" refers to the thickness of the weld being examined; if a weld joins members having different thicknesses at the weld, "t" is the thinner of these thicknesses.





- 3.1.2 Any group of indications in line that have an aggregate length greater than "t" in a length of 12t, except where the distance between the successive indications exceeds 6L where L is the longest imperfection in the group.
- 3.1.3 Porosity in excess of that shown as acceptable in Attachment 2.
- 3.1.4 Root concavity when there is an abrupt change in density as indicated on the radiograph.

#### 4.0 ASME B31.3 ACCEPTANCE CRITERIA

- 4.1 Limitation of imperfections in welds and other components shall be as stated in Attachment 3 or applicable referenced section for the degree of radiography involved.
- 4.2 These acceptance criteria are not applicable to castings or Class K piping.
- 4.3 The gap requirements for RT of socket type weld joints are included in Attachment 3.

#### 5.0 ASME SECTION I ACCEPTANCE CRITERIA

5.1 ASME Section 1, Power Boilers, acceptance criteria shall be in accordance with Attachment 2 and sections 1.1, 1.2 and 1.3.

#### 6.0 ASME SECTION IX ACCEPTANCE CRITERIA

6.1 ASME Section IX, Welding and Brazing Qualification, acceptance criteria shall be in accordance with Attachment 4.

#### 7.0 ASME B31.8 / API 1104 ACCEPTANCE CRITERIA

7.1 ANSI B31.8 acceptance criteria shall be in accordance with API 1104, Attachment 5.

#### 8.0 ASME B31.5 ACCEPTANCE CRITERIA

8.1 ASME B31.5 acceptance criteria, unless otherwise specified, shall be at least that specified for Normal Fluid Service in Table 341.3.2 of ASME B31.3, as provided in Attachment 3.

#### 9.0 ASME B16.34 ACCEPTANCE CRITERIA

9.1 ASME B16.34 acceptance criteria shall be in accordance with Attachment 6.

#### 10.0 API 650 ACCEPTANCE CRITERIA

10.1 API 650 acceptance criteria shall be in accordance with section 1.0.

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#### 11.0 API 620 ACCEPTANCE CRITERIA

11.1 API 620 acceptance criteria shall be in accordance with section 1.0. The finished surface of the reinforcement at the location of the radiograph shall either be flush with the plate or have a reasonably uniform crown that does not exceed the following:

Maximum Thickness of Reinforcement on Welds for RT Examined Joints

Plate Thickness (in.)	Maximum Thickness Of Reinforcement (in.)
≤ 1/2	1/16
> 1/2 - 1	3/32
>1	1/8

#### 11.2 Spot Radiography.

11.2.1 The requirements of 11.1 apply when spot radiography is required or specified. The number and location of spot radiographs and the requirements for retests are to be in accordance with API-620 Section 7.17.

Note: A spot radiograph shall not be considered equivalent to a recheck where complete radiography is mandatory and applied.

- 11.2.2 Spot radiographic examination shall not be less than 6 in, extending along the weld. Where spot radiographic examination is applied at joint intersections, the surface shall be prepared for a distance of 3 in. on each side of the intersection, making the minimum length of examination 6 in. on the horizontal weld and 3 in. on the vertical weld.
- 11.2.3 Retest radiographs when required by API-620 Section 7.17 shall comply with the requirements of 11.1. Spot radiographs may be discarded after the tank has been accepted by the inspector, unless previously requested by the Purchaser.

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# MANDATORY APPENDIX 4 ROUNDED INDICATIONS CHARTS ACCEPTANCE STANDARD FOR RADIOGRAPHICALLY DETERMINED ROUNDED INDICATIONS IN WELDS

## 4-1 APPLICABILITY OF THESE STANDARDS

These standards are applicable to ferritic, austenitic, and nonferrous materials.

#### 4-2 TERMINOLOGY

- (a) Rounded Indications. Indications with a maximum length of three times the width or less on the radiograph are defined as rounded indications. These indications may be circular, elliptical, conical, or irregular in shape and may have tails. When evaluating the size of an indication, the tail shall be included. The indication may be from any imperfection in the weld, such as porosity, slag, or lungsten.
- (b) Aligned Indications. A sequence of four or more rounded indications shall be considered to be aligned when they touch a line parallel to the length of the weld drawn through the center of the two outer rounded indications.
- (c) Thickness t. t is the thickness of the weld, excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t.

#### 4-3 ACCEPTANCE CRITERIA

- (a) Image Density. Density within the image of the indication may vary and is not a criterion for acceptance or rejection.
- (b) Relevant Indications. (See Table 4-1 for examples.) Only those rounded indications which exceed the following dimensions shall be considered relevant.
  - (1)  $\frac{1}{10}t$  for t less than  $\frac{1}{8}$  in. (3 mm)
- (2)  $\frac{1}{64}$  in. for t from  $\frac{1}{6}$  in. to  $\frac{1}{4}$  in. (3 mm to 6 mm), incl.

- (3)  $\frac{1}{32}$  in. for t greater than  $\frac{1}{4}$  in. to 2 in. (6 mm to 50 mm), incl.
  - (4)  $\frac{1}{16}$  in. for t greater than 2 in. (50 mm)
- (c) Maximum Size of Rounded Indication. (See Table 4-1 for examples.) The maximum permissible size of any indication shall be  $\frac{1}{4}t$ , or  $\frac{5}{12}$  in. (4 mm), whichever is smaller; except that an isolated indication separated from an adjacent indication by 1 in. (25 mm) or more may be  $\frac{1}{3}t$ , or  $\frac{1}{4}$  in. (6 mm), whichever is less. For t greater than 2 in. (50 mm) the maximum permissible size of an isolated indication shall be increased to  $\frac{3}{4}$  In. (10 mm).
- (d) Aligned Rounded Indications. Aligned rounded indications are acceptable when the summation of the diameters of the indications is less than t in a length of 12t. See Fig. 4-1. The length of groups of aligned rounded indications and the spacing between the groups shall meet the requirements of Fig. 4-2.
- (e) Spacing. The distance between adjacent rounded indications is not a factor in determining acceptance or rejection, except as required for isolated indications or groups of aligned indications.
- (f) Rounded Indication Charts. The rounded indications characterized as imperfections shall not exceed that shown in the charts. The charts in Figs. 4-3 through 4-8 illustrate various types of assorted, randomly dispersed and clustered rounded indications for different weld thicknesses greater than ½ in. (3 mm). These charts represent the maximum acceptable concentration limits for rounded indications. The charts for each thickness range represent full-scale 6 in. (150 mm) radiographs, and shall not be enlarged or reduced. The distributions shown are not necessarily the patterns that may appear on the radiograph, but are typical of the concentration and size of indications permitted.
- (g) Weld Thickness t less than  $\frac{1}{8}$  in. (3 mm). For t less than  $\frac{1}{8}$  in. (3 mm) the maximum number of rounded indications shall not exceed 12 in a 6 in. (150 mm) length of weld. A proportionally fewer number of indications shall





TABLE 4-1

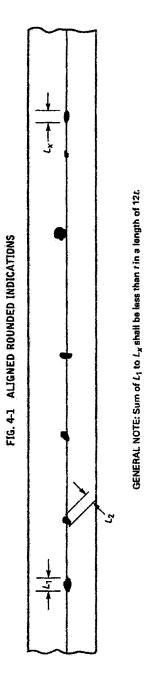
Customary Units				
Thickness 4	Maximum Size of Acceptable Rounded Indication, in.		Maximum Size of Nonrelevant	
in.	Random	Isolated	Indication, in.	
Less than 1/4	1/4t	<b>%</b> t	, ,	
•		•	3/10t	
**************************************	0.031	0.042	0.015	
3/4	0.047	0.063	0.015	
1/4	0.063	0.083	0.015	
<b>ኝ</b> ሬ	0.078	0.104	0.031	
**************************************	0.091	0.125	0.031	
<u>'</u> ፈ	0.109	0.146	0.031	
1/2	0.125	0.168	0.031	
%,	0.142	0.188	0.031	
5%	0.156	0.210	0.031	
7,6 74 11/16	0.156	0.230	0.031	
% to 2, incl.	0.156	0.250	0.031	
Over 2	0.156	0.375	0.063	
Over 2		0.375 Units	0.00	

be permitted in welds less than 6 in. (150 mm) in length.

(h) Clustered Indications. The illustrations for clustered indications show up to four times as many indications in a local area, as that shown in the illustrations for random indications. The length of an acceptable cluster shall not exceed the lesser of 1 in. (25 mm) or 2t. Where more than one cluster is present, the sum of the lengths of the clusters shall not exceed 1 in. (25 mm) in a 6 in. (150 mm) length weld.







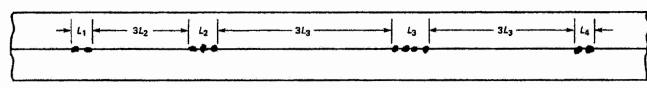
Attachment I



Attachment 1

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Radiographic Acceptance Criteria

#### FIG. 4-2 GROUPS OF ALIGNED ROUNDED INDICATIONS



GENERAL NOTE: Sum of the group lengths shall be less than t in a length of 12t.

#### Maximum Group Length

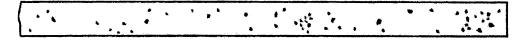
- $L = \frac{1}{4}$  in. (6 mm) for t less than  $\frac{3}{4}$  in. (19 mm)  $L = \frac{1}{3}$ t for  $t \frac{3}{4}$  in. (19 mm) to  $2\frac{1}{4}$  in. (57 mm)  $L = \frac{3}{4}$  in. (19 mm) for t greater than  $2\frac{1}{4}$  in. (57 mm)

#### Minimum Group Spacing

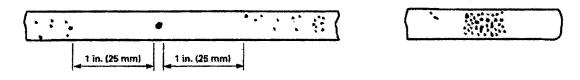
3L where L is the length of the longest adjacent group being evaluated.



FIG. 4-3 CHARTS FOR t EQUAL TO % in. to 1/4 in. (3 mm to 6 mm), INCLUSIVE



(a) Random Rounded Indications [See Note (1)]



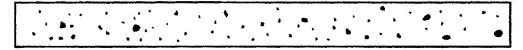
(b) Isolated Indication [See Note (2)]

(c) Cluster

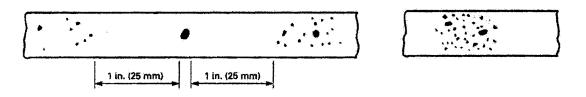
#### NOTES:

- (1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
- (2) Maximum size per Table 4-1.

FIG. 4-4 CHARTS FOR t OVER 14 in. to 36 in. (6 mm to 10 mm), INCLUSIVE



(a) Random Rounded Indications [See Note (1)]



(b) isolated indication [See Note (2)]

(c) Cluster

#### NOTES

- (1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
- (2) Maximum size per Table 4-1.

#### Attachment 1

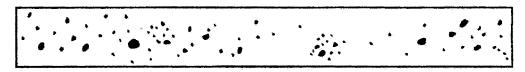
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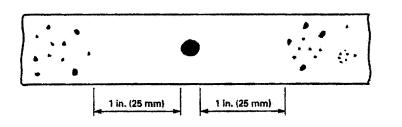


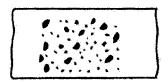


FIG. 4-5 CHARTS FOR ! OVER % in. to % in. (10 mm to 19 mm), INCLUSIVE



#### (a) Random Rounded Indications (See Note (1))





(b) Isolated Indication (See Note (2))

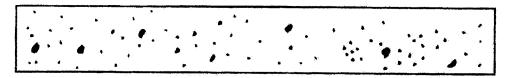
(c) Cluster

#### NOTES:

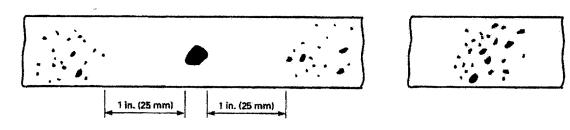
- (1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld. (2) Maximum size per Table 4-1.



FIG. 4-6 CHARTS FOR LOVER 3/4 in. to 2 in. (19 mm to 50 mm), INCLUSIVE



#### (a) Random Rounded Indications (See Note (1))



#### (b) isolated indication [See Note (2)]

(c) Cluster

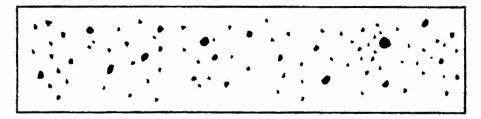
#### NOTES:

Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
 Maximum size per Table 4-1.

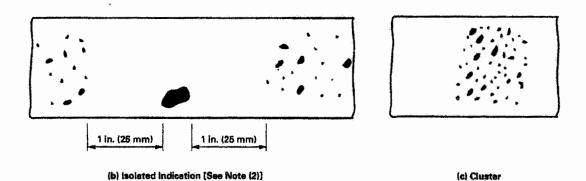




FIG. 4-7 CHARTS FOR t OVER 2 in. to 4 in. (50 mm to 100 mm), INCLUSIVE



#### (a) Random Rounded Indications (See Note (1))



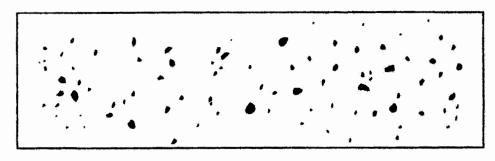
#### NOTES:

- (1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld. (2) Maximum size per Table 4-1.

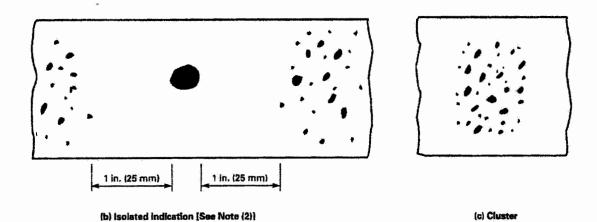




FIG. 4-8 CHARTS FOR t OVER 4 in. (100 mm)



(a) Random Rounded Indications (See Note (1))



- NOTES:
  (1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
  (2) Maximum size per Table 4-1.

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#### ROUNDED INDICATION CHARTS

#### A-250 Acceptance Standard for Radiographically Determined Rounded Indications in Welds

#### A-250.1 Applicability of These Standards.

These standards are applicable to ferritic, austenitic, and non-ferrous materials.

#### A-250.2 Terminology.

A-250.2.1 Rounded Indications. Indications with a maximum length of three times the width or less on the radiograph are defined as rounded indications. These indications may be circular, elliptical, conical, or irregular in shape and may have tails. When evaluating the size of an indication, the tail shall be included. The indication may be from any imperfection in the weld, such as porosity, slag, or tungsten.

A-250.2.2 Aligned Indications. A sequence of four or more rounded indications shall be considered to be aligned when they touch a line parallel to the length of the weld drawn through the center of the two outer rounded indications.

A-250.2.3 Thickness t. t is the thickness of the weld, of the pressure-retaining material, or of the thinner of the sections being joined, whichever is least. If a full penetration weld includes a fillet weld, the thickness of the fillet weld throat shall be included in t.

#### A-250.3 Acceptance Criteria.

A-250.3.1 Image Density. Density within the image of the indication may vary and is not a criterion for acceptance or rejection.

A-250.3.2 Relevant Indications (See Table A-250.3.2 for Examples). Only those rounded indications which exceed the following dimensions shall be considered relevant:

- (a)  $\frac{1}{10}$ t for t less than  $\frac{1}{10}$  in. (3 mm)
- (b)  $\frac{1}{6}$  in. (0.4 mm) for  $t \frac{1}{6}$  in. to  $\frac{1}{4}$  in. (6 mm), inclusive
- (c)  $\frac{1}{32}$  in. (0.8 mm) for  $t \frac{1}{4}$  in. (6 mm) to 2 in. (50 mm), inclusive
- (d) 1/16 in. (1.6 mm) for t greater than 2 in. (50 mm)

A-250.3.3 Maximum Size of Rounded Indication (See Table A-250.3.2 for Examples). The maximum permissible size of any indication shall be  $\frac{1}{4}$ £, or  $\frac{5}{2}$ 2 in. (4 mm), whichever is smaller; except that an isolated indication separated from an adjacent indication by 1 in. (25 mm) or more may be  $\frac{1}{2}$ £, or  $\frac{1}{4}$  in. (6 mm), whichever is less. For t greater than 2 in. (50 mm) the maximum permissible size of an isolated indication shall be increased to  $\frac{3}{6}$  in. (10 mm).

A-250.3.4 Aligned Rounded Indications. Aligned rounded indications are acceptable when the summation of the diameters of the indications is less than t in a length of 12t (see Fig. A-250.3.4-1). The length of groups of aligned rounded indications and the spacing between the groups shall meet the requirements of Figure A-250-3.4-2.

A-250.3.5 Spacing. The distance between adjacent rounded indications is not a factor in determining acceptance or rejection, except as required for isolated indications or groups of aligned indications.

# Table A-250.3.2 Maximum Permissible Size of Rounded indication (Examples Only)

U.S. Customary Units				
	Maximum Size Rounded In	Maximum Size of Nonrevelant		
Thickness 4, in.	Random	Isolated	Indication, in.	
Less than 1/4	'4t	1/34	Tiet	
1/4	0.031	0.042	0.015	
7,4	0.047	0.063	0.015	
1/4	0.063	0.083	0.015	
<b>%</b>	0.078	0.104	0.031	
1/2	0.091	0.125	0.031	
%.	0.109	0.146	0.031	
1/2	0.125	0.168	0.031	
1/16	0.142	0.188	0.031	
×/4	0.156	0.210	0.031	
11/16	0.156	0.230	0.031	
% to 2 incl.	0.156	0.250	0.031	
Over 2	0.156	0.375	0.063	

SI Units				
	Maximum Size of Acceptable Rounded Indication, mm			
Thickness & mm	Random	Isolated	Nonrevelant Indication, mm	
Less than 3	1/42	<b>%</b> t	1/10t	
3	0.79	1.07	0.38	
-5	1.19	1.60	0.38	
6	1.60	2.11	0.38	
8	1.98	2.64	0.79	
10	2.31	3.18	0.79	
11.	2.77	3.71	0.79	
13	3.18	4.27	0.79	
14	3.61	4.78	0.79	
16	3.96	5.33	0.79	
17	3.96	5.84	0.79	
19 to 50 inci.	3.96	6.35	9.79	
Over 50	3.96	9.53	1.60	

A-250.3.6 Rounded Indication Charts. The rounded indications characterized as Imperfections shall not exceed that shown in the charts.

The charts in Figs. A-250,3,6-1 through A-250,3.6-6 illustrate various types of assorted, randomly dispersed, and clustered rounded indications for different weld thicknesses greater than  $\frac{1}{10}$  in (3 mm). These charts represent the maximum acceptable concentration limits for rounded indications.

The chart for each thickness range represents full-scale 6 in. (150 mm) radiographs, and shall not be enlarged or reduced. The distributions shown are not necessarily the patterns that may appear on the radiograph, but are typical of the concentration and size of indications permitted.



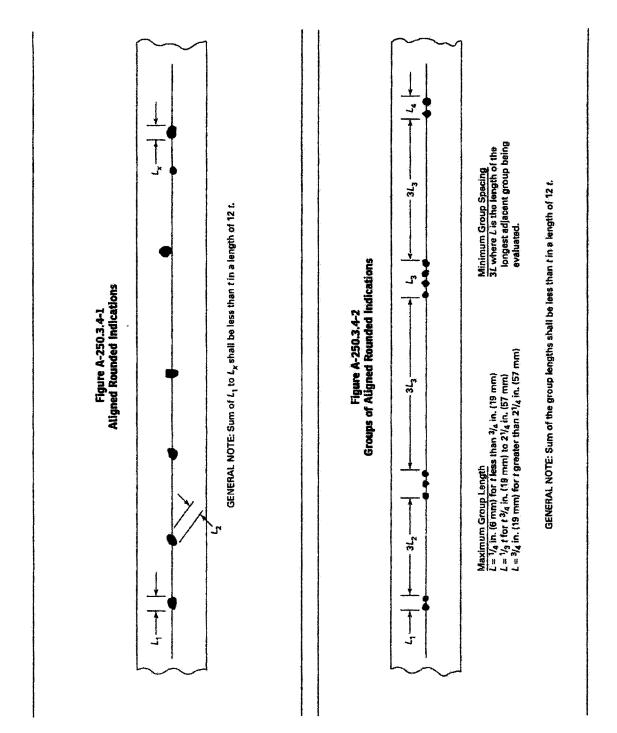




A-250.3.7 Weld Thickness t Less Than  $\frac{1}{16}$  in. (3 mm). For t less than  $\frac{1}{16}$  in. (3 mm), the maximum number of rounded indications shall not exceed 12 in a 6 in. (150 mm) length of weld. A proportionally fewer number of indications shall be permitted in welds less than 6 in. (150 mm) in length.

A-250.3.8 Clustered indications. The illustrations for clustered indications show up to four times as many indications in a local area, as that shown in the illustrations for random indications. The length of an acceptable cluster shall not exceed the lesser of 1 in. (25 mm) or 2t. Where more than one cluster is present, the sum of the lengths of the clusters shall not exceed 1 in. (25 mm) in a 6 in. (150 mm) length of weld.



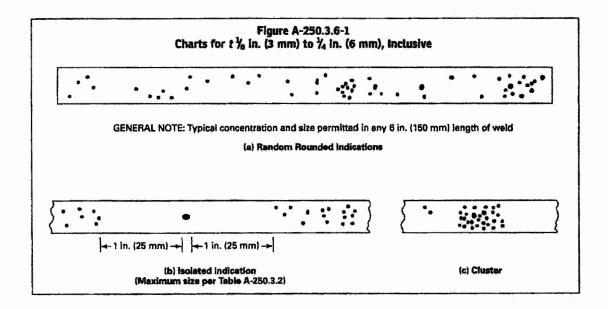


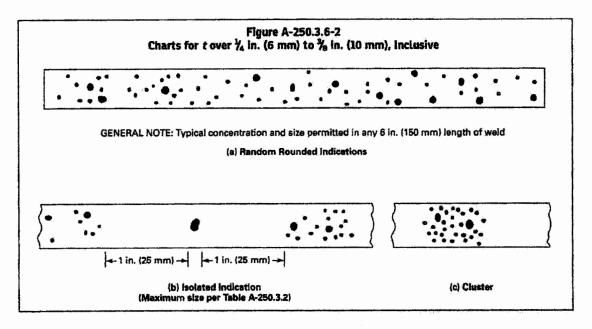
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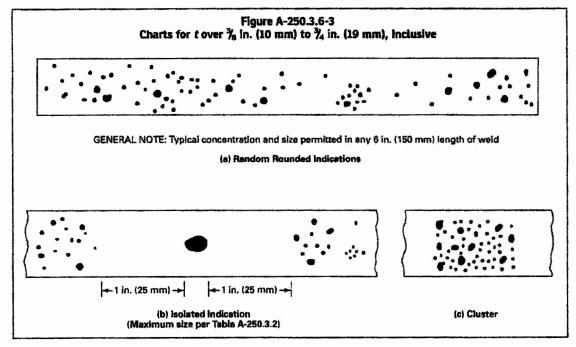


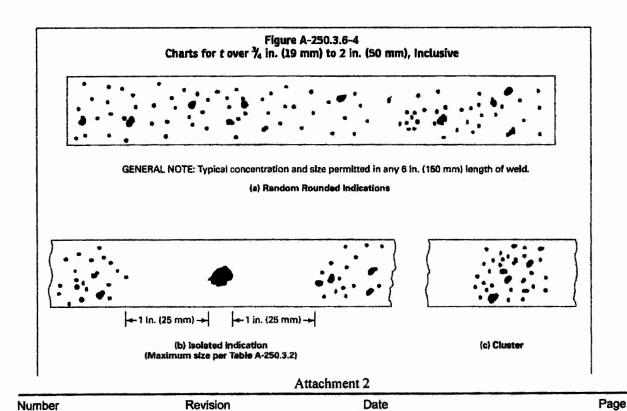
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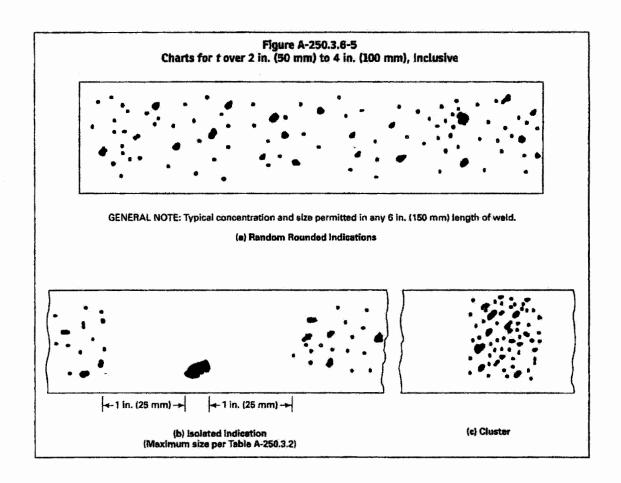
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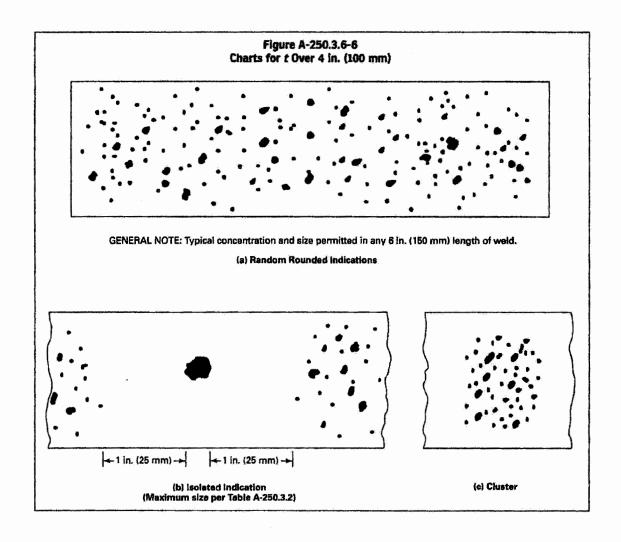
#### Attachment 2



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#### Table 341.3.2 Acceptance Criteria for Welds and Examination Methods for Evaluating Weld Imperfections

	Criteria (A to M) for Types of Welds and for Service Conditions [Note (1)]										Exa	minatio	n Meth	ods
Normal a	Normal and Category M Fluid Service Severe Cyclic Conditions			Category D Fluid Service										
	Type of Wel	d		Type of Wel	d		Type o	f Weld						
Girth, Miter Groove & Branch Connection (Note (2))	Longitudinal Groove  Note (3)	Fillet [Note (4)]	Girth, Miter Groove & Branch Connection [Note (2)]	Longludinal Groove  Note (3)]	Fillet [Note (4)]	Girth and Miler Groove	Longitudinal Groove [Note (3)]	Fillet [Note (4)]	Branch Connection [Note (2)]	Weld Imperfection	Vsual	Radiography	Magnetic Particle	Liquid Penetrant
A	Α	Α	Α	A	Α	A	A	A	A	Crack	1	1	1	1
Ä	A	А	A	A.	A	c	A	N/A	A	Lack of fusion	1	1		
8	Α .	N/A	A	A	N/A	c	A	N/A	В	Incomplete penetration	1	1		
E	E	·Ń/A	D	D	N/A	N/A	N/A	N/A	N/A	Internal porosity		1		
G	G	N/A	F	F	N/A	N/A	N/A	N/A	N/A	internal stag inclusion, tungsten inclusion, or elongated indication		,	• • •	
H	A	н	A	A.	Α	1	A	н	H	Undercutting	1	1		
A	<b>A</b>	A	<b>A</b>	A	Α.	A	A	Α.	A.	Surface porosity or exposed slag inclusion [Note (5)]	1			
N/A	N/A	N/A	l ı	] ]	12	N/A	N/A	N/A	N/A	Surface finish	1			
K	ĸ	N/A	K	K	N/A	K.	ĸ	N/A	K	Concave root surface (suck up)	1	1		
L	L	L		<u> </u>	L	M	м	M	M	Weld reinforcement or Internal protrusion	1		,	<u></u>

#### **GENERAL NOTES:**

- (a) Weld imperfections are evaluated by one or more of the types of examination methods given, as specified in paras. 341.4.1, 341.4.2, 341.4.3, and M341.4, or by the engineering design.
- (b) "N/A" indicates the Code does not establish acceptance criteria or does not require evaluation of this kind of imperfection for this type of
- (c) Check (/) indicates examination method generally used for evaluating this kind of weld imperfection.
- (d) Ellipsis (...) indicates examination method not generally used for evaluating this kind of weld imperfection.



#### Criterion Value Notes for Table 341.3.2

	Criterion	•	
Symbol	Measure	Acceptable Value Limits [Note (6)]	
A	Extent of imperfection	Zero (no evident imperfection)	
В	Depth of incomplete penetration Cumulative length of incomplete penetration	$\leq 1$ mm ( $\frac{7}{12}$ in.) and $\leq 0.2\overline{7}_w$ $\leq 38$ mm (1.5 in.) in any 150 mm (6 in.) weld length	
c	Depth of lack of fusion and incomplete penetration Cumulative length of lack of fusion and incomplete penetration (Note (7))	$\leq 0.2\overline{T}_{W}$ $\leq 38$ mm (1.5 in.) in any 150 mm (6 in.) weld length	
D	Size and distribution of internal porosity	See BPV Code, Section Vill, Division 1, Appendix 4	
E	Size and distribution of internal porosity	For $\widetilde{T}_w \le 6$ mm ( $\frac{1}{4}$ in.), limit is same as D For $\widetilde{T}_w > 6$ mm ( $\frac{1}{4}$ in.), limit is 1.5 × D	
F	Siag inclusion, tungsten inclusion, or elongated indication individual length Individual width Cumulative length	$\leq \overline{T}_w/3$ $\leq 2.5 \text{ mm } (\frac{9}{32} \text{ in.}) \text{ and } \leq \overline{T}_w/3$ $\leq \overline{T}_w \text{ in any } 12\overline{T}_w \text{ weld length}$	
G	Slag inclusion, tungsten inclusion, or elongated indication individual length individual width Cumulative length	$\leq 2\overline{T}_w$ $\leq 3$ mm ( $\frac{1}{6}$ in.) and $\leq \overline{T}_w/2$ $\leq 4\overline{T}_w$ in any 150 mm (6 in.) weld length	
H	Depth of undercut	$\leq 1 \text{ mm } (\frac{1}{32} \text{ in.}) \text{ and } \leq \overline{T}_w/4$	
1	Depth of undercut	$\leq 1.5 \text{ mm } (\frac{1}{16} \text{ in.}) \text{ and } \leq [\overline{T}_{w}/4 \text{ or } 1 \text{ mm } (\frac{1}{12} \text{ in.})]$	
1	Surface roughness	≤ 500 min. Ra in accordance with ASME B46.1	
K.	Depth of root surface concavity	Total joint thickness, Incl. weld reinf., $\geq \overline{T}_w$	
L	Height of reinforcement or internal protrusion [Note (8)] in	For $\overline{T}_{mr}$ mm (in.)	Height, mm (in.)
	any plane through the weld shall be within limits of the applicable height value in the labulation at right, except as provided in Note (9). Weld metal shall merge smoothly into the component surfaces.	\( 6 \frac{1}{2} \)     > 6 (\frac{1}{2}), \leq 13 (\frac{1}{2})     > 13 (\frac{1}{2}), \leq 25 (1)     > 25 (1)	≤ 1.5 (½6) ≤ 3 (⅙) ≤ 4 (⅔) ≤ 5 (⅔)
M	Height of reinforcement or internal protrusion (Note (8)) as described in L. Note (9) does not apply.	Limit is twice the value applicable for L above	

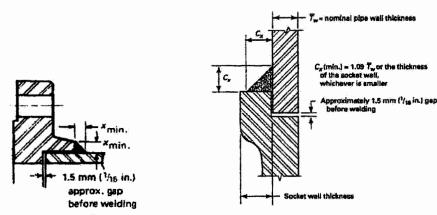
Notes follow on next page



#### **TABLE 341.3.2 (CONT'D)**

#### NOTES:

- Criteria given are for required examination. More stringent criteria may be specified in the engineering design. See also paras. 341.5 and 341.5.3.
- (2) Branch connection weld includes pressure containing welds in branches and fabricated laps.
- (3) Longitudinal groove weld includes straight and spiral seam. Criteria are not intended to apply to welds made in accordance with a standard listed in Table A-1 or Table 326.1. Alternative Leak Test requires examination of these welds; see para. 345.9.
- (4) Fillet weld includes socket and seal welds, and attachment welds for slip-on flanges, branch reinforcement, and supports.
- (5) These imperfections are evaluated only for welds  $\leq 5$  mm (3/16 in.) in nominal thickness.
- (6) Where two limiting values are separated by "and," the lesser of the values determines acceptance. Where two sets of values are separated by "or," the larger value is acceptable. T<sub>w</sub> is the nominal wall thickness of the thinner of two components joined by a butt weld.
- (7) Tightly butted unfused root faces are unacceptable.
- (8) For groove welds, height is the lesser of the measurements made from the surfaces of the adjacent components; both reinforcement and internal protrusion are permitted in a weld. For fillet welds, height is measured from the theoretical throat, Fig. 328.5.2A; internal protrusion does not apply.
- (9) For welds in aluminum alloy only, internal protrusion shall not exceed the following values:
  - (a) for thickness  $\leq 2 \text{ mm} (5/64 \text{ in.})$ : 1.5 mm (1/16 in.);
  - (b) for thickness > 2 mm and <6 mm (1/4 in.): 2.5 mm (3/32 in.).
  - For external reinforcement and for greater thicknesses, see the tabulation for Symbol L.



 $X_{min}$  = the lesser of 1.4 $\overline{T}$  or the hub thickness.

Figure 1 - Socket Welding Flange

Figure 2 - Socket Welding Components other than Flanges

## Figures 1 and 2 Minimum Welding Dimensions and Gap Requirements.







OW-190

OTHER TESTS AND EXAMINATIONS

OW-191

Volumetric NDE

OW-191.1

Radiographic Examination

QW-191.1.1 Method. The radiographic examination in QW-142 for welders and in QW-143 for welding operators shall meet the requirements of Article 2, Section V. The acceptance standards of QW-191.1.2 shall be met.

#### QW-191.1.2 Radiographic Acceptance Criteria

#### **OW-191.2.1 Terminology**

Linear Indications. Cracks, incomplete fusion, inadequate penetration, and slag are represented on the radiograph as linear indications in which the length is more than three times the width.

Rounded Indications. Porosity and inclusions such slag or tungsten are represented on the radiograph as rounded indications with a length three times the width or less. These indications may be circular, elliptical, or irregular in shape; may have tails; and may vary in density.

- QW-191.2.2 Qualification Test Welds. Welder and welding operator performance tests by radiography of welds in test assemblies shall be judged unacceptable when the radiograph exhibits any imperfections in excess of the limits specified below.
  - (a) Linear Indications
    - (1) any type of crack or zone of incomplete fusion or penetration
    - (2) any elongated slag inclusion which has a length greater than:
      - (a) 1/4 in. (3 mm) for t up to 1/4 in. (10 mm), inclusive
      - (b) 1/st for t over 1/s in. (10 mm) to 21/4 in.
      - (57 mm), inclusive
      - (c) 3/4 in. (19 mm) for t over 21/4 in. (57 mm)
    - (3) any group of slag inclusions in line that have an aggregate length greater than t in a length of 12t, except when the distance between the successive imperfections exceeds 6L where L is the longest imperfection in the group.

#### (b) Rounded Indications

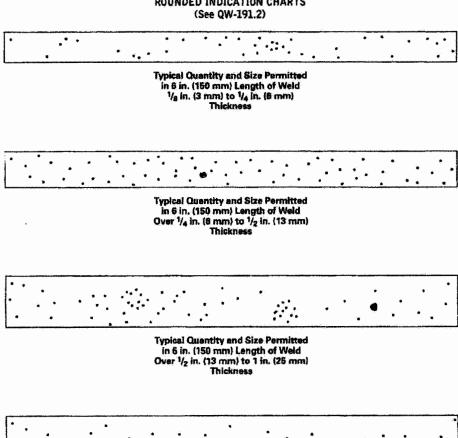
- (1) The maximum permissible dimension for rounded indications shall be 20% of t or 1/2 im.(3mm), whichever is smaller.
- (2) For welds in material less than ¼ in.(3mm) in thickness, the maximum number of acceptable rounded indications shall not exceed 12 in a 6 in. (150 mm) length of weld. A proportionately fewer number of rounded indications shall be permitted in welds less than 6 in. (150 mm)in length.
- (3) For welds in material ¼ in. (3 mm) or greater in thickness, the charts in Appendix 1 represent the maximum acceptable types of rounded indications illustrated in typically clustered, assorted, and randomly dispersed configurations. Rounded indications less than 1/32 in. (.8 mm) in maximum diameter shall not be considered in the radiographic acceptance tests of welders and welding operators in these ranges of material thicknesses.

QW-191.2.3 Production Welds. The acceptance standard for welding operators who qualify on production welds shall be that specified in the referencing Code Section. The acceptance standard for welders who qualify on production welds as permitted by QW-304.1 shall be per QW-191.2.2.





#### APPENDIX I ROUNDED INDICATION CHARTS



Typical Quantity and Size Permitted in 6 in. (150 mm) Length of Weld Over 1 in. (25 mm) Thickness

Attachment 4



Page



## 8 Inspection and Testing of Production Welds

#### 8.1 RIGHTS OF INSPECTION

The company shall have the right to inspect all welds by nondestructive means or by removing welds and subjecting them to mechanical tests. The inspection may be made during the welding or after the weld has been completed. The frequency of inspection shall be as specified by the company.

#### 8.2 METHODS OF INSPECTION

Nondestructive testing may consist of radiographic inspection or another method specified by the company. The method used shall produce indications of imperfections that can be accurately interpreted and evaluated. The welds shall be evaluated on the basis of either Section 9 or, at the company's option, Appendix A. In the latter case, more extensive inspection to determine the imperfection size is required.

Destructive testing shall consist of the removal of completed welds, sectioning of the welds into specimens, and the examination of the specimens. The specimens shall be prepared in accordance with and shall meet the requirements of 6.5. The company shall have the right to accept or reject any weld that does not meet the requirements for the method by which it was inspected. The welder who makes a weld that fails to comply with the requirements may be disqualified from further work.

Operators of nondestructive inspection equipment may be required to demonstrate the inspection procedure's capability to detect defects and the operator's ability to properly interpret the indications given by the equipment.

Trepanning methods of testing shall not be used.

#### 8.3 QUALIFICATION OF INSPECTION PERSONNEL

Welding inspection personnel shall be qualified by experience and training for the specified inspection task they perform. Their qualifications shall be acceptable to the company.

Documentation of these qualifications shall be retained by the company and shall include but is not limited to the following:

- a. Education and experience.
- b. Training.
- c. Results of any qualification examinations.

#### 8.4 CERTIFICATION OF NONDESTRUCTIVE TESTING PERSONNEL

#### 8.4.1 Procedures

Nondestructive testing personnel shall be certified to Level I, II or III in accordance with the recommendations of American Society for Nondestructive Testing, Recommended Prac-

tice No. SNT-TC-1A, ACCP or any other recognized national certification program that shall be acceptable to the company for the test method used. Only Level II or III personnel shall interpret test results.

#### 8.4.2 Record

A record of certified nondestructive testing personnel shall be maintained by the company. The record shall include the results of certification tests, the agency and person granting certification, and the date of certification. Nondestructive testing personnel may be required to arises about their ability. Levels I and II nondestructive testing personnel shall be recertified at least every 3 years. Level III nondestructive testing personnel shall be recertified at least every 5 years.

#### 9 Acceptance Standards for Nondestructive Testing

#### 9.1 GENERAL

The acceptance standards presented in this section apply to imperfections located by radiographic, magnetic particle, liquid penetrant, and ultrasonic test methods. They may also be applied to visual inspection. Nondestructive testing shall not be used to select welds that are subjected to destructive testing in accordance with 6.5.

#### 9.2 RIGHTS OF REJECTION

All nondestructive test methods are limited in the information that can be derived from the indications they produce. The company may therefore reject any weld that appears to meet these acceptance standards if, in its opinion, the depth of an imperfection may be detrimental to the weld.

#### 9.3 RADIOGRAPHIC TESTING

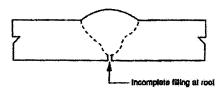
Note: All densities referred to in 9.3.1 through 9.3.13 are based on negative images.

#### 9.3.1 Inadequate Penetration without High-low

Inadequate penetration without high-low (IP) is defined as the incomplete filling of the weld root. This condition is shown schematically in Figure 13. IP shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of IP exceeds 1 in. (25 mm).
- b. The aggregate length of indications of IP in any continuous 12 in. (300 mm) length of weld exceeds 1 in. (25 mm).
- c. The aggregate length of indications of IP exceeds 8% of the weld length in any weld less than 12 in. (300 mm) in length.





Note: One or both root faces may be inadequately filled at the inside surface.

Figure 13—Inadequate Penetration without High-low (IP)

#### 9.3.2 Inadequate Penetration Due to High-low

Inadequate penetration due to high-low (IPD) is defined as the condition that exists when one edge of the root is exposed (or unbonded) because adjacent pipe or fitting joints are misaligned. This condition is shown schematically in Figure 14. IPD shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of IPD exceeds 2 in.
   (50 mm).
- b. The aggregate length of indications of IPD in any continuous 12 in. (300 mm) length of weld exceeds 3 in. (75 mm).

#### 9.3.3 Inadequate Cross Penetration

Inadequate cross penetration (ICP) is defined as a subsurface imperfection between the first inside pass and the first outside pass that is caused by inadequately penetrating the vertical land faces. This condition is shown schematically in Figure 15. ICP shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of ICP exceeds 2 in.
- b. The aggregate length of indications of ICP in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm).

#### 9.3.4 Incomplete Fusion

Incomplete fusion (IF) is defined as a surface imperfection between the weld metal and the base material that is open to the surface. This condition is shown schematically in Figure 16. IF shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of IF exceeds 1 in. (25 mm).
- b. The aggregate length of indications of IP in any continuous 12 in. (300 mm) length of weld exceeds 1 in. (25 mm).
- c. The aggregate length of indications of IF exceeds 8% of the weld length in any weld less than 12 in. (300 mm) in length.

#### 9.3.5 Incomplete Fusion Due to Cold Lap

Incomplete fusion due to cold lap (IFD) is defined as an imperfection between two adjacent weld beads or between the weld metal and the base metal that is not open to the surface. This condition is shown schematically in Figure 17. IFD shall be considered a defect should any of the following conditions exist:

- The length of an individual indication of IFD exceeds 2 in. (50 mm).
- b. The aggregate length of indications of IFD in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm).
- c. The aggregate length of indications of IFD exceeds 8% of the weld length.

#### 9.3.6 Internal Concavity

Internal concavity (IC) is defined in 3.2.8 and is shown schematically in Figure 18. Any length of internal concavity is acceptable, provided the density of the radiographic image of the internal concavity does not exceed that of the thinnest adjacent parent material. For areas that exceed the density of the thinnest adjacent parent material, the criteria for burnthrough (see 9.3.7) are applicable.

#### 9.3.7 Burn-through

- 9.3.7.1 A burn-through (BT) is defined as a portion of the root bead where excessive penetration has caused the weld puddle to be blown into the pipe.
- 9.3.7.2 For pipe with an outside diameter greater than or equal to 2.375 in. (60.3 mm), a BT shall be considered a defect should any of the following conditions exist:
- a. The maximum dimension exceeds <sup>1</sup>/<sub>4</sub> in. (6 mm) and the density in any portion of the BTs image exceeds that of the thinnest adjacent parent material.
- b. The maximum dimension exceeds the thinner of the nominal wall thicknesses joined, and the density in any portion of the BTs image exceeds that of the thinnest adjacent parent
- c. The sum of the maximum dimensions of separate BTs whose image density for any portion of the BTs exceeds that





## Radiographic Acceptance Criteria NDE Supplement

of the thinnest adjacent perent material and exceeds <sup>1</sup>/<sub>2</sub> in. (13 mm) in any continuous 12 in. (300 mm) length of weld or the total weld length, whichever is less.

9.3.7.3 the following conditions exists: 9.3.7.3 For pipe with an outside diameter less than 2.375 in. (60.3 mm), a BT shall be considered a defect when any of

a. The maximum dimension exceeds 1/4 in. (6 mm) and the density in any portion of the BTs image exceeds that of the thinnest adjacent parent material.

material nal wall thicknesses joined, and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent The maximum dimension exceeds the thinner of the nomi-

c. More than one BT of any size is present and the density in any portion of the BTs image exceeds that of the thinnest adjacent parent material.

# 9.3.8 Stag Inclusions

found at the fusion zone. Isolated slag inclusions (ISIs) are irregularly shaped and may be located anywhere in the weld. For evaluation purposes, when the size of a radiographic indication of slag is measured, the indication's maximum dimension shall be considered its length. entrapped in the weld metal or between the weld metal and the parent material. Blongared slag inclusions (BSIs)—e.g., 9.3.8.1 continuous or broken slag lines or wagon tracks-are usually A slag inclusion is defined as a nonmetallic solid

9.3.8.2 For pipe with an outside diameter greater than or equal to 2.375 in. (60.3 mm), slag inclusions shall be considered a defect should any of the following conditions exist:

The length of an ESI indication exceeds 2 in. (50 mm).

Note: Parallel ESI indications separated by approximately the width of the root bead (wagon tracks) shall be considered a single indication unless the width of either of them exceeds <sup>1</sup>/32 in. (0.8 mm). In that event, they shall be considered separate indications.

The aggregate length of RSI indications in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm).

The width of an ESI indication exceeds 1/16 in. (1.6 mm).

d. The width of an ESI Indications in any continuous 12 in. (300 mm) length of ISI indications in any continuous 12 in. (300 mm) length of weld exceeds <sup>1</sup>/2 in. (13 mm).

e. The width of an ISI indication exceeds <sup>1</sup>/8 in. (3 mm).

f. More than four ISI indications with the maximum width of f. (300 mm) 1/8 in. (3 mm) are present in any continuous 12 in. (300 mm) length of weld.

The aggregate length of ESI and ISI indications exceeds 8% of the weld length.

9.3.8.3 For pipe with an outside diameter less than 2.375 in. (60.3 mm), slag inclusions shall be considered a defect should any of the following conditions exist:

a. The length of an ESI indication exceeds three times the thinner of the nominal wall thicknesses joined.

Note: Parellel ESI indications separated by approximately the width of the root bead (wagon tracks) shall be considered a single initiation unless the width of either of them rocceets 1/32 in. (0.8 mm). In that event, they shall be considered separate indications.

c. The aggregate length of ISI indications exceeds two times the thinner of the nominal wall thicknesses joined and the width exceeds one-half the thinner of the nominal wall thickb. The width of an ESI indication exceeds 1/16 in. (1.6 mm). nesses joined.

d. The aggregate length of ESI and ISI indications exceeds 8% of the weld length.

## 9.3.9 Porosity

8.3.9.1 Porosity is defined as gas trapped by solidifying weld metal before the gas has a chance to rise to the surface of the molten puddle and escape. Porosity is generally spherical but may be elongated or irregular in shape, such as piping (wormhole) porosity. When the size of the radiographic indication produced by a pore is measured, the maximum dimension of the indication shall apply to the criteria given in 9.3.9.2 through 9.3.9.4.

9.3.9.2 Individual or scattered porosity (P) shall be considered a defect should any of the following conditions exist:

The size of an individual pore exceeds 1/8 in. (3 mm).

of the nominal wall thicknesses joined. The size of an individual pore exceeds 25% of the thinner

The distribution of scattered porosity exceeds the concentration permitted by Figures 19 or 20.

9.3.9.3 Cluster porosity (CP) that occurs in any pass except the finish pass shall comply with the criteria of 9.3.9.2. CP that occurs in the finish pass shall be considered a defect should any of the following conditions exist.

The diameter of the cluster exceeds 1/2 in. (13 mm).

b. The aggregate length of CP in any continuous 12 in. (300 mm) length of weld exceeds 1/2 in. (13 mm).

9.3.9.4 Hollow-bead porosity (HB) is defined as clongated linear porosity that occurs in the root pass. HB shall be considered a defect should any of the following conditions exist:

(13 mm), The length of an individual indication of HB exceeds 1/2 in

b. The aggregate length of indications of HB in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm).

c. Individual indications of HB, each greater than <sup>1</sup>/<sub>4</sub> in.
(6 mm) in length, are separated by less than 2 in. (50 mm).
d. The aggregate length of all indications of HB exceeds 8% of the weld length.



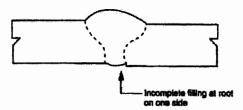


Figure 14-Inadequate Penetration Due to High-Low (IPD)



Figure 15—Inadequate Cross Penetration (ICP)

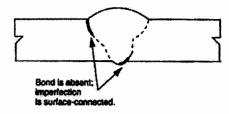


Figure 16—Incomplete Fusion at Root of Bead or Top of Joint (IF)

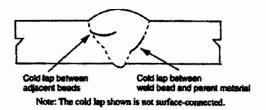


Figure 17-Incomplete Fusion Due to Cold Lap (IFD)

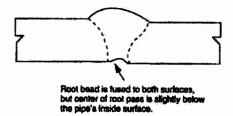
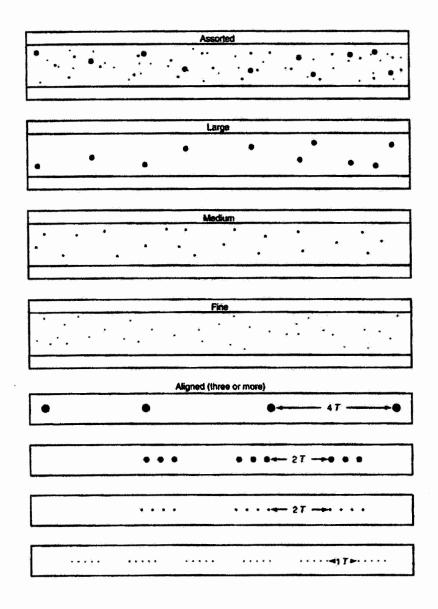


Figure 18—Internal Concavity (IC)







Note: The size of the gas pockets is not drawn to scale: for dimensions, refer to 9.3.9.

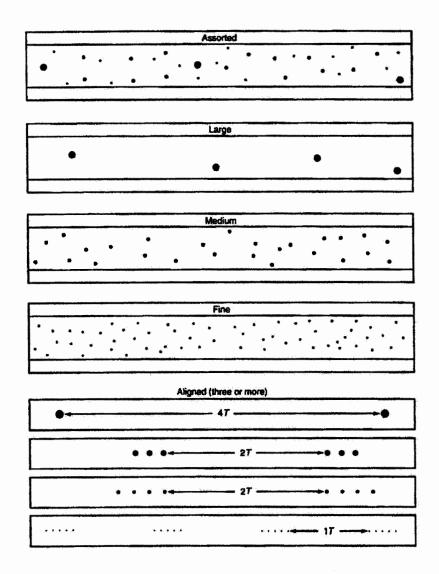
Figure 19—Maximum Distribution of Gas Pockets: Wall Thicknesses Less Than or Equal to 0.500 inch (12.7 mm)

Attachment 5

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Note: The size of the gas pockets is not drawn to scale; for dimensions, refer to 9.3.9.

Figure 20—Maximum Distribution of Gas Pockets: Wall Thicknesses Greater Than 0.500 inch (12.7 mm)

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#### 9.3.10 Cracks

Cracks (C) shall be considered a defect should any of the following conditions exists:

- The crack, of any size or location in the weld, is not a shallow crater crack or star crack.
- b. The crack is a shallow crater crack or star crack with a length that exceeds 5/32 in. (4 mm).

Note: Shallow crater cracks or star cracks are located at the stopping point of weld beads and are the result of weld metal contractions during solidification.

#### 9.3.11 Undercutting

Undercutting is defined as a groove melted into the parent material adjacent to the toe or root of the weld and left unfilled by weld metal. Undercutting adjacent to the cover pass (EU) or root pass (IU) shall be considered a defect should any of the following conditions exists:

- a. The aggregate length of indications of EU and IU, in any combination, in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm).
- b. The aggregate length of indications of EU and IU, in any combination, exceeds one-sixth of the weld length.

Note: See 9.7 for acceptance standards for undercutting when visual and mechanical measurements are employed.

#### 9.3.12 Accumulation of Imperfections

Excluding incomplete penetration due to high-low and undercutting, any accumulation of imperfections (AI) shall be considered a defect should any of the following conditions exist:

- The aggregate length of indications in any continuous 12 in.
   (300 mm) length of weld exceeds 2 in. (50 mm).
- b. The aggregate length of indications exceeds 8% of the weld length.

#### 9.3.13 Pipe or Fitting Imperfections

Imperfections in the pipe or fittings detected by radiographic testing shall be reported to the company. Their disposition shall be as directed by the company.

#### 9.4 MAGNETIC PARTICLE TESTING

#### 9.4.1 Classification of Indications

9.4.1.1 Indications produced by magnetic particle testing are not necessarily imperfections. Magnetic and metallurgical variations may produce indications that are similar to those produced by imperfections but that are not relevant to acceptability. The criteria given in 9.4.1.2 and 9.4.1.3 apply when indications are evaluated.

- 9.4.1.2 Any indication with a maximum dimension of <sup>1</sup>/16 in. (1.6 mm) or less shall be classified as nonrelevant. Any larger indication believed to be nonrelevant shall be regarded as relevant until re-examined by magnetic particle or another non-destructive testing method to determine whether or not an actual imperfection exists. The surface may be ground or otherwise conditioned before re-examination. After an indication is determined to be nonrelevant, other nonrelevant indications of the same type need not be re-examined.
- 9.4.1.3 Relevant indications are those caused by imperfections. Linear indications are those in which the length is more than three times the width. Rounded indications are those in which the length is three times the width or less.

#### 9.4.2 Acceptance Standards

Relevant indications shall be considered defects should any of the following conditions exist:

- a. Linear indications evaluated as crater cracks or star cracks exceed 5/32 in. (4 mm) in length.
- Linear indications are evaluated as cracks other than crater cracks or star cracks.
- c. Linear indications are evaluated as IF and exceed 1 in. (25 mm) in total length in a continuous 12 in. (300 mm) length of weld or 8% of the weld length.

Rounded indications shall be evaluated according to the criteria of 9.3.9.2 and 9.3.9.3, as applicable. For evaluation purposes, the maximum dimension of a rounded indication shall be considered its size.

Note: When doubt exists about the type of imperfection being disclosed by an indication, verification may be obtained by using other nondestructive testing methods.

#### 9.4.3 Pipe or Fitting Imperfections

Imperfections in the pipe or fittings detected by magnetic particle testing shall be reported to the company. Their disposition shall be as directed by the company.

#### 9.5 LIQUID PENETRANT TESTING

#### 9.5.1 Classification of Indications

- 9.5.1.1 Indications produced by liquid penetrant testing are not necessarily imperfections. Machining marks, scratches, and surface conditions may produce indications that are similar to those produced by imperfections but that are not relevant to acceptability. The criteria given in 9.5.1.2 and 9.5.1.3 apply when indications are evaluated.
- 9.5.1.2 Any indication with a maximum dimension of <sup>1</sup>/<sub>16</sub> in. (2 mm) or less shall be classified as nonrelevant. Any larger indication believed to be nonrelevant shall be regarded as relevant until re-examined by liquid penetrant or another nondestructive testing method to determine whether or not an actual





#### ASME B16.34 (Appendix I)

#### 1-2 ACCEPTANCE CRITERIA

- I-2.1 For wall thickness  $t \le 50$  mm ( $t \le 2$  in.) the comparative plates of ASTM E 446 define acceptable indications as shown in Table I-1.
- 1-2.2 For wall thickness 50 mm  $< t \le 115$  mm (2 in.  $< t \le 4.5$  in.) the comparative plates of ASTM E 186 define acceptable indications as shown in Table I-2.
- I-2.3 For wall thickness 115 mm  $< t \le 305$  mm (4.5 in.  $< t \le 12$  in.) the comparative plates of ASTM E 280 define acceptable indications as shown in Table I-3.

Table I-1 Acceptance Criteria for Thickness per Para. I-2.1

Discontinuity Type	Category	Acceptable Comparative Plate ASTM E 446
Gas	A	A2
Sand	B	83
Shrink, Type 1	C	CA2
Shrink, Type 2	Ċ	CB3
Shrink, Type 3	С	CC3
Shrink, Type 4	C	CD3
Hot tears and cracks	D & E	None
Inserts (chills, chaplets)	F	None

Table I-3 Acceptance Criteria for Thickness per Para. I-2.3

Discontinuity Type	Category	Acceptable Comparative Plate ASTM E 280
Gas porosity	A	A3
Sand and stag inclusions	8	83
Shrink, Type 1	c	CA3
Shrink, Type 2	c	CB3
Shrink, Type 3	C	CC3
Crack	D	None
Hot tear	E	None
Insert	F ·	None:

Table I-2 Acceptance Criteria for Thickness per Para. I-2.2

Discontinuity Type	Category	Acceptable Comparative Plate ASTM E 186
Gas porosity	A:	A3
Sand and slag inclusions	8	83
Shrink, Type 1	C C	CA3
Shrink, Type 2	C	CB3
Shrink, Type 3	c	CC3
Crack	D	None
Hot tear	E	None
Insert	F	None

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### Heat Exchanger Design, Inc.

P. O. Box 524 Indianapolis, IN 46206-0524 USA Phone: (317)686-9000 • Fax: (317)686-9100



Liquid Penetrant (PT) Examination Report

Type of Liquid Penetrant; Visible Type of Solvent Removable Type of Liquid Penetrant Materials: All products manufactured by Radnor Welding products (Cantesco Corp.) Cleaner > Penetrant > P101S Developer > D101					■ A5		e.VIII, D e.I, para. 1.1, para re restric	0iv.1, Ag PG-25. a. 136.4. ctive clic	2.1.2.2 4(B) ant specifications)	Procedure HED-PT1.  Examinations Performed By:	mannet in accorda	nce with the
WORK ORDER#: 4474					<u>_</u>					nent or weld location.		
					EXA	MNAT	ION R	ESUL 1				
		Thknss			Source	<u> </u>			Indic	ations	When Pe	rformed
Component or Weld	Material	(inches)			tensity nlight	(Non R	ptable elevant)			Rejected	Date	Time
			A-	amb	ient	Туре	None	Туре	Size (inches)	Remarks		
NC. ND			Ē	A	1900fc		/			FINAL	7-16-13	1:00pm
CBJICBJ2				A	(900fc		/			WELD PREP	7-19-13	8:00 Am
CBJ3, CBJ4	•		Ē	A	1900 fc		/			FINAL	7-23-13	815AM
CBII-CBIZ			F	A	1900°C		V			FINAL	7-25-13	2:00pm
LLI-LLZ		(	B		(100 fc		V			FINAL	7-26-13	
			F	A	fic							
			F	A	fc							
			F	A	fc							
			F	A	fc							
			F	A	fic							
			F	A	fc							
			F	A	fic							
			F	A	fc				٠.	Alan A		
	-		F	A	fc					H Rubblell	WITNESS	
Legend of Indication Types:	L-Linear	R-Rounded		M-	-Multiple					Rick Windell		

### Heat Exchanger Design, Inc.

P. O. Box 524

Indianapolis, IN 46206-0524 USA

Phone: (317)686-9000 • Fax: (317)686-9100



## Certificate of PT Personnel Qualification

Doug McKinney

The individual referenced above is qualified to perform Liquid Penetrant Examination (hereafter referred to as PT) of products constructed by Heat Exchanger Design, Inc. by satisfying the requirements as stated below.

#### References:

- 1) ASME Sec. VIII, Div.1, para. UG-103 stipulates PT shall be done in accordance with Appendix 8.
- 2) ASME Sec.VIII, Div.1, Appendix 8, para. 8-2 requires that personnel shall have their eyes tested annually and that they are competent in the techniques of PT. Specific qualification criteria is described in procedure HED-PT1.

#### Procedure:

HED-PT1 (Rev.4): Liquid Penetrant Examination Procedure (of Heat Exchanger Design, Inc.).

#### Competency:

The individual referenced above has had on-the-job training in the techniques of performing, interpreting and evaluating PT examination in accordance with procedure HED-PT1. The individual has passed the prescribed written examination and the eye examinations consisting of correctly reading a Jaeger No.2 Standard Chart at a distance no less than 12" and Ishihara color test plates.

Individual	Certification	Exam Score	Eye Examination Record			
marviduai	dual Date	Exam Score	Date of Last Exam	Date of Expiration		
Doug McKinney	14-Feb-2008	95%	8-Feb-2013	8-Feb-2014		

We do hereby certify that the information listed above is true. By virtue of these results and with concurrence of the Authorized Inspector (AI), the individual referenced above meets the requirements as specified by ASME Sec.VIII, Div.1 Code for the qualification of personnel performing PT.

David Freedinger, Manager of Q.C., H.H.D., Inc.

WITNESS D

Rick Windell | School 13 REVIEW

It Transfer Equipment

Serving
Petroleum, Petrochemical, Power, Food, and Industrial on Heat Transfer Equipmen

Rev.	By/Date	Description	Heat Exchanger Design, Inc.	Section	Page
04	15-Apr-09	revised chemical mfr	Quality Control Records and Procedures	4 4	1.50
03	19-Nov-04	added light intensity data	Volume I	1A	1 of 2

#### **HED-PT1 (Rev. 4): LIQUID PENETRANT EXAMINATION PROCEDURE**

#### INTRODUCTION:

This procedure governs the Solvent Removable method of liquid penetrant (hereafter referred to as LP) examination to be employed by the COMPANY. This procedure complies with the latest editions of the ASME Section I, Section VIII, Division 1, B31,1 and Section V Code standards.

Non-porous metallic materials, whether ferrous or non-ferrous, may be examined by this procedure. Surface discontinuities such as cracks, seams, laps, cold shuts, lack of bond, laminations, etc. are possible indications of this method of NDE.

Principally, the LP is applied to the surface to be examined and allowed to enter discontinuities. Excess penetrant is removed, the part is dried and the developer applied. The developer acts as both a blotter to absorb penetrant that has been trapped in discontinuities and as a contrasting background to enhance the visibility of penetrant indications.

LP materials used shall be produced by Radnor Welding Products (Cantesco Corp.). Of which all shall be of the solvent removable type. Intermixing materials of various methods is not allowed.

#### **QUALIFICATIONS:**

All personnel performing LP examinations shall be proven competent in accordance with Sec. VIII, Div. 1, App. 8 [see Sec. I, para. PG-25.2.1.2.2 and B31.1, para. 136.3.2] by passing the prescribed written or verbal examination with a 90% minimum score and by satisfactory performance of the procedure as witnessed by the Quality Control Manager. All personnel shall be tested annually for visual acuity with a Jaeger Type #2 Standard Chart at a distance no less than 12" and with Ishihara color test plates.

#### PRE-CLEANING:

In general, results may be obtained when the surface of the part is in the as-welded or as-manufactured condition. Surface preparation by grinding or machining may be required where surface irregularities could mask indications of discontinuities. The surface to be examined and area within 1" shall be dry and free of all dirt, paint, grease lint, scale, flux, weld splatter and other material that could interfere with the examination. Typical cleaning agents are detergents, organic solvents, de-scaling solutions and paint removers. Cleaning agent shall be applied repeatedly until no indications appear on a clean cloth or paper towel. After cleaning, the surface shall be allowed to dry for a period not less than 5 minutes,

#### PENETRANT APPLICATION:

The dye penetrant is a penetrating liquid that enters surface discontinuities. The penetrant shall be applied by the spray method but not until the pre-cleaning operation has been performed and the parts have been completely dried. The temperature of the penetrant and of the surface in question is to be 50-125°F during the entire examination procedure. Dwell time of the penetrant shall be no less than 10 minutes.

	PERMISSION OF DESIGN DEMAS, CALIZEATIONS, ANALYSES, TEST METHODS ON MATERIALS DEVELOPED ON SELECTED BY THE SUPPLIER AN B DOES NOT RELIEVE SUPPLIER FROM FULL COMPLIANCE WITH CONTRACTUAL OBLIGATIONS.	
(	WORK MAY PROCEED.	
,	REVISE AND RESUBINIT, WORK MAY PROCEED SUBJECT TO INCORPORATION OF CHANGES INDICATED.     REVISE AND RESUBINIT WORK SHALL NOT PROCEED.	ĺ
	4. REVIEW NOT REQUIRED. WORK MAY PROCEED.	0
	BY WIT DATE THE TOTAL	P7

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Rev.	By/Date	Description	Heat Exchanger Design, Inc.	Section	Page
02	13-Nov-03	developer dwell was 7 min.	Quality Control Records and Procedures	4 Å	2 of 2
03	20019-Nov-04	added light intensity data	Volume I	1A	2 01 2

#### PENETRANT REMOVAL:

After the specified dwell time has elapsed, any excess penetrant on the surface shall be removed carefully. Removal shall be accomplished by repeatedly wiping the surfaces with a clean, lint-free, *dry* material until most traces of the penetrant have been removed. Then a similar cloth or paper towel *lightly* moistened with solvent shall be used to wipe the surfaces clean of all remaining excess penetrant.

Flushing the surface with solvent is prohibited. After penetrant removal, the surfaces must be allowed to dry by normal evaporation for a period of 10 minutes.

#### **DEVELOPER APPLICATION:**

The developer serves two functions...as a contrasting background for the penetrant, and as a vehicle to draw the penetrant, in the discontinuities, to the surface of the developer film, thus revealing these discontinuities.

A thin, even coating of developer shall be sprayed as soon as permissible after penetrant removal and drying. The developer is a liquid suspension of powdered material that must be thoroughly agitated prior to and during application. The developer dwell time shall be 10 minutes minimum to 30 minutes maximum.

#### **VIEWING TEST RESULTS:**

Observation of the developer may take place immediately and may be accomplished in either natural or artificial light; however, a minimum light intensity of 100fc (1000Lux) is required on the surface to be examined. While some discontinuities can be detected almost instantly after the developer is applied, sufficient dwell time should be allowed for all discontinuities to be revealed.

#### INTERPRETATION of TEST RESULTS:

As the developer dries to a smooth, even, white coating...red indications will appear at the locations of discontinuities. Depth of surface discontinuities may be correlated with the richness of color and speed of bleed-out.

Usually, cracks or similar openings will show a red line, tight cracks or a partially welded lap will show a broken line. Gross porosity may produce large indications covering an entire area. Fine porosity is indicated by random red dots. Acceptance criteria shall be based on PG-25.2.1.2.2 of Sec. I, 136.4.4(B) of B31.1 or App. 8 of Sec. VIII, Div. 1 as applicable unless more restrictive customer specifications apply.

Any indications with major dimensions greater than 1/16" shall be considered relevant. Since red flaw indications will remain visible until wiped off manually, there is no need to rework defective areas immediately. In fact, if salvage is practical, parts can often be reworked with the location and extent of discontinuities still showing, thus simplifying repair.

Re-inspect the parts after repairing discontinuities. The dry developer film can normally be removed during the cleaning operation prior to further processing. Usually it is not necessary to remove the developer at all.

#### REPORTING TEST RESULTS:

Test results shall be documented as required by Sec. V, Art. 6, para. T-690. The examiner shall complete the "Liquid Penetrant Examination Report" for all mandatory examinations.

Rick Windell St. REVIEW REVIEW

## SECTION 7 ASME Code Calculations

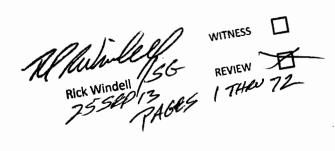
Multiple WITNESS D
REVIEW XX

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VENDOR PRINT	TX3-	-,bc-4006-0012			
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CLIENT CROSS REF					
Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve the supplier from full compliance with contractual obligations.  1. Work may proceed.					
2. Revise		it. Work may proceed subject to incorpor	ration		
3. 🗆 Revise	and resubm	it. Work SHALL NOT proceed.			
4. Review	not required	d. Work may proceed.	21,201		
		-ASP			



Cover Page 2

Bantrel PO# 1083-BC-4008

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

DESIGN CALCULATION

ASME Code Version : 2011a

Analysis Performed by : HEAT EXCHANGER DESIGN

Date of Analysis : Aug 5,2013

PV Elite 2012 (January 2012)

AL

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis: Shell Item: 1 12:22p Aug 5,2013

#### Input Echo, Component 1, Description: Shell

Design Internal Pressure	P	7.65	N/mm²
Temperature for Internal Pressure		177.79	С
User Entered Minimum Design Metal Te	mperature	-28.89	С
Design External Pressure	PEXT	0.10	N/mm²
Temperature for External Pressure		177.79	С
External Pressure Chart Name		CS-2	
Include Hydrostatic Head Components		МО	
Material Specification (Not Normaliz	ed)	SA-106 B	
Material UNS Number		козоо6	
Material Form used		Smls. pipe	
Allowable Stress At Temperature	s	117897.66	kPa
Allowable Stress At Ambient	SA	117897.66	kPa
Yield Stress At Temperature	Sy	209788.91	kPa
Curve Name for Chart UCS 66		В	
Joint efficiency for Shell Joint	E	1.00	
Design Length of Section	L	6194.425	mm
Length of Cylinder for Volume Calcs.	CYLLEN	6194.425	mm
Outside Diameter of Cylindrical Shel	.1 D	114.300	mm
Minimum Thickness of Pipe or Plate	T	5.2673	mm
Nominal Thickness of Pipe or Plate	Tnom	6.0198	mm
Shell/Head Int. Corrosion Allowance	CA	1.5875	mm

NO

Skip UG-16(b) Min. thickness calculation

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units ------

Shell Analysis: Shell Item: 1 12:22p Aug 5,2013

Type of Element:

Cylindrical Shell

#### Internal pressure results, Shell Number 1. Desc.: Shell

ASME Code, Section VIII, Division 1, 2011a

#### Thickness Due to Internal Pressure (Tr):

- = (P\*(D/2-CAE)) / (S\*E+0.4\*P) per Appendix 1-1 (a)(1)
- = (7.65\*(114.3000/2-0.000)/(117897.66\*1.00+0.4\*7.65)
- = 3.6159 + 1.5875 = 5.2034 mm

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

- = (S\*E\*(T-CA-CAE)) / ((D/2-CAE)-0.4\*(T-CA-CAE)) per Appendix 1-1 (a)(1)
- = (117897.66\*1.00\*(3.6798))/(114.3000/2-0.000-0.4\*3.6798)
- $= 7.79 \text{ N/mm}^2$

#### Maximum Allowable Pressure, New and Cold (MAPNC):

- = (SA\*E\*T) / (D/2-0.4\*T) per Appendix 1-1 (a) (1)
- = (117897.66\*1.00\*5.2673)/(114.3000/2-0.4\*5.2673)
- = 11.28 N/mm<sup>2</sup>

#### Actual stress at given pressure and thickness (Sact):

- =  $\{P^*(\{D/2-CAE\}-0.4^*(T-CA-CAE)\}\}$  /  $\{E^*(T-CA-CAE)\}$
- = (7.65\*(((114.3000/2-0.000)-0.4\*(3.6798)))/(1.00\*(3.6798))
- = 115794.82 kPa

#### **SUMMARY OF INTERNAL PRESSURE RESULTS:**

Required Thickness plus Corrosion Allowance, Trca 5.2034 mm

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis: Shell Item: 1 12:22p Aug 5,2013

Actual Thickness as Given in Input 5.2673 mm

Maximum Allowable Working Pressure MAWP 7.792 N/mm<sup>2</sup>

Maximum Allowable Pressure, NC MAPNC 11.282 N/mm²

Design Pressure as Given in Input P 7.653 N/mm²

#### Hydrostatic Test Pressures ( Measured at High Point ):

Hydrotest per UG-99(b); 1.3 \* MAWP \* Sa/S 10.13 N/mm<sup>2</sup>

Hydrotest per UG-99(c); 1.3 \* MAPNC 14.67 N/mm<sup>2</sup>

Pneumatic per UG-100 ; 1.1 \* MAWP \* Sa/S 8.57 N/mm²

#### Minimum Design Metal Temperature per UCS-66 Curve : B

tg = 5.267, tg sr = 5.267, tr = 3.616, c = 1.5875 mm,  $E^* = 1.00$ 

Stress Ratio =  $tr * (E^*) / (tg_sr - c) = 0.983$ , Temp. Reduction = 1 C

Min. Metal Temp. w/o impact per Fig. UCS-66 -29 C

Min. Metal Temp. at Req'd thk. (UCS 66.1) -30 C

Min. Metal Temp. w/o impact per UG-20(f) -29 C

#### External Pressure Results, Shell Number 1, Desc.: Shell

#### ASME Code, Section VIII, Division 1, 2010, 2011a

External Pressure Chart CS-2 at 177.79 C

Elastic Modulus for Material 196362.75 N/mm²

#### Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Shell TCA 3.6798 mm

Outside Diameter of Shell ODCA 114.300 mm

Design Length of Cylinder or Cone SLEN 6194.425 mm



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Bantrel PO# 1083-BC-4008

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units

Shell Analysis : Shell Item: 1 12:22p Aug 5,2013

Diameter / Thickness Ratio (D/T) 31.0613
Length / Diameter Ratio LD 50.0000

Geometry Factor, A f(DT,LD) A 0.0011401

Materials Factor, B, f(A, Chart) B 84397.3984 kPa

Maximum Allowable Working Pressure 3.62 N/mm²

EMAWP =  $\{4*B\}/\{3*(D/T)\}$  =  $\{4*84397.3984\}/\{3*31.0613\}$  = 3.6229

#### Results for Regd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Shell	TCA	1.0236	mm
Outside Diameter of Shell	ODCA	114.300	mm
Design Length of Cylinder or Cone	SLEN	6194.425	mm
Diameter / Thickness Ratio	(D/T)	111.6639	
Length / Diameter Ratio	LD	50.0000	
Geometry Factor, A f(DT,LD)	A	0.0000882	
Materials Factor, B, f(A, Chart)	В	8661.3564	kPa
Maximum Allowable Working Pressure		0.10	N/mm²
EMAWP = (4*B)/(3*(D/T)) = (4*8661.3	564 )/( 3	*111.6639 ) =	0.1034

#### Results for Maximum Length Calculation: No Conversion

Corroded Thickness of Shell	TCA	3.6798	mm
Outside Diameter of Shell	ODCA	114.300	mm
Design Length of Cylinder or Cone	SLEN	0.915E+33	mm
Diameter / Thickness Ratio	(D/T)	31.0613	
Length / Diameter Ratio	LD	50.0000	
Geometry Factor, A f(DT,LD)	A	0.0011401	
Materials Factor, B, f(A, Chart)	В	84397.3984	kPa
Maximum Allowable Working Pressure		3.62	N/mm²
EMAWP = (4*B)/(3*(D/T)) = (4*84397.3)	3984 )/{ 3	*31.0613 ) =	3.6229

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis: Shell Item: 1 12:22p Aug 5,2013

#### Summary of External Pressure Results:

Allowable Pressure at Corroded thickness 3.62 N/mm²

Required Pressure as entered by User 0.10 N/mm²

Required Thickness including Corrosion all. 2.6111 mm

Actual Thickness as entered by User 5.2673 mm

Maximum Length for Thickness and Pressure 0.9150E+33 mm

Actual Length as entered by User 6194.43 mm

#### Weight and Volume Results, Original Thickness:

Volume of Shell Component	VOLMET 0.	1277E+08	mm ^3
Weight of Shell Component	WMET	970.8	N
Inside Volume of Component	VOLID 0.	5238E+08	mm ^3
Weight of Water in Component	WWAT	513.5	N

#### Weight and Volume Results, Corroded Thickness:

Volume	of Shell Componer	nt, Corroded	VOLMETCA	9541454.0	mm ^3
Weight	of Shell Componer	nt, Corroded	WMETCA	725.2	N
Inside	Volume of Compone	ent, Corroded	VOLIDCA	0.5564E+08	mm ^3
Weight	of Water in Compo	onent, Corroded	WWATCA	545.4	N

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Shell Analysis : Inner Pipe/Tube Item: 3 12:22p Aug 5,2013

#### Input Echo, Component 3, Description: Inner Pipe/Tube

Design Internal Pressure	P	10.03	N/mm²
Temperature for Internal Pressure		150.01	C
User Entered Minimum Design Metal Temp	erature	-28.89	С
Design External Pressure	PEXT	7.76	N/mm²
Temperature for External Pressure		177.79	С
External Pressure Chart Name		CS-2	
Include Hydrostatic Head Components		NO	
Material Specification (Not Normalized	)	SA-106 B	
Material UNS Number		к03006	
Material Form used		Smls. pipe	
Allowable Stress At Temperature	s	117897.66	kPa
Allowable Stress At Ambient	SA	117897.66	kPa
Yield Stress At Temperature	Sy	213580.92	kPa
Curve Name for Chart UCS 66		В	
Joint efficiency for Shell Joint	E	1.00	
Design Length of Section	L	6292.850	mm
Length of Cylinder for Volume Calcs.	CYLLEN	6292.850	mm
Outside Diameter of Cylindrical Shell	D	73.025	mm
Minimum Thickness of Pipe or Plate	T	4.5117	mm
Nominal Thickness of Pipe or Plate	Tnom	5.1562	mm
Shell/Head Int. Corrosion Allowance	CA	0.0000	ræn

YES

Skip UG-16(b) Min. thickness calculation

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units ------

Shell Analysis : Inner Pipe/Tube Item: 3 12:22p Aug 5,2013

Type of Element:

Cylindrical Shell

#### Internal pressure results, Shell Number 3, Desc.: Inner Pipe/Tube

ASME Code, Section VIII, Division 1, 2011a

Thickness Due to Internal Pressure (Tr):

- = (P\*(D/2-CAE)) / (S\*E+0.4\*P) per Appendix 1-1 (a)(1)
- $= \{10.03*(73.0250/2-0.000)/(117897.66*1.00+0.4*10.03)\}$
- = 3.0045 + 0.0000 = 3.0045 mm

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

- = (S\*E\*(T-CA-CAE)) / ((D/2-CAE)-0.4\*(T-CA-CAE)) per Appendix 1-1 (a)(1)
- = (117897.66\*1.00\*(4.5117))/(73.0250/2-0.000-0.4\*4.5117)
- $= 15.33 \text{ N/mm}^2$

#### Maximum Allowable Pressure, New and Cold (MAPNC):

- = (SA\*E\*T) / (D/2-0.4\*T) per Appendix 1-1 (a) (1)
- = (117897.66\*1.00\*4.5117)/(73.0250/2-0.4\*4.5117)
- $= 15.33 \text{ N/mm}^2$

#### Actual stress at given pressure and thickness (Sact):

- = (P\*((D/2-CAE)-0.4\*(T-CA-CAE))) / (E\*(T-CA-CAE))
- = (10.03\*(((73.0250/2-0.000)-0.4\*(4.5117)))/(1.00\*(4.5117))
- = 77172.37 kPa

#### **SUMMARY OF INTERNAL PRESSURE RESULTS:**

Required Thickness plus Corrosion Allowance, Trca 3.0045 mm

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis : Inner Pipe/Tube Item: 3 12:22p Aug 5,2013

Actual Thickness as Given in Input 4.5117 mm

Maximum Allowable Working Pressure MAWP 15.326 N/mm²

Maximum Allowable Pressure, NC MAPNC 15.326 N/mm²

Design Pressure as Given in Input P 10.032 N/mm²

#### Hydrostatic Test Pressures ( Measured at High Point ):

Hydrotest per UG-99(b); 1.3 \* MAWP \* Sa/S 19.92 N/mm<sup>2</sup>

Hydrotest per UG-99(c); 1.3 \* MAPNC 19.92 N/mm<sup>2</sup>

Pneumatic per UG-100 ; 1.1 \* MAWP \* Sa/S 16.86 N/mm<sup>2</sup>

#### Minimum Design Metal Temperature per UCS-66 Curve : B

tg = 4.512,  $tg_sr = 4.512$ , tr = 3.005, c = 0.0000 mm,  $E^* = 1.00$ 

Stress Ratio =  $tr * (E*) / (tg_sr - c) = 0.666$ , Temp. Reduction = 19 C

Min. Metal Temp. w/o impact per Fig. UCS-66 -29 C

Min. Metal Temp. at Req'd thk. (UCS 66.1) -47 C

Min. Metal Temp. w/o impact per UG-20(f) -29 C

#### External Pressure Results, Shell Number 3, Desc.: Inner Pipe/Tube

#### ASME Code, Section VIII, Division 1, 2010, 2011a

External Pressure Chart CS-2 at 177.79 C

Elastic Modulus for Material 196362.75 N/mm<sup>2</sup>

#### Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Shell TCA 4.5117 mm

Outside Diameter of Shell ODCA 73.025 mm

Design Length of Cylinder or Cone SLEN 6292.850 mm



Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis: Inner Pipe/Tube

Item: 3 12:22p Aug 5,2013

Diameter / Thickness Ratio (D/T) 16.1858

Length / Diameter Ratio LD 50.0000

Geometry Factor, A f(DT,LD) A 0.0041988

Materials Factor, B, f(A, Chart) B 110078.2812 kPa

Maximum Allowable Working Pressure 9.07 N/mm²

EMAWP = (4\*B)/(3\*(D/T)) = (4\*0.1E+06)/(3\*16.1858) = 9.0681

#### Results for Regd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Shell	TCA	3.9926	mm
Outside Diameter of Shell	ODCA	73.025	mm
Design Length of Cylinder or Cone	SLEN	6292.850	mm
Diameter / Thickness Ratio	(D/T)	18.2903	
Length / Diameter Ratio	LD	50.0000	
Geometry Factor, A f(DT,LD)	A	0.0032882	
Materials Factor, B, f(A, Chart)	В	106414.4609	kPa
Maximum Allowable Working Pressure		7.76	N/mm²
EMAWP = $(4*B)/(3*(D/T))$ = $(4*0.1E+06)$	5)/(3	*18.2903 ) = 7.	7576

#### Results for Maximum Length Calculation: No Conversion

Corroded Thickness of Shell	TCA	4.5117	mm
Outside Diameter of Shell	ODCA	73.025	mm
Design Length of Cylinder or Cone	SLEN	0.123E+08	mm
Diameter / Thickness Ratio	(D/T)	16.1858	
Length / Diameter Ratio	LD	50.0000	
Geometry Factor, A f(DT,LD)	A	0.0041988	
Materials Factor, B, f(A, Chart)	В	110078.2812	kPa
Maximum Allowable Working Pressure		9.07	N/mm²
EMAWP = (4*B)/(3*(D/T)) = (4 * 0.1E+0	)6 }/{ 3 <sup>3</sup>	16.1858 ) = 9.	0681

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis : Inner Pipe/Tube Item: 3 12:22p Aug 5,2013

#### **Summary of External Pressure Results:**

Allowable Pressure at Corroded thickness 9.07 N/mm²

Required Pressure as entered by User 7.76 N/mm²

Required Thickness including Corrosion all. 3.9926 mm

Actual Thickness as entered by User 4.5117 mm

Maximum Length for Thickness and Pressure 0.1234E+08 mm

Actual Length as entered by User 6292.85 mm

#### Weight and Volume Results, No C.A.:

Volume of Shell Component

Weight of Shell Component

WMET 530.8 N

Inside Volume of Component

VOLID 0.2025E+08 mm ^3

Weight of Water in Component

WWAT 198.4 N

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Shell Analysis : Shell Cover HD Item: 4 12:22p Aug 5,2013

#### Input Echo, Component 4, Description: Shell Cover HD

Design Internal Pressure	P	7.65	N/mm²
Temperature for Internal Pressure		177.79	C
User Entered Minimum Design Metal	Temperature	-28.89	С
Design External Pressure	PEXT	0.10	N/mm²
Temperature for External Pressure		177.79	С
External Pressure Chart Name		CS-2	
Include Hydrostatic Head Component	.s	NO	
Material Specification (Not Normal	lized)	SA-516 70	
Material UNS Number		K02700	
Material Form used		Plate	
Allowable Stress At Temperature	s	137892.00	kPa
Allowable Stress At Ambient	SA	137892.00	kPa
Yield Stress At Temperature	Sy	227714.84	kPa
Curve Name for Chart UCS 66		В	
Joint efficiency for Head Joint	E	1.00	
Outside Diameter of Elliptical Hea	ad D	355.600	mm
Minimum Thickness of Pipe or Plate	e T	11.1760	mm
Nominal Thickness of Pipe or Plate	e Tnom	12.7000	mm
Shell/Head Int. Corrosion Allowand	ce CA	1.5875	mm
Aspect Ratio	AR	2.0000	
Length of Straight Flange	STRTFLG	50.8000	mm



Bantrel PO# 1083-BC-4008 Nat'l Gas Heater, Item: BL-E-301; SO:4474 Eng: COS PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN FileName : CC4474 SI Units -----Shell Analysis : Shell Cover HD Item: 4 12:22p Aug 5,2013 Skip UG-16(b) Min. thickness calculation

Type of Element:

Elliptical Head

NO

#### Internal pressure results, Shell Number 4, Desc.: Shell Cover HD

ASME Code, Section VIII, Division 1, 2011a

#### Thickness Due to Internal Pressure (Tr):

= (P\*(D-2.0\*CAE)\*K) / (2\*S\*E+2\*P\*(K-0.1)) per Appendix 1-4 (c) = (7.65\*(355.6000-2\*0.000)\*1.00)/(2\*137892.00\*1.00+2\*7.65\*(1.00-0.1))= 9.3984 + 1.5875 = 10.9859 mm

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

- = (2\*S\*E\*(T-CA-CAE)) / (K\*(D-2\*CAE)-2\*(T-CA-CAE)\*(K-0.1)) per Appendix 1-4(c) = (2\*137892.00\*1.00\*(9.5885))/(1.00\*355.6000-2\*(9.5885)\*(1.00-0.1))
- $= 7.82 \text{ N/mm}^2$

#### Maximum Allowable Pressure, New and Cold (MAPNC):

- = (2\*SA\*E\*T) / (K\*D-2\*T\*(K-0.1)) per Appendix 1-4 (c)
- = (2\*137892.00\*1.00\*11.1760)/(1.00\*355.6000-2\*11.1760\*(1.00-0.1))
- $= 9.19 \text{ N/mm}^2$

#### Actual stress at given pressure and thickness (Sact):

- =  $\{P^*(K^*(D-2^*CAE)-2^*(T-CA-CAE)^*(K-0.1))\}$  /  $(2^*E^*(T-CA-CAE))$
- = (7.65\*(1.00\*355.6000-2\*(9.5885)\*(1.00-0.1)))/(2\*1.00\*(9.5885))
- = 135022.34 kPa

#### **SUMMARY OF INTERNAL PRESSURE RESULTS:**

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis: Shell Cover HD Item: 4 12:22p Aug 5,2013

Required Thickness plus Corrosion Allowance, Trca 10.9859 mm

Actual Thickness as Given in Input 11.1760 mm

Maximum Allowable Working Pressure MAWP 7.816 N/mm<sup>2</sup>

Maximum Allowable Pressure, NC MAPNC 9.187 N/mm<sup>2</sup>

Design Pressure as Given in Input P 7.653 N/mm²

#### Hydrostatic Test Pressures ( Measured at High Point ):

Hydrotest per UG-99(b); 1.3 \* MAWP \* Sa/S  $10.16 \text{ N/mm}^2$ 

Hydrotest per UG-99(c); 1.3 \* MAPNC 11.94 N/mm<sup>2</sup>

Pneumatic per UG-100 ; 1.1 \* MAWP \* Sa/S 8.60 N/mm<sup>2</sup>

Percent Elong. per UCS-79, VIII-1-01-57 (75\*tnom/Rf)\*(1-Rf/Ro) 15.244 %

Note: Please Check Requirements of UCS-79 as Elongation is > 5%.

#### Minimum Design Metal Temperature per UCS-66 Curve : B

tg = 11.176,  $tg_sr = 11.176$ , tr = 9.398, c = 1.5875 mm,  $E^* = 1.00$ 

Stress Ratio =  $tr * (E*) / (tg_sr - c) = 0.980$ , Temp. Reduction = 1 C

Min. Metal Temp. w/o impact per Fig. UCS-66 -25 C

Min. Metal Temp. at Req'd thk. (UCS 66.1) -26 C

Min. Metal Temp. w/o impact per UG-20(f) -29 C

#### External Pressure Results, Shell Number 4, Desc.: Shell Cover HD

#### ASME Code, Section VIII, Division 1, 2010, 2011a

External Pressure Chart CS-2 at 177.79 C

Elastic Modulus for Material 196362.75 N/mm<sup>2</sup>

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis : Shell Cover HD Item: 4 12:22p Aug 5,2013

#### Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Head	TCA	9.5885	mm
Outside Diameter of Shell	ODCA	355.600	mm
Diameter / Thickness Ratio	(D/T)	37.0861	
Geometry Factor, A f(DT,LD)	A	0.0037450	
Materials Factor, B, f(A, Chart)	В	108430.5078	kPa
Maximum Allowable Working Pressure		3,25	N/mm²

EMAWP = B/(K0\*(D/T)) = 0.1E+06/(0.9000\*37.0861) = 3.2487

#### Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Head	TCA	0.9291	mm
Outside Diameter of Shell	ODCA	355.600	mm
Diameter / Thickness Ratio	(D/T)	382.7430	
Geometry Factor, A f(DT,LD)	A	0.0003629	
Materials Factor, B, f(A, Chart)	В	35627.0117	kPa
Maximum Allowable Working Pressure		0.10	N/mm²
EMAWP = $B/(K0*(D/T)) = 35627.0117/(0.9)$	9000 *382.74	130 ) = 0.103	4

#### Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	3.25	N/mm²
Required Pressure as entered by User	0.10	N/mm²
Required Thickness including Corrosion all.	2.5166	mm
Actual Thickness as entered by User	11.1760	mm

#### Weight and Volume Results, Original Thickness:

Volume of Shell Component	VOLMET	2501235.8	mm ^3
Weight of Shell Component	WMET	190.1	и
Inside Volume of Component	VOLID	4844414.0	mm ^3
Weight of Water in Component	WWAT	90.9	N

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis : Shell Cover HD Item: 4 12:22p Aug 5,2013

Inside Vol. of 50.80 mm Straight VOLSCA 4430867.0 mm ^3

Total Volume for Head + Straight VOLTOT 9275281.0 mm ^3

#### Weight and Volume Results, Corroded Thickness:

Volume of Shell Component, Corroded VOLMETCA 2188581.2 mm ^3
Weight of Shell Component, Corroded WMETCA 166.3 N
Inside Volume of Component, Corroded VOLIDCA 4984202.0 mm ^3
Weight of Water in Component, Corroded WWATCA 93.1 N
Inside Vol. of 50.80 mm Straight, Corr. VOLSCA 4515698.5 mm ^3
Total Volume for Head + Straight Corroded VOLTCA 9499901.0 mm ^3

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Shell Analysis : Shell Cover SF Item: 5 12:22p Aug 5,2013

# Input Echo, Component 5, Description: Shell Cover SF

Design Internal Pressure	P	7.65	N/mm²
Temperature for Internal Pressure		177.79	С
User Entered Minimum Design Metal Temp	erature	-28.89	С
Design External Pressure	PEXT	0.10	N/mm²
Temperature for External Pressure		177.79	С
External Pressure Chart Name		CS-2	
Include Hydrostatic Head Components		NO	
Material Specification (Not Normalized	)	SA-516 70	
Material UNS Number		к02700	
Material Form used		Plate	
Allowable Stress At Temperature	s	137892.00	kPa
Allowable Stress At Ambient	SA	137892.00	kPa
Yield Stress At Temperature	Зу	227714.84	kPa
Curve Name for Chart UCS 66		В	
Joint efficiency for Shell Joint	Е	1.00	
Design Length of Section	L	50.800	mm
Length of Cylinder for Volume Calcs.	CATTEN	50.800	mm
Outside Diameter of Cylindrical Shell	D	355.600	mm
Minimum Thickness of Pipe or Plate	Т	12.7000	mm
Nominal Thickness of Pipe or Plate	Tnom	12.7000	mm
Shell/Head Int. Corrosion Allowance	CA	1.5875	mm

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis : Shell Cover SF Item: 5 12:22p Aug 5,2013

Type of Element:

Cylindrical Shell

#### Internal pressure results, Shell Number 5. Desc.: Shell Cover SF

ASME Code, Section VIII, Division 1, 2011a

#### Thickness Due to Internal Pressure (Tr):

- $= \{P^*(D/2-CAE)\} / (S^*E+0.4^*P) \text{ per Appendix 1-1 (a) (1)}$
- = (7.65\*(355.6000/2-0.000)/(137892.00\*1.00+0.4\*7.65)
- = 9.6536 + 1.5875 = 11.2411 mm

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

- = (S\*E\*(T-CA-CAE)) / ((D/2-CAE)-0.4\*(T-CA-CAE)) per Appendix 1-1 (a)(1)
- = (137892.00\*1.00\*(11.1125))/(355.6000/2-0.000-0.4\*11.1125)
- $= 8.84 \text{ N/mm}^2$

## Maximum Allowable Pressure, New and Cold (MAPNC):

- = (SA\*E\*T) / (D/2-0.4\*T) per Appendix 1-1 (a) (1)
- = (137892.00\*1.00\*12.7000)/(355.6000/2-0.4\*12.7000)
- $= 10.14 \text{ N/mm}^2$

#### Actual stress at given pressure and thickness (Sact):

- = (P\*((D/2-CAE)-0.4\*(T-CA-CAE))) / (E\*(T-CA-CAE))
- = (7.65\*(((355.6000/2-0.000)-0.4\*(11.1125)))/(1.00\*(11.1125))
- = 119386.89 kPa

## **SUMMARY OF INTERNAL PRESSURE RESULTS:**

Required Thickness plus Corrosion Allowance, Trca 11.2411 mm



Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Item: 5 12:22p Aug 5,2013

Shell Analysis : Shell Cover SF

Actual Thickness as Given in Input

12.7000 mm

Maximum Allowable Working Pressure

8.839 N/mm<sup>2</sup>

Maximum Allowable Pressure, NC

MAWP

MAPNC 10.139 N/mm<sup>2</sup>

Design Pressure as Given in Input

P 7.653 N/mm<sup>2</sup>

#### Hydrostatic Test Pressures ( Measured at High Point ):

Hydrotest per UG-99(b); 1.3 \* MAWP \* Sa/S 11.49 N/mm²

Hydrotest per UG-99(c); 1.3 \* MAPNC 13.18 N/mm²

Pneumatic per UG-100 ; 1.1 \* MAWP \* Sa/S 9.72 N/mm²

Percent Elongation per UCS-79 ( 50 \* tnom/Rf \* (1-Rf/Ro) ) 3.704 %

#### Minimum Design Metal Temperature per UCS-66 Curve : B

tg = 12.700,  $tg_sr = 12.700$ , tr = 9.654, c = 1.5875 mm,  $E^* = 1.00$ 

Stress Ratio =  $tr * (E*) / (tg_sr - c) = 0.869$ , Temp. Reduction = 7 C

Min. Metal Temp. w/o impact per Fig. UCS-66 -21 C

Min. Metal Temp. at Req'd thk. (UCS 66.1) -29 C

Min. Metal Temp. w/o impact per UG-20(f) -29 C

## External Pressure Results, Shell Number 5, Desc.: Shell Cover SF

## ASME Code, Section VIII, Division 1, 2010, 2011a

External Pressure Chart CS-2 at 177.79 C

196362.75 N/mm<sup>2</sup> Elastic Modulus for Material

## Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Shell TCA 11.1125 mm

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

ODCA 355.600 mm Outside Diameter of Shell SLEN Design Length of Cylinder or Cone 50.800 mm Diameter / Thickness Ratio (D/T) 32.0000 Length / Diameter Ratio LD 0.1429 A 0.1134390 Geometry Factor, A f(DT,LD) Materials Factor, B, f(A, Chart) B 121289.8047 kPa

5.05 N/mm<sup>2</sup>

EMAWP = (4\*B)/(3\*(D/T)) = (4\*0.1E+06)/(3\*32.0000) = 5.0539

#### Results for Regd Thickness for Ext. Pressure (Tca):

Maximum Allowable Working Pressure

Corroded Thickness of Shell	TCA	0.5063	mm
Outside Diameter of Shell	ODCA	355.600	mm
Design Length of Cylinder or Cone	SLEN	50.800	mm
Diameter / Thickness Ratio	(D/T)	702.3177	
Length / Diameter Ratio	LD	0.1429	
Geometry Factor, A f(DT,LD)	A	0.0005549	
Materials Factor, B, f(A, Chart)	В	54477.3750	kPa
Maximum Allowable Working Pressure		0.10	N/mm²
	0000 1/1 0	*****	0 100

EMAWP = (4\*B)/(3\*(D/T)) = (4\*54477.3750)/(3\*702.3177) = 0.1034

#### Results for Maximum Length Calculation: No Conversion

Maximum Allowable Working Pressure		3.45	N/mm²
Materials Factor, B, f(A, Chart)	В	82863.1719	kPa
Geometry Factor, A f(DT,LD)	A	0.0010742	
Length / Diameter Ratio	LD	50.0000	
Diameter / Thickness Ratio	(D/T)	32.0000	
Design Length of Cylinder or Cone	SLEN	0.685E+31	mm
Outside Diameter of Shell	ODCA	355.600	mm
Corroded Thickness of Shell	TCA	11.1125	mm

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units ------

Shell Analysis : Shell Cover SF Item: 5 12:22p Aug 5,2013

EMAWP = (4\*B)/(3\*(D/T)) = (4\*82863.1719)/(3\*32.0000) = 3.4527

#### Summary of External Pressure Results:

Allowable Pressure at Corroded thickness 5.05 N/mm²

Required Pressure as entered by User 0.10 N/mm²

Required Thickness including Corrosion all. 2.0938 mm

Actual Thickness as entered by User 12.7000 mm

Maximum Length for Thickness and Pressure 0.6847E+31 mm

Actual Length as entered by User 50.80 mm

#### Weight and Volume Results, Original Thickness:

Volume of Shell Component	VOLMET	694999.9	mm ^3
Weight of Shell Component	WMET	52.8	N
Inside Volume of Component	VOLID	4350185.0	mm ^3
Weight of Water in Component	TAWW	42.6	N

## Weight and Volume Results, Corroded Thickness:

Volume of Shell Component,	Corroded	VOLMETCA	610940.7	mm ^3
Weight of Shell Component,	Corroded	WMETCA	46.4	N
Inside Volume of Component,	Corroded	VOLIDCA	4434244.5	mm ^3
Weight of Water in Component,	Corroded	WWATCA	43.5	N

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Shell Analysis : C/D Reduction Item: 6 12:22p Aug 5,2013

# Input Echo, Component 6, Description: C/D Reduction

Design Internal Pressure	P	9.93	N/mm²
Temperature for Internal Pressure		150.01	¢
User Entered Minimum Design Metal Temp	erature	-28.89	С
Design External Pressure	PEXT	0.10	N/mm²
Temperature for External Pressure		150.01	С
External Pressure Chart Name		CS-2	
Include Hydrostatic Head Components		NO	
Material Specification (Not Normalized	)	SA-105	
Material UNS Number		к03504	
Material Form used		Forgings	
Allowable Stress At Temperature	S	137892.00	kPa
Allowable Stress At Ambient	SA	137892.00	kPa
Yield Stress At Temperature	Sy	219110.38	kPa
Curve Name for Chart UCS 66		В	
Joint efficiency for Shell Joint	E	1.00	
Design Length of Section	L	50.800	min
Length of Cylinder for Volume Calcs.	CYLLEN	50.800	mm
Inside Diameter of Cylindrical Shell	D	76.200	mm
Minimum Thickness of Pipe or Plate	T	7.9375	mm
Nominal Thickness of Pipe or Plate	Tnom	7.9375	mm
Shell/Head Int. Corrosion Allowance	CA	1.5875	mm

NO

Skip UG-16(b) Min. thickness calculation

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis : C/D Reduction Item: 6 12:22p Aug 5,2013

Type of Element:

Cylindrical Shell

#### Internal pressure results, Shell Number 6. Desc.: C/D Reduction

ASME Code, Section VIII, Division 1, 2011a

#### Thickness Due to Internal Pressure (Tr):

- = (P\*(D/2+CA)) / (S\*E-0.6\*P) per UG-27 (c)(1)
- = (9.93\*(76.2000/2+1.5875))/(137892.00\*1.00-0.6\*9.93)
- = 2.9865 + 1.5875 = 4.5740 mm

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

- = (S\*E\*(T-CA-CAE)) / ((D/2+CA)+0.6\*(T-CA-CAE)) per UG-27 (c) (1)
- = (137892.00\*1.00\*(6.3500))/((76.2000/2+1.5875)+0.6\*6.3500)
- $= 20.13 \text{ N/mm}^2$

## Maximum Allowable Pressure, New and Cold (MAPNC):

- = (SA\*E\*T) / (D/2+0.6\*T) per UG-27 (c) (1)
- = (137892.00\*1.00\*7.9375)/(76.2000/2+0.6\*7.9375)
- $= 25.54 \text{ N/mm}^2$

#### Actual stress at given pressure and thickness (Sact):

- = (P\*((D/2+CA)+0.6\*(T-CA-CAE))) / (E\*(T-CA-CAE))
- = (9.93\*((76.2000/2+1.5875)+0.6\*(6.3500)))/(1.00\*(6.3500))
- = 68008.34 kPa

## **SUMMARY OF INTERNAL PRESSURE RESULTS:**

Required Thickness plus Corrosion Allowance, Trca 4.5740 mm

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units ------

Shell Analysis: C/D Reduction Item: 6 12:22p Aug 5,2013

Actual Thickness as Given in Input 7.9375 mm

Maximum Allowable Working Pressure MAWP 20.131 N/mm²

Maximum Allowable Pressure, NC MAPNC 25.536 N/mm<sup>2</sup>

Design Pressure as Given in Input P 9.928 N/mm<sup>2</sup>

## Hydrostatic Test Pressures ( Measured at High Point ):

Hydrotest per UG-99(b); 1.3 \* MAWP \* Sa/S 26.17 N/mm²

Hydrotest per UG-99(c); 1.3 \* MAPNC 33.20 N/mm<sup>2</sup>

Pneumatic per UG-100 ; 1.1 \* MAWP \* Sa/S 22.14 N/mm<sup>2</sup>

#### Minimum Design Metal Temperature per UCS-66 Curve : B

tg = 7.938, tg sr = 7.938, tr = 2.987, c = 1.5875 mm,  $E^* = 1.00$ 

Stress Ratio = tr \* (E\*) / (tg\_sr - c) = 0.470 , Temp. Reduction = 39 C

Min. Metal Temp. w/o impact per Fig. UCS-66 -29 C

Min. Metal Temp. at Req'd thk. (UCS 66.1) -48 C

Min. Metal Temp. w/o impact per UG-20(f) -29 C

#### External Pressure Results, Shell Number 6, Desc.: C/D Reduction

#### ASME Code, Section VIII, Division 1, 2010, 2011a

External Pressure Chart CS-2 at 150.01 C

Elastic Modulus for Material 199810.14 N/mm<sup>2</sup>

#### Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Shell TCA 6.3500 mm

Outside Diameter of Shell ODCA 92.075 mm

Design Length of Cylinder or Cone SLEN 50.800 mm

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis : C/D Reduction	Ite	em: 6 12	:22p Aug 5,2013	
Diameter / Thickness Ratio	(D/T)	14.5000		
Length / Diameter Ratio	LD	0.5517		
Geometry Factor, A f(DT,LD)	A	0.0543067		
Materials Factor, B, f(A, Chart)	В	122668.7188	kPa	
Maximum Allowable Working Pressure		11.28	N/mm²	

EMAWP = (4\*B)/(3\*(D/T)) = (4\*0.1E+06)/(3\*14.5000) = 11.2801

## Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Shell	TCA	0.2312	mm
Outside Diameter of Shell	ODCA	92.075	mm
Design Length of Cylinder or Cone	SLEN	50.800	mm
Diameter / Thickness Ratio	(D/T)	398.1975	
Length / Diameter Ratio	LD	0.5517	
Geometry Factor, A f(DT,LD)	A	0.0003092	
Materials Factor, B, f(A, Chart)	В	30886.9531	kPa
Maximum Allowable Working Pressure		0.10	N/mm²
EMAMP = $(4*B)/(3*(D/T))$ = $(4*30886.5)$	9531 )// 3	*398.1975 ) =	0.1034

## Results for Maximum Length Calculation: No Conversion

Corroded Thickness of Shell	TCA	6.3500	mm
Outside Diameter of Shell	ODCA	92.075	mm
Design Length of Cylinder or Cone	SLEN	0.501E+32	mm
Diameter / Thickness Ratio	(D/T)	14.5000	
Length / Diameter Ratio	LD	50.0000	
Geometry Factor, A f(DT,LD)	A	0.0052319	
Materials Factor, B, f(A, Chart)	В	119631.2891	kPa
Maximum Allowable Working Pressure		11.00	N/mm²
EMAWP = $(4*B)/(3*(D/T))$ = $(4*0.1E+06)$	5 )/( 3	*14.5000 ) = 11	.0008

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Shell Analysis : C/D Reduction Item: 6 12:22p Aug 5,2013

#### Summary of External Pressure Results:

Allowable Pressure at Corroded thickness 11.28 N/mm²

Required Pressure as entered by User 0.10 N/mm²

Required Thickness including Corrosion all. 1.8187 mm

Actual Thickness as entered by User 7.9375 mm

Maximum Length for Thickness and Pressure 0.5009E+32 mm

Actual Length as entered by User 50.80 mm

## Weight and Volume Results, Original Thickness:

Volume of Shell Component	VOLMET	106582.8	mm ^3
Weight of Shell Component	WMET	8.1	N
Inside Volume of Component	AOTID	231666.7	mm ^3
Weight of Water in Component	WWAT	2.3	N

## Weight and Volume Results, Corroded Thickness:

Volume of Shell Component,	Corroded	VOLMETCA	86875.0	mm ^3
Weight of Shell Component,	Corroded	WMETCA	6.6	N
Inside Volume of Component,	Corroded	VOLIDCA	251374.4	mm ^3
Weight of Water in Component	t, Corroded	WWATCA	2.5	N

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Nozzle Analysis : Nozzle A/B Item: 1 12:22p Aug 5,2013

# Input Echo, Nozzle Item 1, Description: Nozzle A/B

Design Internal Pressure ( Case 1 )	P	7.65	N/mm²
Temperature for Internal Pressure	TEMP	177.79	C
Design External Pressure ( Case 2 )	PEXT	0.10	N/mm²
Temperature for External Pressure	TEMPEX	177.79	C
Maximum Allowable Pressure New & Cold	(Case 3)	7.65	N/mm²

Include	Hydrostatic	Read	Components	NO
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Shell or Head Material (Not Normalized or	NA)	SA-106 B	
Material UNS Number		козоо6	
Shell/Head Allowable Stress at Temperature	s	117897.66	kPa
Shell/Head Allowable Stress At Ambient	SA	117897.66	kPa
Shell/Head Yield Stress at Temperature	Зу	209788.91	kPa
Outside Diameter of Cylindrical Shell	D	114.300	mm
Design Length of Section	L	6194.425	mm
Actual Thickness of Shell or Head	T	5.2673	mm
Corrosion Allowance for Shell or Head	CAS	1.5875	mm

Is	this	Nozzle	a	Radial	Nozzle		YES
Is	this	Nozzle	a	Latera]	l Nozzle	(Y-angle)	МО

The Attached Flange is Class CL 600 Grade GR 1.1

Nozzle Material	(Not Normalized or NA)	SA-106 B
Material DNS Num	nher	K03006



Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Nozzle Analysis: Nozzle A/B Item: 1 12:22p Aug 5,2013

Nozzle Allowable Stress at Temperature SN 117897.66 kPa

Nozzle Allowable Stress At Ambient SNA 117897.66 kPa

Diameter Basis for Nozzle BASISN OD

Nominal Diameter of Nozzle DIA 50.800 mm

Nozzle Size and Thickness Basis DBN Nominal

Nominal Thickness of Nozzle THKNOM SCH 160

Corrosion Allowance for Nozzle CAN 1.5875 mm

Joint Efficiency of Shell Seam at Nozzle ES 1.00

Joint Efficiency of Nozzle Neck EN 1.00

Insert or Abutting Nozzle Type NTYP Insert

Outward Projection of Nozzle HO 152.400 mm

Weld leg size between Nozzle and Pad/Shell WO 6.3500 mm

Groove weld depth between Nozzle and Vessel WGNV 6.0198 mm

ASME Code Weld Type per UW-16.1 C

Method used for checking Nozzle opening UG-37

Method used for checking Large Nozzles App. 1-10

Is this is Manway/Access/Inspection Opening No

Skip Iterative Failure Thickness Calculations Yes

#### Reinforcement CALCULATION, Description: Nozzle A/B

ASME Code, Section VIII, Division 1, 2011a, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 60.325 mm.

Actual Thickness Used in Calculation 8.738 mm



Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Nozzle Analysis: Nozzle A/B Item: 1 12:22p Aug 5,2013

#### Internal Pressure Results for SHELL/HEAD:

Reqd thk per UG-37(a) of Cylindrical Shell, Tr Internal Pressure

Thickness Due to Internal Pressure:

- = (P\*(D/2-CAE)) / (S\*E+0.4\*P) per Appendix 1-1 (a)(1)
- = (7.65\*(114.3000/2-0.000)/(117897.66\*1.00+0.4\*7.65)
- = 3.6159 + 1.5875 = 5.2034 mm

Reqd thk per UG-37(a) of Cylindrical Shell, Tr Mapnc case

Thickness Due to Internal Pressure:

- = (P\*(D/2-CAE)) / (S\*E+0.4\*P) per Appendix 1-1 (a)(1)
- = (7.65\*(114.3000/2-0.000)/(117897.66\*1.00+0.4\*7.65)
- = 3.6159 + 0.0000 = 3.6159 mm

## External Pressure Results for SHELL/HEAD:

## Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	3.62	N/mm²
Required Pressure as entered by User	0.10	N/mm²
Required Thickness including Corrosion all.	2.6111	mm
Actual Thickness as entered by User	5.2673	mm.
Maximum Length for Thickness and Pressure	0.9150E+33	mm
Actual Length as entered by User	6194.43	mm

#### **Internal Pressure Results for NOZZLE:**

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Nozzle Analysis : Nozzle A/B Item: 1 12:22p Aug 5,2013

Regd thk per UG-37(a) of Nozzle Wall, Trn Internal Pressure

#### Thickness Due to Internal Pressure:

- = (P\*(D/2-CAE)) / (S\*E+0.4\*P) per Appendix 1-1 (a)(1)
- = (7.65\*(60.3250/2-0.000)/(117897.66\*1.00+0.4\*7.65)
- = 1.9084 + 1.5875 = 3.4959 mm

#### Reqd thk per UG-37(a) of Nozzle Wall, Trn Mapnc case

#### Thickness Due to Internal Pressure:

- = (P\*(D/2-CAE)) / (S\*E+0.4\*P) per Appendix 1-1 (a)(1)
- = (7.65\*(60.3250/2-0.000)/(117897.66\*1.00+0.4\*7.65)
- = 1.9084 + 0.0000 = 1.9084 mm

#### External Pressure Results for Nozzie per UG-28:

#### Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	20.98	N/mm²
Required Pressure as entered by User	0.10	N/mm²
Required Thickness including Corrosion all.	1.8712	mm
Actual Thickness as entered by User	8.7376	mm
Maximum Length for Thickness and Pressure	0.2349E+33	mm
Actual Length as entered by User	152.40	mm

#### UG-40, Limits of Reinforcement : Internal Pressure

Effective	material	diameter	limit,		DL	92.050	mm	
Effective	material	thickness	limit,	no pad	TLNP	9.200	mm	

#### UG-40, Limits of Reinforcement: Mapric case



Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Nozzle Analysis: Nozzle A/B Item: 1 12:22p Aug 5,2013

Effective material diameter limit, DL 85.700 mm

Effective material thickness limit, no pad TLNP 13.168 mm

NOTE: Taking a UG-36(c)(3)(a) exemption for Nozzle A/B .

This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles, go to the Miscellaneous Tab.

Opening size: 46.025, Shell/Head Req. thk.: 3.616 mm

Weight of Nozzle, with Flange, Uncorroded 52.78 N

Weight of Nozzle, with Flange, Corroded 50.09 N

#### Minimum Design Metal Temperature (MDMT) Results:

MDMT of Shell, UCS curve : B

tg = 5.267,  $tg\_sr = 5.267$ , tr = 3.616, c = 1.5875 mm,  $E^* = 1.00$ 

Stress Ratio =  $tr * (E*) / (tg_sr - c) = 0.983$ , Temp. Reduction = 1 C

Min. Metal Temp. w/o impact per Fig. UCS-66 -29

Min. Metal Temp. at Req'd thk. (UCS 66.1) -30 C

Min. Metal Temp. w/o impact per UG-20(f) -29 C

MDMT of Nozzle Neck to Flange Weld, UCS Curve : B

tg = 8.738,  $tg_sr = 8.738$ , tr = 1.908, c = 1.5875 mm,  $E^* = 1.00$ 

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Nozzle Analysis: Nozzle A/B Item: 1 12:22p Aug 5,2013

Stress Ratio =  $tr * (E*) / (tg_sr - c) = 0.267$ , Temp. Reduction = 78 C

Min. Metal Temp. w/o impact per Fig. UCS-66 -29 C

Min. Metal Temp. at Req'd thk. (UCS 66.1) -104 C

Min. Metal Temp. w/o impact per UG-20(f) -29 C

## MDMT of Nozzle-Shell/Head Weld for the Nozzle (UCS-66(a)1(b)), Curve : B

tg = 5.267,  $tg_sr = 5.267$ , tr = 3.616, c = 1.5875 mm,  $E^* = 1.00$ 

Stress Ratio =  $tr * (E*) / (tg_sr - c) = 0.983$ , Temp. Reduction = 1 C

Min. Metal Temp. w/o impact per Fig. UCS-66 -29 C

Min. Metal Temp. at Req'd thk. (UCS 66.1) -30 C

Min. Metal Temp. w/o impact per UG-20(f) -29 C

Governing MDMT of the Shell : -30 C

Governing MDMT of all the sub-joints on this junction: -30 C

#### Weld Size Calculations, Nozzle Number 1, Desc.: Nozzle A/B

Intermediate Calcs. for nozzle/shell welds Tmin 3.6798 mm

#### Results Per UW-16.1:

Required Thickness Actual Thickness

Nozzle Weld 2.5759 = 0.7 \* Tmin 4.4901 = 0.707 \* WO, mm

#### M.A.W.P. Results Based on, Shell and Nozzle neck:

Converged M.A.W.P for given geometry AMAWP 7.792 N/mm<sup>2</sup>

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Nozzle Analysis: Nozzle A/B Item: 1 12:22p Aug 5,2013

#### Flange Pressure Rating for CL 600 GR 1.1 (ASME/ANSI B16.5/.47 2006 Ed.):

Pressure Rating for B16.5 Flange at : 178 C is: 8.871 N/mm<sup>2</sup>

Pressure Rating for B16.5 Flange at : 21 C is :  $10.204 \text{ N/mm}^2$ 

#### Minimum Design Metal Temperature of Flange Without Impact Testing, Curve: B

Stress Ratio, Sfrat = Design Pressure / Flange Rating at MDMT = 7.65 / 10.20 = 0.750

Min. Metal Temp. w/o impact per UCS-66(c) -29 C

Reduction in Min. Metal Temp. per UCS-66.1 using Sfrat 14 C

Final Minimum Metal Temperature at Design Pressure -43 C

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units ------

Nozzle Analysis : C/D Flg. Ref Item: 2 12:22p Aug 5,2013

# Input Echo, Nozzle Item 2, Description: C/D Flg. Ref

Design Internal Pressure ( Case 1 ) P	9.93	N/mm²
Temperature for Internal Pressure TEMP	150.01	С
Design External Pressure ( Case 2 ) PEXT	0.10	N/mm²
Temperature for External Pressure TEMPEX	150.01	С
Include Hydrostatic Head Components	NO	
Shell or Head Material (Not Normalized or NA)	SA-105	
Material UNS Number	коз504	
Shell/Head Allowable Stress at Temperature S	137892.00	kPa
Shell/Head Allowable Stress At Ambient SA	137892.00	kPa
Shell/Head Yield Stress at Temperature Sy	219110.38	kPa
Inside Diameter of Cylindrical Shell D	76.200	mm
Design Length of Section L	50.800	mm
Actual Thickness of Shell or Head T	7.9375	mm
Corrosion Allowance for Shell or Head CAS	1.5875	mm
Is this Nozzle a Radial Nozzle	YES	;

The Attached Flange is Class CL 900 Grade GR 1.1

Is this Nozzle a Lateral Nozzle (Y-angle)

Nozzle Material (Not Normalized or NA) SA-105 
Material UNS Number K03504 
Nozzle Allowable Stress at Temperature SN 137892.00 kPa

NO

Diameter Basis for Nozzle

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Nozzle Analysis : C/D Flg. Ref Item: 2 12:22p Aug 5,2013

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Nozzle Allowable Stress At Ambient SNA 137892.00 kPa

Inside Diameter of Nozzle DIA 76.200 mm

Nozzle Size and Thickness Basis DBN Actual

Actual Thickness of Nozzle THK 7.9375 mm

Corrosion Allowance for Nozzle CAN 1.5875 mm

Joint Efficiency of Shell Seam at Nozzle ES 1.00

Joint Efficiency of Nozzle Neck EN 1.00

Insert or Abutting Nozzle Type NTYP Abutting
Outward Projection of Nozzle HO 228.600 mm
Weld leg size between Nozzle and Pad/Shell WO 6.3500 mm
Groove weld depth between Nozzle and Vessel WGNV 7.9375 mm

ASME Code Weld Type per UW-16.1 A

Method used for checking Nozzle opening UG-37

Method used for checking Large Nozzles App. 1-7

Is this is Manway/Access/Inspection Opening No

Skip Iterative Failure Thickness Calculations Yes

#### Flange Pressure Rating for CL 900 GR 1.1 (ASME/ANSI B16.5/.47 2006 Ed.):

Pressure Rating for B16.5 Flange at : 150 C is : 13.539 N/mm²

Pressure Rating for B16.5 Flange at : 21 C is : 15.306 N/mm²

## Minimum Design Metal Temperature of Flange Without Impact Testing, Curve: B

Stress Ratio, Sfrat = Design Pressure / Flange Rating at MDMT = 9.93 / 15.31 = 0.649

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Bantrel PO# 1083-BC-4008

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Nozzle Analysis : C/D Flg. Ref Item: 2 12:22p Aug 5,2013

Min. Metal Temp. w/o impact per UCS-66(c) -29 C

Reduction in Min. Metal Temp. per UCS-66.1 using Sfrat 20 C

Final Minimum Metal Temperature at Design Pressure -48 C

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis : S4474- Struct Item: 1 12:22p Aug 5,2013

# Input Echo, Horizontal Vessel Item 1, Description: S4474- Struct (Looking at Saddle Only)

Design Internal Pressure	7.65	N/mm²
Design Temperature	177.79	С
Corrosion Allowance for Vessel	1.5875	mm
Shell Material	SA-106 B	
Shell Material UNS Number	козоо6	
Shell Operating Allowable Stress	117897.66	kPa
Shell Ambient Allowable Stress	117897.66	kPa
Head Material	SA-516 70	
Head Material UNS Number	ко2700	
Head Operating Allowable Stress	137892.00	kPa
Head Ambient Allowable Stress	137892.00	kPa
Density of Shell and Head Material	7750.3999	kg/m³
Density of Stored Liquid	999.5419	kg/m³
Liquid Height in Vessel	106.9403	mm

NOTE: Liquid Height is not entered, it is being set equal to the vessel ID.

Extra Weight		3780.800	N
Saddle Reaction Force Factor	ftr	3.00	
Distance from Center of Vessel to St	upport B	222.25	mm
Baseplate Length		279.400 <b>0</b>	min
Baseplate Thickness		12.7000	mm
Baseplate Width		76.2000	mm
Number of Ribs ( inc. outside ribs	)	2	

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis: S4474- Struct Item: 1 12:22p Aug 5,2013

Rib Thickness 6.3500 mm

Web Thickness 6.3500 mm

Web Location Side

Height of Center Web 158.7500 mm

Design Temperature of Base Structure 177.79 C
Saddle\Baseplate\Rib\Web Material SA-516 70
Saddle\Baseplate\Rib\Web Material UNS Number K02700
Operating Allowable Stress 137892.00 kPa

Ambient Allowable Stress 137892.00 kPa

Force Coefficient (Shape factor) Cf 0.600

Extra Area 0.0000 m²

Design Wind Code ASCE 7-95

Importance Factor 1.000

Wind Velocity 40.233 m/sec

Exposure Category C

Height above Grade 1.829 m

Type of Hill None

Seismic Zone Idenifier, Zone 4 Zone 3

User Entered Seismic Zone Coefficient 0.2750

Diameter Basis for Vessel OD

Shell Diameter 114.300 mm

Shell Length Tangent to Tangent 7.010 m

Thickness of Shell 5.2673 mm

Shell Joint Efficiency 1.0000

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units ------

Horizves Analysis : S4474- Struct Item: 1 12:22p Aug 5,2013

Head Type Flat

Head Thickness 74.6125 mm

Head Joint Efficiency 1.0000

Distance from Saddle to Vessel Tangent 1524.000 mm

Saddle Width 44.450 mm

Saddle Bearing Angle 150.0000 degrees

Wear Pad Thickness 0.0000 mm

Wear Pad Extension above Horn of Saddle 0.0000 mm

Wear Pad Width 0.000 mm

N

Stiffening Ring Present

#### Results for Horizontal Vessel Number 1, Description: S4474- Struct

#### Wind Load Results per ASCE-7 95

Alpha factor from Table C6-2 : 9.5

Zg from Table C6-2 : 274.32 m

Velocity Pressure Exposure Coeff. Kz (C3) : 0.8489

Gust Effect Factor (Rigid) G per Eq. 6-4 : 0.8500

Wind velocity Pressure qz at mid from Eq 6-15 : 0.843 kPa

Wind velocity Pressure, P = qz \* G : 0.716 kPa

#### Wind( ASCE #7 ) and Seismic Results:

#### Transverse Wind Load Component, Ftw:

 $Ftw = (AFT * Cf * QZ * Cnv_Fac) * 0.5$ 

Ftw = (1.227 \* 0.600 \* 0.7164 \* 1000.22449)\* 0.5

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis: S4474- Struct Item: 1 12:22p Aug 5,2013

Ftw = 263.801 N

#### Longitudinal Wind Load Component, Flw:

$$Flw = (AFL * QZ * Cnv_fac)$$

Flw = (0.023 \* 0.7164 \* 1000.22449)

Flw = 16.538 N

#### Transverse Earthquake Load Component, Fte:

Fte = 
$$(Cs * Wo) * 0.5$$

Fte = 
$$(0.2750 * 5475.67) * 0.5$$

Fte = 752.904 N

## Longitudinal Earthquake Load Component, Fle:

Fle = Cs \* Wo

Fle = 0.2750 \* 5475.67

Fle = 1505.809 N

#### Saddle Reaction Force due to Transverse Forces, Qr:

$$Qr = ftr * Max(Ftw, Fte) * B / E$$

Qr = 3.0 \* Max(263.80, 752.90) \* 222.2500 / 113.4721

Qr = 4423.985 N

#### Saddle Reaction Force due to Longitudinal forces, QI:

$$Q1 = Max(16.54, 1505.81, 0.00, 0.00) * 222.2500 / 3962.3999$$

Q1 = 84.460 N

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

$$Q = Wo/2 + Max(Qr, Ql)$$

W

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Bantrel PO# 1083-BC-4008

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis: S4474- Struct Item: 1 12:22p Aug 5,2013

Q = 2737.83 + Max(4423.99, 84.46)

Q = 7161.819 N

### Summary of Loads on this Saddle Support:

Vertical Load on this Saddle	7161.82	N
Transverse Shear Load on this Saddle	752.90	N
Longitudinal Shear Load on this Saddle	1505.81	N

#### Formulae and substitutions for ZICK Analysis

Shell and Head Required Thickness and MAWP:

## Shell:

Thickness Due to Internal Pressure:

```
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
```

- = (7.65\*(114.3000/2-0.000)/(117897.66\*1.00+0.4\*7.65)
- = 3.6163 + 1.5875 = 5.2038 mm

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

Less Operating Hydrostatic Head Pressure of 0.00 N/mm<sup>2</sup>

```
= \{S*E*(T-CA-CAE)\} / \{(D/2-CAE)-0.4*(T-CA-CAE)\} per Appendix 1-1 (a)(1)
```

- = (117897.66\*1.00\*(3.6798))/(114.3000/2-0.000-0.4\*3.6798)
- $= 7.79 0.00 = 7.79 \text{ N/mm}^2$

Maximum Allowable Pressure, New and Cold (MAPNC):

- = (SA\*E\*T) / (D/2-0.4\*T) per Appendix 1-1 (a)(1)
- = (117897.66\*1.00\*5.2673)/(114.3000/2-0.4\*5.2673)
- $= 11.28 \text{ N/mm}^2$

```
Bantrel PO# 1083-BC-4008
Nat'l Gas Heater, Item: BL-E-301; SO:4474
Eng: COS
PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN
FileName : CC4474 SI Units -----
Horizves Analysis : S4474- Struct
                                                           1 12:22p Aug 5,2013
                                             Item:
Actual stress at given pressure and thickness (Sact):
  = (P*((D/2-CAE)-0.4*(T-CA-CAE))) / (E*(T-CA-CAE))
  = (7.65*(((114.3000/2-0.000)-0.4*(3.6798)))/(1.00*(3.6798))
  = 115810.67 \text{ kPa}
Flat Head:
Thickness Due to Internal Pressure:
  = (D) * SQRT(Z*CF*P/(S*E)) per UG-34 (c) (3)
  = (114.3000) *SQRT (1.00*0.30*7.65/(137892.00*1.00))
  = 14.7497 + 1.5875 = 16.3372 \text{ mm}
Max. All. Working Pressure at Given Thickness (MAWP):
Less Operating Hydrostatic Head Pressure of 0.00 N/mm<sup>2</sup>
  = ((T-CA-CAE)/D)^2 * ((S*E)/(CF*Z)) per UG-34 (c) (3)
  = ((73.0250)/114.3000)**2*((137892.00*1.00)/(0.30*1.00))
  = 187.62 - 0.00 = 187.62 \text{ N/mm}^2
Maximum Allowable Pressure, New and Cold (MAPNC):
  = (T/D)^2*((S*E) / (CF*Z)) per UG-34 (c) (3)
  = (74.6125/114.3000)**2*((137892.00*1.00)/(0.30*1.00))
  = 195.87 \text{ N/mm}^2
Actual stress at given pressure and thickness (Sact):
  = (Z*CF*P) / (((T-CA-CAE)/D)^2)*E)
  = (1.00*0.30*7.65)/((((73.0250)/114.3000)**2)*1.00)
  = 5625.51 \text{ kPa}
Longitudinal Bending (+-) at Midspan
```

=  $(3*Q*L/12*K.2 / (PI*R^2 * (T-CA)))$ 

M

```
= K * X * 4 * A / L
```

= 6.224 \* 0.217 \* 4 \* 127.000 / 7.010 = 1.1758

# Longitudinal Bending (+-) at Saddle

```
= (3*Q*L/12 * K.1 / (PI * R^2 * (T - CA)))
= ( 3* 7161 /12 * 7.01 * 1.1758 ) /
  ( PI * 53.4702 * 53.4702 * ( 5.2673 - 1.5875 )))
= 446531.09 kPa
```

#### Longitudinal Pressure Stress

```
= DP*((SID/2+CA)-0.4*(T-CA))/(2.0*(T-CA))
```

AN

```
Bantrel PO# 1083-BC-4008

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName: CC4474 SI Units

Horizves Analysis: S4474- Struct Item: 1 12:22p Aug 5,2013

= 7.7 * (( 103.77 / 2 + 1.5875 - 0.4 * ( 5.267 - 1.5875 )) /

( 2.0 * ( 5.267 - 1.5875 ))

= 54070.90 kPa

Note: The Longitudinal Stress from Zick Analysis is combined with the

Longitudinal Pressure Stress to get the total stress.

Tangential Shear in Shell near Saddle

= 0 * K 4 * // L-H-2a /// L-H-b )/( R*/T-Ca))
```

```
= Q * K.4 * (( L-H-2A )/( L+H ))/( R*(T-CA))
= 7161 * 0.7988 * (( 7.01 - 0.00 - 2 * 1.52 )/
( 7.01 + 0.00 ))/( 53.4702 * ( 5.2673 - 1.5875 ))
= 16435.22 kPa
```

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

```
= -Q /(4*TEM*(SADWTH+1.56*SQRT(R*(T-CA))))-3.0*Q*K.7/(2*TEB)
= -7161 /{ 4 * 3.6798 * (44.45 + 1.56*SQRT(53.4702 *3.6798 )})
-3 * 7161 * 0.0320 / ( 2 * 13.5411 )
= -32723.00 kPa
```

Circumferential Compression at Bottom of Shell

```
= (Q*(.K.9/( TEM9*( B+1.56 * SQRT( R * TEM9 ))))
= (7161 *(0.6733 /(3.6798 *(44.45 +1.56*SQRT(55.06 *3.6798 ))))
= -19659.71 kPa
```

#### RESULTS for VESSEL RIBS, WEB and BASE

Moment of Inertia of Saddle - Lateral Direction

Y A AY Ay^2 Io

n.l

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units ------

Item: 1 12:22p Aug 5,2013

Horizves Analysis : S4474- Struct 148. Shell 2. 0. 273. 91. 4. ο. 0. Ο. Wearplate ٥. 75. ٥. 67682. 5066978. 1527035. Web BasePlate 152. 0. 147484. 22476474. 13007. 233. 0. 215313. 27543726. 1540133. Totals

Value C1 = Sumof(Ay)/Sumof(A) 110. mm Value I =  $Sumof(Ay^2) + Sumof(Io) - Cl*Sumof(Ay) = 5337772.$  mm\*\*4

Value As = Sumof(A) - Ashell 0. m<sup>2</sup>

 $K1 = (1+\cos(b)-.5*\sin(b)^2)/(pi-b+\sin(b)*\cos(b)) = 0.2594$ 

Fh = K1 \* Q = 0.2594 \* 7161.819 = 1857.578 N

Tension Str., St = (Fh/As) = 992.4338 kPa

Allowed Str., Sa = .6 \* Yield Stress = 136628.9062 kPa

d = B - R\*Sin(theta) / theta = 172.7638 mm

Bending Moment, M = Fh \* d 321.0524 N-m

Bending Stress, Sbnd = ( M \* Cl / I ) = 6630.9019 kPa

Allowed Str., Sa = .66 \* Yield Str. = 150291.7969 kPa

#### Minimum Thickness of Basepiate

= ( 3 \* Q \* BasePlateWidth / ( 2 \* BasePlateLength \*

AllStress ))놘

= (3 \* 7161 \* 76.20 / (2 \* 279.400 \* 150291.797))

= 4.415 mm

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis: S4474- Struct Item: 1 12:22p Aug 5,2013

#### Calculation of Axial Load, Intermediate Values and Compressive Stress:

Effective Baseplate Length (e)

- = ( Bplen Clearance ) / ( Nribs 1)
- = (279.4000 25.4) / (2 1) = 254.0000 mm

Baseplate Pressure Area (Ap)

- = e \* Bpwid / 2
- = 254.0000 \* 76.2000 / 2 = 0.0097 m<sup>2</sup>

Axial Load (P)

- = Ap \* Bp
- = 9677.40 \* 1239.31 = 3255.37 N

Area of the Rib and Web (Ar)

- = ( Bpwid Clearance Webtk ) \* Ribtk + e/2 \* Webtk
- = (76.200 25.4 6.350) \* 6.350 + 254.0000 / 2 \* 6.350
- $= 0.001 \text{ m}^2$

Compressive Stress (Sc)

- = P/Ar
- = 3255.37 / 0.0011 = 2990.2065 kPa

#### **Check of Outside Ribs**

#### Inertia of Saddle, Outer Ribs - Axial Direction

	Y	A	AY	Ay^2	Io
Rib	29.	0.	7489.	96315.	57161.
Web	3.	0.	2560.	31303.	5420.
Values	9.	0.	10050.	127618.	62580.

```
Bantrel PO# 1083-BC-4008
```

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Horizves Analysis : \$4474- Struct

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# AISC Unity Check on Outside Ribs ( must be $\leq 1.0$ )

```
Check = Sc/Sca + (Rm/Z)/Sba

Check = 2990.21 / 132304.61 + (67.59 / 4594.738) / 150291.80

Check = 0.12
```

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en

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Horizves Analysis : S4474- Leg Item: 2 12:22p Aug 5,2013

## Input Echo, Horizontal Vessel Item 2, Description: S4474- Leg (Looks at each leg connection at the saddle.)

Design Internal Pressure	7.65	N/mm²
Design Temperature	177.79	С
Corrosion Allowance for Vessel	1.5875	mm
Shell Material	SA-106 B	
Shell Material UNS Number	козоо6	
Shell Operating Allowable Stress	117897.66	kPa
Shell Ambient Allowable Stress	117897.66	kPa
Head Material	SA-516 70	
Head Material UNS Number	ко2700	
Head Operating Allowable Stress	137892.00	kPa
Head Ambient Allowable Stress	137892.00	k₽a
Density of Shell and Head Material	7750.3999	kg/m³
Density of Stored Liquid	999.5419	kg/m³
Liquid Height in Vessel	106.9403	mm

NOTE: Liquid Height is not entered, it is being set equal to the vessel ID.

Extra Weight		222.400	N
Saddle Reaction Force Factor	ftr	3.00	
Distance from Center of Vessel to Support	. В	222.25	mm
Baseplate Length		279.4000	mm
Baseplate Thickness		12.7000	mm
Baseplate Width		76.2000	RIM
Number of Ribs ( inc. outside ribs )		2	

W

Bantrel PO# 1083-BC-4008

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units

Horizves Analysis : S4474- Leg Item: 2 12:22p Aug 5,2013

Rib Thickness 6.3500 mm

Web Thickness 6.3500 mm

Web Location Side

Height of Center Web 158.7500 mm

Design Temperature of Base Structure 177.79 C

Saddle\Baseplate\Rib\Web Material SA-516 70

Saddle\Baseplate\Rib\Web Material UNS Number K02700

Operating Allowable Stress 137892.00 kPa

Ambient Allowable Stress 137892.00 kPa

Force Coefficient (Shape factor) Cf 0.600

Extra Area 0.0000 m<sup>2</sup>

Design Wind Code ASCE 7-95

Importance Factor 1.000

Wind Velocity 40.233 m/sec

Exposure Category C

Height above Grade 1.829 m

Type of Hill None

Seismic Zone Idenifier, Zone 4 Zone 3

User Entered Seismic Zone Coefficient 0.2750

Diameter Basis for Vessel OD

Shell Diameter 114.300 mm

Shell Length Tangent to Tangent 7.010 m

Thickness of Shell 5.2673 mm

Shell Joint Efficiency 1.0000

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis : S4474- Leg Item: 2 12:22p Aug 5,2013

Head Type Flat

Head Thickness 74.6125 mm

Head Joint Efficiency 1.0000

Distance from Saddle to Vessel Tangent 1524.000 mm

Saddle Width 44.450 mm

Saddle Bearing Angle 180.0000 degrees

Wear Pad Thickness 0.0000 mm

Wear Pad Extension above Horn of Saddle 0.0000 mm

Wear Pad Width 0.000 mm

Ring Location OD

Stiffening Ring Material SA-516 70

Stiffening Ring Material UNS Number K02700

Ring Allowable Stress 137892.00 kPa

Ring Compressive Yield Stress at Temp. 227714.84 kPa

Stem Height, Thickness 50.8000 6.3500 mm

Cross Width, Height 0.0000 0.0000 mm

#### Results for Horizontal Vessel Number 2, Description: S4474- Leg

Wind Load Results per ASCE-7 95

Alpha factor from Table C6-2 : 9.5

Zg from Table C6-2 : 274.32 m

Velocity Pressure Exposure Coeff. Kz (C3) : 0.8489

Gust Effect Factor (Rigid) G per Eq. 6-4 : 0.8500

Wind velocity Pressure qz at mid from Eq 6-15 : 0.843 kPa

Wind velocity Pressure, P = qz \* G : 0.716 kPa

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis : S4474- Leg Item: 2 12:22p Aug 5,2013

# Vessel Stress Summary

Shell Allowable Stress used in Calcul	ation	117897.66	kPa
Shell Compressive Yield used in Calcul	ation	209788.91	kPa
Head Allowable Stress used in Calcul	ation	137892.00	kPa
Ring Allowable Stress used in Calcul	ation	137892.00	kPa
Volume of Vessel	,	0.06	m **3
Weight of Vessel, Empty		1312.79	N
Weight of Vessel, Full		1929.98	N
Shell Thk. + CA, Reqd. vs. Actual	5.204	5.267	mm
Head Thk. + CA, Reqd. vs. Actual	16.337	74.612	mm
Shell M.A.W.P. , Reqd. vs. Actual	7.65	7.79	N/mm²
Head M.A.W.P. , Reqd. vs. Actual	7.65	187.62	N/mm²
	Actual	Allowable	
Long. Stress at Top of Saddles	78826.45	117897.66	kPa
Long. Stress at Bottom of Saddles	29315.35	117897.66	kPa
Long. Stress at Top of Midspan	36963.81	117897.66	kPa
Long. Stress at Bottom of Midspan	71177.99	117897.66	kPa
Tangential Shear in Shell	2259.64	94318.12	kPa
Circ. Compressive Stress in Shell	-6414.08	-104894.45	kPa
Stiffener Circ. Stress at Shell	-1078.80	-104894.45	kPa
Stiffener Circ. Stress at Tip	-2153.00	-113857.42	kPa

# Wind( ASCE #7 ) and Seismic Results:

and

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis : \$4474- Leg

Item: 2 12:22p Aug 5,2013

#### Transverse Wind Load Component, Ftw:

$$Ftw = (AFT * Cf * QZ * Cnv_Fac) * 0.5$$

Ftw = 
$$(1.227 * 0.600 * 0.7164 * 1000.22449) * 0.5$$

Ftw = 263.801 N

#### Longitudinal Wind Load Component, Flw:

$$Flw = \{ 0.023 * 0.7164 * 1000.22449 \}$$

Flw = 16.538 N

#### Transverse Earthquake Load Component, Fte:

Fte = ( 
$$Cs * Wo$$
 ) \* 0.5

Fte = 
$$(0.2750 * 1929.98) * 0.5$$

Fte = 265.373 N

#### Longitudinal Earthquake Load Component, Fle:

$$Fle = 0.2750 * 1929.98$$

Fle = 530.746 N

#### Saddle Reaction Force due to Transverse Forces, Qr:

$$Qr = ftr * Max(Ftw, Fte) * B / E$$

$$Qr = 3.0 * Max( 263.80 , 265.37 ) * 222.2500 / 117.4750$$

Qr = 1506.170 N

#### Saddle Reaction Force due to Longitudinal forces, QI:

$$Q1 = Max(16.54, 530.75, 0.00, 0.00) * 222.2500 / 3962.3999$$

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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Horizves Analysis: S4474- Leg Item: 2 12:22p Aug 5,2013

Q1 = 29.769 N

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

Q = Wo/2 + Max(Qr, Ql)

Q = 964.99 + Max(1506.17, 29.77)

Q = 2471.162 N

#### Summary of Loads on this Saddle Support:

Vertical Load on this Saddle	2471.16	N
Transverse Shear Load on this Saddle	265.37	N
Longitudinal Shear Load on this Saddle	530.75	N

#### Formulae and substitutions for ZICK Analysis

Shell and Head Required Thickness and MAWP:

# Shell:

Thickness Due to Internal Pressure:

```
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a) (1)
```

= (7.65\*(114.3000/2-0.000)/(117897.66\*1.00+0.4\*7.65)

= 3.6163 + 1.5875 = 5.2038 mm

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

Less Operating Hydrostatic Head Pressure of 0.00 N/mm<sup>2</sup>

```
= (S*E*(T-CA-CAE)) / ((D/2-CAE)-0.4*(T-CA-CAE)) per Appendix 1-1 (a)(1)
```

= (117897.66\*1.00\*(3.6798))/(114.3000/2-0.000-0.4\*3.6798)

 $= 7.79 - 0.00 = 7.79 \text{ N/mm}^2$ 

Maximum Allowable Pressure, New and Cold (MAPNC):

Bantrel PO# 1083-BC-4008 Nat'l Gas Heater, Item: BL-E-301; SO:4474 Eng: COS PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN FileName : CC4474 SI Units -----Item: 2 12:22p Aug 5,2013 Horizves Analysis : S4474- Leg = (SA\*E\*T) / (D/2-0.4\*T) per Appendix 1-1 (a)(1) = (117897.66\*1.00\*5.2673)/(114.3000/2-0.4\*5.2673) $= 11.28 \text{ N/mm}^2$ Actual stress at given pressure and thickness (Sact): = (P\*((D/2-CAE)-0.4\*(T-CA-CAE))) / (E\*(T-CA-CAE))= (7.65\*(((114.3000/2-0.000)-0.4\*(3.6798)))/(1.00\*(3.6798))= 115810.67 kPa Flat Head: Thickness Due to Internal Pressure: = (D) \* SQRT(Z\*CF\*P/(S\*E)) per UG-34 (c) (3) = (114.3000) \*SQRT(1.00\*0.30\*7.65/(137892.00\*1.00)) = 14.7497 + 1.5875 = 16.3372 mmMax. All. Working Pressure at Given Thickness (MAWP): Less Operating Hydrostatic Head Pressure of 0.00 N/mm<sup>2</sup> =  $((T-CA-CAE)/D)^2 * ((S*E)/(CF*Z))$  per UG-34 (c) (3) = ((73.0250)/114.3000)\*\*2\*((137892.00\*1.00)/(0.30\*1.00)) $= 187.62 - 0.00 = 187.62 \text{ N/mm}^2$ 

#### Maximum Allowable Pressure, New and Cold (MAPNC):

- =  $(T/D)^2*((S*E) / (CF*Z))$  per UG-34 (c) (3)
- = (74.6125/114.3000)\*\*2\*((137892.00\*1.00)/(0.30\*1.00))
- $= 195.87 \text{ N/mm}^2$

#### Actual stress at given pressure and thickness (Sact):

- $= (Z*CF*P) / ((((T-CA-CAE)/D)^2)*E)$
- = (1.00\*0.30\*7.65)/((((73.0250)/114.3000)\*\*2)\*1.00)

```
Bantrel PO# 1083-BC-4008
Nat'l Gas Heater, Item: BL-E-301; SO:4474
Eng: COS
PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN
FileName : CC4474 SI Units
Horizves Analysis : S4474- Leg
                                        Item: 2 12:22p Aug 5,2013
  = 5625.51 kPa
Longitudinal Bending (+-) at Midspan
  = ( 3*Q* L/12 * K.2 / ( PI * R^2 * ( T - CA )))
  = ( 3* 2471 /12 * 7.01 * 0.1306 ) /
    ( PI * 53.4702 * 53.4702 * ( 5.2673 - 1.5875 )))
  = 17107.09 kPa
Compute the area ratio [K]:
  = Pi * (Sin(Delta)/Delta - Cos(Delta) ) / (Delta + Sin(Delta) * Cos(Delta) -
    (Delta + Sin(Delta) * Cos(Delta) - 2 * Sin(Delta) * Sin(Delta)/Delta)
  = Pi * (Sin(3.142) / 3.142 - Cos(3.142)) / (3.142 + Sin(3.142) *
    Cos(3.142) - 2 * Sin(3.142) * Sin(3.142) / 3.142)
  = 1.0000
Compute the moment fraction [X]:
  = (1 - (1 - A/L + (R^2 - H^2)/(2 * A*L))/(1 + (4*H)/(3 * L))
  = \{1 - (1 - 127.000 / 7.010 + (4.456^2 - 0.000^2) / (2 * 127.000 * 7.010)) / (3 + 127.000 * 7.010) \}
    (1 + (4 * 0.000)/(3 * 7.010))
  = 0.2173
Intermediate Product [K.1]:
  = K * X * 4 * A / L
  = 1.000 * 0.217 * 4 * 127.000 / 7.010 = 0.1889
Longitudinal Bending (+-) at Saddle
  = (3*Q*L/12 * K.1 / (PI * R^2 * (T - CA)))
  = ( 3* 2471 /12 * 7.01 * 0.1889 ) /
    ( PI * 53.4702 * 53.4702 * ( 5.2673 - 1.5875 )))
```

M

```
Bantrel PO# 1083-BC-4008
Nat'l Gas Heater, Item: BL-E-301; SO:4474
Eng: COS
PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN
FileName : CC4474 SI Units -----
Horizves Analysis : S4474- Leg
                                                          2 12:22p Aug 5,2013
                                               Item:
  = 24755.55 \text{ kPa}
Longitudinal Pressure Stress
  = DP*((SID/2+CA)-0.4*(T-CA))/(2.0*(T-CA))
  = 7.7 * (( 103.77 / 2 + 1.5875 - 0.4 * ( 5.267 - 1.5875 )) /
    ( 2.0 * ( 5.267 - 1.5875 ))
  = 54070.90 kPa
Note: The Longitudinal Stress from Zick Analysis is combined with the
   Longitudinal Pressure Stress to get the total stress.
Tangential Shear in Shell near Saddle
  = (Q/(PI*SR*(T-CA))) * ((L-2A)/(L+(4/3) H))
  = (2471 / PI * 53.47 * (5.2673 - 1.5875)))
    * (( 7.01 - 2 * 1.52 )/( 7.01 + (4/3) * 0.00 ))
  = 2259.64 kPa
Circumferential Compression at Bottom of Shell
  = (Q*(K.9/(TEM9*(B+1.56 * SQRT(R * TEM9)))))
  = (2471 *(0.6366 /(3.6798 *(44.45 +1.56*SQRT(55.06 *3.6798 ))))
  = -6414.08 kPa
Length of Shell included with the Ring
  = 21.8823 \text{ mm}
Moment of Inertia of the Ring only - Iring
 = 0.0000 mm ^4
```

Moment of Inertia of the Ring + the Shell  $\sim$  I

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Horizves Analysis : S4474- Leg Item: 2 12:22p Aug 5,2013

 $= 0.1E+06 \text{ mm }^4$ 

#### Circumferential Stress in Shell at Stiffener

- = K.8 \* Q / ARING + K.9 \* Q \* R / ZRING1
- = 0.2520 \* 2471 / 0.0004 + 0.0175 \* 2471 \* 53.47 /

4961,2661

= -1078.80 kPa

#### Circumferential Stress in stiffener at Tip

- = -K.8 \* Q / ARING K.9 \* Q \* R / ZRING2
- = -0.2520 \* 2471 / 0.00 0.0175 \* 2471 \* 53.47 /

3802.5684

= -2153.00 kPa

#### **RESULTS for VESSEL RIBS, WEB and BASE**

#### Moment of Inertia of Saddle - Lateral Direction

	Y	А	AY	Ay^2	Io
Shell	2.	0.	148.	273.	91.
Wearplate	4.	0.	0.	0.	0.
Web	75.	0.	67682.	5066978.	1527035.
BasePlate	152.	0.	147484.	22476474.	13007.
Totals	233.	0.	215313.	27543726.	1540133.

Value As = Sumof(A) - Ashell =  $0. m^2$ 

```
Bantrel PO# 1083-BC-4008
Nat'l Gas Heater, Item: BL-E-301; SO:4474
Eng: COS
PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN
FileName : CC4474 SI Units -----
Horizves Analysis : S4474- Leg
                                   Item: 2 12:22p Aug 5,2013
K1 = (1+\cos(b)-.5*\sin(b)^2)/(pi-b+\sin(b)*\cos(b)) = 0.3181
 Fh = K1 * Q = 0.3181 * 2471.162 = 786.096 N
 Tension Str., St = (Fh/As) =
                                           419.9816 kPa
 Allowed Str., Sa = .6 * Yield Stress = 136628.9062 kPa
 d = B - R*Sin(theta) / theta
                                              178.1800 mm
 Bending Moment, M = Fh * d
                                             140.1235 N-m
 Bending Stress, Sbnd = (M * C1 / I) = 2894.0598 kPa
 Allowed Str., Sa = .66 * Yield Str. = 150291.7969 kPa
Minimum Thickness of Baseplate
  = ( 3 * Q * BasePlateWidth / ( <math>2 * BasePlateLength *
   AllStress ))냥
  = ( 3 * 2471 * 76.20 / ( 2 * 279.400 * 150291.797 ) } \
  = 2.594 \text{ mm}
Calculation of Axial Load, Intermediate Values and Compressive Stress:
 Effective Baseplate Length (e)
  = ( Bplen - Clearance ) / ( Nribs - 1)
  = ( 279.4000 - 25.4 ) / ( 2 - 1 ) = 254.0000 mm
 Baseplate Pressure Area (Ap)
  = e * Bpwid / 2
  = 254.0000 * 76.2000 / 2 = 0.0097 m^{2}
```



Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Horizves Analysis: S4474- Leg Item: 2 12:22p Aug 5,2013

Axial Load (P)

= Ap \* Bp

= 9677.40 \* 427.62 = 1123.26 N

Area of the Rib and Web (Ar)

= ( Bpwid - Clearance - Webtk ) \* Ribtk + e/2 \* Webtk

= ( 76.200 - 25.4 - 6.350 ) \* 6.350 + 254.0000 /2 \* 6.350

 $= 0.001 \text{ m}^2$ 

Compressive Stress (Sc)

= P/Ar

= 1123.26 / 0.0011 = 1031.7610 kPa

#### **Check of Outside Ribs**

#### Inertia of Saddle, Outer Ribs - Axial Direction

	Y	A	AY	Ay^2	Io
Rib	29.	0.	7489.	96315.	57161.
Web	3.	0.	2560.	31303.	5420.
Values	9.	0.	10050.	127618.	62580.

$$\begin{split} & \text{KL/R} < \text{Cc ( } 16.0561 < 129.5732 \text{ ) per AISC E2-1 9th Edition} \\ & \text{Sca} = (1-(\text{Klr})^2/(2^*\text{Cc}^2))^*\text{Fy/}(5/3+3^*(\text{Klr})/(8^*\text{Cc})-(\text{Klr}^3)/(8^*\text{Cc}^3) \\ & \text{Sca} = (1-(16.06)^2/(2*129.57^2)) * 227714 / \\ & (5/3+3^*(16.06)/(8^*129.57)-(16.06^3)/(8^*129.57^2) \\ \end{split}$$

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

Check = Sc/Sca + (Rm/Z)/Sba

Sca = 131920.70 kPa

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Bantrel PO# 1083-BC-4008

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis : S4474- Leg Item: 2 12:22p Aug 5,2013

Check = 1031.76 / 131920.70 + (25.61 / 4594.738) / 150291.80

Check = 0.04

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Design Internal Pressure

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

7.65 N/mm²

#### Input Echo, Horizontal Vessel Item 3, Description: S4474- Bundle Pull

Design Temperature	177.79	С
Corrosion Allowance for Vessel	1.5875	mm
Shell Material	SA-106 B	
Shell Material UNS Number	к03006	
Shell Operating Allowable Stress	117897.66	kPa
Shell Ambient Allowable Stress	117897.66	kPa
Head Material	SA-516 70	
Head Material UNS Number	K02700	
Head Operating Allowable Stress	137892.00	kPa
Head Ambient Allowable Stress	137892.00	kPa
Density of Shell and Head Material	7750.3999	kg/m³
Density of Stored Liquid	999.5419	kg/m³
Liquid Height in Vessel	106.9403	mm
NOTE: Liquid Height is not entered, it is being set equal to the	ressel ID.	
Extra Weight	0.000	N
Saddle Reaction Force Factor ftr	3.00	
Distance from Center of Vessel to Support B	222.25	mm
Baseplate Length	279.4000	mm
Baseplate Thickness	12.7000	mm
Baseplate Width	76.2000	mm
Number of Ribs ( inc. outside ribs )	2	

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis: \$4474- Bundle Item: 3 12:22p Aug 5,2013

Rib Thickness 6.3500 mm

Web Thickness 6.3500 mm

Web Location Side

Height of Center Web 158.7500 mm

Design Temperature of Base Structure 177.79 C

Saddle\Baseplate\Rib\Web Material SA-516 70

Saddle\Baseplate\Rib\Web Material UNS Number K02700

Operating Allowable Stress 137892.00 kPa

Ambient Allowable Stress 137892.00 kPa

Wind Loads Present N

Friction Coefficient mu 0.20

User defined Longitudinal Force Flu 2224.00 N

Seismic Loads Present N

Diameter Basis for Vessel OD

Shell Diameter 114.300 mm

Shell Length Tangent to Tangent 7.010 m

Thickness of Shell 5.2673 mm

Shell Joint Efficiency 1.0000

Head Type Flat

Head Thickness 74.6125 mm

Head Joint Efficiency 1.0000

Distance from Saddle to Vessel Tangent 1524.000 mm

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN

FileName : CC4474 SI Units -----

Horizves Analysis : S4474- Bundle Item: 3 12:22p Aug 5,2013

Saddle Width 44.450 mm

Saddle Bearing Angle 150.0000 degrees

Wear Pad Thickness 0.0000 mm

Wear Pad Extension above Horn of Saddle 0.0000 mm

Wear Pad Width 0.000 mm

Stiffening Ring Present

N

1694.87 N

#### Results for Horizontal Vessel Number 3, Description: S4474- Bundle

#### **Vessel Stress Summary**

Weight of Vessel, Full

Shell Allowable Stress	used in Calculation	117897.66	kPa
Shell Compressive Yield	used in Calculation	209788.91	kPa
Head Allowable Stress	used in Calculation	137892.00	kPa

Volume of Vessel	0.06	m	**3
Weight of Vessel,	Empty 1077.68	N	

Shell Thk. + CA,	Reqd. vs. Act	ual 5.204	5.267	mm
Head Thk. + CA,	Reqd. vs. Act	ual 16.337	74.612	mm
Shell M.A.W.P. ,	Reqd. vs. Act	ual 7.65	7.79	N/mm²
Head M.A.W.P.,	Reqd. vs. Act	cual 7.65	187.62	N/mm²

						Actual	Allowable	
Long.	Stress	at	Top	of	Saddles	114685.05	117897.66	kPa
Long.	Stress	at	Bottom	of	Saddles	-6543.25	-117238.69	kPa
Long.	Stress	at	Top	of	Midspan	47340.81	117897.66	kPa

Nat'l Gas Heater, Item: BL-E-301; SO:4474

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FileName : CC4474 SI Units

Horizves Analysis : S4474- Bundle Item: 3 12:22p Aug 5,2013

Long. Stress at Bottom of Midspan 60800.98 117897.66 kPa

Tangential Shear in Shell 2230.99 94318.12 kPa

Circ. Stress at Horn of Saddle -4441.97 -176846.48 kPa

Circ. Compressive Stress in Shell -2668.70 -104894.45 kPa

#### Longitudinal force due to Friction, Flf:

Flf = mu \* W0/2

Flf = 0.200 \* 847.43

Flf = 169.487 N

#### Saddle Reaction Force due to Longitudinal forces, QI:

Q1 = Max( Flw, Fle, Flf, Flu ) \* B / Ls

Q1 = Max(16.54, 530.75, 169.49, 2224.00) \* 222.2500 / 3962.3999

Q1 = 124.744 N

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

Q = Wo/2 + Max(Qr, Ql)

Q = 847.43 + Max(1506.17, 124.74)

Q = 972.178 N

#### Summary of Loads on this Saddle Support:

Vertical Load on this Saddle 972.18 N Transverse Shear Load on this Saddle 0.00 N Longitudinal Shear Load on this Saddle 2224.00 N

#### Formulae and substitutions for ZICK Analysis

Shell and Head Required Thickness and MAWP:

Ow

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Horizves Analysis: S4474- Bundle Item: 3 12:22p Aug 5,2013

#### Shell:

Thickness Due to Internal Pressure:

- = (P\*(D/2-CAE)) / (S\*E+0.4\*P) per Appendix 1-1 (a)(1)
- = (7.65\*(114.3000/2-0.000)/(117897.66\*1.00+0.4\*7.65)
- = 3.6163 + 1.5875 = 5.2038 mm

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

Less Operating Hydrostatic Head Pressure of 0.00 N/mm²

- = (S\*E\*(T-CA-CAE)) / ((D/2-CAE)-0.4\*(T-CA-CAE)) per Appendix 1-1 (a)(1)
- = (117897.66\*1.00\*(3.6798))/(114.3000/2-0.000-0.4\*3.6798)
- $= 7.79 0.00 = 7.79 \text{ N/mm}^2$

#### Maximum Allowable Pressure, New and Cold (MAPNC):

- = (SA\*E\*T) / (D/2-0.4\*T) per Appendix 1-1 (a)(1)
- = (117897.66\*1.00\*5.2673)/(114.3000/2-0.4\*5.2673)
- $= 11.28 \text{ N/mm}^2$

#### Actual stress at given pressure and thickness (Sact):

- = (P\*((D/2-CAE)-0.4\*(T-CA-CAE))) / (E\*(T-CA-CAE))
- = (7.65\*(((114.3000/2-0.000)-0.4\*(3.6798)))/(1.00\*(3.6798))
- = 115810.67 kPa

#### Flat Head:

Thickness Due to Internal Pressure:

- = (D) \* SQRT(Z\*CF\*P/(S\*E)) per UG-34 (c) (3)
- = (114.3000)\*SQRT(1.00\*0.30\*7.65/(137892.00\*1.00))
- = 14.7497 + 1.5875 = 16.3372 mm



```
Bantrel PO# 1083-BC-4008
Nat'l Gas Heater, Item: BL-E-301; SO:4474
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FileName : CC4474 SI Units -----
Horizves Analysis : S4474- Bundle
                                                         3 12:22p Aug 5,2013
                                             Item:
Max. All. Working Pressure at Given Thickness (MAWP):
Less Operating Hydrostatic Head Pressure of 0.00 N/mm²
  = ((T-CA-CAE)/D)^2 * ((S*E)/(CF*Z)) per UG-34 (c) (3)
  = ((73.0250)/114.3000)**2*((137892.00*1.00)/(0.30*1.00))
  = 187.62 - 0.00 = 187.62 \text{ N/mm}^2
Maximum Allowable Pressure, New and Cold (MAPNC):
  = (T/D)^2*((S*E) / (CF*Z)) per UG-34 (c) (3)
  = (74.6125/114.3000)**2*((137892.00*1.00)/(0.30*1.00))
  = 195.87 \text{ N/mm}^2
Actual stress at given pressure and thickness (Sact):
  = (Z*CF*P) / (((T-CA-CAE)/D)^2)*E)
  = (1.00*0.30*7.65)/((((73.0250)/114.3000)**2)*1.00)
  = 5625.51 \text{ kPa}
Longitudinal Bending (+-) at Midspan
  = (3*Q*L/12 * K.2 / (PI * R^2 * (T - CA)))
  = ( 3* 972 /12 * 7.01 * 0.1306 ) /
    ( PI * 53.4702 * 53.4702 * ( 5.2673 - 1.5875 )))
  = 6730.09 \text{ kPa}
Compute the area ratio [K]:
  = Pi * (Sin(Delta)/Delta - Cos(Delta) ) / (Delta + Sin(Delta) * Cos(Delta) -
    (Delta + Sin(Delta) * Cos(Delta) - 2 * Sin(Delta) * Sin(Delta)/Delta)
  = Pi * (Sin(1.614) / 1.614 - Cos(1.614)) / ( 1.614 + Sin(1.614) *
    Cos(1.614) - 2 * Sin(1.614) * Sin(1.614) / 1.614)
  = 6.2238
```

and

```
Bantrel PO# 1083-BC-4008
Nat'l Gas Heater, Item: BL-E-301; SO:4474
Eng: COS
PV Elite 2012 Licensee: HEAT EXCHANGER DESIGN
FileName : CC4474 SI Units ------
Horizves Analysis : S4474- Bundle
                                             Item:
                                                       3 12:22p Aug 5,2013
Compute the moment fraction [X]:
  = (1 - (1 - A/L + (R^2 - H^2))/(2 * A*L))/(1 + (4*H))/(3 * L)))
  = (1 - (1 - 127.000 /7.010 + (4.456<sup>2</sup> - 0.000<sup>2</sup>)/(2 * 127.000 * 7.010 )) /
    (1 + (4 * 0.000)/(3 * 7.010))
  = 0.2173
Intermediate Product [K.1]:
  = K * X * 4 * A / L
  = 6.224 * 0.217 * 4 * 127.000 / 7.010 = 1.1758
Longitudinal Bending (+-) at Saddle
  = (3*Q*L/12*K.1 / (PI*R^2 * (T-CA)))
  = ( 3* 972 /12 * 7.01 * 1.1758 ) /
    ( PI * 53.4702 * 53.4702 * ( 5.2673 - 1.5875 )))
  = 60614.15 kPa
Longitudinal Pressure Stress
  = DP*((SID/2+CA)-0.4*(T-CA))/(2.0*(T-CA))
  = 7.7 * ({ 103.77 / 2 + 1.5875 - 0.4 * ( 5.267 - 1.5875 )} /
    ( 2.0 * ( 5.267 - 1.5875 ))
  = 54070.90 kPa
Note: The Longitudinal Stress from Zick Analysis is combined with the
  Longitudinal Pressure Stress to get the total stress.
Tangential Shear in Shell near Saddle
  = Q * K.4 * ((L-H-2A)/(L+H))/(R*(T-CA))
```

= 972 \* 0.7988 \* ({ 7.01 - 0.00 - 2 \* 1.52 }/

(7.01 + 0.00 })/(53.4702 \* (5.2673 - 1.5875 ))

Per

```
Bantrel PO# 1083-BC-4008
```

Nat'l Gas Heater, Item: BL-E-301; SO:4474

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Horizves Analysis: S4474- Bundle Item: 3 12:22p Aug 5,2013

= 2230.99 kPa

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

```
= -Q /(4*TEM*(SADWTH+1.56*SQRT(R*(T-CA))))-3.0*Q*K.7/(2*TEB)
```

= -972 / (4 \* 3.6798 \* (44.45 + 1.56\*SQRT(53.4702 \*3.6798)))

-3 \* 972 \* 0.0320 / (2 \* 13.5411)

= -4441.97 kPa

#### Circumferential Compression at Bottom of Shell

```
= (Q*(K.9/(TEM9*(B+1.56 * SQRT(R * TEM9))))
```

= (972 \*(0.6733 /(3.6798 \*(44.45 +1.56\*SQRT(55.06 \*3.6798 ))))

= -2668.70 kPa

#### RESULTS for VESSEL RIBS, WEB and BASE

#### Moment of Inertia of Saddle - Lateral Direction

	Υ	A	AY	Ay^2	Io
Shell	2.	0.	148.	273.	91.
Wearplate	4.	0.	0.	0.	0.
Web	75.	0.	67682.	5066978.	1527035.
BasePlate	152.	0.	147484.	22476474.	13007.
Totals	233.	0.	215313.	27543726.	1540133.

Value C1 = Sumof(Ay)/Sumof(A) = 110. mm Value I = Sumof(Ay<sup>2</sup>) + Sumof(Io) - C1\*Sumof(Ay) = 5337772. mm\*\*4 Value As = Sumof(A) - Ashell = 0.  $m^2$ 

 $K1 = \{1+\cos(b)-.5*\sin(b)^2\}/(pi-b+\sin(b)*\cos(b)\} = 0.2594$ 

W

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units ------

Horizves Analysis : S4474- Bundle Item: 3 12:22p Aug 5,2013

Fh = K1 \* Q = 0.2594 \* 972.178 = 252.156 N

Tension Str., St = (Fh/As) = 134.7174 kPa

Allowed Str., Sa = .6 \* Yield Stress = 136628.9062 kPa

d = B - R\*Sin(theta) / theta = 172.7638 mm

Bending Moment, M = Fh \* d = 43.5811 N-m

Bending Stress, Sbnd = (M \* C1 / I) = 900.1086 kPa

Allowed Str., Sa = .66 \* Yield Str. = 150291.7969 kPa

#### Minimum Thickness of Baseplate

= ( 3 \* Q \* BasePlateWidth / ( 2 \* BasePlateLength \*

AllStress )) 3

= ( 3 \* 972 \* 76.20 / ( 2 \* 279.400 \* 150291.797 )) 1/2

= 1.627 mm

#### Calculation of Axial Load, Intermediate Values and Compressive Stress:

Effective Baseplate Length (e)

= ( Bplen - Clearance ) / ( Nribs - 1)

= (279.4000 - 25.4) / (2 - 1) = 254.0000 mm

Baseplate Pressure Area (Ap)

= e \* Bpwid / 2

= 254.0000 \* 76.2000 / 2 = 0.0097 m<sup>2</sup>

Axial Load (P)

Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units

Horizves Analysis: S4474- Bundle Item: 3 12:22p Aug 5,2013

= Ap \* Bp

= 9677.40 \* 168.23 = 441.90 N

Area of the Rib and Web (Ar)

= ( Bpwid - Clearance - Webtk ) \* Ribtk + e/2 \* Webtk

= { 76.200 - 25.4 - 6.350 } \* 6.350 + 254.0000 /2 \* 6.350

 $= 0.001 m^2$ 

Compressive Stress (Sc)

= P/Ar

= 441.90 / 0.0011 = 405.9041kPa

#### **Check of Outside Ribs**

#### Inertia of Saddle, Outer Ribs - Axial Direction

	Y	A	AY	Ay^2	Io
Rib	29.	0.	7489.	96315.	57161.
Web	3.	0.	2560.	31303.	5420.
Values	9.	0.	10050.	127618.	62580.

$$KL/R < Cc$$
 ( 14.9370 < 129.5732 ) per AISC E2-1 9th Edition

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

$$Sca = (1-(14.94)^2/(2 * 129.57^2)) * 227714 /$$

Sca = 132304.61 kPa

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

Check = Sc/Sca + (Rm/Z)/Sba

Check = 405.90 / 132304.61 + (99.83 / 4594.738) / 150291.80

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Nat'l Gas Heater, Item: BL-E-301; SO:4474

Eng: COS

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FileName : CC4474 SI Units -----

Horizves Analysis: S4474- Bundle Item: 3 12:22p Aug 5,2013

Check = 0.15

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# **SECTION 8**

# Nozzle Loads Provided By Client For Verification By HED Purposes Only

Mulleff WITNESS D
REVIEW ST

4006-0014

Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve the supplier

2. Revise and resubmit. Work may proceed subject to incorporation

 $t_{w(lower)} = 0.237 in$ 

 $Leg_{41} = 0.25 in$ 

from full compliance with contractual obligations.

3. Revise and resubmit. Work SHALL NOT proceed. not required. Work may proceed.

1. Work may proceed.

of changes indicated.

BANTREL VENDOR PRINT

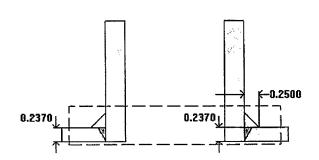
EQUIPMEN NUMBER

CLIENT **CROSS REF** 

Shell 0°

#### Shell In/Out (A/B)

#### ASME Section VIII Division 1, 2010 Edition, A11 Addenda



Note: round inside edges per UG-76(c)

Location and Orientation

Located on: Orientation:

Nozzle center line offset to datum line: 6 in

8.25 in End of nozzle to shell center: No

Passes through a Category A joint:

Nozzle

Access opening: No

Material specification: SA-106 B Smls pipe (II-D p. 10, ln. 40)

NPS 2 Sch 160 Description:

Inside diameter, new: 1.687 in Nominal wall thickness: 0.344 in Corrosion allowance: 0.0625 in

Projection available outside vessel, Lpr: 2.87 in

Projection available outside vessel to flange face, Lf: 6 in

0.2074 in Local vessel minimum thickness:

Liquid static head included: 0 psi Longitudinal joint efficiency: 1

**ASME B16.5-2009 Flange** 

NPS 2 Class 600 WN A105 Description:

SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, ln. Bolt Material:

32)

Affeitable	lel)
Rick Windell	

WITNESS

Blind included:

Rated MDMT:

Liquid static head:

MAWP rating:

MAP rating:

Hydrotest rating:

PWHT performed:

Circumferential joint radiography:

No

-43.6°F per UCS-66(b)(1)(b)

0 psi

1,286.6 psi @ 352°F

1,480 psi @ 70°F

2,225 psi @ 70°F

No

None UW-11(c) Type 1

#### Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 1,130.39 psi @ 352 °F						UG-45 No: Thickness Su The nozzle pa	mmary (in)	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is	his nozzle is exempt from area calculations per UG-36(c)(3)(a)					0.1973	0.301	

# UG-41 Weld Failure Path Analysis Summary

The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary						
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status			
Nozzle to shell fillet (Leg <sub>41</sub> )	<u>0.1014</u>	0.175	weld size is adequate			

## Calculations for internal pressure 1,130.39 psi @ 352 °F

Fig UCS-66.2 general note (1) applies.

Nozzle is impact test exempt per UCS-66(d) (NPS 4 or smaller pipe).

Nozzle UCS-66 governing thk: 0.2074 in Nozzle rated MDMT: -155 °F

# Parallel Limit of reinforcement per UG-40

$$L_R = MAX(d, R_n + (t_n - C_n) + (t - C))$$
  
= MAX(1.812, 0.906 + (0.344 - 0.0625) + (0.2074 - 0.0625))  
= 1.812 in

# Outer Normal Limit of reinforcement per UG-40

$$L_{H} = MIN(2.5*(t-C), 2.5*(t_{n}-C_{n})+t_{e})$$
  
= MIN(2.5\*(0.2074 - 0.0625), 2.5\*(0.344 - 0.0625) + 0)  
= 0.3623 in

# Nozzle required thickness per UG-27(c)(1)

$$t_{m} = P*R_{n}/(S_{n}*E - 0.6*P)$$

```
= 1,130.39*0.906 / (17,100*1 - 0.6*1,130.39)
= 0.0624 in
```

# Required thickness t<sub>r</sub> from UG-37(a)

$$t_r = P*R_o / (S*E + 0.4*P)$$
  
= 1,130.39\*2.25 / (17,100\*1 + 0.4\*1,130.39)  
= 0.1449 in

## This opening does not require reinforcement per UG-36(c)(3)(a)

# UW-16(c) Weld Check

Fillet weld: 
$$t_{min}$$
 = lesser of 0.75 or  $t_{n}$  or  $t$  = 0.1449 in  $t_{c(min)}$  = lesser of 0.25 or 0.7\* $t_{min}$  =  $0.1014$  in  $t_{c(actual)}$  = 0.7\*Leg = 0.7\*0.25 = 0.175 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

#### **UG-45 Nozzle Neck Thickness Check**

$$\begin{array}{lll} t_{a}\,UG^{-} &=& P*R\,/\,(S*E-0.6*P) + Corrosion \\ 27 &=& 1,130.39*0.906\,/\,(17,100*1-0.6*1,130.39) + 0.0625 \\ &=& 0.1249\,\,\mathrm{in} \\ \end{array}$$

$$\begin{array}{lll} t_{a}\,UG^{-} &=& 0.1225\,\,\mathrm{in} \\ 22 &=& \max[\,\,t_{a}\,UG^{-}27\,,\,\,t_{a}\,UG^{-}22\,\,] \\ &=& \max[\,\,0.1249\,\,,\,\,0.1225\,\,] \\ &=& 0.1249\,\,\mathrm{in} \\ \end{array}$$

$$t_{b1} &=& P*R_{o}\,/\,(S*E+0.4*P) + Corrosion \\ &=& 1,130.39*2.25\,/\,(17,100*1+0.4*1,130.39) + 0.0625 \\ &=& 0.2074\,\,\mathrm{in} \\ \end{array}$$

$$t_{b1} &=& \max[\,\,t_{b1}\,,\,\,t_{b}\,UG^{16}\,] \\ &=& \max[\,\,0.2074\,\,,\,\,0.125\,\,] \\ &=& 0.2074\,\,\mathrm{in} \\ \end{array}$$

```
\begin{array}{rcl} t_b & = & \min[\ t_{b3} \ , t_{b1} \ ] \\ & = & \min[\ 0.1973 \ , 0.2074 \ ] \\ & = & 0.1973 \ in \end{array} \begin{array}{rcl} t_{UG-45} & = & \max[\ t_a \ , t_b \ ] \\ & = & \max[\ 0.1249 \ , 0.1973 \ ] \\ & = & 0.1973 \ in \end{array}
```

Available nozzle wall thickness new,  $t_n = 0.875*0.344 = 0.301$  in

The nozzle neck thickness is adequate.

#### **Applied Loads**

Radial load:

 $P_r = -416lb_f$ 

Circumferential moment:  $M_c = 1,300 lb_f in$ 

Circumferential shear:

 $V_c = -200 lb_f$ 

Longitudinal moment:

 $M_{L} = 1,300 lb_{f} in$ 

Longitudinal shear:

 $V_{L} = -247 lb_{f}$ 

Torsion moment:

 $M_{t} = 1,300 lb_{f} in$ 

Internal pressure:

 $P = 1,130.39 \, psi$ 

Mean shell radius:

 $R_{\rm m} = 2.148 \, \rm in$ 

Local shell thickness:

t = 0.1449 in

Shell yield stress:

 $S_v = 30,400 \, \text{psi}$ 

# Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_{\rm m}$$
 / t = 2.148 / 0.1449 = 14.8237

Pressure stress intensity factor, I = 1 (derived from PVP-Vol. 399, pages 77-82)

Local circumferential pressure stress = I\*P\*R; /t=16,191 psi

Local longitudinal pressure stress =  $I*P*R_i / (2*t) = 8,096 \text{ psi}$ 

Maximum combined stress  $(P_L + P_b + Q) = 50,883$  psi

Allowable combined stress  $(P_L + P_b + Q) = +-3*S = +-51,300 \text{ psi}$ 

The maximum combined stress (P<sub>L</sub>+P<sub>b</sub>+Q) is within allowable limits.

Maximum local primary membrane stress  $(P_1) = 23,234$  psi

Allowable local primary membrane stress  $(P_L) = +-1.5*S = +-25,650$  psi

The maximum local primary membrane stress (P<sub>1</sub>) is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	β	A <sub>u</sub>	A	B <sub>u</sub>	B	C <sub>u</sub>	C	D <sub>u</sub>	ď
3C*	0.9233	0.4837	0	0	0	0	1,234	1,234	1,234	1,234
4C*	1.6524	0.4837	2,209	2,209	2,209	2,209	0	0	0	0
1C	0.0551	0.4837	0	0	0	0	6,550	-6,550	6,550	-6,550
2C-1	0.0163	0.4837	1,938	-1,938	1,938	-1,938	0	0	0	0

3A*	0.5883	0.4837	0	0	0	0	-2,365	-2,365	2,365	2,365
1A	0.0686	0.4837	0	0	0	0	- 24,527	24,527	24,527	- 24,527
3B*	1.2026	0.4837	-4,834	-4,834	4,834	4,834	0	0	0	0
IB-1	0.0145	0.4837	-5,184	5,184	5,184	-5,184	0	0	0	0
Pı	ressure stress*		16,191	16,191	16,191	16,191	16,191	16,191	16,191	16,191
Total ci	rcumferential :	stress	10,320	16,812	30,356	16,112	-2,917	33,037	50,867	- 11,287
Primary memb	rane circumfer	ential stress*	13,566	13,566	23,234	23,234	15,060	15,060	19,790	19,790
3C*	0.9233	0.4837	1,234	1,234	1,234	1,234	0	0	0	0
4C*	1.6524	0.4837	0	0	0	0	2,209	2,209	2,209	2,209
1 <b>C-</b> 1	0.0318	0.4837	3,780	-3,780	3,780	-3,780	0	0	0	0
2C	0.0302	0.4837	0	0	0	0	3,590	-3,590	3,590	-3,590
4A*	1.6009	0.4837	0	0	0	0	-6,435	-6,435	6,435	6,435
2A	0.0328	0.4837	0	0	0	0	- 11,727	11 <b>,727</b>	11,727	- 11,727
4B*	0.5954	0.4837	-2,393	-2,393	2,393	2,393	0	0	0	0
2B-1	0.0257	0.4837	-9,189	9,189	9,189	-9,189	0	0	0	0
P	ressure stress*		8,096	8,096	8,096	8,096	8,096	8,096	8,096	8,096
Total	longitudinal st	ress	1,528	12,346	24,692	-1,246	-4,267	12,007	32,057	1,423
Primary mem	brane longitud	linal stress*	6,937	6,937	11,723	11,723	3,870	3,870	16,740	16,740
Shear from M			1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013
Cir	Circ shear from V <sub>c</sub>			-370	370	370	0	0	0	0
Lon	Long shear from V <sub>L</sub>			0	0	0	457	457	-457	-457
Total Shear stress			643	643	1,383	1,383	1,470	1,470	556	556
Combin	ned stress (P <sub>L</sub> +	P <sub>b</sub> +Q)	10,367	16,903	30,676	17,577	-5,210	33,139	50,883	12,759

Note: \* denotes primary stress.

# Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{split} &\sigma_{n \, (Pm)} = P^*R_i \, / \, (2^*t_n) - P_r \, / \, (\pi^*(R_o^2 - R_i^2)) + M^*R_o \, / \, I \\ &= 1,130.39^*0.906 \, / \, (2^*0.2385) - -416 \, / \, (\pi^*(1.1875^2 - 0.906^2)) + 1,838.5^*1.1875 \, / \, 1.0326 \\ &= 4,486 \, \mathrm{psi} \end{split}$$

The average primary stress  $P_m$  (see Division 2 5.6.a.1) across the nozzle wall due to internal pressure + external loads is acceptable ( $\leq S = 17,100 \text{ psi}$ )

#### Shear stress in the nozzle wall due to external loads

$$\sigma_{\text{shear}} = (V_L^2 + V_c^2)^{0.5} / (\pi^* R_i^* t_n)$$

$$= (247^2 + 200^2)^{0.5} / (\pi^* 0.906^* 0.2815)$$

$$= 397 \text{ psi}$$

$$\sigma_{\text{torsion}} = M_t / (2^* \pi^* R_i^2 t_n)$$

$$= 1,300 / (2^* \pi^* 0.906^2 0.2815)$$

$$= 895 \text{ psi}$$

$$\sigma_{\text{total}} = \sigma_{\text{shear}} + \sigma_{\text{torsion}}$$

$$= 397 + 895$$

$$= 1,292 \text{ psi}$$

UG-45: The total combined shear stress (1,292 psi) is below than the allowable (0.7\*S<sub>n</sub> = 0.7\*17,100 = 11,970 psi)

#### Reinforcement Calculations for MAP

The attached ASME B16.5 flange limits the nozzle MAP.

υG	UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 1,480 psi @ 70 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is	This nozzle is exempt from area calculations per UG-36(c)(3)(a)						0.1348	0.301	

# UG-41 Weld Failure Path Analysis Summary The marks is execut from weld strength calculations per UW 15/h)

The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary						
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status			
Nozzle to shell fillet (Leg <sub>41</sub> )	0.1452	0.175	weld size is adequate			

# Calculations for internal pressure 1,480 psi @ 70 °F

# Parallel Limit of reinforcement per UG-40

$$L_{R} = MAX(d, R_{n} + (t_{n} - C_{n}) + (t - C))$$

$$= MAX(1.687, 0.8435 + (0.344 - 0) + (0.2074 - 0))$$

$$= 1.687 \text{ in}$$

# Outer Normal Limit of reinforcement per UG-40

$$L_{H} = MIN(2.5*(t-C), 2.5*(t_{n}-C_{n})+t_{e})$$

$$= MIN(2.5*(0.2074-0), 2.5*(0.344-0)+0)$$

$$= 0.5185 in$$

#### Nozzle required thickness per UG-27(c)(1)

$$t_{rn} = P*R_n / (S_n*E - 0.6*P)$$
  
= 1,480\*0.8435 / (17,100\*1 - 0.6\*1,480)  
= 0.077 in

# Required thickness t<sub>r</sub> from UG-37(a)

$$t_r = P*R_o / (S*E + 0.4*P)$$
  
= 1,480\*2.25 / (17,100\*1 + 0.4\*1,480)

#### = 0.1882 in

# This opening does not require reinforcement per UG-36(c)(3)(a)

# UW-16(c) Weld Check

Fillet weld: 
$$t_{min}$$
 = lesser of 0.75 or  $t_{n}$  or  $t$  = 0.2074 in  $t_{c(min)}$  = lesser of 0.25 or 0.7\* $t_{min}$  =  $0.1452$  in  $t_{c(actual)}$  = 0.7\*Leg = 0.7\*0.25 = 0.175 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

#### **UG-45 Nozzle Neck Thickness Check**

= 0.1348 in

Availa le nozzle all thickness ne ,  $t_n = 0.875 \ 0.344 = 0.301$  in

The nozzle neck thickness is ade uate.

#### Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in <sup>2</sup> ) For Pe = 520.7 psi @ 352 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is exempt from area calculations per UG-36(c)(3)(a)						<u>0.1302</u>	0.301	

## **UG-41 Weld Failure Path Analysis Summary**

Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary						
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status			
Nozzle to shell fillet (Leg <sub>41</sub> )	0.1014	0.175	weld size is adequate			

Calculations for external pressure 520.7 psi @ 352 °F

Parallel Limit of reinforcement per UG-40

$$L_R = MAX(d, R_n + (t_n - C_n) + (t - C))$$
  
= MAX(1.812, 0.906 + (0.344 - 0.0625) + (0.2074 - 0.0625))  
= 1.812 in

Outer Normal Limit of reinforcement per UG-40

$$L_{H} = MIN(2.5*(t - C), 2.5*(t_{n} - C_{n}) + t_{e})$$

$$= MIN(2.5*(0.2074 - 0.0625), 2.5*(0.344 - 0.0625) + 0)$$

$$= 0.3623 \text{ in}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.0652$  in

From UG-37(d)(1) required thickness  $t_r = 0.1449$  in

This opening does not require reinforcement per UG-36(c)(3)(a)

UW-16(c) Weld Check

Fillet weld: 
$$t_{min}$$
 = lesser of 0.75 or  $t_n$  or  $t$  = 0.1449 in  $t_{c(min)}$  = lesser of 0.25 or 0.7\* $t_{min}$  =  $0.1014$  in

$$t_{c(actual)} = 0.7*Leg = 0.7*0.25 = 0.175$$
 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

## UG-45 Nozzle Neck Thickness Check

$$\begin{array}{lll} t_{a}\, UG^{-} & = & 0.1277 \text{ in} \\ 28 & & & & \\ t_{a}\, UG^{-} & = & 0.0958 \text{ in} \\ 22 & & & & & \\ t_{a} & & & & & \\ & & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & &$$

Available nozzle wall thickness new,  $t_n = 0.875*0.344 = 0.301$  in

The nozzle neck thickness is adequate.

# External Pressure, (Corroded & at 352 °F) UG-28(c)

$$L/D_0 = 6.3389/2.375 = 2.6690$$
  
 $D_0/t = 2.375/0.0652 = 36.4249$ 

From table G: A = 0.002179From table CS-2: B = 14,224.8916 psi

$$P_a = 4*B / (3*(D_o/t))$$
  
= 4\*14,224.89 / (3\*(2.375 / 0.0652))  
= 520.7 psi

Design thickness for external pressure  $P_a = 520.7 \text{ psi}$ 

$$t_a = t + Corrosion = 0.0652 + 0.0625 = 0.1277$$
"

# **SECTION 9**

# **Thermal Calculation Sheet / TSS**

Mumbel SG REVIEW RESS



BANTREL	JOB	VP NO.	REV				
VENDOR PRI	<b>√</b> Τ 10	083-BC-4006-0064					
EQUIPMENT NUMBER		BL=E-301					
CLIENT CROSS REF							
Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve the supplier from full compliance with contractual obligations.							
2. Revis	may proceed. e and resubm inges indicate	it. Work may proceed subject to incorpora	ation				
3. Revis	e and resubm	it. Work SHALL NOT proceed.  Work may proceed.	4. 20				

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Rick Windell 15613		



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Indianapolis, IN.,	16205					Fax:(317)686-9100
, , , , , , , , , , , , , , , , , , , ,		HEAT EXCHANGE	R SPECIF	ICATION SHE	ET	Page 1
				Job No.	4474	
Customer	Cenovus Energy		-		r No. 1083-BC-4006	
Address				Proposal No.		
Plant Location				Date	3/19/2013	Rev 0
Service of Unit	Natural Gas Heater (	Normal Case)		Item No.	BL-E-301	
Size 90 x 65 x 609		SH4K1-20-00-24UV-2C3	3D	Horz.	Conn. In 1 Paralle	l 1 Series
Surf/Unit (Gross/Ef				Surf/Shell (Gro	ss/Eff) 8.30 / 8.27 m2	
		PERFORMANCE	OF ONE	UNIT		
Fluid Allocation		Shell			T	ube Side
Fluid Name		Ethylene Glycol (50 wt%	) / H2O		Natural Gas	
Fluid Quantity, Tota	al kg/hr	1638	8.01			3616.00
Vapor (In/Out)					3616.00	3616.00
Liquid		1638.01	1	638.01		
Steam						
Water						
Noncondensables						
Temperature (In/O	ıt) C	150.00		100.00	5.00	35.00
Density	kg/m3	990.40	1	034.1	63.900	53.190
Viscosity	mN-s/m2	0.3640	0	.7100	0.0128	0.0130
Molecular Weight, 1					17.16	17.16
Molecular Weight, I	Noncondensables					
Specific Heat	kJ/kg-C	3.7401	3	3.5401	2.8401	2.6700
Thermal Conductiv	ity W/m-C	0.3905		.3915	0.0381	0.0410
Latent Heat	kJ/kg					
Inlet Pressure	kPa	997.	.345			6981.50
Velocity	m/s	0.1	15			5.39
Pressure Drop, Allo	w/Calc kPa	70.001		0.628	70.001	3.209
Fouling Resistance		0.000	0180			.000180
Heat Exchanged N	flegaWatts 0.0829		MTD (Co	rrected)	104.8 C	
Transfer Rate, Sen	rice 95.6	7 W/m2-K Clean	17	71.69 W/m2-K	C Actual	150.79 W/m2-K
	CONSTRUC	TION OF ONE SHELL			Sketch (Bund	e/Nozzle Orientation)
		Shell Side	Tı	ube Side		
Design/Test Pressu	ure kPaG	7650 / Code	9930 / Co	ode	Security and the second security and the second sec	and with the second sec
Design Temperatur	e C	-28.8 / 178	-28	3.8 / 150		
No Passes per She		1		1	A POSSESSION OF THE PROPERTY O	
Corrosion Allowand	e mm	1,5	1.5 (e	xcept tube)	] " "	الممالك المهادات
Connections	in mm	1 @ 2" 600# RF	1@3"9			
Size &	Out mm	1 @ 2" 600# RF	1@3"9	00# RF		
Rating	Intermediate					
Inner Pipe - (1) 2 1.	/2" Sch 40 pipe (73mm			Length 6.096r	n nom	
Tube Type	Longitudinal Fin - (24	12.7mm fins x 0.89mm thk x 6096		Material	SA-106B, C	Stl Fins
Shell		SA-106B Pipe (114.3mr		Shell Cover		70 Weldment
Channel or Bonnet		/105 Weldment		Channel Cove		
Tubesheet-Stationa				Tubesheet-Flo		
Floating Head Cov				Impingement F	Plate None	
Baffles-Cross	N/A Type NONI					
Baffles-Long	N/A	Seal Typ	8			
Supports-Tube	N/A	U-Bend			Type	
Bypass Seal Arran	gement	Tube-Tub	besheet Jo	oint	Welded	
Expansion Joint	N/R	Туре				
Rho-V2-Inlet Nozzi				0.00	Bundle Exit 0.00	kg/m-s2
Gaskets-Shell Side		type Tube Sid	ė	Kammpro type	)	
-Floating Head					.,	
Code Requirement		ction VIII, Div. I			TEMA Class	
Weight/Shell 804.		Filled with Water 921.2			Bundle 150.62	kg
Remarks: 1. Lifting	& Grounding lugs red	quired. 2. Insulation is inclu	ıded in gu	ote, but due to	potential damage durin	g shipment, HED
strongly advises th	at insulation is installe	d on site, and cannot be re	esponsible	for damage to	Insulation during shipn	nent. 3. Maximum length
s 6500mm. 4. This	is HED's standard se	parated head double pipe	hairpin de	sign with indep	endent bolting, 5. Hydr	otest at minimum 1 hour with
chart. 6. Note that	due to manufacturing	restrictions on finned pipe	inner pipe	will be fabricat	ted using return bend a	nd straight pipes with two
circumferential wel	ds.					
					Reprinte	ed with Permission (v6 SP3)

Alfabrill SC REVIEW RICK WINDER 23.568/3



BANTREL	JOB	VP NO.	REV					
VENDOR PRINT	1000 1001 100							
EQUIPMENT NUMBER	BL-	-E-301						
CLIENT CROSS REF								
design details, developed or se	Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve the supplier from full compliance with contractual obligations.							
		it. Work may proceed subject to incorpor	ation					
_		it. Work SHALL NOT proceed. i. Work may proceed.	1,2013					

Witness D

Rick Windell

25 SEP 13

REVIEW

P.O.Box 524

Tel:(317)686-9000

Indianapolis, IN.,	46205							Fax:(317)686-9100
			HEAT EXCHANGE	R SPEC	FICATION SHE	ET		Page 1
					Job Na.	4474		
Customer	Cenovu	s Energy			Purchase Orde	r No. 1083-B0	C-4006	
Address					Proposal No.	616-12		
Plant Location					Date	3/19/2013		Rev 0
Service of Unit	Natural	Gas Heater (N	laximum Case)		Item No.	BL-E-301		
Size 90 x 65 x 609		Туре	SH4K1-20-00-24UV-2C3	3D	Horz.	Conn. In	1 Parallel	1 Series
Surf/Unit (Gross/Ef			Shell/Unit	1	Surf/Shell (Gro			
	,		PERFORMANCE	OF ON				
Fluid Allocation			Shell			1	Tuh	e Side
Fluid Name			Ethylene Glycol (50 wt%			Natural Gas		
Fluid Quantity, Total	al	kg/hr	359					26.02
Vapor (In/Out)					***************************************	7926		7926.02
Liquid			3591.00	<b></b>	3591.00	1	01011	
Steam					-			
Water						1		
Noncondensables				-		<del> </del>		<del> </del>
Temperature (In/O		C	150.00	$\vdash$	100.00	5.0	00	35.00
Density		kg/m3	990.40		1034.1	63.9		53.190
Viscosity		mN-s/m2	0.3640		0.7100	0.01		0.0130
Molecular Weight,	Vanor	HIN-SHILZ	0.3040	$\vdash$	V.1 100	17.		17.16
Molecular Weight,		eneables				17.	.10	17.10
	ACHICOLIGI	kJ/kg-C	3.7400	$\vdash$	3.5400	2,84	00	2 6700
Specific Heat	it.							2.6700
Thermal Conductive Latent Heat	ity	W/m-C	0.3904	L	0.3914	0.03	101	0.0410
		kJ/kg	007	000		<del> </del>		04.50
Inlet Pressure		kPa	997.			ļ		81.50
Velocity	10.1	m/s	0.3	32	0.500			1.82
Pressure Drop, Alic		kPa	70.000	100	2.569	70.0		14.945
Fouling Resistance		m2-K/W	0.000			1 1212 2	0.0	00180
Heat Exchanged M					orrected)	104.8 C		
Transfer Rate, Sen	/ice		W/m2-K Clean	- '	297.66 W/m2-K			239.96 W/m2-K
		CONSTRUC	TION OF ONE SHELL			Sket	ch (Bundle/	Nozzle Orientation)
			Shell Side		ube Side	4		
Design/Test Pressu		kPaG	7650 / Code	9930 / C		4		
Design Temperatur		С	-28.8 / 178	-2	8.8 / 150	4		
No Passes per She			1		1			
Corrosion Allowand		mm	1.5		except tube)	4	3	
Connections	ln	inch	1 @ 2" 600# RF		900# RF	4		
Size &	Out	inch	1 @ 2" 600# RF	1@3"9	900# RF	4		
Rating	Interme			<u> </u>		1		
Inner Pipe - (1) 2 1					Length 6.096r			
Tube Type	Longitue		12.7mm fins x 0.89mm thk x 6098		Material		-106B, C St	
Shell			A-1068 Pipe (114.3mm	n OD)	Shell Cover		105/516 70	Weldment
Channel or Bonnet			105 Weldment		Channel Cover			
Tubesheet-Stationa		SA-516-70			Tubesheet-Flo			
Floating Head Cov		N/A			Impingement F	Plate Nor	ne	
Baffles-Cross	N/A	Type NONE						
Baffles-Long	N/A		Seal Typ	e				
Supports-Tube	N/A		U-Bend			Type		
Bypass Seal Arran	gement		Tube-Tuk	esheet.	loint	Welded		
Expansion Joint		N/R	Туре					····
Rho-V2-Inlet Nozzi		276.81 kg/m			0.00	Bundle Exit	0.00	kg/m-s2
Gaskets-Shell Side		Kammpro ty	/pe Tube Sid	е	Kammpro type			
-Floating Head		N/A						
Code Requirement		ASME Sect	ion VIII, Div. 1			TEMA Class		
Weight/Shell 804.	22		Filled with Water 921.2			Bundle 150	0.62	kg
Remarks: 1. Lifting	& Groui	nding lugs requ	uired, 2. Insulation is inclu	ided in q	uote, but due to	potential dam	age during	shipment, HED
			on site, and cannot be re			****		
								est at minimum 1 hour with
			estrictions on finned pipe					
circumferential wel								
							Reprinted	with Permission (v6 SP3)
			**************************************					

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Rick Windell SG REVIEW D

25 SEL 13



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P.O.Box 524

Indianapolis, IN., 46205 Fax:(317)686-9100 HEAT EXCHANGER SPECIFICATION SHEET Page 1 Job No. Purchase Order No. 1083-BC-4006 Cenovus Energy Customer Address Proposal No. 616-12 Plant Location Date 2/22/2013 Rev 0 Service of Unit Natural Gas Heater (Turndown Case) Item No. BL-E-301 SH4K1-20-00-24UV-2C3D Size 90 x 65 x 6096mm 1 Parallel Type Horz. Conn. In 1 Series Surf/Unit (Gross/Eff) 8.30 / 8.27 m2 Surf/Shell (Gross/Eff) 8.30 / 8.27 m2 Shell/Unit PERFORMANCE OF ONE UNIT Fluid Allocation Shell Side Tube Side Ethylene Glycol (50 wt%) / H2O Natural Gas Fluid Name Fluid Quantity, Total kg/hr 897.750 1981.50 1981.50 1981.50 Vapor (In/Out) Liquid 897.750 897.750 Steam Water Noncondensables 150.00 100.00 Temperature (In/Out) 5.00 35.00 63.900 990.40 1034.1 53.190 Density kg/m3 0.7100 Viscosity mN-s/m2 0.3640 0.0128 0.0130 Molecular Weight, Vapor 17.16 Molecular Weight, Noncondensables 3.5400 2.8400 2.6700 kJ/kg-C 3.7400 Specific Heat 0.0381 Thermal Conductivity W/m-C 0.3904 0.3914 0.0410 **Latent Heat** kJ/kg Inlet Pressure kPa 997.332 6981.50 8.117e-2 2.95 Velocity m/s 70.000 70.000 0.999 Pressure Drop, Allow/Calc kPa 0.199 0.000180 Fouling Resistance (min) m2-K/W 0.000180 Heat Exchanged MegaWatts 0.0454 104.8 C MTD (Corrected) 52.43 W/m2-K Clean 108.81 W/m2-K Actual 100.02 W/m2-K Transfer Rate, Service CONSTRUCTION OF ONE SHELL Sketch (Bundle/Nozzle Orientation) Tube Side Shell Side Design/Test Pressure kPaG 7650 / Code 9930 / Code Design Temperature C -28.8 / 178 -28.8 / 150 No Passes per Shell Corrosion Allowance mm 1.5 1.5 (except tube) Connections @ 2" 600# RF @ 3" 900# RF mm 1 @ 2" 600# RF 1 @ 3" 900# RF Size & Out mm Rating Intermediate Inner Pipe - (1) 2 1/2" Sch 40 pipe (73mm OD) Length 6.096m nom Tube Type Longitudinal Fin - (24) 12.7mm fins x 0.89mm thk x 6096mm Ig Material SA-106B, C Stl Fins Shell 4" Sch 40 SA-106B Pipe (114.3mm OD) Shell Cover SA105/516 70 Weldment Channel or Bonnet SA-516-70/105 Weldment Channel Cover N/A Tubesheet-Stationary SA-516-70 Tubesheet-Floating N/A Floating Head Cover N/A Impingement Plate None Type NONE Baffles-Cross Baffles-Long N/A Seal Type Supports-Tube N/A **U-Bend** Type Bypass Seal Arrangement Tube-Tubesheet Joint Welded N/R **Expansion Joint** Type 17.30 kg/m-s2 Bundle Entrance Rho-V2-Inlet Nozzle 0.00 **Bundle Exit** 0.00 ka/m-s2 Gaskets-Shell Side Kammpro type Tube Side Kammpro type -Floating Head N/A ASME Section VIII, Div. I Code Requirements **TEMA Class** Filled with Water 921.2 Bundle 150.62 Remarks: 1. Lifting & Grounding lugs required. 2. Insulation is included in quote, but due to potential damage during shipment, HED strongly advises that insulation is installed on site, and cannot be responsible for damage to insulation during shipment. 3. Maximum length is 6500mm. 4. This is HED's standard separated head double pipe hairpin design with independent bolting. 5. Hydrotest at minimum 1 hour with chart. 6. Note that due to manufacturing restrictions on finned pipe inner pipe will be fabricated using return bend and straight pipes with two circumferential welds. Reprinted with Permission (v6 SP3)

PERMISSIONS TO PROCEED DOES NOT CONSTRUCTE DESCRIPTIONEE OR APPROVAL OF DESIGN DETAILS, CALCULATIONS, ANGLYSES, TEST METHODS OR MATERIALS DEVELOPED OR SELECT-0 4 YING SUPPLIER AND DOES NOT RELIEVE SUPPLIEN FROM FULL COMPLIANCE WITH CONTRACTUAL OBLIGATIONS. WORK MAY PROCEED. With comment REVISE AND RESUBMIT. WORK MAY PROCEED SUBJECT TO INCORPORATION OF CHANGES INDICATED.
REVISE AND RESUBMIT. WORK SHALL NOT PROCEED. REVIEW NOT REQUIRED. WORK MAY PROCEED. WI DATE MUTCH 14 2473

BANTREL	JOB	M/R NO.	VP NO.	REV
VENDOR PRINT	1083	BC-4006	0605	0
EQUIPMENT - NUMBER -	BI	-E-30		
CLIENT . CROSS REF -				

# **SECTION 10**

# **Weld Procedures & Welder Certifications**

Muhileff WITNESS D

Rick Windell S6 REVIEW 25 SEP 13

25 SEP 13

901 East Beecher St

# Welding Procedure Specification (WPS)

I-S, IT/MI-S-BHN, ITI-IT2 I) GTAW / Manual  fillet welds  Backing  No backing  No backing  Gouged & back welded  Gouged & back welded  Gouged & back welded  T-joint  No backing all base metal thicknesses and	Root Opening 3/16" max 3/16" max 1/4" max 1/4" max 1/4" max 1/4" max 1/4" max 1/32" max 3/32" max	Groove Angle 50 deg min 45 deg min 50 deg min 45 deg min 45 deg min 45 deg min	Root Face 1/8" max 1/8" max 3/16" max 3/16" max 3/16" max	Groove Radius
Backing No backing No backing No backing Gouged & back welded Gouged & back welded Gouged & back welded T-joint No backing	3/16" max 3/16" max 1/4" max 1/4" max 1/4" max 1/32" max	50 deg min 45 deg min 50 deg min 45 deg min	1/8" max 1/8" max 3/16" max 3/16" max	Groeve Radius
Backing No backing No backing Gouged & back welded Gouged & back welded Gouged & back welded T-joint No backing	3/16" max 3/16" max 1/4" max 1/4" max 1/4" max 1/32" max	50 deg min 45 deg min 50 deg min 45 deg min	1/8" max 1/8" max 3/16" max 3/16" max	Groove Radius
Backing No backing No backing Gouged & back welded Gouged & back welded Gouged & back welded T-joint No backing	3/16" max 3/16" max 1/4" max 1/4" max 1/4" max 1/32" max	50 deg min 45 deg min 50 deg min 45 deg min	1/8" max 1/8" max 3/16" max 3/16" max	Groeve Radius
No backing No backing Gouged & back welded Gouged & back welded Gouged & back welded I-joint No backing	3/16" max 3/16" max 1/4" max 1/4" max 1/4" max 1/32" max	50 deg min 45 deg min 50 deg min 45 deg min	1/8" max 1/8" max 3/16" max 3/16" max	Groove Radius
No backing Gouged & back welded Gouged & back welded Gouged & back welded I-joint No backing	3/16" max 1/4" max 1/4" max 1/4" max 1/32" max	45 deg min 50 deg min 45 deg min	1/8" max 3/16" max 3/16" max	
Gouged & back welded Gouged & back welded Gouged & back welded I-joint No backing	1/4" max 1/4" max 1/4" max 1/32" max	50 deg min 45 deg min	3/16" max 3/16" max	
Gouged & back welded Gouged & back welded I-joint No backing	1/4" max 1/4" max 1/32" max	45 deg min	3/16" max	eggent de que en est en estado para la estado en estado
Gouged & back welded I-joint No backing	1/4" max 1/32" max	And the second of the second o		
T-joint No backing	1/32" max	45 deg min		Kalian barrer were reasons arreined grown and
No backing			3/40 HBA	naanime
	3/32 max		and the second	· ····································
all base metal thicknesses and	. to a company of the	an antistigation to the second of the second		engagin and the secondary
	all diameters.	Section 19 1 1 man and the section of the section o	سراعشو مطاعفم سيلب استستناني	generalis, a communication and a
	ocono que emmenejan en carden alimat e	<del>- ili</del>	والمسارية والمناهد المعارية بالمارة	
S SHOWN ARE NOT INCLUSERING SPECIFICATION OR				
No. 1 & 2 Thickness Ran No. 1 & 2	ge: 0.0625 in. to 10	).6400 in.		
	Postweld H	leat Treatment (QV	V-407)	
50 et	PWIIT Typ	e: No PWIII will be	: performed	1907 1908 MINOR TO 11 11 1
: <b>261 પ</b> ્ર	PWIII I'en	iperature :	None	
None		ding Time:	None	
<sup>a</sup> F applies to impact applicati	ons			
deposit > 1.25" and $\leq l = 1.50$ °		and stream		
Vith wire brush clean 1 inch (2	5 (nm) on both sides	of weld joint		
enter control of the	. New consection of the contract contra	900 a		
ween each pass. When cor -53° F. See PQR 1T14T2 fo 0.094" min. base metal thki jualified per QW-405.2. Any	mpleted, remove all or details. nss, 45673 J/in. ma o combination of Gr	I slag and projection ax. heat input, 50° F	ns. · min. preheat &	.261° F-max.
F1-IT2 Revised notes accor	rdingly. This WPS a	and existing PQR's	1T1, 1T/M1-S a	ind 17/M1-S-BHN
in this amount are march and	that the tast is able is.	ora mesimana di salahad	عدية مثا أشعيد القند	aredona a suitebolka
	a a mental menta	ic prepared, werded.	and icsico macci	Manice with the
11/1	1.1			
3. Whole	care )		Quality Control N	lanager
Un'si Fre	edinise:	Date		
NCE DR				
i, 160t)	BANTRE	L JOB M/R NO	VPNO. R	EV
	Berring	3 3 15	6 0007 70	
FFLERS	VENUO DEL			
PPLER FULL	VENOOR PRI	(\$L-€-3	01	
FFLERS	SQUEPMENT MUMBER	BL-E-3	0)	
FFLERS	EQUIPM NT	BL-E-3		
FULL BJECT	SQUEPMENT MUMBER	BL-E-3	01	=
FULL	SQUEPMENT MUMBER	BL-E-3	VITNESS 2011 F	orm 011 - Format (
	No. 1 & 2  Storm 1 & 3  Storm 1	Postweld H  50 °F PWITT Typ  1. 261 °F PWITT Typ  261 °F PWITT Ton  None PWITT Hole  F applies to impact applications  deposit > 1.25" and = 1.50".  With wire brush clean Linch (25 mm) on both sides in required, grind until all defects are removed, maintained during thermal cutting, tacking, and ween each pass. When completed, remove all -53° F. See PQR 1T14T2 for details.  0.094" min. base metal thknss, 45673 J/in. maintained per QW-405.2. Any combination of Grand 1T1-IT2 for hardness test results.  F1-IT2 Revised notes accordingly. This WPS all the ASMIL Code.  The ASMIL Code.  Davat Freedamen.</td <td>Postweld Heat Treatment (QV 50 PWITT type: No PWITT will be 261 PWITT temperature: None PWITT temperature: None PWITT Holding Time:  F applies to impact applications  deposit &gt; 1.25° and &lt;= 1.50°.  With wire brush clean 1 inch (25 inm) on both sides of weld joint in required, grind until all defects are removed, maintained during thermal cutting, tacking, and welding operation ween each pass. When completed, remove all slag and projection-53° F. See PQR 1T14T2 for details.  0.094" min. base metal thknss, 45673 J/in. max. heat input, 50° F qualified per QW-405.2. Any combination of Group 1 and 2 materiand 1T1-IT2 for hardness test results.  F1-IT2 Revised notes accordingly. This WPS and existing PQR's in this record are correct and that the test welds were prepared, welded. The ASME Code  Basic Parks and Freedanger 96 2012 Date</td> <td>Postweld Heat Treatment (QW-407)  50 °F PWITT Type: No PWITT will be performed  261 °F PWITT Temperature: None  None PWITT Holding Time: None  F applies to impact applications  deposit &gt; 1.25" and &lt;= 1.50".  With wire brush clean I inch (25 imm) on both sides of weld joint in required, grind until all defects are removed.  maintained during thermal cutting, tacking, and welding operations.  ween each pass. When completed, remove all slag and projections.  -53° F. See PQR 1T1-IT2 for details.  0.094" min. base metal thknss, 45673 J/in. max. heat input, 50° F min. preheat &amp; qualified per QW-405.2. Any combination of Group 1 and 2 materials qualified, and 1T1-IT2 for hardness test results.  F1-IT2 Revised notes accordingly. This WPS and existing PQR's 1T1, 1T/M1-S at in this record are correct and that the test welds were prepared, welded, and tested in according to the ASME Code.  33: When Code are correct and that the test welds were prepared, welded, and tested in according to the ASME Code.  9 6 2012 Quality Control Velace.</td>	Postweld Heat Treatment (QV 50 PWITT type: No PWITT will be 261 PWITT temperature: None PWITT temperature: None PWITT Holding Time:  F applies to impact applications  deposit > 1.25° and <= 1.50°.  With wire brush clean 1 inch (25 inm) on both sides of weld joint in required, grind until all defects are removed, maintained during thermal cutting, tacking, and welding operation ween each pass. When completed, remove all slag and projection-53° F. See PQR 1T14T2 for details.  0.094" min. base metal thknss, 45673 J/in. max. heat input, 50° F qualified per QW-405.2. Any combination of Group 1 and 2 materiand 1T1-IT2 for hardness test results.  F1-IT2 Revised notes accordingly. This WPS and existing PQR's in this record are correct and that the test welds were prepared, welded. The ASME Code  Basic Parks and Freedanger 96 2012 Date	Postweld Heat Treatment (QW-407)  50 °F PWITT Type: No PWITT will be performed  261 °F PWITT Temperature: None  None PWITT Holding Time: None  F applies to impact applications  deposit > 1.25" and <= 1.50".  With wire brush clean I inch (25 imm) on both sides of weld joint in required, grind until all defects are removed.  maintained during thermal cutting, tacking, and welding operations.  ween each pass. When completed, remove all slag and projections.  -53° F. See PQR 1T1-IT2 for details.  0.094" min. base metal thknss, 45673 J/in. max. heat input, 50° F min. preheat & qualified per QW-405.2. Any combination of Group 1 and 2 materials qualified, and 1T1-IT2 for hardness test results.  F1-IT2 Revised notes accordingly. This WPS and existing PQR's 1T1, 1T/M1-S at in this record are correct and that the test welds were prepared, welded, and tested in according to the ASME Code.  33: When Code are correct and that the test welds were prepared, welded, and tested in according to the ASME Code.  9 6 2012 Quality Control Velace.

#### Welding Procedure Specification (WPS)

WPS No.: 1T1	THE THE PARTY OF T	Rev. No.: 7	Control Statement Control (Control (Con			n in management and electric field data do illustration described in the electric described in t		Page 2 of 2
First Process:		GTAW	animate and an	**************************************	Type:		Manual	
Filler Metal (Q	(W-404)							
Weld Deposit Li	mits:	1.500 in. maxi	mum	titue o deservaçõe e e e e e e e e e e e e e e e e e e				
AWS Classificat	ion:	ER70S-2			SFA Specif	ication: 5.18	F-No.	6
A-No. or Chemis	cal Composition:		1		•			
	duct Form:							
	en:		e e - e - e - e - e - e - e - e - e - e		GTAW Flux	C:	N/A	della seguina
Position (QW-4					Technique	(QW-410)		
Position of Joint		All Positions			Stringer or	Weave Bead	Stringer and w	eave bead
	R:					s Cup Size	#5 to # f	
Gas (QW-408)				mental radio over		and a second professional second second	None	agasi anna na sa'agasiana wa anna kannalida nan u unu
Shielding:	100% Argon		18-24	CFII	Multiple / S	ingle Pass (per sid	e): Single o	r multipass
	00% Argon (as need							
				CFH				
Electrical Chara	acteristics (QW-40	19)						
	d Polarity:	DCEN (str	aight)					
Pulsed Current:	manife of the factor of the constitution are given as	N/A	and white appropriate and the	1.6 feldelengrep - no.e. :				
l'ungsten Type:	EWTb-2	Size:	1/16*-3	/32"				
Max, Heat Input	(J/in):	45673	Mary represent to the con-	,, 'e				
Maximum Fleat I Value derived fro Volts x Amp Travel Speed (in	om formula: s x 60	plementary Es	sential app	dications	(Impacts). Co	nsider qualified ba	se metal ranges whe	n deriving value.
			First Pr	ocess We	lding Param	eters		
Layer(s)	Fill	er Metal	25		Curre	ni	* * * * * * * * * * * * * * * * * * * *	Fravel Speed
and/or	AWS	, · · · · · · · · · · · · · · · · · · ·	iize	Typ	e and	Amperage	Voltage	Range
Pass(es)	Classification	. (	în.1		larity	Range	Range	(in/min)
Any	ER70S-2		/16	DOEN	(straight)	70-150	Variable	Variable
Any	ER70S-2		/32		(straight)		Variable	Variable
Any	ER70S-2		1/8	DCEN	(straight)	130-275	Variable	Variable

DCEN (straight)

3/16

200-375

Variable

Any

Any

ER70S-2

Variable

901 East Beecher St

#### Procedure Qualification Record (PQR)

Welding Process(es) / Ty	pe(s): (I) GTAW/Wianual			
Joint Design (QW-402	-		Buse Metals (QW-403)	
Weld Type:	Groove weld	***************************************	Specification Type and Grade:	
Groove Type:		en men entre Laba agreementote		4-106. Grade B
Backing:	None	# 100 mm. 100 mm. 100 mm. 100 mm.	Appropriate Communication Comm	No.   Group No.
Root Opening: 0.0	April Company on the Company of the	063 in.	Thickness (in.): 0.358	
Groove Angle: 60	<u>)                                    </u>		Diameter (in.): 1.315	
			Preheat (QW-406)	
			Minimum Preheat Temperature:	50 °F
	60 to 75 dag.		Preheat Maintenance:	None
`	<b>Y</b>		Maximum Interpass Temperature:	400 °F
			Postweld Heat Treatment (QW-407)	
\			Type: No PWHT per	rformed
(т	\ /. \		PWHT Temperature: None	al.
, ,	1 \ / 1		PWHT Holding Time: Nor	ne br.
	NOTE ARE CHOOME		PWHI Floriding Filme: (40)	ordinini di America ne e di Administrativa
SI First Process:	RF± 1/16 <sup>-1</sup>   F NGLE VEE GROOVE GTAW	understein mit, etnamaja espradosjakojes	Туре: Малиа	nost singlionigija milinalissuusia nyyvennassa (* s. s. 2014 – 201).
Si First Process: Filler Metals (QW-404	RTAW	uname û manê monejapo	Type: Manua Electrical Characteristics (QW-409)	and adoption file and the contract of the cont
First Process: Filler Metals (QW-404 AWS Classification;	RTAW	namani il namo apancaco	Type: Manua Electrical Characteristics (QW-409)	nost singlionigija milinalissuusia nyyvennassa (* s. s. 2014 – 201).
First Process: Filler Metals (QW-404 AWS Classification; SFA Specification;	GTAW  ()  ER70S-2  5.18  F-No.:	sumani i mino mpunchen	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: [ Fungsten Type: EWTh-2	l XCI:N (straight)
First Process: Filler Metals (QW-404 AWS Classification; SFA Specification; A-No, or Chemical Com	GTAW  (1)  ER70S-2  5.18  F-No.:	sumanni ama mpananan	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: I Fungsten Type: I:WIh-2 Pulsed Current:	DCEN (straight) Size: 3/32"
First Process: Filler Metals (QW-404 AWS Classification; SFA Specification; A-No, or Chemical Com Filler Metal Product For	GTAW  (1)  ER70S-2  5.18  F-No.:  oposition:  m:  Bure (Solid)	6	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: I fungsten Type: IEWIh-2 Pulsed Current:  Welding Details	DCEN (straight) Size: 3/32"
First Process: Filler Metals (QW-404 AWS Classification; SFA Specification; A-No, or Chemical Com	GTAW  (i)  ER70S-2  5.18  F-No.:  position:  I  Bare (Solid)  None	6	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: Fungsten Type: EWTh-2 Pulsed Current:	DCEN (straight) Size: 3/32"
First Process: Filler Metals (QW-404 AWS Classification; SFA Specification: A-No, or Chemical Com Filler Metal Product For Consumable Insert:	GTAW  (1)  ER70S-2  5.18  F-No.:  uposition:  Im:  Bare (Solid)  None  None	6	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: Ifungsten Type: EWTh-2 Pulsed Current: Welding Details Filler Metal Size (in.): 3/32	DCEN (straight) Size: 3/32"
First Process: Filler Metals (QW-404 AWS Classification; SFA Specification: A-No, or Chemical Com Filler Metal Product For Consumable Insert: GTAW Flux:	GTAW  (i)  ER70S-2  5.18  F-No.:  position:  I  Bare (Solid)  None	6	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: Fungsten Type: EWTh-2 Pulsed Current: Welding Details Filler Metal Size (in.): Amperage Used: 150	DCEN (straight) Size: 3/32"
First Process: Filler Metals (QW-404 AWS Classification: SFA Specification: A-No, or Chemical Com Filler Metal Product For Consumable Insert: GTAW Flux: Weld Deposit 't' (in.):	GTAW  (1)  ER70S-2  5.18  F-No.:  uposition:  Im:  Bare (Solid)  None  None	<b>6</b>	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: If fungsten Type: EWTh-2 Pulsed Current: Welding Details Filler Metal Size (in.): 3/32 Amperage Used: 150 Voltage Used: Varies	DCEN (straight) Size: 3/32"
First Process: Filler Metals (QW-404 AWS Classification; SFA Specification: A-No, or Chemical Com Filler Metal Product For Consumable Insert: GTAW Flux: Weld Deposit 't' (in.); Positions (QW-405)	GTAW  (1)  ER70S-2  5.18  F-No.:  sposition:  III:  Bare (Solid)  None  None  0.358	<b>6</b>	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: If Fungsten Type: EWTh-2 Pulsed Current: Welding Details Filler Metal Size (in.): 3/32 Amperage Used: 150 Voltage Used: Varies I ravel Speed (in/min): Varies	CEN (straight) Size: 3/32" Jone
First Process: Filler Metals (QW-404 AWS Classification: A-No, or Chemical Com Filler Metal Product For Consumable Insert: GTAW Flux: Weld Deposit 't' (in.): Positions (QW-405) Position of Joint: Weld Progression:	GTAW  (i)  ER70S-2  5.18  F-No.:  position:  II  Bare (Solid)  None  None  0.358  6G-45 degree pipe	<b>6</b>	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: If Fungsten Type: EWTh-2 Pulsed Current: Welding Details Filler Metal Size (in.): 3/32 Amperage Used: 150 Voltage Used: Varies I ravel Speed (in/min): Varies Max. Heat Input (J/in):	CEN (straight) Size: 3/32" Jone
First Process: Filler Metals (QW-404 AWS Classification: SFA Specification: A-No, or Chemical Com Filler Metal Product For Consumable Insert: GTAW Flux: Weld Deposit 't' (in.): Positions (QW-405) Position of Joint: Weld Progression: Gas (QW-408)	GTAW  (1)  ER70S-2  5.18  F-No.:  oposition:  m:  Bare (Solid)  None  None  0.358  6(i - 45 degree pipe  Vertical up	CFH	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: If Fungsten Type: EWTh-2 Pulsed Current: Welding Details Filler Metal Size (in.): 3/32 Amperage Used: 150 Voltage Used: Varies I ravel Speed (in/min): Varies Max. Heat Input (J/in): Technique (QW-410) Thermal Processes:	CEN (straight) Size: 3/32" Jone N/R
First Process: Filler Metals (QW-404 AWS Classification: SFA Specification: A-No, or Chemical Com Filler Metal Product For Consumable Insert: GTAW Flux: Weld Deposit 't' (in.): Positions (QW-405) Position of Joint: Weld Progression: Gas (QW-408)	GTAW  (1)  ER70S-2  5.18  F-No.:  position:  Im:  Bare (Solid)  None  None  0.358  6Gi - 45 degree pipe  Vertical up	and the second	Type: Manua Electrical Characteristics (QW-409) Current Type and Polarity: If Fungsten Type: EWTh-2 Pulsed Current: Welding Details Filler Metal Size (in.): 3/32 Amperage Used: 150 Voltage Used: Varies I ravel Speed (in/min): Varies Max. Heat Input (J/in): Technique (QW-410) Thermal Processes:	CEN (straight) Size: 3/32" Jone N/R

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Rick Windell SO REVIEW REVIEW

#### Procedure Qualification Record (PQR)

POR No.: ITI Page 2 of 2 Tensile Test (QW-150) Diameter Ultimate Total Ultimate Unit Area Failure Type  $(in^2)$ Stress (PSI) and Location Specimen No. (in.) Load (1b) 75000 70021 1.315 1.0711 Base metal 1.315 1.0720 75750 70662 Base metal Guided Bend Tests (QW-160) Type and Figure No. Result Type and Figure No. Result QW-462.3(a) Face bend Acceptable QW-462.3(a) Root bend Acceptable QW-462.3(a) Root bend QW-462.3(a) Face bend Acceptable Acceptable Data transferred to new form 6-Sep-2012. Welder's Name: Darrell Witt I.D.: D Stamp No.: D PQR was done and welding of coupon was witnessed by: Heat Exchanger Design, Inc. Test conducted by: Professional Service Industries, Inc. (PSI) Lab Test No.: 88618 We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Spde. Prepared and Accepted By: Quality Control Manager

## Procedure Qualification Record (PQR)

Welding Process(es) / Type(s): (1) GTAW / Manual (2) GMAW / Set  Joint Design (QW-402)  Weld Type: Groove weld  Groove Type: Double-V groove  Backing: Back-gouged and back welded	Base Metals (QW-403) Specification Type and Grade: SA-516. Grade 70 to SA-516. Grade 70
Weld Type: Groove weld Groove Type: Double-V groove Backing: Back-gouged and back welded	Specification Type and Grade:
Groove Type: Double-V groove Backing: Back-gouged and back welded	
Backing: Back-gouged and back welded	SA-516 Grade 70 to SA-516 Grade 70
	P-No. 1 Group No. 2 to P-No. 1 Group No. 2
Root Opening: 0.063 in. Root Face: 0.063 in.	Thickness (in.): 8 to 1.5
Groove Angle: 60 °	Preheat (QW-406)
	Minimum Preheat Temperature: 50 °F
	Preheat Maintenance: None
60 to 75 deg.	Maximum Interpass Temperature: 550 °F
	Postweld Heat Treatment (QW-407)
	Type: No PWHT performed
	PWHT Temperature: None ***
T	PWHT Holding Time: None hr.
DOUBLE VEE GROOVE	
	Type: Manual
Filler Metals (QW-404)	Electrical Characteristics (QW-409)
Filler Metals (QW-404) AWS Classification: ER70S-2	Electrical Characteristics (QW-409)  Current Type and Polarity: DCEN (straight)
Filler Metals (QW-404) AWS Classification: ER70S-2 SFA Specification: 5.18 F-No.; 6	Electrical Characteristics (QW-409)  Current Type and Polarity: DCEN (straight)  Tungsten Type: EWTh-2 Size: 3/32°
Filler Metals (QW-404) AWS Classification: ER70S-2 SFA Specification: 5.18 F-No.: 6 A-No. or Chemical Composition: I	Electrical Characteristics (QW-409)  Current Type and Polarity: DCEN (straight)  Tungsten Type: EWTh-2 Size: 3/32"  Welding Details
Filler Metals (QW-404) AWS Classification: ER70S-2 SFA Specification: 5.18 F-No.; 6 A-No. or Chemical Composition: I Filler Metal Product Form: Bare (Solid)	Electrical Characteristics (QW-409)  Current Type and Polarity: DCEN (straight)  Tungsten Type: EWTh-2 Size: 3/32"  Welding Details  Filler Metal Size (in.): 3/32
Filler Metals (QW-404) AWS Classification: ER70S-2 SFA Specification: 5.18 F-No.; 6 A-No. or Chemical Composition: I Filler Metal Product Form: Bare (Solid) Consumable Insert: None	Electrical Characteristics (QW-409)  Current Type and Polarity:  Tungsten Type:  EWTh-2  Size:  3/32"  Welding Details  Filler Metal Size (in.):  Amperage Used:  150
Filler Metals (QW-404) AWS Classification: ER70S-2 SFA Specification: 5.18 F-No.: 6 A-No. or Chemical Composition: I Filler Metal Product Form: Bare (Solid) Consumable Insert: None GFAW Flux: None	Electrical Characteristics (QW-409)  Current Type and Polarity:  Tungsten Type: EWTh-2 Size: 3/32"  Welding Details  Filler Metal Size (in.): 3/32   -   -    Amperage Used: 150   -   -    Voltage Used: Varies   -
Filler Metals (QW-404) AWS Classification: ER70S-2 SFA Specification: 5.18 F-No.: 6 A-No. or Chemical Composition: I Filler Metal Product Form: Bare (Solid) Consumable Insert: None GFAW Flux: None	Electrical Characteristics (QW-409)  Current Type and Polarity:  Tungsten Type:  EWTh-2  Size:  3/32"  Welding Details  Filler Metal Size (in.):  Amperage Used:  150
Filler Metals (QW-404)  AWS Classification: ER70S-2  SFA Specification: 5.18 F-No.; 6  A-No. or Chemical Composition: I  Filler Metal Product Form: Bare (Solid)  Consumable Insert: None  GFAW Flux: None  Weld Deposit 'I' (in.): 0.75	Electrical Characteristics (QW-409)  Current Type and Polarity:  Tungsten Type: EWTh-2 Size: 3/32"  Welding Details  Filler Metal Size (in.): 3/32   -   -    Amperage Used: 150   -   -    Voltage Used: Varies   -
Filler Metals (QW-404)  AWS Classification: ER70S-2  SFA Specification: 5.18 F-No.: 6  A-No. or Chemical Composition: I  Filler Metal Product Form: Bare (Solid)  Consumable Insert: None  GFAW Flux: None  Weld Deposit 'I' (in.): 0.75  Positions (QW-405)  Position of Joint: IG - Flat	Electrical Characteristics (QW-409)  Current Type and Polarity:  Tungsten Type: EWTh-2 Size: 3/32"  Welding Details  Filler Metal Size (in.): 3/32   -   -    Amperage Used: 150   -   -    Voltage Used: Varies   -   -    Travel Speed (in/min): Varies   -   -    Max. Heat Input (J/in): N/R  Technique (QW-410)
Filler Metals (QW-404)  AWS Classification: ER70S-2  SFA Specification: 5.18 F-No.: 6  A-No. or Chemical Composition: I  Filler Metal Product Form: Bare (Solid)  Consumable Insert: None  GFAW Flux: None  Weld Deposit 'I' (in.): 0.75  Positions (QW-405)  Position of Joint: IG - Flat	Electrical Characteristics (QW-409)  Current Type and Polarity:  Tungsten Type: EWTh-2 Size: 3/32"  Welding Details  Filler Metal Size (in.): 3/32   -   -    Amperage Used: 150   -   -    Voltage Used: Varies   -    Travel Speed (in/min): Varies   -    Max. Heat Input (J/in): N/R
Filler Metals (QW-404)  AWS Classification: ER70S-2  SFA Specification: 5.18 F-No.: 6  A-No. or Chemical Composition: I  Filler Metal Product Form: Bare (Solid)  Consumable Insert: None  GFAW Flux: None  Weld Deposit 't' (in.): 0.75  Positions (QW-405)  Position of Joint: IG - Flat  Weld Progression: N/A	Electrical Characteristics (QW-409)  Current Type and Polarity:  Tungsten Type: EWTh-2 Size: 3/32"  Welding Details  Filler Metal Size (in.): 3/32   -   -    Amperage Used: 150   -   -    Voltage Used: Varies   -   -    Travel Speed (in/min): Varies   -   -    Max. Heat Input (J/in): N/R  Technique (QW-410)
Filler Metals (QW-404)  AWS Classification: ER70S-2  SFA Specification: 5.18 F-No.: 6  A-No. or Chemical Composition: I  Filler Metal Product Form: Bare (Solid)  Consumable Insert: None  GTAW Flux: None  Weld Deposit 't' (in.): 0.75  Positions (QW-405)  Position of Joint: IG - Flat  Weld Progression: N/A  Gas (QW-408)	Electrical Characteristics (QW-409) Current Type and Polarity:  DCEN (straight)  Fungsten Type:  EWTh-2  Size:  3/32"  Welding Details  Filler Metal Size (in.):  Amperage Used:  Voltage Used:  Varies  Travel Speed (in/min):  Max. Heat Input (J/in):  Technique (QW-410)  Thermal Processes:  No  Stringer or Weave Bead:  Stringer and weave head
Filler Metals (QW-404)  AWS Classification: ER70S-2  SFA Specification: 5.18 F-No.: 6  A-No. or Chemical Composition: I  Filler Metal Product Form: Bare (Solid)  Consumable Insert: None  GTAW Flux: None  Weld Deposit 't' (in.): 0.75  Positions (QW-405)  Position of Joint: IG - Flat  Weld Progression: N/A  Gas (QW-408)  Shielding: 100% Argon 20 CFII	Electrical Characteristics (QW-409) Current Type and Polarity:  Tungsten Type: EWTh-2 Size: 3/32" Welding Details Filler Metal Size (in.): 3/32   -   -   Amperage Used: 150   -   -   Voltage Used: Varies   -   Travel Speed (in/min): Varies   -   Max. Heat Input (J/in): N/R  Technique (QW-410) Thermal Processes: No Stringer or Weave Bead: Stringer and weave bead

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## Procedure Qualification Record (PQR)

Second Proc	ess:	<b>GMAW</b>			Type:	Semiauton	natic	
Filler Metal:	s (QW-404)				Electrical Characteristics (	QW-409)		
AWS Classif	ication:	ER70S-6	<u> </u>		Current Type and Polarity:		OCEP (reverse)	
SFA Specific	ation: 5.18	F-No.:		6	Transfer Mode:		ray arc	
A-No. or Ch	emical Composition:		1		Welding Details			
Filler Metal I	Product Form:	Bare (S	iolid)		Filler Metal Size (in.):	0.045	-	*
Supplementa	l Filler Metal:	Nor	ie	distribution in the same is	Amperage Used:	280	-	mendant watering
	t 't' (in.):				Wire Feed Speed (in/min):	Varies	l	-
	Than 1/2":				Voltage Used:	28	-	**************************************
Positions (Q	(W-405)				Travel Speed (in/min):	Varies		
Position of Jo	oint:	IG - Flat		traction of the country to the contract of the country of the coun	Max. Heat Input (J/in):		N/R	
Weld Progres	ssion:	N/A		HERMONOVICE CC ON TO A	Technique (QW-410)			
Gas (QW-4)	08)				Thermal Processes:	American and deep	No	- marrow was are reason as in
Shielding:	99% Argon, 1% O2		28	CFH	Stringer or Weave Bead:	A TOTAL CONTRACTOR ASSESSMENT A TOTAL	Stringer bead	ن در
Backing:	None		-	CFH	Nozzle / Gas Cup Size:	managaria (aminatan	1/2"	
frailing:	None None	eccomon sum	o's tylusom in t	CFH	Contact Tube to Work Distar	166;	1/4" to 1/2"	
					Multiple / Single Pass (per si	de):	Multipass	

Municipal WITNESS AREVIEW REVIEW

#### Procedure Qualification Record (PQR)

Page 3 of 3 PQR No.: 1T/M1-S Tensile Test (QW-150) Ultimate Total Ultimate Unit Failure Type Diameter Area and Location Specimen No. (in.) (in²) Load (lb) Stress (PSI) 77400 Ductile - BM 0.496 0.193 14934 1. 76600 Ductile - 8M 0.498 0.195 14940 18 77800 Ductile - BM 21 0.496 0.193 15006 2B 0.498 0.195 14976 76800 Ductile - BM Guided Bend Tests (QW-160) Type and Figure No. Result Type and Figure No. Result QW-4622 Side bend QW-462.2 Side bend Acceptable Acceptable QW-462.2 Side bend Acceptable QW-462.2 Side bend Acceptable Hardness Test - Rockwell-B hardness Location Readings SA-516, Grade 70 BM 76 SA-516. Grade 70 HAZ. 83 90 Weld metal Data transferred to new form 6-Sep-2012. Welder's Name: Evans, Robert I.D. E Stamp No.: E PQR was done and welding of coupon was witnessed by: Heat Exchanger Design, Inc. l'est conducted by: Sherry Laboratories - Muncie, IN Lab Test No.: 1999030779 We certify that the statements in this record are correguland that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASMIL Code. Prepared and Accepted By: 9/6/2012 Quality Control Manager

Multiple WITNESS D

901 East Beecher St

#### Procedure Qualification Record (PQR)

	I-S-BHN es) / Type(s): (1) G				ITI & IMI-S emiautomatic	emissi- cox		Page I of 3
Joint Design (Q Weld Type: Groove Type:	<u></u>	roove weld uble-V groove			Base Metals (QW-403) Specification Type and C SA-516. Grade 70 P-No. I Group No.	irade:	Guidelperson of a set divide on setting	Water to draw with the same of
	0.063 in.	,,		in.	Thickness (in.): 0.	******	10 1-170.	Group (40
Groove Angle:	60 °	deq.			Preheat (QW-406) Minimum Preheat Tempo Preheat Maintenance: Maximum Interpass Tem	of nadas inclusionismos recovers	None	of
,	*	<b>Y</b> ,	,		Postweld Heat Treatme Type:			
(	7-	1/16" ± 1/32"			PWHT Temperature: PWHT Holding Time:	v .josje evo (1-4-0-2004)	None	

#### **DOUBLE VEE GROOVE**

First Process:		GTAW			Type: Manual			
Filler Metals (QV	/-404)				<b>Electrical Characterist</b>	tics (QW-409	)	
<b>AWS Classification</b>	1:	ER70S-2			Current Type and Polar	ity:	DCEN (stra	ight)
SFA Specification:	5.18	F-No.:	6	)	Tungsten Type:	EW1h-2	Size:	3/32"
A-No. or Chemical	Composition:		1		Welding Details	7		
Filler Metal Produc	t Form:	Bare (Sc	olid)		Filler Metal Size (in.):	3/32	•	•
Consumable Insert:		None			Amperage Used:		•	
GTAW Flux:		None			Voltage Used:			
Weld Deposit 't' (in	.):	0.25			Travel Speed (in/min):	7		•
Positions (QW-40	5)				Max. Heat Input (J/in):		19286	
Position of Joint:		IG - Flat	mer c		Technique (QW-410)			
Weld Progression:		N/A		0.000.000	Thermal Processes:		No	W
Gas (QW-408)					Stringer or Weave Bead	: Str	inger and wea	ve bead
Shielding:	100° Argon	ś	20	CFH	Nozzle / Gas Cup Size:		6	
Backing:	None	*		CFH	Multiple / Single Pass t	per side):	Multi	pass
Trailing:	None	1		CFH				

1) Peening was not used with this weld test.

2) No pass > 1/2" thick.

Multiple WITNESS D
REVIEW REVIEW

#### Procedure Qualification Record (PQR)

PQR No.: 17	/MI-S-BHN		-					Page 2 of
Second Proc	ess:	<b>GMAW</b>			Type:	Semiautor	natic	
Filler Metal	s (QW-404)				<b>Electrical Characteristics</b>	(QW-409)		
AWS Classif	ication:	ER70S-6	Whiteham		Current Type and Polarity:		DCEP (reverse	:)
SFA Specific	ation: 5.18	F-No.:		6	Transfer Mode:			
A-No. or Ch	emical Composition:		1		Welding Details			
Filler Metal	Product Form:	Bare (S	olid)		Filler Metal Size (in.):	0.045		
Supplementa	Filler Metal:	Non	e		Amperage Used:	290		1
Weld Deposi	t T (in.):	0.25			Wire Feed Speed (in/min):		•	1
Pass Greater	Than 1/2":	No			Voltage Used:	29		1
Positions (C					Travel Speed (in/min):	6	+	
osition of J	oint:	IG - Flat			Max. Heat Input (J/in):			random o Vivordombiana
	ssion:				Technique (QW-410)			
Gas (QW-4					Thermal Processes:	to the second of	No	
Shielding:	99% Argon, 1% O2		28	CFH	Stringer or Weave Bead			
	None				Nozzle / Gas Cup Size:			
					Contact Tube to Work Dista			
					Multiple / Single Pass (per s	de):	Multipas	s

#### Procedure Qualification Record (PQR)

PQR No.: IT/MI-S-BHN

Tensile Test (QW-150) Diameter Area Ultimate Total Ultimate Unit Failure Type and Location Load (lb) Stress (PSI) (in.)  $(in^2)$ Specimen No. Hardness Test - Brinell hardness Location Readings SA-516. Grade 70 BM - GMA 165 SA-516. Grade 70 BM - GTA 165 176 SA-516. Grade 70 HAZ. - GM SA-516, Grade 70 HAZ - GTA 176 Weld metal 218 Hardness testing performed using a Telebrineller kit. Data transferred to new form 6-Sep-2012. Stamp No.: G Welder's Name: Manor, Greg 1.D.: G PQR was done and welding of coupon was witnessed by: Heat Exchanger Design, Inc Fest conducted by: Heat Exchanger Design, Inc Lab Test No.: We certify that the statements in this record are correctand that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code. 9/6/2012 Quality Control Manager Prepared and Accepted By:

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Rick Windell 56	REVIEW	

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901 East Beecher St

#### Procedure Qualification Record (PQR)

PQR No:: 1T1-IT2	Date: 8/21/2012 WPS No.:	ITI			Page 1 of 3
Welding Process(es) Type(s):	(I) G I A W / Manua)				
Joint Design (QW-402)	Communicated	Base Metals (QW-403)	du.		
Weld Type:	Groove weld Single-V groove	Specification Type and Gra		0'4 E14 C'	J. 70
Groove Type:	n butt, no back weld	SA-285, Grade C		,	de 70
	The state of the s	P-No. 1 Group No.		P-No. 1	Group No. 2
- nomination and notice and notic	in. Root Face: 0.063 in.	Thickness (in.): 0.1875	5 to	0.1875	eriori delle Manifestationi delle
Groove Angle: 60		Preheat (QW-406)			
		Minimum Preheat Tempera	ture:	139	্দ
	to 75 deg.	Preheat Maintenance:	. an governoissessessessessesses	None	***************************************
شر ک	160 75 dag.	Maximum Interpass Tempe		161	
<b>*</b>	*	Coupon preheated to 139° i	F.	ارخاند وحداء ويوجع عصما	anna and and a second and a second and a second
, \	/ /	Postweld Heat Treatment	(QW-407)	)	
	<i>j</i> /	Type:	No PWHT	performed	
<b>Δ</b> Τ   <b>Δ</b>	/. \	PWHT Temperature:	one °F		
/ '/ '		PWIII Holding Time: None hr			
INST ± INST	1/16" ± 1/32"				
SINGLE '	VEE GROOVE	Tyne:	······································	osi	Norman III. oo oler addisel ku eest 100 See
SINGLE First Process:		Type: Electrical Characteristics	Man (OW-409)		S saw of an absorbed below 18 for
SINGLE First Process: Filler Metals (QW-404)	VEE GROOVE  GTAW	Electrical Characteristics	(QW-409)		ieht)
SINGLE  First Process: Filler Metals (QW-404) AWS Classification:	VEE GROOVE	Electrical Characteristics Current Type and Polarity:	(QW-409)		iight) 3/32"
SiNGLE  First Process: Filter Metals (QW-404) AWS Classification: SFA Specification: 5.18	VEE GROOVE  GTAW  ER70S-2  F-No 6	Electrical Characteristics	(QW-409)	DCEN (stra	Carlo Car
SINGLE  First Process: Filler Metals (QW-404) AWS Classification:	VEE GROOVE  GTAW  ER70S-2  F-No 6	Electrical Characteristics Current Type and Polarity: Tungsten Type: EW Pulsed Current:	(QW-409)	DCEN (stra Size:	Carlo Car
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition	VEE GROOVE  GTAW  ER70S-2  F-No.: 6	Electrical Characteristics Current Type and Polarity: Tungsten Type: EW Pulsed Current: Welding Details	( <b>QW-489)</b> /1h-2	DCEN (stra Size: N/A	Carlo Car
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition Filler Metal Trade Name:	VEE GROOVE  GTAW  ER70S-2  F-No.: 6  1  Radnor & ESAB	Electrical Characteristics Current Type and Polarity: Tungsten Type: EW Pulsed Current: Welding Details Filler Metal Size (in.):	(QW-409)	DCEN (stre Size: N/A	Carlo Car
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition Filler Metal Trade Name: Filler Metal Product Form:	VEE GROOVE  GTAW  ER70S-2  F-No.: 6  1: 1  Radnor & ESAB  Bare (Solid)	Electrical Characteristics Current Type and Polarity: Tungsten Type: EW Pulsed Current: Welding Details Filler Metal Size (in.): Amperage Used:	(QW-409) /1h-2 //16 //10-121	DCEN (stra Size: N/A 3/32 165	Carlo Car
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition Filler Metal Trade Name: Filler Metal Product Form: Consumable Insert:	VEE GROOVE  GTAW  ER70S-2  F-No 6  1: 1  Radnor & ESAB  Barc (Solid)  None	Electrical Characteristics Current Type and Polarity: Tungsten Type: EW Pulsed Current: Welding Details Filler Metal Size (in.):	( <b>QW-409)</b> /1h-2 	DCEN (stra Size: N/A 3/32 165	Carlo Car
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition Filler Metal Trade Name: Filler Metal Product Form: Consumable Insert: GTAW Flux:	VEE GROOVE  GTAW  ER70S-2  F-No 6  1  Radnor & ESAB  Barc (Solid)  None  N/A	Electrical Characteristics Current Type and Polarity: Tungsten Type: EW Pulsed Current: Wetding Details Filler Metal Size (in.): Amperage Used: Voltage Used:	(QW-409) /Th-2 1/16 110-121 14.7-16.1 3.30	DCEN (stre Size N/A 3/32 165	Carlo Car
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition Filler Metal Trade Name: Filfer Metal Product Form: Consumable Insert: GTAW Flux: Weld Deposit 't' (in.):	VEE GROOVE  GTAW  ER70S-2  F-No 6  1  Radnor & ESAB  Barc (Solid)  None  N/A	Electrical Characteristics Current Type and Polarity: Tungsten Type: EW Pulsed Current: Wetding Details Filler Metal Size (in.): Amperage Used: Voltage Used: Travel Speed tin/min):	(QW-409) /Th-2 1/16 110-121 14.7-16.1	DCEN (stra Size: N/A 3/32 165 17.9 3.88	Carlo Car
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition Filler Metal Trade Name: Filfer Metal Product Form: Consumable Insert: GTAW Flux: Weld Deposit 't' (in.): Positions (QW-405)	FR70S-2 F-No 6  Radnor & ESAB Bare (Solid) None N/A 0.1875	Electrical Characteristics Current Type and Polarity: Tungsten Type: f:W Pulsed Current: Wetding Details Filler Metal Size (in.): Amperage Used: Voltage Used: Travel Speed tin/min): Max. Heat Input (J/in):	(QW-409) /Th-2 1/16 110-121 14.7-16.1 3.30	DCEN (stra Size: N/A 3/32 165 17.9 3.88	Carlo Car
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition Filler Metal Trade Name: Filfer Metal Product Form: Consumable Insert: GTAW Flux: Weld Deposit 't' (in.): Positions (QW-405) Position of Joint:	FR70S-2 F-No 6  Radnor & ESAB Bare (Solid) None N/A 0.1875	Electrical Characteristics Current Type and Polarity: Tungsten Type: EW Pulsed Current: Wetding Details Filler Metal Size (in.): Amperage Used: Voltage Used: Travel Speed tin/min): Max. Heat Input (J/in): Technique (QW-410)	(QW-409) (Th-2 1/16 110-121 14-7-16.1 3.30	DCEN (stre Size: N/A 3/32 165 17.9 3.88 45673	3/32
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition Filler Metal Trade Name: Filler Metal Product Form: Consumable Insert: GTAW Flux: Weld Deposit 't' (in.): Positions (QW-405) Position of Joint: Weld Progression:	ER70S-2 F-No.: 6  Radnor & ESAB Bare (Solid) None N/A 0.1875  3G - Vertical Vertical op	Electrical Characteristics Current Type and Polarity: Tungsten Type: f:W Pulsed Current: Wetding Details Filler Metal Size (in.): Amperage Used: Voltage Used: Travel Speed tin/min): Max. Heat Input (J/in): Technique (QW-410) Thermal Processes:	(QW-409) (Th-2 1/16 110-121 14-7-16.1 3.30	DCEN (stre Size: N/A 3/32 165 17.9 3.88 45673	3/32
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition Filler Metal Trade Name: Filler Metal Product Form: Consumable Insert: GTAW Flux: Weld Deposit 't' (in.): Positions (QW-405) Position of Joint: Weld Progression: Gas (QW-408)	ER70S-2 F-No.: 6  Radnor & ESAB Bare (Solid) None N/A 0.1875  3G - Vertical Vertical op	Electrical Characteristics Current Type and Polarity: Tungsten Type: EW Pulsed Current: Welding Details Filler Metal Size (in.): Amperage Used: Voltage Used: Travel Speed tin/min): Max. Heat Input (J/in): Technique (QW-410) Thermal Processes: Stringer or Weave Bead:	(QW-409) (Th-2 1/16 110-121 14.7-16.1 3.30	DCEN (stre Size: N/A 3/32 165 17.9 3.88 45673 No nger and wea	3/32"

1.16" size filler used Radnor beat # SA94784: 3.32" size filler used ESAB heat # 065938.

Mundell Review Review

#### Procedure Qualification Record (PQR)

PQR No.: 1T1-1T2

Page 2 of 3

			Additional V	Veiding Parameters			
Layer(s)	The second secon	Filler Met	al	Currer	nt		Travel Speed
and/or		AWS	Size	Type and	Amperage	Voltage	Range
Pass(cs)	Process	Classification	(in.)	Polarity	Range	Range	(in/min)
1	GTAW	ER70S-2	1/16	DCEN (straight)	110-121	14.7-16.1	3.30
2	GTAW	ER70S-2	3/32	DCEN (straight)	113-165	15.4-17.9	3.88
3	GTAW	ER70S-2	3/32	DCEN (straight)	76-111	13.3-17.0	2,65
4	GTAW	ER70S-2	3/32	DCEN (straight)	92-177	13.5-14.5	4.0

Pass layer #4 applied from the back side after back grinding.

## TEST TEMPERATURE DETERMINATION:

Test temp, determined per UG-84(e)(5)(b): test shall be conducted at a temp, lower than the MDMT by an amount equal to the difference of the temp, reductions in Table UG-84.2 for the actual material thickness and the specimen thickness....

Actual material thickness: 0.1875" Temp Reduction: 22°F (interpolated)

Specimen thickness: 0.131°

Temp Reduction: 35°F

Applicable test temp. reduction: 35° minus 22° F = 13° F

Test temperature differential per l'able UG-84.4: SA285-C min Y = 30 ksi: SA516-70 min Y = 38 ksi

therefore 10° f' test temp, credit.

Final result is the -56° F test temperature qualities for -53° F.

Rick Windell S REVIEW

#### Procedure Qualification Record (PQR)

Page 3 of 3 PQR No.: 1T1-IT2 Toughness Tests (QW-170) Drop Test Impact Specimen Notch Notch Temp. Value Lateral Expansion Weight (Mils) Number Location Type (°F) (H-lb) o Shear Break 47 HAZ-285 "V" -56 22 65 70 "V" 25 70 **HAZ-285** -56 HAZ-285 -56 14 25 40 3 "V" 40 37 Weld metal -56 17 "V" 19 45 4 Weld metal -56 Weld metal "V" -56 22 60 46 "V" 30 HAZ-516 -56 13 80 "V" 8 HAZ-516 -56 25 18 6 9 HAZ-516 "V" -36-9 40 Hardness Test - Vickers hardness Location Readings SA-285, Grade C BM 152 162 163 147 SA-285. Grade C HAZ 153 156 173 180 SA-516. Grade 70 BM 158 SA-516, Grade 70 HAZ 204 194 193 153 156 Weld metal 156 SA516-70 min. specified yield = 38 ksi: Min. impact results of full size specimens = 15 FT/LB per Fig. UG-84.1. \$A285-C min. specified yield = 30 ksi: Min. impact results of full size specimens = 15 FT/LB per Fig. UG-84.1. IMPACT TESTING NOTES: Full size specimen = 10mm. Test specimen size of 3.3mm = 0.33 Factor. 15 FT/LB x 0.33 = 4.95 FT/LB min. average. 4.95 FT/LB x 0.66 = 3.27 FT/LB min. single specimen. See Weld Detail page for determination of test temperature. Welder's Name: Curtis, David LD.: X Stamp No.: X PQR was done and welding of coupon was witnessed by Heat Exchanger Design, Inc. Lab Test No.: B12081888 l'est conducted by: Sherry Laboratories - Broken Arrow, OK We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASMI Code. Prepared and Accepted By 96.2012 Quality Control Manager

Multiple SE REVIEW REVIEW

## Welding Procedure Specification (WPS)

WPS No.: 1M1-S Supporting PQR(s): 1T/M1-S, 1T/M1 Welding Process(es) / Type(s): (1) GN			6	Date: 9/6/2012		Page 1 of 2	
Joint Design (QW-402) Weld Type: Groove and fillet			The foliage and discount of the				
Double bevel Go	Backing No backing No backing buged & back welde buged & back welde	3 3 d <u>l</u> d	ot Opening /16" max 16" max /4" max	Groove Angle 50 deg min 45 deg min 50 deg min 45 deg min	Root Face 1.8" max 1.8" max 3.16" max 3.16" max	Groove Radius	
Double-V groove Square groove Square groove Fillet Welds: All fillet sizes on all bas	T-joint No backing se metal thicknesses	3	32" max 32" max 32" max neters	45 deg min	3-16" max		
Retainers: None WELD JOINT DESCRIPTIONS SHO REFERENCE IN AN ENGINEERING JOINTS SHOWN IN THIS WPS							
Base Metals (QW-403)           P-No.         1         Group No.           to P-No.         1         Group No.		s Range: 0,	1875 in. to 10	2.6400 in			
Preheat (QW-406)			Postweid F	leat Treatment (QV	V107)		
Minimum Preheat Temperature:	50	એ.		e. No PWH I will be	•	3.	
Maximum Interpass Temperature: Prehent Maintenance:	293 None	ol-	PWIII Ten	•	Vone Vone	ŋ	
1) Maximum interpass temp. 293° F ap		licutions	1 4111 1101	ung ime	TONE		
only							
2) Preheat to 200° F min, if weld depo	sit > 1.25" and 🚈	1.50".					
Initial and Interpass Cleaning: With v Method of Back Gouging: When requ				of weld joint			
Minimum preheat must be maint     Welds shall be cleaned between	tained during ther	mal cutting	, tacking, an				
3) Charpy Impact qualified to -53° I 4) Impact qualified: -53° F for 0.09 preheat & 293° F max. interpass to qualified	F. See PQR 1M1- 4" min. (limited to emp. Flat and home	S-CIT for d 0.1875" mi zontal posi	letails n.) base mei tions only qu	tal thknss, 23627 J	in max heatinpu		
5) See PQR's 1T/M1-S-BHN and I	M1-S-CIT for hard	iness lest r	results				
Rev. 6: Re-performed PQR 1M1-S- transferred to new forms.	-CIT Revised not	es accordir	ngly This Wi	PS and existing PQ	R's 1T/M1-S and '	1T/M1-S-BHN	
We certify that the statements in the requirements of Section IX of the	,	A-	e test welds w	ere prepared, welded.	, and tested in accor	dance with the	
Prepared and Accepted By	Devil	Med receivance	ergu	9 6 2012 Date	Quality Control Ma	mager PA	11/12
					101	100	
				14	Russel		WITNESS
PERHISSIONS TO PROCEED DOES NOT CONSTITUTE ACCEPTANT APPROVAL OF OCCORN DEDUIS, CALCULATIONS, ANALYSES, APPROVAL OF OCCORN DEDUIS, CALCULATION THE SUP JANO DOES NOT RELIEVE SUPPLIER FROM F	HST PLIEN		BANTREL VENDOR PRINT	JOB MR NO	VRMPK MARKLEI	156	REVIEW
COMPLIANCE WITH CONTRACTUAL OBLICATIONS.	7		EQUIPMENT HUMBEL CLIENT	BL-E-30		/	
WORK MAY PROCEED  2. BELIES BUS BEST WINDY MAY BRANCED SIEST		<b>~</b>	CROSS-RET -				
REVISE AND RESUBINIT WORK MAY PROCEED SUBJI- TO INCORPORATION OF CHANGES INDICATED  REVISE AND RESUBINIT WORK BINALL INDT PROCEE	- Can	1AW-	spray	transfer st	nd be res	brussurace	and _
4. REVIEW NOT RECURRED WORK MAY PROCEED.  BY 1ATT DATE ADDITE	OL TOTAL	<del> pass</del>	<del>25 01</del>	by, when	Mari Fee	mi Oli, Farmai (	7
unic, /TP/11	01,2013	<del>√√ √√</del>	elds pe	r Cenorus	Welding	The total	
	<u> </u>	The	comm	rent is del	eted.		

#### Welding Procedure Specification (WPS)

maximum OS-6 1 re (So id)		No Pass Grenter Fhan 2" A/low SFA Specification: 5.18	emiautomatic sed F-No. 6
0S-6 1			
11		SFA Specification: 5.18	Γ-No. 6
l re (So id)			
re (So id)			
		Technique (QW-410)	
tions		Stringer or Weave Bead	Stringer bead
y		Nozzle Gas Cup Size:	3 8" to 5 8"
		Peening:	None
25-40	CFH	Contact Tube to Work Distance	: I-4" to I 2"
-	CFH	Multiple Single Pass (per side)	i: Single or multipuss
-	CHI		
P (reverse)			
rc			
/55			
	25-40	25-40 CFH - CFH - CHI P (reverse)	Peening:  25-40 CFH Contact Tube to Work Distance - CFH Multiple Single Pass (per side - CHI  P (reverse)

Maximum Heat Input applies to Supplementary Essential applications (Impacts). Consider qualified base metal ranges when deriving value. Value derived from formula:

Volts v Amps v 60 Travel Speed (inches/minute)

#### First Process Welding Parameters

			***************************************				
flayer(s)	Filler Met	al	Curre	ent	Wire		I ravel Speed
and/or	AWS	Size	Lype and	.\mperage	Feed Speed	Voltage	Range
Pass(es)	Classification	(in.)	Polarity	Range	(in mm)	Range	(in/min)
Λny	ER70S-6	0.035	DCEP (reverse)	160-225	Variable	24-32	Variable
Any	ER70S-6	0.045	DCEP (neverse)	190-350	Variable	29-34	Variable
Any	ER70S-6	1-16	DCEP (reverse)	200-400	Variable	29-34	Variable

Rick Windell SC REVIEW 2013 Form 813 - Form

#### Procedure Qualification Record (PQR)

Joint Design (QW-402)		Base Metals (QW-4	(03)				
Weld Type:	Groove weld	Specification Type ar	nd Grade:				
Groove Type: D	ouble-V groove	SA-516. Grade 70	to 5	A-5 /6, Grade	270		
	ed and back welded	P-No. 1 Group	No. 2 to P-	No I	Gro≕p No.		
Root Opening: 0.063 in.	Root Face: 0.063	in. Thickness (in.):	8 to				
Groove Angle: 60 °	75 deg.	Preheat (QW-406) Minimum Preheat Le Preheat Maintenance Maximum Interpass 1	mperature:	50 None 550	' <b>ት</b>		
Y	<b>Y</b>	Postweld Heat Treat	tment (QW-407)				
, \	/ ,		Type: No PWHT performed				
		PWH F Temperature	No	ne.	ા		
1/8" ± 1/18"	100 ± 102	PWH F Holding Time	: Y	one	,, hr		
DOUBLE VE	EE GROOVE	Tunas	Manu	ra!			
DOUBLE VE	EE GROOVE GTAW	Type:	Manu	sa <b>i</b>			
DOUBLE VE First Process: Filler Metals (QW-404)	GTAW	Electrical Character	istics (QW-409)		ehti		
DOUBLE VE First Process: Filler Metals (QW-404) AWS Classification:	GTAW ER70S-2	Electrical Character Current Type and Pol	ristics (QW-409) arity:	DCEN (straig	-		
DOUBLE VE First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18	GTAW ER70S-2	Electrical Character Current Type and Pol Tungsten Type	istics (QW-409)		ght) 3.32*		
DOUBLE VE First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition:	GTAW  ER70S-2  F-No.: 6	Electrical Character Current Type and Pol	ristics (QW-409) arity: EWH1-2	DCEN (straig	-		
DOUBLE VE First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition: Filler Metal Product Form:	GTAW ER70S-2 F-No.: 6	Electrical Character Current Type and Pol Fungsten Type: Welding Details Filler Metal Size (in.)	ristics (QW-409) arity: EWH1-2	DCEN (straig	-		
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition: Filler Metal Product Form: Consumable Insert:	GTAW  ER70S-2  F-No.:  Bare (Solid)	Electrical Character Current Type and Pol Fungsten Type: Welding Details	ristics (QW-409) arity: EW Hi-2	DCEN (straig	-		
DOUBLE VE First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: SFAW Flux:	GTAW  ER70S-2 F-No.: 6  Bare (Solid)  None	Electrical Character Current Type and Pol Fungsten Type: Welding Details Filler Metal Size (in.) Amperage Used:	istics (QW-409) arity: EW Hi-2 : 3 32 150 Vuries	DCEN (straig	-		
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: SFA Specific	GTAW  ER70S-2 F-No.: 6  Bare (Solid) None None	Electrical Character Current Type and Pol Fungsten Type Welding Details Filler Metal Size (in.) Amperage Used: Voltage Used:	istics (QW-409) arity: EW Hi-2 : 3 32 150 Varies : Varies	DCEN (straig	-		
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: SFA Weld Deposit 't' (in.): Positions (QW-405)	GTAW  ER70S-2 F-No.: 6  Bare (Solid) None None	Electrical Character Current Type and Pol Fungsten Type: Welding Details Filler Metal Size (in.) Amperage Used: Voltage Used: Fravel Speed (in/min)	istics (QW-409) arity: EW Hi-2  150 Varies  Varies  O:	DCLN (straig Size: - -	-		
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: SFA Specific	GTAW  ER70S-2 F-No.: 6  Bare (Solid) None None 0.75	Electrical Character Current Type and Pol Fungsten Type: Welding Details Filler Metal Size (in.) Amperage Used: Voltage Used: Fravel Speed (m/min) Max. Heat input (J-in	istics (QW-409) arity: EW Hi-2  150 Varies  Varies  O:	DCLN (straig Size: - -	-		
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: SFA Specific	GTAW  ER70S-2 F-No.: 6  Bare (Solid) None None 0.75  IG - Flat	Electrical Character Current Type and Pol Fungsten Type: Welding Details Filler Metal Size (in.) Amperage Used: Voltage Used: Fravel Speed (m/min) Max. Heat Input (J in Technique (QW-410	istics (QW-409) arity:	DCEN (straig Size:	3-32*		
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: STAW Flux: Weld Programmed Insert: SFAW Flux: Weld Deposit 't' (in.): Positions (QW-405) Position of foint: Weld Progression: Gas (QW-408)	GTAW  ER70S-2 F-No.: 6  Bare (Solid) None None 0.75  IG - Flat N/A	Electrical Character Current Type and Pol Fungsten Type: Welding Details Filler Metal Size (in.) Amperage Used: Voltage Used: Fravel Speed (m/min) Vax. Heat Input (J in Technique (QW-410 Thermal Processes:	istics (QW-409) arity:	DCEN (straig Size: - - N/R No nger and weav-	3-32** - - - - -		
First Process: Filler Metals (QW-404) AWS Classification: SFA Specification: 5.18 A-No. or Chemical Composition: Filler Metal Product Form: Consumable Insert: GTAW Flux: Weld Deposit 't' (in.): Positions (QW-405) Position of foint: Weld Progression: Gns (QW-408)	GTAW  ER70S-2 F-No.: 6  Bare (Solid) None None 0.75  IG - Flat N/A	Electrical Character Current Type and Pol Fungsten Type: Welding Details Filler Metal Size (in.) Amperage Used: Voltage Used: Fravel Speed (m/min) Max. Heat Input (J-in Technique (QW-410 Thermal Processes: Stringer or Weave Be	istics (QW-409) arity:	DCEN (straig Size: - - NR No oger and weave	3.32**		

Rick Windell SG REVIEW 2911 Formal 811 Formal 81

#### Procedure Qualification Record (PQR)

PQR No 117	WI1-S					LEGS 7 01 7
Second Proce	\$\$:	GMAW		Type:	Semiautomatic	
Filler Metals	(QW-404)			Electrical Characteristics	(QW-409)	
AWS Classific	ation.	ER70S-6		Current Type and Polarity:	DCEP (reverse	) <u> </u>
	tion: 5.18	F-No.:	6	Transfer Mode:	Spray arc	
A-No. or Cher	nical Composition:	!		Welding Details		
Filler Metal Pr	roduct Form:	Bare (Solid)		Filler Metal Size (in.)	0.045	: •
Supplemental	Filler Metal:	None	-	Amperage Used:	280 -	·
Weld Deposit	't' (in.):	0.75		Wire Feed Speed (in min):	Varies -	i . •
Pass Greater T	han 1/5":	No		Voltage Used	28	·
Positions (Q\	₩-405)			Travel Speed ('n min):	Vuries -	· . •
Position of Joi	nt:	1G - Flat		Max. Fleat input (J'in):	N/R	
Weid Progress	ion:	N A		Technique (QW-410)		
Gas (QW-408	B)			Thermal Processes:	No	
Shielding:	99% Argon. I% O2	28	CFH	Stringer or Weave Bead.	Stringer bead	
Backing:	None	· •	CFH	Nozzie Gas Cup Size	1/2"	
frailing:	None	-	CHI	Contact Tube to Work Dista	nee   4° to 1.3	<b>)</b> "
				Multiple   Single Pass (per s	ide) Multipas	s

Rick Windell SG REVIEW 2812 berm 011 berm 011

<sup>1)</sup> Peening was not used with this weld test.

<sup>2)</sup> No pass > 1.2" thick.

#### Procedure Qualification Record (PQR)

PQR No.: IT/MI-S

Page 3 of 3

Tensile Test (QW-150) Diameter Area Ultimate Total Ultimate Unit Failure Type (in<sup>a</sup>) Stress (PSI) and Location (in) Load (lb) Specimen No. 0 193 77400 Ductile - BM 11 0.496 14934 0.498 0.195 76600 14940 Ductile - BM lΒ 2 <u>r</u> 0.496 0.193 15006 77800 Ductile - BM 76800 28 0.498 0.195 14976 Ductile - BM Guided Bend Tests (QW-160) Type and Figure No. Result Type and Figure No. Result QW-462.2 Side bend Acceptable QW-4622 Side bend Acceptable QW-462.2 Side bend Acceptable QW-4622 Side bend Acceptable Hardness Test - Rockwell-8 hardness Location SA-516. Grade 70 BM 76 SA-516. Grade 70 IIAZ 83 Weld metal 90 Data transferred to new form 6-Sep-2012. Stamp No., E 1.D.: E Welder's Name: Evans, Robert PQR was done and welding of coupon was witnessed by: Heat Exchanger Design, Inc. Lab Test No.: 1999030779 Lest conducted by: Sherry Laboratories - Muncie, IN We certify that the statements in this record are correct and that the test wolds were prepared, welded, and tested in accordance with the requirements of Section 1X of the ASME-Code. Who Hellings Prepared and Accepted By: 9/6-2012 Quality Control Manager Date

Rick Windell SC REVIEW 2011 Farm 011 - Format (

#### Procedure Qualification Record (PQR)

Joint Design (QW-	402)				Base Metals (QW-4	031			
Weld Type:		roove weld			Specification Type an				
Groove Type:	Do	uble-V groove			SA-516. Grade 70			SA-516, Gra	de 70
Backing:		ed and back weld	********			No. 2		P-No. 1	
	0.063 in.		0.063	in.	Thickness (in.):	0.5	10	1-1401	Group 140.
Groove Angle:	60	ADDI PACE.	V.V0J	411.			=		
CHOOVE MIRIE.	00				Preheat (QW-406)				
					Minimum Preheat Te	•	<b>:</b> :	50	°F
	60 to 75	den.			Preheat Maintenance:			None	
	1	~			Maximum Interpass I	emperati	ire:	550	۶.
	*	<b>y</b>			Postweid Heat Treat	ment (Q	W-407	)	
\					Type:	No	PWIIT	performed	
7	1	/1			PWHT Temperature:		N	one	ek.
	T ) (	1/16" ± 1/32"			PWHT Holding T'me	:	1	Nonc	hr.
1	1 / !								
<del> </del>	_ <b>_</b> _/	\ <u></u>							
,	1/8"± 1/16"	/							
	DOUBLE VE	GROOVE							
First Process:		GTAW			Type:		Mar	uai	
Filler Metals (QW-	404)				Electrical Character	istics (Q	W-409	)	
AWS Classification:		ER70S-2			Current Type and Poli	urity:		DCEN (stm	night)
SFA Specification:	5.18	F-No:	6		Fungsten Type:	EWTh	-2	Size:	3/32"
A-No or Chemical C	Composition:	1			Welding Details	2	-		
Filler Metal Product	Form:	Bare (Solid)			Filler Metal Size (in.)	:	3/32		
Consumable Insert:		None			Amperage Used:		150	-	
GFAW Flux:		None			Voltage Used:		15	-	
Weld Deposit 't' (in.)	I.	0.25			travel Speed (in/min)	) <u>.</u>	7	-	
Positions (QW-405)	}				Max. Heat Input (J/in	l:		19286	
Position of Joint:		IG - Flat			Technique (QW-410	)) -			
Weld Progression:		N.Y			Thermal Processes:			No	
Gas (QW-408)					Stringer or Weave Bea	ad:	Str	inger and wea	ve bead
Shielding:	100% Argon	20	<b>;</b>	CFII	Nozzle Gus Cup Siza	e:		- 6	
Backing.	None	-		CFII	Multiple Single Pass	(per side	):	Multi	pass
frailing:	None	-		CFH		•			•
1) Peening was not u 2) No pass ~ 1.2" thi		ld test.							
!) No pass * 1 2" the	uk								
		1		ا (رج	leff	W/iTN	ESS	П	
		M	M	ile	lell,	WITN	ESS	]011 Fee	muti forma

#### Procedure Qualification Record (PQR)

FQK 140	7:411-3-011:4								1 860 - 01 0
Second Proc	ess;	GMAW			Type:	Semiaut	omatic		
Filler Metals	s (QW-404)				Electrical Characteristics	(QW-409)			
AWS Classif	ication:	ER70S-6			Current Type and Polarity		DCE	(revers	e)
SFA Specific	ation: 5 18	F-No.:	6		Transfer Mode:		Spray a	ne	
A-No. or Che	emical Composition:	1			Welding Details				
Filler Metal	Product Form:	Bare (Solid)			Filler Metal Size (in.)	0.045	_1		
Supplemental	Filler Vietal	None			Amperage Used	290	_}	•	1
Weld Deposi	l 't' (in.):	0.25			Wire Feed Speed (in/min):	varies			1,
Pass Greater	Than 'a".	No			Voltage Used:	29	1	-	
Positions (Q					Travel Speed (in/min):	6			
Position of Jo	oint:	IG - Flat			Max Heat Input (J/in):			100	
	ssion	N A			Technique (QW-410)				
Gas (QW-46					Thermal Processes:		No		
Shielding:	99% Argon. 1% O2	28	1	CFH	Stringer or Weave Bend:		Strin	er bead	***
Backing:	None	-		CFH	Nozzle Gas Cup Size		. 1	2"	
l'railing:	None			CFH	Contact Tube to Work Dista	nce.		4" to 1	2*
-					Multiple Single Pass ther's	ide):		Multipa	ss

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<sup>1)</sup> Peening was not used with this weld test.
2) No pass > 1/2" thick.

#### Procedure Qualification Record (PQR)

Page 3 of 3 PQR No.: 1T/M1-S-BHN Tensile Test (QW-150) Diameter Ultimate Total Ultimate Unit Area Failure Type Specimen No. (in.) (in²) Load (ib) Stress (PS1) and Location Hardness Test - Brinell hardness Location Readings SA-516, Grade 70 BM - GMA 165 SA-516. Grade 70 BM - GTA 165 SA-516. Grade 70 HAZ - GM 176 SA-516. Grade 70 HAZ - GTA 176 Weld metal 218\_ Hardness testing performed using a Telebrineller kit. Data transferred to new form 6-Sep-2012. Welder's Name: Manor, Greg I.D. G Stamp No G PQR was done and welding of coupon was witnessed by: Heat Exchanger Design, Inc Fest conducted by. Heat Exchanger Design, Inc. Lah Test No -We certify that the statements in this record are correct/and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME-Code. Prepared and Accepted By: 9/6/2012 Quality Control Manager

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#### Procedure Qualification Record (PQR)

PQR No.: IM1-S-C		Date: 8/21/2012		: <u>IMI-S</u>		Page 1 of 3		
Welding Process(es)  Joint Design (QW-		AVIAW / Semiautom	BCIC	Base Metals (QW-403)				
Weld Type.	•	roove weld		Specification Type and Gr	rade:			
Groove Type:		ngle-V groove		SA-285, Grade C	to SA-516.	Grade 70		
Backing:		ed and back weld		P-No. 1 Group No.				
-	0.063 in.	*	.063 in	4, 1440				
Groove Angle:						<u> </u>		
0.00 to 1 (11) Bio.				Preheat (QW-406)		³F		
				Minimum Preheat Temper		-		
	80 la 75	den.	Preheat Maintenance	Non				
	1			Maximum Interpass Temp Coupon preheated to 143°	·3 ·r			
	*	7			•			
\		/		Postweld Heat Treatment (QW-407)				
2	1	7		Type:	d			
	т \	/		PWIIT Temperature:	None	. °F		
1	1 \/	/		PWIIT Holding Time:	None	hr.		
<del> </del>		+						
1		-1/15 ± 1/32						
	185 ± 1716							
	SINGLE VEE	GROOVE						
First Process:		GMAW		Type:	Seminutomatic			
Filler Metals (QW-	-404)			Electrical Characteristics	s (QW-409)			
AWS Classification:		ER70S-6		Current Type and Polarity:	: DCLP	(reverse)		
SFA Specification:	5.18	No.:	6	Fransfer Mode:	Sprus arc			
A-No, or Chemical (	Composition.	ı		Welding Details	• •			
Filler Metal Trade N	•	National Standard		Filler Victul Size (in )	0.045			
Filler Metal Product	Form:	Bure (Solid)		Amperage Used	350			
Supplemental Filler	Vietal:	None		Wire Feed Speed (in/min)	330			
Weld Deposit 'I' (in.)	):	0.1875		Voltage Used:	25			
Pass Greater Than		No		Fravel Speed (in/min):	22.22-26.32			
Positions (QW-405				Max. Heat Input (J/in):	236	27		
Position of Joint.	-	G - Horizontal		Technique (QW-410)				
Weld Progression:	_	N/A		Thermal Processes:	No			
Gas (QW-408)				Stringer or Weave Bead:	Stringe	er bead		
	a Argon. (% O3	10	CFH	•	1 2			
Backing:	Vone	-	CFII		lance:	4"-1 2"		
l railing.	None	•	CHI			and multipass		

Filter metal heat # D80522 | Chemical elements verified as C ± 0.07, Mn  $\approx$  1.46; Si = 0.84. Wire feeder setting # 3.2.

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#### Procedure Qualification Record (PQR)

PQR No.: 1M1-S-CIT

Page 2 of 3

Additional Welding Parameters							
Layer(s)		Filler Met	al	Curren	1		Travel Speed
and/or		AWS	Size	Type and	Amperage	Voltage	Range
Pass(es)	Process	Classification	(in.)	Polarity	Range	Range	(in/min)
1	GMAW	ER70S-6	3/32	DCEP (reverse)	350	25	22.22
2	GMAW	ER705-6	3/32	DCEP (reverse)	350	25	26 32
3	GMAW	ER70S-6	3/32	DCEP (reverse)	350	25	23.81

Pass layer # 3 applied from the back side after back grinding.

## TEST TEMPERATURE DETERMINATION:

Test temp, determined per UG-84(c)(5)(b); test shall be conducted at a temp, lower than the MDMT by an amount equal to the difference of the temp, reductions in Table UG-84.2 for the actual material thickness and the specimen thickness....

Actual material (hickness: 0.1875" Temp Reduction: 22°F (interpolated)

Specimen thickness: 0.131"

Temp Reduction: 35°F

Applicable test temp. reduction: 35° minus 22° F = 13° F

Lest temperature differential per Table UG-84.4: SA285-C min Y = 30 ksi: SA516-70 min Y = 38 ksi

therefore 10° F test temp, credit.

Final result is the -56° F test temperature qualifies for -53° F.

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#### Procedure Qualification Record (PQR)

PQR No.: IMI-S-CIT Page 3 of 3

Toughness Tests (QW-170)							
			Test	Impact			Drop
Specimen	Notch	Notch	Temp.	Value		Luteral Expansion	Weight
Number	Location	lype	(°F)	(II-lb)	o Shear	(Mils)	Break
ı	HAZ-285	"V"	-56	11	35	26	
2	HAZ-285	"V"	-56	23	95	54	<u>.</u> . <del>.</del>
3	HAZ-285	"V"	-56	15	45	36	-
4	Weld metal	"V"	-56	22	70	39	
5	Weld metal	"V"	-56	7	25	14	
6	Weld metal	"V"	-56	30	75	49	•
7	HAZ-516	"V"	-56	7	55	18	•
8	HAZ-516	"V"	-56	6	55	17	
9	HAZ-516	"V"	-56	7	55	18	•

#### Hardness Test - Vickers hardness

Location	11 41 1 10 11 11	Commence of the contract of		Readings		
SA-285. Grade C BM	156	157				
SA-285, Grade C HAZ	163	186			-	
SA-516. Grade 70 BM	172	195				
SA-516. Grade 70 HAZ	203	215	,			
Weld metal	190	196				

SA516-70 min, specified yield 138 kgi; Min, impact results of full size specimens = 15 F1/LB per Fig. UG-84.1. SA285-C min. specified yield = 30 ksi: Min, impact results of full size specimens 15 F1/LB per Fig. UG-84 L. IMPACT TESTING NOTES:

Full size specimen = 10mm. Test specimen size of 3.3mm = 0.33 Factor.

15 l'1 l.B x 0.33 = 4.95 FT/LB min, average, 4.95 FT/LB x 0.66 = 3,27 l'1 l.B min, single specimen.

See Weld Detail page for determination of test temperature.

Welder's Name: Curtis, David

Stamp No.: X

PQR was done and welding of coupon was witnessed by: Heat Exchanger Design, Inc.

Test conducted by: Sherry Laboratories - Broken Arrow, OK

Lab Test No.: B12081887

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

Prepared and Accepted By:

9-6-2012 Quality Control Manager

Rick Windell S REVIEW REVIEW

# HEAT EXCHANGER DESIGN INC.



# 901 East Beecher Street • Indianapolis, IN. 46203 WELDER OR WELDING OPERATOR PERFORMANCE QUALIFICATION

Stamp: <u>A</u> Welder's	Name: JON ALL	ISON		Date: 10/18/00
WPS No: <u>1T1</u> Welding process used: <u>GTA</u>	Rev: 05 WP	Q Number:		Date: <u>10/17/02</u>
Welding process used: GTA	W / manual	to	SA-10	6, Grade B
Base material(s): SA	-100, Grade b			or grade b
Wolding wariables (OW-350	) Actua	l Values	Range	Qualified
Welding variables (QW-350 Type of weld joint	Pine	Groove		and Fillets
** Backing (QW-402)	No bac	king need		Without backing
P-No. to P-No. (QW-403).	1 NO Dat	to 1		
P-No. to P-No. (QW-405).	····	2750	1 00	" minimum
Pipe diameter - groove (i	11.)	3730 4360		PS limits
Base metal thickness (in. AWS classification (info)	J <u>U.</u>	4300	WI	5 IIIIIUS
AWS classification (info)	<u> </u>	10		E VV
Filler metal spec. (SFA N	0.)	6		5.XX F 6
Filler metal F-Number	· · · ·		Wi thou	
Consumable insert	<u>NO 1118</u>	ert useu	WICHOUN	insert only
Weld deposit - groove (in	.)	4300		20" maximum
Welding position (QW-405) Weld progression	<u>DG -</u>	45 Deg.		positions
Weld progression	···· vert	ical Up	vert	ical Up (n4)
Backing gas (QW-408)				nout backing gas
GTAW welding current/pola				straight) only
Machine welding (QW-360)	Actua	l Values		Qualified
Direct/Remote visual cont				n.a.
Automatic joint tracking.	· · · · <u> </u>	.a.	<del>,</del>	n.a.
Single/multiple pass per	sider	.a.		n.a.
(n4) The root pass when i	t is removed to	o sound weld	metal in thash pass may	ne preparation y be up or down.
		Test Results		
Figure No. and Type	Result	Figure No.	and Type	Result
None		None		
None		None	•	,
None	,	110116		
Radiographic test results	: Acceptable r	er QW-302.2	and QW-191	
Other test notes : Visual	examination s	atisfactory )	per <u>QW-302.4</u>	4 and OW-190.
Welding test conducted by	. Hoat Evobano	or Decim		
Mech. tests conducted by:			Lab test no.	. IN-6212A
We certify that the state coupons were prepared, we of Section IX of the ASME	lded, and test	record are coed in accorda	orrect and tance with the	that the test ne requirements
Certified By: Davi	Trealings	<u> </u>	10/17/02 )	Quality Control
		*K	Philiples	WITNESS
			Rick Windell	SG REVIEW S

# HEAT EXCHANGER DESIGN INC.

901 East Beecher Street • Indianapolis, IN. 46203

# N. 46203 MAC

# WELDER OR WELDING OPERATOR PERFORMANCE QUALIFICATION

ma 11- 11/1 0	2 Marie. Ook wit	1720W		
WPS NO: IMI-D	Rev: 04 WI	Q Number:		Date: <u>10/17/02</u>
Welding process used: GMA	AW / semi-auto			
Stamp: <u>A</u> Welder's WPS No: <u>1M1-S</u> Welding process used: <u>GM</u> Base material(s): <u>S</u>	A-516, Grade 70	to	SA-51	.6, Grade 70
Welding variables (QW-350	) \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	l Walues	Dance	Ovalified
Metorud Agrapres (AM-22)	Diate	T AGINER		and Fillets
Type of weld joint				
** Backing (QW-402)	<u>Back</u>	ng usea		eacking only
P-No. to P-No. (QW-403)	· · · · · · — — — —	to <u>1</u>	P-1 thru P	P-11, P-4X & P34
Pipe diameter - groove (i	in.) <u>r</u>	ı.a.	2.87	75" minimum
Base metal thickness (in. AWS classification (info)	.)0.	6250	WE	S limits
AWS classification (info)	) <u>E</u>	₹70S-6		
riller metal spec. (Sra r	NO.)	0.10		5.XX
Filler metal F-Number		6		5.XX F 6
Consumable insert	I	1.a.		n.a.
Weld deposit - groove (in	n.) 0,	5000		limits
Welding position (QW-405)	$\frac{2G-1}{}$	Iorizontal	Flat 8	Horizontal
Weld progression				n.a.
Backing gas (QW-408)	No back	ng gas used		n.a.
GMAW transfer mode	Snr:	T Arc		se, or Globular
Machine welding (QW-360)	A atus	1 Values		Qualified
Direct (Perets wisus) sent	AULUC - Towa	r varnes	nange	
Direct/Remote visual cont	CLOI.	1.a.		n.a.
Automatic joint tracking. Single/multiple pass per		1.a.		n.a.
Single/multiple pass per	SIGE	l.d.		n.a.
Fillet Welds: All base ma	atorial thickne	ecce fillst	circe and	diamotore
** Welds with backing inc				
Notes:		ara acapte-we	rueu jornes.	•
140 CG2 ·				
				Welman
		**************************************		
	Guided Bend	Test Results		
Figure No. and Type	Guided Bend Result	Test Results Figure No.		Result
	T	Figure No.		Result
None	T	Figure No.		Result
	T	Figure No.		Result
None None	Result	Figure No. None	and Type	Result
None None Radiographic test results	Result	Figure No. None None Der OW-302.2	and Type	
None None	Result	Figure No. None None Der OW-302.2	and Type	
None None Radiographic test results Other test notes : <u>Visual</u>	Result s: Acceptable relation s	Figure No. None None Der OW-302.2	and Type and QW-191 per QW-302.4	
None None Radiographic test results Other test notes : <u>Visual</u> Welding test conducted by	Result s: Acceptable relation services y: Heat Exchange	Figure No. None None Der OW-302.2 Satisfactory Ger Design In	and Type and QW-191 per QW-302.4	and QW-190.
None None Radiographic test results Other test notes : <u>Visual</u>	Result s: Acceptable relation services y: Heat Exchange	Figure No. None None Der OW-302.2 Satisfactory Ger Design In	and Type and QW-191 per QW-302.4	and QW-190.
None None Radiographic test results Other test notes : <u>Visual</u> Welding test conducted by Mech. tests conducted by	Result s: Acceptable relation s y: Heat Exchance: US INSPECTION	Figure No. None None Der OW-302.2 Satisfactory Ger Design Industry SERVICES	and Type  and QW-191  per QW-302.4  c. Lab test no.	and QW-190.
None None Radiographic test results Other test notes : Visual Welding test conducted by Mech. tests conducted by We certify that the state	Result s: Acceptable relation s y: Heat Exchance: US INSPECTION ements in this	Figure No.  None None  Der OW-302.2  Satisfactory  Ger Design In  J SERVICES  record are co	and Type  and QW-191  per QW-302.4  c. Lab test no.	and QW-190.  IN-L6212B  that the test
None None Radiographic test results Other test notes : <u>Visual</u> Welding test conducted by Mech. tests conducted by	Result  s: Acceptable is a selection of the selection of	Figure No.  None None  Der OW-302.2  Satisfactory  Ger Design In  J SERVICES  record are co	and Type  and QW-191  per QW-302.4  c. Lab test no.	and QW-190.  IN-L6212B  that the test
None None Radiographic test results Other test notes: Visual Welding test conducted by Mech. tests conducted by We certify that the state coupons were prepared, we of Section IX of the ASM	Result  s: Acceptable relation s  y: Heat Exchance: US INSPECTION  ements in this elded, and test  code.	Figure No.  None None  Der OW-302.2  Satisfactory  Ger Design In  I SERVICES  record are collected in accord	and Type and QW-191 per QW-302.4 c. Lab test no. orrect and the	In-L6212B that the test
None None Radiographic test results Other test notes: Visual Welding test conducted by Mech. tests conducted by We certify that the state coupons were prepared, we of Section IX of the ASM	Result  s: Acceptable relation s  y: Heat Exchance: US INSPECTION  ements in this elded, and test  code.	Figure No.  None None  Der OW-302.2  Satisfactory  Ger Design In  I SERVICES  record are collected in accord	and Type and QW-191 per QW-302.4 c. Lab test no. orrect and the	In-L6212B that the test
None None Radiographic test results Other test notes: Visual Welding test conducted by Mech. tests conducted by We certify that the state coupons were prepared, we of Section IX of the ASM	Result  s: Acceptable relation s  y: Heat Exchance: US INSPECTION  ements in this elded, and test  code.	Figure No.  None None  Der OW-302.2  Satisfactory  Ger Design In  I SERVICES  record are collected in accord	and Type and QW-191 per QW-302.4 c. Lab test no. orrect and the	and QW-190.  IN-L6212B  that the test
None None Radiographic test results Other test notes: Visual Welding test conducted by Mech. tests conducted by We certify that the state coupons were prepared, we of Section IX of the ASM	Result  s: Acceptable is a selection of the selection of	Figure No.  None None  Der OW-302.2  Satisfactory  Ger Design In  I SERVICES  record are collected in accord	and Type and QW-191 per QW-302.4 c. Lab test no. orrect and the	In-L6212B that the test
None None Radiographic test results Other test notes: Visual Welding test conducted by Mech. tests conducted by We certify that the state coupons were prepared, we of Section IX of the ASM	Result  s: Acceptable relation s  y: Heat Exchance: US INSPECTION  ements in this elded, and test  code.	Figure No.  None None Der OW-302.2 Satisfactory Ger Design Ind SERVICES record are coded in accord	and Type  and QW-191  per QW-302.4  c. Lab test no.  orrect and the stance with the stance win	and QW-190.  IN-L6212B  that the test ne requirements  Quality Control
None None Radiographic test results Other test notes: Visual Welding test conducted by Mech. tests conducted by We certify that the state coupons were prepared, we of Section IX of the ASM	Result  s: Acceptable relation s  y: Heat Exchance: US INSPECTION  ements in this elded, and test  code.	Figure No.  None None Der OW-302.2 Satisfactory Ger Design Ind SERVICES record are coded in accord	and Type  and QW-191  per QW-302.4  c. Lab test no.  orrect and the correct an	and QW-190.  IN-L6212B  that the test ne requirements  Quality Control
None None Radiographic test results Other test notes: Visual Welding test conducted by Mech. tests conducted by We certify that the state coupons were prepared, we of Section IX of the ASM	Result  s: Acceptable relation s  y: Heat Exchance: US INSPECTION  ements in this elded, and test  code.	Figure No.  None None Der OW-302.2 Satisfactory Ger Design Ind SERVICES record are coded in accord	and Type  and QW-191  per QW-302.4  c. Lab test no.  orrect and the correct an	and QW-190.  IN-L6212B  that the test ne requirements  Quality Control
None None Radiographic test results Other test notes: Visual Welding test conducted by Mech. tests conducted by We certify that the state coupons were prepared, we of Section IX of the ASM	Result  s: Acceptable relation s  y: Heat Exchance: US INSPECTION  ements in this elded, and test  code.	Figure No.  None None Der OW-302.2 Satisfactory Ger Design Ind SERVICES record are coded in accord	and Type and QW-191 per QW-302.4 c. Lab test no. orrect and the	and QW-190.  IN-L6212B  that the test ne requirements  Quality Control

# Welder or Welding Operator Performance Qualification (WPQ)

	PQ No.:		Date: 2/22/201	
Welding process(es) / type(s) used: GTAV	v / Manuai	int type(s) qualified: Groove and F	llos Waldo	
Type of joint welded: Pipe Groove weld  Base metal(s) welded: SA-106, Grade B to	JO SA 106 Grada D	int type(s) quantied: Ordove and F	net weids	
Base metal(s) weided: 5A-100, Grade B to	O SA-100, Glade B			
Welder Variables (QW-350)	Actual Val	ues Used	Range Qualified	
P- or S-Number to P- or S-Number	P-No. 1 to	P-No. 1	P-1 thru P-15F,P-34 & P-4X	
Base metal thickness (in.)	0.43	36	WPS Limits	
Pipe diameter (in.)	2.37	75	1.00" minimum	
	GTAW /	Manual	GTAW / Manual	
Backing **	No backi	ng used	With or without backing	
AWS classification	ER70	S-2		
Filler metal specification (SFA)	5.1	8	5.xx	
Filler metal F-No.	6		F-No. 6	
Filler metal product form	Bare (S	Solid)	Bare / metal cored	
Consumable insert	No inser	the state of the s	Without insert only	
Deposit thickness (in.) [>= 3 layers]	0.436 [		0.8720" maximum	
Welding position	6G - 45 de		All Positions	
Weld progression	Vertic		Vertical up (n4)	
Backing gas	No backing		With or Without backing gas	
GTAW welding current / polarity	DCEN (s	traight)	DCEN (straight)	
Machine Welding Variables (QW-360)	Actual Val	ues Used	Range Qualified	
Direct / remote visual control	N/A	<b>\</b> .	N/A	
Automatic voltage control	N/2	$\mathbf{A}_{i}$ , $\mathbf{A}_{i}$	N/A	
Automatic joint tracking	N/	A	N/A	
Welding position	N/.	<b>A</b> YATTA MARAPAN KANDALAN MEMBALAH	N/A	
Consumable insert	N/A	and the second s	N/A	
Backing **	N/A	and the second s	N/A	
Single / multiple pass per side	N/A	A	N/A	
Fillet Welds: Qualified to make fillet weld ** Welds with backing include fillets and Notes: (n4) The root pass, when remove up or down.	double-welded groo d to sound weld met	ve welds.		
Figure Number and Type	Result	Figure Number and Type	Result	
None None	***************************************	None None		
None		None	ta ipat kannag agasta ing atangga pasanggar ajawa di sapa ya miyana dara a dara ang di sapanag	
None		None		
Visual examination results: Visual exam s	atisfactory per QW-	302.4 and QW-194		
Volumetric test results: Acceptable Per Q'	W-302.2 and QW-19			
Welding test conducted by: Heat Exchang	er Design, Inc	이미크 대화 경화 기를 가는 나는 것 같다.		
Mechanical/Radiographic tests conducted by		apolis, IN	Lab test no.: 342032	
We certify that the statements in this recorrequirements of Section IX of the ASME (			ed, and tested in accordance with the inization: Heat Exchanger Design, Inc	

Mulley WITNESS

RICK WINDER SANGES

REVIEW C

# Welder or Welding Operator Performance Qualification (WPQ)

Welder Variables (QW-350)	Actual Va	lues Used	Range	Qualified	
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1		P-1 thru P-15F,P-34 & P-4X		
Base metal thickness (in.)	0.6	525	WPS Limits		
Pipe diameter (in.)	N,	/A	2.875"	minimum	
	GTAW / Manual	GMAW / Semiauto	GTAW / Manual	GMAW / Semiauto	
Backing **	No backing used	Backing used	With or without backing	With backing only	
AWS classification	ER70S-2	ER70S-6			
Filler metal specification (SFA)	5.18	5.18	5.xx	5.xx	
Filler metal F-No.	6	6	F-No. 6	F-No. 6	
Filler metal product form	Bare (Solid)	N/A	Bare / metal cored	N/A	
Consumable insert	No insert used	N/A	Without insert only	N/A	
Deposit thickness (in.) [>= 3 layers]	0.125 [N/A]	0.5 [Yes]	0.2500" maximum	WPS Limits	
Welding position	1G - Flat	2G - Horizontal	Flat only	Flat & Horizontal	
Weld progression	N/A	N/A	N/A	N/A	
Backing gas	No backing gas used	No backing gas used	W/WO backing gas	W/WO backing gas	
GTAW welding current / polarity	DCEN (straight)	N/A	DCEN (straight)	N/A	
GMAW / FCAW transfer mode	N/A	Spray arc	N/A	Spray, Pulsed, or Globula	
Machine Welding Variables (QW-3	60) Actual Va	dues Used	Range	Qualified	
Direct / remote visual control	N/A	ı N/A	N/A	N/A	
Automatic voltage control	N/A	N/A	N/A	N/A	
Automatic joint tracking	N/A	N/A	N/A	N/A	
Welding position	N/A	N/A	N/A	N/A	
Consumable insert	N/A	N/A	N/A	N/A	
Backing **	N/A	N/A	N/A	N/A	
Single / multiple pass per side	N/A	N/A	N/A	N/A	
Fillet Welds: Qualified to make fillet ** Welds with backing include fillets Notes: Root pass of 1/8" thk deposit	and double-welded groot t per WPS 1T1 (GTAW)	ove welds,	plied. Applied 0.5" thick de		
Figure Number and Type	Result	Figure Numbe		Result	
None		Non			
None		None	e		
None		None	e		
Visual examination results: Visual ex Volumetric test results: Acceptable F					
Welding test conducted by: Heat Exc	The state of the s			water proportion of the state o	
		nanolis IN	Tah	test no.: 342032	
Mechanical/Radiographic tests condu	2170 27. 1170121			n accordance with the	

Rick Windell So 2011 Form 19 REVIEW 2011 Form 011 - Format C

# Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: Burd, Dustin	Stamp: <u>U</u>		
Test WPS No.: <u>1T1</u> Rev.: <u>07</u>	WPQ No.:		Date: 9/4/2012
Welding process(es) / type(s) used:	GTAW / Manual		
Type of joint welded: Pipe Groove v	weld Joint ty	pe(s) qualified: Groove and	Fillet Welds
Base metal(s) welded: SA-106, Grad	le B to SA-106, Grade B		
Welder Variables (QW-350)	Actual Values U	Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No	o. 1	P-1 thru P-15F,P-34 & P-4X
Base metal thickness (in.)	0.436		WPS Limits
Pipe diameter (in.)	2.375		1.00" minimum
i ipo diamiotos (-iii)	GTAW / Man	ual	GTAW / Manual
Backing **	No backing us	sed	With or without backing
AWS classification	ER70S-2		
Filler metal specification (SFA)	5.18		5.xx
Filler metal F-No.	6		F-No. 6
Filler metal product form	Bare (Solid)	)	Bare / metal cored
Consumable insert	No insert use		Without insert only
Deposit thickness (in.) [>= 3 layers]			0.8720" maximum
Welding position	6G - 45 degree		All Positions
Weld progression	Vertical up		Vertical up (n4)
Backing gas	No backing gas		With or Without backing gas
GTAW welding current / polarity	DCEN (straig	ht)	DCEN (straight)
Machine Welding Variables (QW-	360) Actual Values	Used	Range Qualified
Direct / remote visual control	N/A		N/A
Automatic voltage control	N/A		N/A
Automatic joint tracking	N/A		N/A
Welding position	N/A		N/A
Consumable insert	N/A		N/A
Backing **	N/A		N/A
Single / multiple pass per side	N/A		N/A
Fillet Welds: Qualified to make fill  ** Welds with backing include fille  Notes: (n4) The root pass, when a  up or down.	ts and double-welded groove w	relds.	second side, and the cover or wash pass may b
		end Test (QW-160)	
Figure Number and Type	Result	Figure Number and Ty	pe Result
None	· .	None	
None		None	
None		None	
Visual examination results: Visual Volumetric test results: Acceptable		4 and QW-194	
Welding test conducted by: Heat E	xchanger Design, Inc		
Mechanical/Radiographic tests cond	lucted by: Acuren - Indianapol	is, IN	Lab test no.: 317581-1
We certify that the statements in thi requirements of Section IX of the A			elded, and tested in accordance with the organization: Heat Exchanger Design, Inc
Certified By:	aufat Medi		5/2012 Quality Control Manager
	David Freedinger	8	Date

Rick Windell SC REVIEW SAUGH

# Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: Burd, Dustin Stamp: Test WPS No.: 1M1-S Rev.: 06	<u>U</u> WPQ No.:		Date: 9/4/2012
			<i>5</i> 44. <u>574.2542</u>
Welding process(es) / type(s) used: GMAV	V / Manual	pe(s) qualified: Groove and Fille	t Welds
Type of joint welded: Plate Groove weld  Base metal(s) welded: SA-516, Grade 70 t		pe(s) quarmed. Groove and Time	t W clus
Base metal(s) welded: SA-316, Grade 70 b	0 5A-510, Glade 70		
Welder Variables (QW-350)	Actual Values U	sed	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No	o. 1 I	P-1 thru P-15F,P-34 & P-4X
Base metal thickness (in.)	0.625		WPS Limits
Pipe diameter (in.)	N/A		2.875" minimum
	GMAW / Man		GMAW / Manual
Backing **	Backing used	<u> </u>	With backing only
AWS classification	ER70S-6		
Filler metal specification (SFA)	5.18		5.xx
Filler metal F-No.	6		F-No. 6
Filler metal product form	Bare (Solid)		Bare / metal cored
Consumable insert	No insert use	d	Without insert only
Deposit thickness (in.) [>= 3 layers]	0.5 [Yes]		WPS Limits
Welding position	2G - Horizont	al	Flat & Horizontal
Weld progression	N/A		N/A
Backing gas	No backing gas	used	With or Without backing gas
GMAW / FCAW transfer mode	Spray arc		Spray, Pulsed, or Globular
Machine Welding Variables (QW-360)	Actual Values U	Used ·	Range Qualified
Direct / remote visual control	N/A		N/A
Automatic voltage control	N/A		N/A
Automatic joint tracking	N/A		N/A
Welding position	N/A		N/A
Consumable insert	N/A		N/A
Backing **	N/A		N/A
Single / multiple pass per side	N/A		N/A
Fillet Welds: Qualified to make fillet wel-	ds of any size on all base	material thicknesses and pipe diar	neters of any size.
** Welds with backing include fillets and			
Notes: Root pass of 1/8" thk deposit per	WPS 1T1 (GTAW) prese	nt when 1M1-S applied.	
	Guided Be	and Test (QW-160)	
Figure Number and Type	Result	Figure Number and Type	Result
None		None	
None		None	
None		None	
Visual examination results: Visual exam : Volumetric test results: Acceptable Per Q	satisfactory per QW-302.4	4 and QW-194	
Welding test conducted by: <u>Heat Exchange</u> Mechanical/Radiographic tests conducted		is, IN	Lab test no.: 317581-1
We certify that the statements in this recorrequirements of Section IX of the ASME  Certified By:			, and tested in accordance with the ization: Heat Exchanger Design, Inc Quality Control Manager

WITNESS Rick Windell REVIEW

901 East Beecher Street Indianapolis, IN 46203

## Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: Curtis, David	Stamp: X				
Test WPS No.: <u>1T1</u> Rev.: <u>05</u>	WPQ No.;		Date: 8/16/2007		
Welding process(es) / type(s) used:	GTAW / Manual				
Type of joint welded: Pipe Groove		ype(s) qualified: Groove and Fillet	Welds		
Base metal(s) welded: SA-106, Gr	ade B to SA-106, Grade B	·			
Welder Variables (QW-350)	Actual Values	Used	Range Qualified		
P- or S-Number to P- or S-Number	P-No. 1 to P-N	Vo, 1 P	-1 thru P-11,P-34 & P-4X		
Base metal thickness (in.)	0.436		WPS Limits		
Pipe diameter (in.)	2,375		1.00" minimum		
	GTAW / Mai		GTAW / Manual		
Backing **	No backing u	sed	With or without backing		
AWS classification	ER70S-2		<del></del>		
Filler metal specification (SFA)	5,18		5.xx		
Filler metal F-No.	6		F-No. 6		
Filler metal product form	Bare (Solid		Bare / metal cored		
Consumable insert	No insert us		Without insert only		
Deposit thickness (in.) [>= 3 layers			0,8720" maximum		
Welding position	6G - 45 degree		All Positions		
Weld progression	Vertical up		Vertical up (n4)		
Backing gas	No backing gas		ith or Without backing gas		
GTAW welding current / polarity	DCEN (straig	gnt)	DCEN (straight)		
Machine Welding Variables (QW	-	Used	Range Qualified		
Direct / remote visual control	N/A		N/A		
Automatic voltage control	N/A		N/A		
Automatic joint tracking	N/A		N/A		
Welding position	N/A		N/A		
Consumable insert	N/A		N/A		
Backing **	N/A		N/A		
Single / multiple pass per side	N/A		N/A		
		material thicknesses and pipe diame	ters of any size.		
** Welds with backing include fill Notes: (n4) The root pass, when a up or down.			ide, and the cover or wash pass may be		
	Guided Be	end Test (QW-160)			
Figure Number and Type	Result	Figure Number and Type	Result		
None		None			
None		None			
None		None			
Visual examination results: Visua	exam satisfactory per OW-302.	4 and OW-194			
Radiographic test results: Accepta	ble Per QW-302.2 and QW-191				
Welding test conducted by: Heat I					
Radiographic tests conducted by: _	U S Inspection Services		Lab test no.: 78035		
We certify that the statements in the requirements of Section IX of the	7.1	e test coupons were prepared, welder			
( ),	Will and	Organiza	tion: Heat Exchanger Design, Inc.		
Certified By:	David Freedinger	7/31/2007 Date	Quality Control Manager		

Rick Windell REVIEW

#### Heat Exchanger Design, Inc.

901 East Beecher Street Indianapolis, IN 46203

#### Welder or Welding Operator Performance Qualification (WPQ)

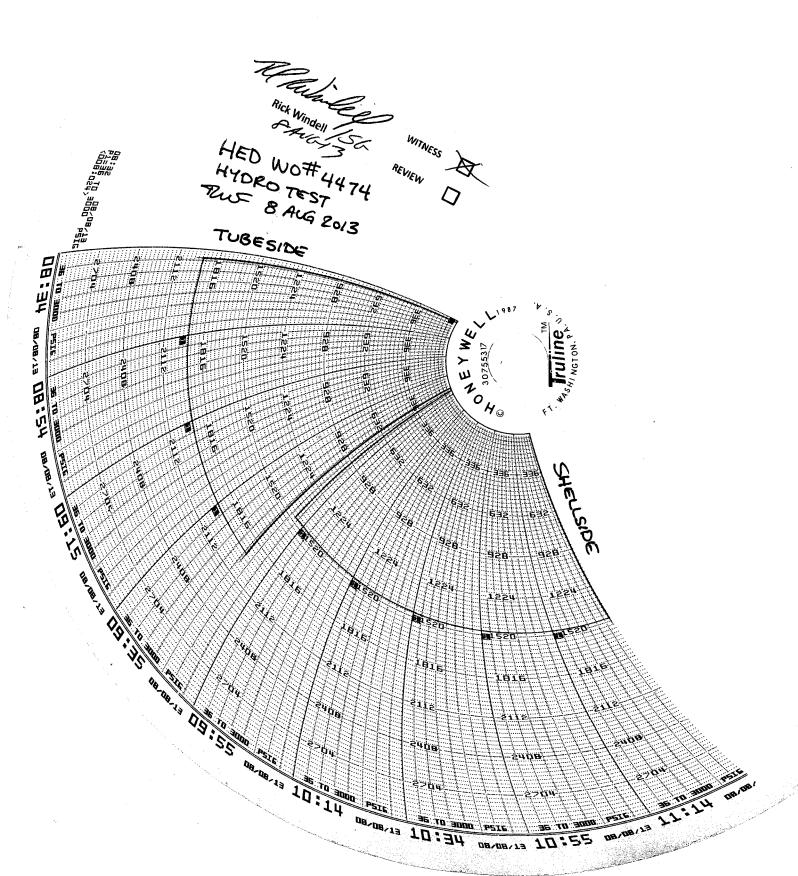
	tamp: X		Deta. 9/39/3807
Test WPS No.: <u>1M1-S</u> Rev.: <u>04</u>			Date: 8/28/2007
Welding process(es) / type(s) used: G Type of joint welded: Plate Groove w	eld Joint t	ype(s) qualified: Groove and Fill	et Welds
Base metal(s) welded: SA-516, Grade	70 to SA-516, Grade 70	<del></del>	
Welder Variables (QW-350)	Actual Values	Used	Range Qualified
P- or S-Number to P- or S-Number	P-No, 1 to P-N	lo. 1	P-1 thru P-11,P-34 & P-4X
Base metal thickness (in.)	0.625		WPS Limits
Pipe diameter (in.)	N/A		2.875" minimum
• • •	GMAW / Semi	iauto	GMAW / Semiauto
Backing **	Backing use	ed	With backing only
AWS classification	ER70S-6		
Filler metal specification (SFA)	5,18		5.xx
Filler metal F-No.	6	· · · · · · · · · · · · · · · · · · ·	F-No, 6
Filler metal product form	N/A		N/A
Consumable insert	N/A		N/A
Deposit thickness (in.) [>= 3 layers]	0.5 [Yes]		WPS Limits
Welding position	2G - Horizon N/A	ıtaı	Flat & Horizontal
Weld progression	No backing gas	nood	N/A With or Without backing gas
Backing gas GMAW / FCAW transfer mode	Spray arc	useu	Spray, Pulsed, or Globular
GMAW / PCAW transfer mode	Spray are		spray, 1 dised, or Gloudiar
Machine Welding Variables (QW-36	·	Used	Range Qualified
Direct / remote visual control			N/A
Automatic voltage control	N/A	<del></del>	N/A
Automatic joint tracking	N/A		N/A
Welding position	N/A N/A	<del></del>	N/A N/A
Consumable insert	N/A N/A		N/A N/A
Backing ** Single / multiple pass per side	N/A N/A		N/A N/A
		matarial this manage and nine dis	
Fillet Welds: Qualified to make fillet  ** Welds with backing include fillets			neters of any size.
Notes: Root pass of 1/8" thk deposit			
Trotes. Troot pass of 1/6 the deposit		end Test (QW-160)	
Figure Number and Type	Result	Figure Number and Type	Result
None	Zvodate	None None	Royale
None		None	
None		None	
Visual examination results: Visual ex Radiographic test results: Acceptable		4 and QW-194	
Welding test conducted by: Heat Excl			
Radiographic tests conducted by: US			Lab test no.; 80439
We certify that the statements in this requirements of Section IX of the ASN  Certified By:			zation: Heat Exchanger Design, Inc.
		AV lin	hillelf WITNESS []

ndell SG REVIEW DEL

## **SECTION 11**

# Chart, Gauges & Chart Recorder Calibration Records

Muhileff WITNESS D
Rick Windell SG REVIEW XX



Calibration, Sales & Repair from every angle.

## Report of Calibration

#### Client Information

HEAT EXCHANGER

901 E. BEECHER STREET INDIANAPOLIS, IN 46203 Purchase Order #: 003601-00

Calibration Performed

and Verified By:

Title: **TECHNICIAN** 

Location: INDIANAPOLIS LAB

Brant Berson

**Humidity:** 

46 %

#### Unit Submitted for Calibration

Asset ID:

ASH3000B

Serial Number: Manufacturer:

UNKNOWN **ASHCROFT** 

Model Number:

3000 X 20 PSIG

Description: Calibration Date:

PRESSURE GAUGE, DIAL TYPE June 17, 2013

interval:

12 MONTHS

Due Date:

June 17, 2014 Physical Condition: SERVICEABLE

Calibration Result: PASS

#### Calibration Procedure

Procedure Code	Revision

CP-00047 С Calibration Artifacts

Artifact ID **Due Date** Traceability TL90000045 01/11/2015 800191241

This instrument has been processed in accordance with the Tangent Labs quality system and is traceable to the International System of Units through the National Institute of Standards and Technology, other national or international standards, or acceptable intrinsic standards. The Tangent Labs quality system is accredited to ISO/IEC 17025:2005 by A2LA and is compliant with ISO-10012, MIL-STD-45662A, and cGMP21CFR820. The results represented on this report relate only to the item and date described on page one of this report. Although the item calibrated may meet performance specifications at the time of calibration, the calibration due date of the unit does not imply continuing conformance to specifications during the calibration interval. Any number of factors may cause the unit to drift out of specification and/or performance. This report may not be reproduced. except in full, without the written approval of Tangent Labs.

A 'F' indicates the measured value was outside the limits for the test point. Any 'F' results in a 'Fail' calibration result. An 'A' indicates an adjustment was made to the unit petween the 'As Received' and 'As Returned' measurement runs. Any 'A' results in an 'Adjusted' calibration result. A 'R' indicates a return of value only and no passifial determination was made. Any 'R' results in a 'ROV' calibration result. A 'Pass' calibration result means that all measured values fall within the unmodified tolerance limits. It does not constitute a certification that the true values are within the tolerance limits, as that would require the tolerance limits to be reduced by the uncertainty.

Measurement uncertainty was calculated in accordance with the ISO Guide to the Expression of Uncertainty in Measurement using a coverage factor of 2 (k=2) providing a confidence level of approximately 95%. Measurement uncertainties are available by request or Calibration and Measurement Capabilities are available at www.tangentlabs.com We welcome your feedback. Please contact us so we know how we are performing

#### Calibration Notes

#### Accredited

Parameter	Nominal	As Received	As Returned	-Tol. Limit	+Tol. Limit	Units
10% Increasing Pressure	300	300	300	280	320	psig
50% Increasing Pressure	1500	1480	1480	1480	1520	psig
90% Increasing Pressure	2700	2680	2680	2680	2720	psig
90% Decreasing Pressure	2700	2680	2680	2680	2720	psig
50% Decreasing Pressure	1500	1480	1480	1480	1520	psig
10% Decreasing Pressure	300	300	300	280	320	psia

**End of Data Section** 

Mulliness
REVIEW
Rick Windell

Report No.:

800208863

2845 Tobey Drive Indianapolis, IN 46219 TE 317.487.2378 FAX 317.487.2375 FREE 888.701.2378 www.tangentlabs.com



## Report of Calibration

#### Client Information

HEAT EXCHANGER

901 E. BEECHER STREET INDIANAPOLIS, IN 46203 Purchase Order #: 003601-00

Calibration Performed

and Verified By:

**TECHNICIAN** Title: Location: INDIANAPOLIS LAB

Brant Benson Temperature:

**Humidity:** 

#### Unit Submitted for Calibration

Asset ID:

ASH5000B

Serial Number: Manufacturer:

UNKNOWN **ASHCROFT** 

Model Number:

1279-5000 X 50 PSIG

Description:

PRESSURE GAUGE, DIAL TYPE

Calibration Date:

June 17, 2013

Interval: Due Date: 12 MONTHS June 17, 2014

Physical Condition: SERVICEABLE

Calibration Result: PASS

#### Calibration Procedure

Procedure Code	Revision
CP-00047	С

Calibration Artifacts

**Artifact ID Due Date** Traceability TL90000045 01/11/2015 800191241

This instrument has been processed in accordance with the Tangent Labs quality system and is traceable to the International System of Units through the National Institute of Standards and Technology, other national or international standards, or acceptable intrinsic standards. The Tangent Labs quality system is accredited to ISO/IEC 17025:2005 by A2LA and is compliant with ISO-10012, MIL-STD-45662A, and cGMP21CFR820. The results represented on this report relate only to the item and date described on page one of this report. Although the item calibrated may meet performance specifications at the time of calibration, the calibration due date of the unit does not imply continuing conformance This report may not be reproduced, to specifications during the calibration interval. Any number of factors may cause the unit to drift out of specification and/or performance. except in full, without the written approval of Tangent Labs.

A 'F' indicates the measured value was outside the limits for the test point. Any 'F' results in a 'Fait' calibration result. An 'A' indicates an adjustment was made to the unit between the 'As Received' and 'As Returned' measurement runs. Any 'A' results in an 'Adjusted' calibration result. A 'R' indicates a return of value only and no passfall determination was made. Any 'R' results in a 'ROV' calibration result. A 'Pass' calibration result means that all measured values fall within the unmodified tolerance limits. It does not constitute a certification that the true values are within the tolerance limits, as that would require the tolerance limits to be reduced by the uncertainty.

Measurement uncertainty was calculated in accordance with the ISO Guide to the Expression of Uncertainty in Measurement using a coverage factor of 2 (k=2) providing a confidence level of approximately 95%. Measurement uncertainties are available by request or Calibration and Measurement Capabilities are available at www.tangentlabs.com. We welcome your feedback. Please contact us so we know how we are performing.

#### Calibration Notes

Accredited

7100.04/104						
Parameter	Nominal	As Received	As Returned	-Tol. Limit	+Tol. Limit	Units
10% Increasing Pressure	500	500	500	450	550	psig
50% Increasing Pressure	2500	2500	2500	2450	2550	psig
90% Increasing Pressure	4500	4450	4450	4450	4550	psig
90% Decreasing Pressure	4500	4450	4450	4450	4550	psig
50% Decreasing Pressure	2500	2500	2500	2450	2550	psig
10% Decreasing Pressure	500	500	500	450	550	psig

**End of Data Section** 

Mulandell 156 REVIEW
25 SEP 13

Report No.:

800208871



Calibration, Sales & Repair from every angle.

## Report of Calibration

#### Client Information

HEAT EXCHANGER

901 E. BEECHER STREET INDIANAPOLIS, IN 46203 Purchase Order #: 003074-00

Calibration Performed

and Verified By:

**TECHNICIAN** Title:

Location: INDIANAPOLIS LAB

Brant Berson

Temperature:

**Humidity:** 35 %

#### Unit Submitted for Calibration

Asset ID:

0727Y774747200006

Serial Number:

0727Y774747200006

Manufacturer:

HONEYWELL

Model Number:

DR45AT + 425H3-18

Description: Calibration Date:

PRESSURE RECORDER February 15, 2013

Interval:

12 MONTHS

Due Date:

February 15, 2014 Physical Condition: SERVICEABLE

Calibration Result: PASS

#### Calibration Procedure

Procedure Code	Revision
CP-00047	С

Calibration Artifacts

**Due Date** Traceability

Artifact ID TL90000045

01/11/2015

800191241

This instrument has been processed in accordance with the Tangent Labs quality system and is traceable to the International System of Units through the National Institute of Standards and Technology, other national or international standards, or acceptable intrinsic standards. The Tangent Labs quality system is accredited to ISO/IEC 17025/2005 by A2LA and is compliant with ISO-10012, MIL-STD-45662A, and cGMP21CFR820. The results represented on this report relate only to the item and date described on page one of this report. Although the item calibrated may meet performance specifications at the time of calibration, the calibration due date of the unit does not imply continuing conformance to specifications during the calibration interval. Any number of factors may cause the unit to drift out of specification and/or performance. This report may not be reproduced, except in full, without the written approval of Tangent Labs.

A 'F' indicates the measured value was outside the limits for the test point. Any 'F' results in a 'Fail' calibration result. An 'A' indicates an adjustment was made to the unit between the 'As Received' and 'As Returned' measurement runs. Any 'A' results in an 'Adjusted' calibration result. A 'R' indicates a return of value only and no pass/fail determination was made. Any 'R' results in a 'ROV calibration result. A 'Pass' calibration result means that all measured values fall within the unmodified tolerance limits. It does not constitute a certification that the true values are within the tolerance limits, as that would require the tolerance limits to be reduced by the uncertainty.

Measurement uncertainty was calculated in accordance with the ISO Guide to the Expression of Uncertainty in Measurement using a coverage factor of 2 (k=2) providing a confidence level of approximately 95%. Measurement uncertainties are available by request or Calibration and Measurement Capabilities are available at www.tangentlabs.com. We welcome your feedback. Please contact us so we know how we are performing.

#### Calibration Notes

Calibrated as a system with H168987

Parameter	Nominal	As Received	As Returned	-Tol. Limit	+Tol. Limit	Units
Display	0	0	0	-100	100	psig
	1000	970	970	900	1100	psig
	2000	1958	1958	1900	2100	psig
	3000	2954	2954	2900	3100	psig
	4000	3952	3952	3900	4100	psig
Chart	0	0	0	-100	100	psig
	1000	970	970	900	1100	psig
3. T. 7. 100	2000	1960	1960	1900	2100	psig
	3000	2960	2960	2900	3100	psig
	4000	3960	3960	3900	4100	psiq

**End of Data Section** 

Mushilly 56
Rick Windell 255 LL 3

Report No.:

800195574

2845 Tobey Drive Indianapolis, IN 46219 TE 317.487.2378 FAX 317.487.2375 FREE 888.701.2378 www.tangentlabs.com

Page 1 of 1

## **SECTION 12**

# Surface Preparation / Coating Inspection Reports & Procedure

Multiple WITNESS D

Rick Windell 156 REVIEW 75

25 Std 13

## Heat Exchanger Design, Inc. P. O. Box 524

P. O. Box 524 Indianapolis, IN 46206-0524 USA Phone: (317)686-9000 • Fax: (317)686-9100



### **Coating Inspection Report**

Sales (	Order#	Here Tipen	Com	ponent !	
4474			Entire Unit		
Date Performed: 9-17-13	Read	lings Tak	ten By: Doug M	cKinney QC Inspector	
Air Temp	Surface Temp	Dew Point		Dolotivo Unmidity	
(Must be 5°F	(Must be 5°F > Dew Point)		Dew Polit	Relative Humidity	
77.4 °F	76.8 °F	68.6 °F		73.9 %	
Coating Used	Batch Number(s)	F	Required D.F.T.	Actual D.F.T.	
Carboline Carbozine 1			3.11 mils		
Part A Batch# 13AD5770L			2-3 mils	A	
Part B Batch# 13AD80			Average of (30) Readings		

<sup>\*\*</sup>Painting performed indoors in a controlled environment\*\*

Muller WITNESS II

Rick Windell 13

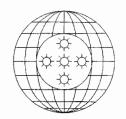
25 413

## Heat Exchanger Design, Inc.

P. O. Box 524

Indianapolis, IN 46206-0524 USA

Phone: (317)686-9000 • Fax: (317)686-9100



## Surface Preparation Inspection Report

Sales	Order#	Component		
4474		Ent	ire Unit	
	Environmen	ital Conditions		
Date Performed: 9-16-1	3 Rea	dings Taken By: Doug N	AcKinney QC Inspector	
Air Temp (Must be 5°)	Surface Temp F > Dew Point)	Dew Point	Relative Humidity	
75.6 °F	74.2 °F	68.1 °F	69.8 %	
	Surface Pro	file Inspection		
Preparation Required: F	Blast per SSPC-SP10	Required Profile Depth: 2-3 mils min.		
Testex PRESS- www.testextape.com  2.6 20.5 33 (C+XC)/2 64 08 1.5 2.5	O-FILM™ HT  X-Coarse  1.5 to 4.5 mil  38 to 115 μm  XC Made in USA  115 μm  4.5 mil	Testex PRESS www.lestextape.com  2.5  20.2 38 (C+XC)/2 64  0.8 1.5 2.5	X-Coarse  1.5 to 4.5 mil 38 to 115 μm  XC  Made in USA 115 μm  4.5 mil	
Component Examined: Shell		Component Examined: Shell		
Inspections Performed By: Doug McKinney QC Inspector				

<sup>\*\*</sup>Blasting performed indoors in a controlled environment\*\*

Mulabell SG REVIEW REVIEW 25 PREVIEW



BANTREL	JOB	VP NO.	REV		
VENDOR PRINT	1083-	-BC-4006-0022	0		
EQUIPMENT NUMBER	BL-E-30	1			
CLIENT CROSS REF					
Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve the supplier from full compliance with contractual obligations.  1. Work may proceed. 2. Revise and resubmit. Work may proceed subject to incorporation					
of changes indicated.  3. Revise and resubmit. Work SHALL NOT proceed.					
4. Reviews	ngt requiret	d. Work may proceed.	11,20		

Mundell SG REVIEW AND 13

## Heat Exchanger Design, Inc.

P. O. Box 524

Indianapolis, IN 46206-0524 USA

Phone: (317)686-9000 • Fax: (317)686-9100



#### Surface Preparation and Paint Procedure

Revision 0

Customer: Cenovus Energy, Inc.

Purchase Order #: 1083-BC-4006

Item #: BL-E-301

Work Order #: 4474

This document outlines the requirements for surface preparation and coating of the equipment referenced above that is to be applied after construction is complete.

This procedure meets or exceeds the requirements set forth in the clients Specification, Steel Structures Painting Council (SSPC) Surface Preparation Specification SP10 and the paint manufacturer's instructions for mixing and application. Paint products used are manufactured by the Carboline® Protective Coating Company.

During fabrication, all surfaces to be welded shall be ground and wire brushed clean to insure that all scale, rust and foreign matter has been removed from an area 2" either side of the center of the weld.

Before proceeding with surface preparation and coating, all welds shall be complete and inspected for integrity and size, vessel dimensions shall be verified and all applicable Non Destructive Examination shall have been performed.

After performing hydrostatic testing, all parts shall be unbolted so that each component may be treated separately. Mask gasket surfaces and openings to prevent blast media and coating from damaging the sealing surfaces or entering inside the vessel. The items are now ready for external surface preparation and coating.

All operations are performed indoors.

#### Final Surface Preparation:

All external surfaces shall be sandblasted accordingly as described below. Profile shall be measured by use of Tes-Tex tape. Be sure to blast all flange faces (except gasket surfaces) and bolt holes. Blast media used is coal slag abrasive. Blasting shall not be performed when:

- 1) relative humidity exceeds 85%
- surface temperature is less than 5°F greater than dew point

Blast to SSPC-SP10 to a profile of 2-3 mils.

Vessel shall be primed immediately after sandblasting with 2-3 mils DFT average of inorganic zinc (Carbozinc 11® by Carboline). The primer shall be applied by the conventional spray method. Apply primer when:

- 1) ambient temperature is in the range of 40°F to 130°F
- 2) relative humidity is in the range of 30 to 95%
- 3) metal surface temperature is more than 5°F greater than dew point

Rick Windell So & ANGLES Serving Petroleum, Petrochemical, Power, Food, and Industrial of

901 East Beecher Street Indianapolis, IN 46203 USA

#### Thickness Measurement:

After primer has dried, the dry film thickness (DFT) shall be measured using a digital coating thickness gage. If the readings result in a low average, a subsequent coating shall be applied as required.

#### Documentation:

Environmental conditions and thickness readings shall be documented as required.

#### Order of Events and Assembly:

- 1) All components and sub-assemblies will be blasted and fully coated as described above.
- 2) After coating has cured adequately to handle, the vessel shall be re-assembled using service bolting and new gaskets.

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#### Selection & Specification Data

Generic Type

Solvent Based Inorganic Zinc

Description

Time-tested corrosion resistant primer that protects steel galvanically in the harshest environments. For over five decades, Carbozinc 11 (CZ 11) has been the industry standard for high-performance inorganic zinc protection on steel structures worldwide.

Features

- Carbozinc 11 meets Class B slip co-efficient and creep testing criteria for use on faying surfaces.
- Rapid cure. Dry to handle in 45 minutes at 60°F (16°C) and 50% relative humidity.
- Low temperature cure down to 0°F (-18°C).
- High zinc loading.
- Meets FDA requirements in gray color.
- Very good resistance to salting.
- May be applied with standard airless or conventional spray equipment.
- VOC compliant in certain areas

Color

Green (0300); Gray (0700)

Finish

**Primers** 

Self Priming

Topcoats

May be coated with Acrylics, Epoxies, or Polyurethanes depending on exposure and need.

Not required for certain exposures. Under certain conditions, a mist cost

is required to minimize topcoat bubbling.

Service Temperature Untopcoated

Continuous: 750°F (400°C)

Non-Continuous: 800°F (427°C) With recommended high heat topcoats:

Continuous: 1000°F (538°C) Non-Continuous: 1200°F (649°C)

Dry Film Thickness 2.0 - 3.0 mils (51 - 76 microns) per coat

Dry film thickness up to 5.0 mils (150 microns) is acceptable

Solids Content

By Weight 79%

Zinc Content in DryBy Weight 85%

Film

Theoretical Coverage Rates 1000 square feet at 1 mil (24.5 square meters/liter at 25 microns) DFT; 333 square feet at 3 mils (8.2

square meters/liter at 75 microns) DFT.

**VOC Values** 

As Supplied EPA Method 24: 4.0 lbs./gal (479 g/l)

Thinned:

Termen: 7 oz/gał w/ #24: 4.1 lbs./gal (492 g/l) 5 oz/gał w/ #26: 4.1 lbs./gal (492 g/l) 5 oz/gał w/ #33: 4.1 lbs./gal (492 g/l) 8 oz/gał w/ #254: 4.0 lbs./gal (507 g/l) se ere nominal values.

#### Substrates & Surface Preparation

General

Surfaces must be clean and dry. Employ adequate methods to remove dirt, dust, oil and all other contaminants that could interfere with adhesion of the coating.

Steel

Non-Immersion: SSPC-SP6 and obtain a 1.0-3.0 mil (25-75 micron) angular blast profile (Reference ASTM

D4417)

## **Performance Data**

Test Method	System	Results
AASHTO M300 Bullet Hole Immersion Paragraph 4.6.9	1 ct, CZ11 over Abrasive blasted steel	No blistering or rusting of coating or rusting of bare steel area after 650 hrs. Immersion in 5% sod
ASTM A-325 Slip Co-efficient	Blasted Steel 1 ct. CZ 11 @6 mils (150 microns)	0.68; meets requirement for Class B rating
ASTM B117 Salt Spray	1 ct CZ11 at 2 mils dry film thickness over blasted steel.	No rusting blistering cracking delamination after 43000 hrs. Moderate salting of the surface only.
ASTM D3363 Pencil Hardness	1 ct. CZ11	Pencil Hardness *2H*

Test reports and additional data available upon written request.

#### Mixing & Thinning

Mixing

Power mix base, then combine and power mix as follows. Pour zinc filler very slowly into premixed base with continuous agitation, Mix until free of lumps. Pour mixture through a 30 mesh screen. DO NOT MIX PARTIAL KITS.

Tip: Sifting zinc through a window screen will aid in the mixing process by breaking up or catching dry zinc

Thinning May be thinned up to 5 oz/gal (4%) with #26 or #33 for

ambient and warm surfaces. For extremely warm or windy conditions (above 85°F/29°C)may be thinned up to 8 oz/gal (6%) with #254. In cool weather (below 40°F (4°C)), thin up to 7 oz/gal (6%) with #21. Use of thinners other than those supplied or recommended by Carboline may adversely affect product performance and void product warranty, whether expressed or

implied.

Ratio 1 Gal. Kit - Part A - .75 gal

1 Gal Klt - Zinc Filler - 14.6lbs 5 Gal Kit - Part A - 3.75 gai 5 Gal Kit - Zinc Filler - 73 lbs.

Pot Life

8 Hours at 75°F (24°C) and less at higher

WITHESS

temperatures. Pot life ends when coating becomes too

viscous to use.

March 2013

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0250 To the best of our knowledge the technical data contained herein is true and accurate on the date of publication and is subject to charge without prior notice. Here may also recommended to verify correctness before specifying or ordering. No guarantee of accuracy is given or implied. We guarantee to products the description of carboline quality control. We assume no responsibility for coverage, performance or injuries resulting from use. Liability, if any, is limited to replacement of products. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY CARBOLINE, EXPRESS OR IMPLIED, STATUTORY, BY OPERATION OF LAW, OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Carbolines and Carboguards

Page 1 of 2

## Carbozinc<sup>®</sup> 11

#### Application Equipment Guidelines

Listed below are general equipment guidelines for the application of this product. Job site conditions may require modifications to these guidelines to achieve the desired results.

(General)

2

Spray Application The following spray equipment has been found suitable and is available from equipment

manufacturers. Keep material under mild agitation during application. If spraying stops for more than 10 minutes, recirculate the material remaining in the spray line. Do not leave mixed primer in the hoses

during work stoppages.

Conventional Spray

Agitated pressure pot equipped with dual regulators, 3/8" I.D. minimum material hose, with a maximum length of 50 feet; 0.070" I.D. fluid tip and appropriate

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Airless Spray

Pump Ratio: 30:1 (min.) GPM Output: 3.0 (min.) Material Hose: 3/8" I.D. (min.)

Tip Size: 0.019-0.023\*

Output PSI: 1500-2000 Filter Size: 60 mesh PTFE packings are recommended and available from

the pump manufacturer.

Brush

For touch-up of areas less than one square foot only.

Use medium bristle brush and avoid rebrushing.

Roller

Not recommended.

#### **Application Conditions**

Condition	Material	Surface	Ambient	Humidity
Minimum	0 °F (-18 °C)	0 °F (-18 °C)	0 °F (-18 °C)	30%
Maximum	130 °F (54 °C)	200 °F (93 °C)	130 °F (54 °C)	95%

This product simply requires the substrate temperature to be above the daw point. Condense due to substrate temperatures below the dew point can cause flash rusting on prepared steel and interfere with proper adhesion to the substrate. Special application techniques may be required above or below normal application conditions.

#### Curing Schedule

Surface Temp. & 50% Relative Humidity	Dry to Handle	Dry to Recoat & Topcoat w/ other finishes
0 °F (-18 °C)	4 Hours	7 Days
40 °F (4 °C)	1 Hours	48 Hours
60 °F (16 °C)	45.0 Minutes	24 Hours
80 °F (27 °C)	45.0 Minutes	18 Hours
100 °F (38 °C)	15.0 Minutes	16 Hours

These times are based on a 3.0-4.0 mil (75-100 micron) dry film thickness. Higher film thickness, These times are based on a 3.0-4.0 mil (75-100 micron) dry film thickness, higher film thickness, insufficient ventilation or coolar temperatures will require tonger cure times and could result in solvent entrapment and premature faiture. Huntidly levels below 50% will require longer cure times. Notes: Any salting that appears on the zinc surface as a result of prolonged weathering exposure must be removed prior to the application of additional coatings. Also, loose zinc must be removed from the cured film by ubbing with filterglass screen wire if: 1) The Carbozinc III is to be used without a topcoat in immersion service and "zinc pick up" could be detrimental, or 2) When "dry spray/overspray" is evident on the cured film and a topcoat will be applied. For accelerated curing surface the carbotic hambitty is habus 40% village as initial 2-bour ambitant cure. Solve 2-bour of where the relative humidity is below 40%, allow an initial 2-hour embient cure. Follow 2 hour curs with water misting or steam to keep the coated surface wet for a minimum of 8 hours and until the coated surface achieves a "2H" pencil hardness per ASTM D3363.

#### Cleanup & Safety

Use Thinner #21 or Isopropyl Alcohol. In case of Cleanup

spillage, absorb and dispose of in accordance with

local applicable regulations.

Read and follow all caution statements on this product Safety

data sheet and on the MSDS for this product. Employ

normal workmanlike safety precautions.

Ventilation

When used as a tank lining or in enclosed areas, thorough air circulation must be used during and after application until the coating is cured. The ventilation system should be capable of preventing the solvent vapor concentration from reaching the lower explosion limit for the solvents used. In addition to ensuring proper ventilation, appropriate respirators must be

used by all application personnel.

#### Packaging, Handling & Storage

Shelf Life Part A: 12 months at 75°F (24°C)

Part B: 24 months at 75°F (24°C)

\*Shelf Life: (actual stated shelf life) when kept at recommended storage

conditions and in original unopened containers.

Shipping Weight (Approximate)

1 Gallon Kit - 23 lbs (10 kg) 5 Gallon Kit - 113 lbs (51 kg)

Storage

40° -100°F (4-38°C). 0-90% Relative Humidity

Temperature & Humidity

Flash Point

Part A: 55°F (13°C)

(Setaflash) Zinc Filler: NA

Store Indoors. Storage

Contract - Linings - Flavoronling

2150 Schuetz Rd., St. Louis, MO 63146 PH: 314-644-1000 Toli-Free: 800-848-4545

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March 2013
To the best of our knowledge the technical data contained herein is true and accurate on the date of publication and is subject to change without prior notice. User must contact Carboline Comp to verify correctness before specifying or ordering. No guarantee of accuracy is given or implied. We guarantee our products to conform to Carboline quality control. We assume no responsibility coverage, performance or injuries resulting from use. Liability, if any, is limited to replacement of products. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY CARBOLINE, EXPRESS OR IMPLIED, STATUTORY, BY OPERATION OF LAW, OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Carboline® and Carboquard® are registered trademarks of Carboline Company.

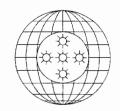
## **SECTION 13**

## Certificate of Compliance & Dimensional Verification

Mulabell SG REVIEW A SER 13

# Heat Exchanger Design, Inc. P. O. Box 524 Indianapolis, IN 46206-0524 USA

Phone: (317)686-9000 - Fax: (317)686-9100



Customer:	Cenovus Energy, Inc.
Purchase Order #:	1083-BC-4006
Item#:	BL-E-301
Sales Order #:	4474
•	e vessel(s) referenced above has been designed, constructed and tested
n accordance with the relevant of Division 1 Code as applicable.	drawings, the customer specifications and the A.S.M.E. Section VIII
	rithin the Manufacturer's Equipment Record Book verify that proper ructive Examination and testing have been applied.
The vessel dimensions have tipulated on the applicable draw	e been checked and verified to be within acceptable tolerances as vings.
2.46.11	
Certified by:	
Certified by: Bicko L'Hussong	
	WITNESS Rick Windell S6 REVIEW

## **SECTION 14**

## **Performance Guarantee**

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## Heat Exchanger Design, Inc.

P. O. Box 524
Indianapolis, IN 46206-0524. USA.
Phone: (317) 686-9000 • Fax: (317) 686-9100
www.hed-inc.com, e-mail: sales@hed-inc.com

May 29, 2013



To whom it may concern,

Heat Exchanger Design, Inc. does hereby in writing guarantee the thermal, mechanical, and hydraulic design for the heat exchangers we are providing on our SO 4474, Bantrel's 1083-BC-4006. The pressure drop and flow induced vibrations are within acceptable limits as per the data provided.

David E. Bradshaw

BANTREL	JOB	VP NO.	REV				
VENDOR PRINT	183-	166-4006-0019	0				
EQUIPMENT NUMBER	Y	bL-E-30\					
CLIENT CROSS REF							
Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve the supplier from full compliance with contractual obligations.							
		it. Work may proceed subject to incorpor	ation				
		it. Work SHALL NOT proceed.  I. Work may proceed.					
BY:	N1	Lagrange 11, i	2013				

WITNESS Rick Windell Food, and Industrial on Heat Transfer Equipment 901 East Beecher Street. Indianapolis, IN 46203. USA

## **SECTION 15**

## **Inspection & Test Plan**

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Rick Windell 136		



BANTREL	JOB	VP NO.	REV						
VENDOR PRINT	10	083-BC-41064-0017	1						
EQUIPMENT NUMBER	F	bL-E-301							
CLIENT CROSS REF									
design details, of developed or set from full compliant.  1. Work materials with the set of changes.  3. Revise and Revis	calculations elected by the cance with constant proceed. and resubmites indicate and resubmites and resubmites and resubmites indicate and resubmites	it. Work may proceed subject to incorpor	olier ration						

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Heat Exchanger Design, Inc. P. O. Box 524 Indianapolis, IN 46206-0524 USA Phone: (317)686-9000 - Fax: (317)686-9100



Inspection and Test Plan 28-May-2013 Revision 1 P.O. #: 1083-BC-4006 Item #: BL-E-301 Customer: Cenovus Energy, Inc. Work Order #: 4474 Description: Natural Gas Heater

				ORMED Y:	
NO.	ACTIVITY		Vendor	Client	REMARKS
1	Inspection of raw material: Qty, Markings, MTR's etc. All pressure bour	ndary materials	P		
	and welded attachments are in accordance with A.S.M.E. Sections II a Codes.		BLA		
2	Inspection of machined parts.	BCX	- P		
3	In process fabrication inspection:	BLH	P		
	a) verification of WPS/PQR(s)	BOH	- P		
	b) verification of filler metal	BL4	P		
	c) verification of welder's qualifications	BLA	P		
	d) inspection of weld joint preparations and fit-ups	BLH	Ď		
	e) inspection of root pass and final welds	BUH	– P		
	f) verification of appurtenance layout	Best	- P		
4	Confirmation of valid NDE personnel qualifications & proper NDE proces	dures. BLA	- P	ew	
5	Perform PT examination of:	Bit		-	
	a) areas as required by A.S.M.E. Sec.VIII, Div.1 Code	BLA	- P	Rh	$\nu_l$
	b) lift lug final welds	BOLL	P	RA	V
6	Final visual inspection of welds, dimensions and orientations.	BUN	- P	No.	
7	Perform Spot RT of shell and tube sides. Verify film and review reader sh	eet. But	- R	-	Subcontracted
8	Perform hydrostatic testing w/potable water per ASME Code @ 50	°F min. Hold	P	нД	)
<u> </u>	pressure in each chamber individually for 1 hour using chart recorder.  Perform blast and paint per client specification TR-43-SPC-0	BLN 0-019-01 and	-		
	manufacturer's recommendations. Each sub-assembly shall be treated in	dividually prior		İ	
9	to final assembly to insure flange faces and bolts holes are coated. I preparation & verify blast profile and coating thickness & appearance.		P		
1	SP10 and prime 2-3 mils DFT Carbozine 11.	BUH.			
10	Confirm Canadian Registration (CRN) through province of Alberta is rec		P	w	/
11	Verification of nameplate stamping.	BLH	P	a	
12	Verify insulation installed per client specification TR-43-SPC-00-021-02.	BC#	R	N	Subcontracted - certification supplied by installer
13	Inspection of shipment preparation. Blow completely dry, oil flange face covers & plastic wrap. Verify one(1) set of spare gaskets is included.	es, bolted wood BL <del>U</del>	P	н	Client perform final inspection
14	Acquire Inspection / Shipping Release from client.	But	P	н	Client provide after final inspection
15	Review of Manufacturer's Equipment Record Book & Dispatch Dossier	BUSH	- P	R	
NOTE "Vend			- Perform - Review		
l		w	- Witnes		
"Clien	refers to Cenovus Energy or their assigned Third Party Inspector			nust be pre n Inspectio	
<u></u>		<del>/</del> 2 ····			



# SECTION 16 Material Test Reports

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Rick Windell SG REVIEW 25 SCR13



## Job Order Detailed BOM Report Job Order Detail BOM Report, Ordered by Component Part Number

Job Order Number Equal to 00834-0000

Date: 08/02/2013 Time - 14:24:25 Page# 1

Job	Part Number	Rev	Quantity	Status	S.O.	Customer
00834-0000	Default		1.0000 EA	RELEASED	004474	000207 CENOVUS ENERGY, INC
	SH4K1-20-00-24UV-2C3D	NS				
	4474					

ltem No.	Facility	Component Part	Rev	Component Part Description LOG# HEAT#	<b>Quantity Required</b>
	Default	ELBOW 2.5 S40 90° LR BW	NS	2.5" SCH 40 LONG RADIUS 90° BUTT WELD ELBOW - SA234-WPB-TOE LB70	02 2.0000 EA
		BOM Memo: INNER PIPE			
	Default	FLANGE 14 600 XS RFWN	NS	14"-600# RFWN ANSI FLG - XS BORE - SA105 TJS 694A0	1.0000 EA
		BOM Memo: SHELL COVER ASS'Y			
	Default	FLANGE 2 600 S160 RFWN	000	2"-600# RFWN ANSI FLG - SCH 160 BORE - SA105N HW2 BAOY	2.0000 EA
		BOM Memo: NOZ "A & B"			
	Default	FLANGE 3 900 RFLWN	NS	3"-900# RFLWN ANSI FLG X 9" LG - SA105 TKU G807	2.0000 EA
		BOM Memo: MODIFY BY MACHINING ENDS	NOZ "C & D'		
	Default	GASKET 14 600 STD RING	NS	14"-600# STD RING GASKET - CS/GRAPHITE W/ 19.375" OD GAUGE RING	3.0000 EA
		BOM Memo: KAMMPRO TYPE CS/GRAPHITE (1) TEST; (1) RE-ASSEMBLY; (1)			
	Default	GASKET RING	NS	RING GASKET - 3/16" THK X 3.938" OD X 3.063" ID - CS/GRAPHITE	6.0000 EA
		BOM Memo: 3/16" THK KAMMPROFILE STYL (2) TEST; (2) RE-ASSEMBLY; (2)		APHITE	
	Default	HEAD 2:1 SE 0.5 X 14 OD	NS	14" OD X 0.5" NOM (0.44" MIN) THK X 2" SF TRW AVJA-2506448	1.0000 EA
		BOM Memo: 30° SINGLE OUTWARD BEVEL -	SA516-70N -	SHALL CONFORM TO UG-79, UG-81 & UCS-79	
	Default	LIFT LUG SIZE 2	000	SA516 70N CIT -50F OXG 1616/1	2.0000 EA
	Default	NAME PLATÈ KPA	000	METRIC "KPA" NOTATION - SS316	1.0000 EA
	Default	NAME PLATE MAEWP	000	EXT. PRESSURE NOTATION - SS316	1.0000 EA
		BOM Memo:			
	Default	NUT .75-10 HEAVY HEX	NS	3/4"-10 HEAVY HEX NUT - SA194-2H	48.0000 EA
	Default	NUT 1.375-8 HEAVY HEX	NS	1.375"-8 HEAVY HEX NUT - SA194-2H	40.0000 EA
	Default	PIPE 2 S160 SA106B	NS	2" SCH 160 PIPE X 8" LG - SA106-B TLW 105825	1.0000 EA
		BOM Memo: HED CUT (2) 3.75" LG - NOZ "A	₿ B"		
	Default	PIPE 2.5 S40 FINNED	NS	2.5" SCH 40 PIPE X 20'-7.75" LG - SA106-B - W/LONG. FINS TRJ 335364	2.0000 EA
		BOM Memo: PIPE FINNED WITH:			

(24) 0.035" THK x 0.5" HIGH LONGITUDINAL FINS x 20' LG - C-STL

w/ 5" and 2.75" BARE ENDS

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## Job Order Detailed BOM Report Job Order Detail BOM Report, Ordered by Component Part Number

Job Order Number Equal to 00834-0000

Date: 08/02/2013 Time - 14:24:25 Page # 2

Default	PIPE 2.5 S40 SA106B	000 2.5" SCH 40 PIPE - SA106-B MPX A82443	0.2083 FT
	BOM Memo: CUT (1) 2.5" LG - INNER PIPE SH	HORT SPOOL	
Default	PIPE 4 S120 SA106B	000 4" SCH 120 PIPE - SA106-B — ODF 77223K	0.3333 FT
	BOM Memo: CUT (1) 4" LG - MACHINE INTO (	(4) SP4474 SPLIT RINGS	
Default	PIPE 4 S40 SA106B	NS 4" SCH 40 PIPE X 20'-6" MIN R/L - SA106-B-TLX 26598, TLY B05997	2.0000 EA
	BOM Memo: HED CUT (2) x 20'-3.875" LG		
Default	PIPE SPECIAL SA106B	NS 4.25" OD X 1" WALL PIPE X 15" LG - SA106-B TLZ 221868	1.0000 EA
	BOM Memo: MACHINE INTO (2) T4474 TUBES	SHEETS	
Default	PLATE 0.25 SA516 70	000 1/4" THK PLATE - SA516-70 —— ORM W7K692	3.7084 SQF
	BOM Memo: CUT:	· · · · · · · · · · · · · · · · · · ·	
	(2) 23" x 8.5" BURNED SHAPES - (1) 7" x 13" - NPL BRKT FACE PL		
	(1) / X 13 - NPL BRKT FACE FE (1) 4" x 13" - NPL BRKT STAND-C		
Default	PLATE 0.375 SA240 304/L	000 3/8" THK PLATE - SA240-304/304L PID 4TJ4	0.1528 SQF
Doladii	BOM Memo: CUT (2) 5.5" X 2" BURN SHAPES		
Default	PLATE 0.5 SA516 70N	000 1/2" THK PLATE - SA516-70N PFP R0473-11AB	0.4583 SQF
	BOM Memo: CUT (2) 3" x 11" BURN SHAPES	- SUP'T BASE PLATES	
Default	PLATE 2 SA516-70N	000 2" THK PLATE - SA516-70N RXX 8778	1.0035 SQF
	BOM Memo: CUT (2) 8.5" OD x 3.75" ID BURN	ED RINGS; MACHINE INTO (2) TPF4474 FLANGES	
Default	PLATE 2 SA516-70N	000 2" THK PLATE - SA516-70N RXX 8778	1.0035 SQF
	BOM Memo: CUT (2) 8.5" OD x 2.75" ID BURN	ED RINGS; MACHINE INTO (2) TF4474 FLANGES	
Default	PLATE 2 SA516-70N	000 2" THK PLATE - SA516-70N RXX 8778	1.0035 SQF
	BOM Memo: CUT (2) 8.5" OD x 3.75" ID BURN	ED RINGS; MACHINE INTO (2) SPF4474 FLANGES	
Default	PLATE 2 SA516-70N	000 2" THK PLATE - SA516-70N RXX 8778	1.0035 SQF
	BOM Memo: CUT (2) 8.5" OD x 3.75" ID BURN	ED RINGS; MACHINE INTO (2) SF4474 FLANGES	
Default	PLATE 3.25 BURNED DISC	NS 3.25" THK X 24.13" DIA BURNED DISC PLATE - SA516-70N TMI C5506	1.0000 EA
	BOM Memo: MACHINE INTO (1) CF4474 FLAN	NGE	
Default	SR4-2	000 SEAL RING SA106B	6.0000 EA
	BOM Memo: (2) TEST; (2) RE-ASSEMBLY; (2)	SPARE	
Default	STUD .75-10 X 5	000 3/4"-10 X 5" LG STUD - SA193-B7	16.0000 EA
	BOM Memo: 5" LG END-TO-END		
Default	STUD .75-10 X 6	000 3/4"-10 X 6" LG STUD - SA193-B7	16.0000 EA
	BOM Memo: 6" LG END-TO-END		
		and the same of th	

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## Job Order Detailed BOM Report

Job Order Detail BOM Report, Ordered by Component Part Number Job Order Number Equal to 00834-0000 Date: 08/02/2013 Time - 14:24:25 Page # 3

Default STUD 1.375"-8 X 10 LG 1.375"-8 X 10" LG STUD - SA193-B7 20.0000 EA BOM Memo: 10" LG END-TO-END Default WASHER 0.75 SAE N FLAT 000 3/4" SAE "N" NARROW FLAT WASHER 48.0000 EA BOM Memo: ZINC PLATED WROUGHT STEEL Default WASHER 1.375 SAE N FLAT NS 1.375" SAE "N" NARROW FLAT WASHER 40.0000 EA BOM Memo: ZINC PLATED WROUGHT STEEL **End Of Report** 

This report was requested by BHUSSONG

Multiples WITNESS D

Rick Windell SG REVIEW P

PAUG-13



#### INSPECTION CERTIFICATE

PANTECH STEEL INDUSTRIES SDN. BHD. ...... LOT 13258 & 13259, Jalan Haji Abd. Menan, Off Jalan Menu, 42200 Kleng, Salangor, Malaysia.

Tet: 603-3393 1633 Fax: 603-3393 1733 E-mail: pentech2@stmernyx.com

#### WROUGHT CARBON STEEL BUTTWELDING FITTINGS

INSPECTION DOCUMENT: EN 10204:2004 Type 3.1



PED 40/2005 Annual Court 4-1

Purchaser:

ALLIED FITTING CORP

25-May-10

Order No.	No.		Spec	ification 1o	r Pipe		Specification for Fittings: Made from Seamless Pipe					Specification for Inspection						
22210PS-2	,	E 6537	E 6537 ASTM A106 - 08 / API SL - 07 PSL1 Gr. B & NACE MR0175 - 03						ASTM A234 - 07 / ASME SA 234 - 07 WPB					ASME 816.9 - 07				
Heat No.	Heat No. Product & Size							Quantity (pcs)			Pipe f	MER			Pipe Heat No.			
CZ 108 1°90 DEG LR STD ELBOW								20	100		MINMETA	LS YINGKO	U MEDIL	IM PLATE			T206-4067	
LB 902	2.4	S DEG L	R STD E	TBOM.					4	36		JUNGYIN	CITY BEAM	LESS ST	TEEL TUB	<u> </u>		09-214184
JN 303	JN 303 2" 45 DEG LR STD ELBOW								1	5-5		YA	ITAI STEEL I	PIPE PL	ANT			081-01649
L 401	2' 45 DEG LR STD ELBOW								,	27		JANGYIN	CITY SEAM	LESS ST	BEL TUBE			09-213207
LB 702	V 210	2. 80 DE	O LR ST	D ELBOW	,				34	00		80	ashan iro	N & STE	EL			307476
	Visual E	curninati	on.			Dimen	sional Ins	paction	,,,	Heet Treatment						Magnet	ic Particle	Testing
	G	000					GOOD		н					HA.				
	G	200					GOOD		н					N.A				
	GC	00D					G000		н					NA NA				
	GC	300					6000		**				NA					
	G(	200					6000		н .					NA NA				
Specif	Screetion					Chemical Composition (%)					Tensile Te			st ~ Hardr				
	som took :		С	Si	Mh	P	S	Ni	Cr	Mo	S	٧		CE	YS.	TS	E	
M	ire	, L	x108	x100	x100	x1000	x1000	x100	x100	x100	x100	x1000		x100	(KSI	MPa)	(%)	(HB)
M	BX	J		10	29		-	•	-	•	•	-		•	240	415	22	
Heat No.		J	30	-	106	50	58	40	40.	15	40	80		50	•	655	-	.197
CZ	106		20	25	53	17	13	•	3	2	10	0.1		-31	325	445	28.0	155
LB	902	$\Box$	18	23	55	30	5	1	. 1	0	1	2		28	324	437	28.4	94
. <b>N</b> EL	303	$\Box$	21	24	44	15	12	2	3	1	1	10		31	310	490	29.5	154
L4	<b>1</b> 01		16	22	57	27	6	0	1	0	1	3		26	300	544	33.4	94
LB	702			21	76	15	•	3	4	1	8	3		24	350	461	20.6	128

WE HEREBY CENTRY THAT THE PRODUCT DESCRIBED HEREIN HAS BEEN MANUFACTURED, SAMPLED, TESTED AND INSPECTED IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION

AND PURCHASE ORDER; AND SATISFIED THE REQUIREMENTS.

TENSILE REQUIREMENT: CONFORMS TO ASTM AS70 STANDARD, LONGITUDINAL DIRECTION, GAUGE LENGTH 2" (50mm)

NOTE:

VS: Yeard Strength

O: Heated to \$10°C and quench in water.

TB: Tenelle Strongth

T: Temper between 500°C - 890°C.

5: Stress releved in temperature between 595°C - 690°C and cooled in still air.

H : Hot formed in temperature between \$20°C - 660°C and cooled in s68 of

Bit 5-24-13

## f104562

CLIENTE / Customer / Client

FORGINGS FLANGES&FITTINGS LLC. 8900 RAILWOOD DRIVE, **SUITE B** HOUSTON, TX 77078 USA

**CERTIFICADO DE INSPECCION** 

No.

DIN EN 10204 / 3.1 Inspection Certificate - Certificat de Réception 150 10474 / 3.1

9987 ULMA FORJA, S.COOP.

PRODUCTO Article - Produit **FLANGES** 

SU PEDIDO N.º Your Order No. Vatre Cde. N.º

13/12/2010

134769 HOJA: Page: 1

af. - de 10/05/2010

Certified acc. PED 97/23/EC+AD2000-W0 by TÜV Rheinland N.º 01 202 E/Q 02 7443

MARCA DEL FABRICANTE Mark of factory Marque du fabricant

B\* Zubillaga, 3 - Apdo. 14 20580 OÑATI (Gipuzkoa) SPAIN Tel.; 34 - 943 780552 Fasc 34 - 943 781808 E-mail: ulma@ulmapiping.com

B0355

NORMAS APLICABLES Requirements - Normes Applicables **ASME B16.5-09** 

MATERIAL CORRESPONDIENTE ASTMA105N-09 Materiel Correspondent - Qualité ASME SA105N-09

MODO DE FUSION (\*) Steel Meking - Elaboration de l'acier

NACE MR-01-75/ISO15158-2-05 & MR-01-03/03

FECHA:

Dale:

171523-INDIANAPOLIS

DEPARTAMENTO QUALITY ASSURANCE

E = Elec. Y = Oxigano basico					Deb	arientent					
PARTIDA CANTIDAE Item Quentity Poste Quentité	DESCRIPCION Description Description	OBSERVACIONES Remarks Observations (*)		T.Strength	Y.Skength		ESTRICCION Red. Area Striction %	RESILIENCIA Impact last Résilience Joules	MEDIA Average Majerna	*C	DUREZA Hardness Dureté HB
220 F68WA140 9	BLIND 10 150LB RF A105N	NE NE NE NE	695A0 674A0 658A0 496A0 666TD 694AD 873M0	496 502 518 519 511 515 531	315 311 317 318 302 318 372	28,60 29,00 30,10 30,70 28,30 29,80 31,80	54,00 54,60 55,80 58,00 55,20 56,00 57,00				147 155 148 158 150 157 150 157 149 156 150 167 154 160

		1													
COLADAN.º Heat No		C	OMPOS	ICION (	<b>QUIMIC</b>	A - STEE	L MAK	ER'S LA	DLE AN	ALYSIS	- ANAL	YSE CH	IMIQUE		
N.ºCoulde	С%	SI %	Mn %	P%	S %	Cr%	Ni %	Mo %	Nb %	V %	Cu %	AI %	Ti %	N %	CEq %
496A0 658A0 666T0 673M0 674A0 894A0 695A0	0,210 0,200 0,190 0,180 0,190 0,200 0,180	0,260 0,230 0,170 0,230 0,180 0,240 0,180	0,860 0,840 0,800 1,210 0,830 0,860 0,830	0,010 0,011 0,024 0,013 0,012 0,009 0,025	0,001 0,001 0,012 0,005 0,006 0,008 0,008	0,110 0,090 0,050 0,050 0,060 0,080 0,070	0,080 0,100 0,110 0,070 0,080 0,080 0,070	0,040 0,040 0,018 0,009 0,010 0,050 0,009	0,002 0,001 0,003 0,002 0,001 0,001 0,002	0,001 0,002 0,001 0,064 0,002 0,002 0,003	0,220 0,210 0,370 0,130 0,140 0,230 0,140	0,040 0,030 0,000 0,029 0,027 0,031 0,029	0,000 0,000 0,000 0,000 0,000 0,000 0,000	0,000 0,000 0,000 0,000 0,000 0,000 0,000	0,404 0,387 0,369 0,420 0,357 0,390 0,349

(\*) OBSERVACIONES:

Remarks

N\_NORMALIZED AT 900 C AND ALLOWED TO COOL IN STILL AIR

- Las dimensiones y la condición superficial se haltaran satisfactorias.

- Dimension and surface condition were found acceptable. Los dimensions et étals de surfaçe sont satisfaisants.

 Los materielos citados cumpiso las normas aplicables. - Manufacturing regularments are satisfied.

- Les normes applicables sont respectées.

EL INSPECTOR Works Inspector - L'Inspecteur

BH 5-3-13



Rick Windell 156

WITNESS

## Piping Products, Inc.

# FORGED STEEL FLANGES & SPECIAL FITTINGS P. O. Box 9525, Houston, TX 77261 Phone: 713-675-5374, 800-775-5374, Fax: 713-675-7910

#### LL TEST REPOR

INDIANAPOLIS, IN 46203 INDIANAPOLIS, IN 46204 TAG N  ITEMS  ITEMS  INDIANAPOLIS, IN 46204 TAG N  ITEMS  ITEMS  INDIANAPOLIS, IN 46204 TAG N  INDIANAPOLIS, IN 46204 T		RVICE PIPE BOX 33805	& Suppi	¥		7.0	RVICE I 2 SO.NI		2. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.		D	CUST PC DATE PI S/O I	17 i 173	0/99			17_
10	IN	id iana polis	, IN 4	16203		ī.	ID I ANAPO	LIS, I				The state of the s				$\mathcal{H}^{w}$	
1 1/2 300 NN RP XH SA105 125-250 AARH 30 1 1/2 600 NN RF 160 SA105N 125 AARH 40 2 600 NN RF 160 SA105N 125 AARH  CHEMICAL PROPERTIES  IM HEAT NO. C SM. NN PHOS SUL GR N. NO N CO CU Y AL ME CEQ 10 AXUX 0.190 0.200 0.910 0.011 0.027 0.077 0.150 0.040 0.000 0.320 0.020 0.000 0.020 0.090 20 ASOH 0.170 0.220 0.840 0.013 0.015 0.015 0.050 0.010 0.000 0.000 0.210 0.000 0.000 0.020 30 AUPP 0.190 0.220 1.050 0.010 0.019 0.080 0.070 0.020 0.000 0.000 0.170 0.025 0.000 0.000 40 BAOY 0.190 0.260 0.890 0.006 0.020 0.050 0.090 0.018 0.000 0.000 0.220 0.004 0.000 0.000 0.373  PHYSICAL PROPERTIES  ITM YIELD TENSILE ELONG. RED. BIN CHARPY LAT. SHEAR TES 3TRENGTH STRENGTH XIN2" AREA HARDNESS 10 44,000 75,500 31.20 55.00 152 20 43,470 75,940 30.00 69.00 159-163	ITM	2 150 DES	CRIPTION	look		931061	1 125154	A AARU	MENE								
30 1 1/2 600 WN RF 160  SA105N 125 AARH 40 2 600 WN RF 160  SA105N 125 AARH    CHEMICAL PROPERTIES   SA105N 125 AARH		The state of the s				The state of the s											
SAIDSN 125-ARR    SAIDSN 125-ARR    CHEMICAL PROPERTIES   N   CQ   CU   Y   AL   NE   CFQ   CF						11.00											
TIM HEATNO, C SIL MN PHOS SUL CR NI NO N CO SU Y AL US CEQ 10 AXUX 0.190 0.200 0.910 0.011 0.027 c.975 0.150 0.040 c.200 0.000 0.320 0.320 0.000 0.020 0.399 0.000 0.170 0.220 0.840 0.013 c.016 0.150 0.050 0.050 0.00								**************************************									
IM HEATNO. C SAL MM PHOS SUL CR NI MQ N CQ CU Y AL NE CEQ 10 AXUX 0.190 0.200 0.910 0.01: 0.027 c.575 0.150 5.045 c.550 0.000 0.320 0.020 0.000 0.020 20 ASON 0.170 0.220 0.840 0.013 c.516 0.160 0.000 0.010 c.500 0.000 5.320 0.022 0.000 0.020 30 AUPP 0.190 0.220 1.050 0.010 0.019 0.080 0.070 0.020 0.000 0.000 0.170 0.025 0.000 0.000 0.406 40 BAOY 0.190 0.260 0.890 0.066 0.020 0.050 0.090 0.018 0.000 0.000 0.170 0.025 0.000 0.000 0.373  PHYSICAL PROPERTIES  IM YIELD TENSILE ELONG. RED. BHN CHARPY  STRENGTH %IN 1." AREA HARDNESS IEST EXTENSITY %IN 1." AREA HARDNESS IEST EXTENSITY 0.000 0.0					Ville Ville			CUEIM	190	ADE DTIES							
10 AXUX	T 64	HESTNO		SH	sen.	PHOS	SUL		Section and supplied that the	the state of the s	the Control of the Control	CO	CU	V	AL	NE	CIEO
10 AUPP				0.200				C . 575						0.020		9.020	
## 10 BAOY	20	ASQN	0.170	0.220	0.840	0.013	C. 316	0.160	0.060	0,010	0.000	0.000	0.210	G.CC2	C. CCO	0.001	0.352
## VIELD TENSILE ELONG. REO. BMN CHARPY LAT. SHEAR TENSILE FROM BIRENGTH % IN 2" AREA HARDNESS IEST EXPAN FRAG. TENSILE ELONG. 75,500 31.20 55.00 152 0.00  20 43,470 75,940 30.00 69.00 159-163 0.00  30 51,497 70,840 38.40 61.70 143-143 0.00  40 √ 46,620 70,896 33.10 62.20 147-147 ITEM NOTES  10 NORM @ 1650F. A/C  20  30 NORM @ 1650F 3 HRS A/C  40 √ NORM @ 1675F 4 HRS A/C  ORDER NOTES	30	AUPP /	0.190	0.220	1.050	0.010	0.019	0.080	0.070				0.170	0.026	0.000	0.000	0.406
TIM YIELD TENSILE ELONG RED. BMN CHARPY  STRENGTH STRENGTH & IN 2" AREA HARDNESS IEST EXPAN PRAG. IEST  10 44,000 75,500 31.20 55.00 152 0.00  20 43,470 75,940 30.00 69.00 159-163 0.00  30 51,497 70,840 38.40 61.70 143-143 0.00  40 46,620 70,896 33.10 62.20 147-147 ITEM NOTES  10 NORM @ 1650F. A/C  20  30 NORM @ 1650F 3 HRS A/C  40 NORM @ 1675F 4 HRS A/C  ORDER NOTES	40	BAOYV	0.190	0.260	0.890	0.006	0.020		Scan Box 11 Province	<b>等级等级等。</b> 到1000		0.000	0.220	0.004	0.000	0.000	0.373
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20 43,470 75,940 30.00 69.00 159-163 0.00 30 51,497 70,840 38.40 61.70 143-143 40 46,620 70,896 33.10 62.20 147-147  ITEM NOTES  16 NORM @ 1650F. A/C 20 30 NORM @ 1650F 3 HRS A/C 40 NORM @ 1675F 4 HRS A/C  CRDER NOTES	1 1						NESS		Bry.	ISI				EXPAN			
30 51,497 70,840 38.40 61.70 143-143 40 46,620 70,896 33.10 62.20 147-147  10 NORM 6 1650F. A/C 20 30 NORM 8 1650F 3 HRS A/C 40 NORM 8 1675F 4 HRS A/C  CRDER NOTES							163										Straight and Carter
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30 NORM @ 1650F 3 HRS A/C 40 NORM @ 1675F 4 HRS A/C ORDER NOTES	10	NORM @ 16	50F. A/C					•									
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ORDER NOTES	30	NORM @ 16	50F 3 HJ	RS A/C													
	40	NORM @ 16	75F 4 HG	RS A/C		, .											
								0	RDER NO	OTES .							

#### Additional Notes or Comments:

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

Piping Products, Inc.



14527 Smith Rd. Humble, Texas 77396 TEL: (281) 441-4088 FAX: (281) 441-8899

**REPORT NUMBER** 74405

**DATE** 4/26/2013

FCI ORDER NUMBER 60366 Processed I.A.W. EN10204 3.1

**CUSTOMER ORDER NUMBER** 

SOLD/SHIPPED TO

8077

TEXAS FLANGE & FITTING SUPPLY, INC.

P.O. BOX 2889

**PEARLAND** 

TX 77581

USA

Item Quantity Description

2

3" X 900 X 9" LG RF LWN

TKU

TAG# J290-20203

HEAT NUMBER:

G807 V

**MATERIAL TYPE:** 

**SA105N** 

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

.185 C .940 Mn .0310 P .0240 S .220 Si .070 Cr .010 Mo .004 V Cu .020 .020 Ni .001 Cb

Yield PSI Tensile PSI Elongation

**Reduction of Area Hardness** 

80,550 35 65

54,157

156 HBW

Al .021

CE

.36

Rick Windell 156 REVIEW

**Heat Treatment** 

NORMALIZED

**Temperature** 

1670 °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

Name:

Rene Ordonez

Title:

QA Representative

Bit 5-6-13





#### FORT WORTH F & D HEAD CO P.O. BOX 79700 FORT WORTH, TEXAS 76179-0700

#### **COVER SHEET**

CUSTOMER HEAT EXCHA	ANGER	CUSTO 33	MERS P.O. N 75-00-LOST	JMBER	DATE 06/03/1	3
CODE LETTER	QTY.	SIZE-OD. OR ID.	THICKNESS	PLATE MFG	HEAT NUMBER	SLAB NUMBER
ALVA	1	14"OD	1/2"NOM	NUCOR	2506448	01
		TRW	-			
		, , ,				
		·				-
				•		
				Whu	hell !	WITNESS
HOT FORMED X				THER V	PAUL)	REVIEW 3
MATERIAL SA516-7	0		STYLE 2	2:1 ELLIPTICA	L	
			SF: <b>2"</b> BEVEL: DR:		DUTSIDE [	INSIDE 🗆
WO# 155028			MIN: .46	<b>;</b> "	LAND ICR	

FORT WORTH F & D HEAD COMPANY CERTIFIES THAT HEADS MANUFACTURED FROM MATERIAL REPRESENTED BY THIS REPORT COMPLY WITH ASME CODE SECTION II & SECTION VIII, DIVISION I. ALL HEADS COMPLY WITH UG-81(a) AND UG 79.

WE CERTIFY THAT THESE HEADS WERE HOT FORMED ABOVE 1,650 DEGREES FAHRENHEIT, HELD FOR A MINIMUM OF 30 MINUTES, AND AIR COOLED.



BLH 6-10-13

Roxanne Taylor
FORT WORTH F & D HEAD CO.



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

## Mill Test Report



Isauing Date: 09/18/2012

Marking:

B/L No.: 336963

Load No.: 338934

Our Order No.: 104552/2

Cust. Order No.: 11246

Vehicle No: ALY 91688

Specification: 0.5000" x 88.000" x 480.000"

Sold To: RANGER STEEL SERVICES 1225 NORTH LOOP W. STE 850 Ship To: RANGER STEEL C/O AHR TRUCKING

AND STORAGE

ASTM A518 70-10/ASME SA516 70 PVQ 2011 Addenda Cu .15 Max, Sn

HOUSTON,TX 77008

**BNSF TRACK 8813** 

.020 Max Normalized Test Coupons at 1650 F

FT WORTH, TX 78179

Heat No	C	Min		P	8	SI	Си	Ni	Cr	Mo	Alftot	) V		Nb	TI	N	Ca	В	8n	CEC		
2506448	0.18	1.00	0.		0.002	0.21	0.13	0.14	0.05	0.02	0.02	4 0.00	14	0.001	0.001		0.0011		0.007	0.38	0.26 -	Ä٧٦
2506450	0.18	1,01	0.	.011	0.002	0.20	0.15	0.13	0.06	0.02	0.02	9 0.00	14	0.001	0.001		0.0009	0.0003	0.00B	0.38	0.25	
		T	enstk	Test											Charpy	Impac	ta					١.
Pinte Serial · No	Places	Tons	Die,	(psi) Ybek		(pa) Tonsilo	Elongation % in 2°	Elongati % in 8°		Dir.	1	tres.	2	(%) ahear	3	(14) show		%) hear	Size	Temp	Min Ave.	
2506448-01	4	13.06	T T	60,00 54,30		74,200 72,500		23.0 24.9		>-	$\sqrt{\lambda}$	JA										
2506450-04	6	19.60	T	47,40	00 7	4,700		24.6		•	•											
2506450-05	5	16.33	Т	48,8	00 7	6,500		24.1														
2506450-04	6	19.60	T	45,7	00 7	2,200		27,5	N													
2506450-05	5	16.33	Т	45,70	00 7	1,700		24.4	N													

otherwise noted in Specification.

Test coupons only, normalized 60 minutes per inch of thickness at 1880 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 the material. Misrcury has not been used in the direct manufacturing of this material, Produced as continuous cast discrete plate as-rolled, unless

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.

Yield by 0.5EUL method unless otherwise specified. Caq = C+(Mn/6)+((Cn+Mo+V)/5)+((Cu+NI)/15)

Pom = C+(58/30)+(Mn/20)+(Cu/20)+(N/30)+(Cu/20)+(Mn/15)+(V/10)+6B

Melited 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 Compilers. DIN 50049 3.1.B/EN 10204 3.18(2004), DIN EN 10204 3.1(2005) compliant. For ABS grades only, Quality Assurance cartificate 09-MMPQA-548

09/20/2012 8:16:01 AM

Q.C. By

J.D.

,

Укран Ukra		METAJIJI AZ	УРГИЧЕ OVSTAL						ЛЬ		ETTY IDIN					09-	2932	26	Da	te	06.1	0.20	006	Лист She		1	из of	1		Пист Shee	
1, ya. Ger	орского, г.Ма	риуполь, 87500 факс	380 (629) 52-	70-00					_															Leparsi	ky st., i	Mariup	ol, 8750	DO fax	38D (6	<b>29)</b> 52	-70
	ERICTBO O II	рисмочиых испыт te	жинях		EN	1020	4-3.1			T	_	Pesy	пьтат	H NC	пыта	ний		,			Te	st re	sults			,	,	<del></del>			
Kontpar Contrac	rr № 1036 No		nufacturer's		on order	No	4007	06-0547	$\ $	8 9 8 9					15	§	£\$	<b>.</b>		22											
Referen									ءِ[[	2 5 th	and a	Tole	H	100	1	50			1	4		1	1						ļ		
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Mapka of		ME/ASTM VA516-70 MT	Стандар Standard	TEI ASME	SA516/S A516/A5	A516M	-04		╟	1816/1	0.50	├	-	Ŧ	+68	50.6	77.6	32	-	-	-	_	-	$\vdash$	<del> </del>		_			_	╀
Grane of	LT		Statings	ASME	SA20/SA 1 A20/A20	20M-0	4	7	12	1816/1	+	0.39	0.39	i.	-50			<u> </u>	26	33	44	35	<del>                                     </del>					$\vdash$			H
<u> </u>					1 nzujnzu				[3]	1616/2	0.50			T	+68	50.9	77.6	32													Г
Bышав Steelmal	ca ring process	Konneprepani Made by the BO	enaco6 apoks IF Process	водства					4	1616/2	0.50	0,39	0.39	L	-50 +68	56.6	70.5	30	28	33	41	35	_	ļ					_		ļ.,
<del></del>									١	1817/1	0.50	0,39	0.39	i.	-50	30.6	78.3	-30	72	74	71	72	├	-	_	-	-	<del>   </del>			┝
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# TUBOS REUNIDOS INDUSTRIAL, S.L.U Barrio Sagarribai, 2 - 01470 AMURRIO (Spain)



CERTIFICADO DE CALIDAD MILL TEST CERTIFICATE





PAG. 1/4

Nº 0000300368/1 Rev. 000

CLIENTE

PEDERAL STEEL SUPPLY, INC

ADITRAS CONDES

3940

PRODUCTO

TUBERÍA SIN GOLDADURA LAMINADA RN CALIENTS HOF FINISHED SZAMZÍST TUBES

REF. FABRICA

30001140¥

extremos

BISELADOS MEVELLED THOS

PROTECCIÓN SUPERF

LACA SECA EXTERIOR CO DRY LICOUERED

NORMA / GRADO

A/SA51.07/106 06/API5L 07PSL1 GRADES B & C (A/SA 106)

PROCESO FUSION WELTHG PROCESS

HORNO ELECTRICO ACERO TOTALMENTE CALMADO ELECTRIC FURNACE / FULLY HILLED

espec. Ádiciónales:

NACE MRO 1 75/MRO 103.

FAB. DE PALANQUILLA. BILLETS MANUFACTURE

COLADA CONTINUA

DIMENSIONES

2.376" OD X 0 344" X

ESTADO SUPERFICIAL SURFACE CONDITION

REQUISITOS SUP

FEDERAL STEEL SUPPLY, INC. THESE TEST REPORTS APPLY TO: YOUR P. O. #\_\_\_\_ ...... ... ...

MARCAS.

ESTAMPADO.

PINTADO.

CODIGO COLOR COLOR COLOR

TUBOS REUNIOOS INDUSTRIAL GARANTIZA QUE TODAS LOS TUDOS CUBIERTOS POR ESTE CERTIFICADO CUMPLEN LOS REQUISITOS DEL PEDIDO Y CON LAS ESPECIFICACIONES ARRIBA MENCIONADAS. TUBOS REUNIOOS INDUSTRIAL CERTIEY THAT ALL THE TUBER O OVERED BY THA CENTIFICATE COMPLY WATH ORDER REQUIREMENTS AND ADOYS MENTIQUED SPECIFICATIONS.

AMURRIO 02:03:2011

Rick Windell EVIEWED AI 5-16-13

WITNESS



## TUBOS REUNIDOS INDUSTRIAL, S.L.U Barrio Sagarribaj, 2 - 01470 AMURRIO (Spain)

EN 10204:2004 / 3.1

CERTIFICADO DE CALIDAD MILL TEST CERTIFICATE



PAG. 2/4

Nº 0000300358/1 Rev. 000

NORM BRUYO LAM ENFR AL AIRE / AS ROLLED COOLED IN STILL AIR

DESCRIPCION SUMMISTRO / DESCRIPTION OF DISTRICT

ITEM FAB.	ITEM CLI. CURNTE MEM	LONG.INDIV (F)	GOLADA CAST HR	Nº TUBOS	LONG. TOTAL (F)	PESO(KG) WEIGHT	
000050	\$	38,000 42,000	105525	65	3.281,023	11.011	•
TOTAL				85	3 761.023	11011	

#### PNSAYOS NO DESTRUCTIVOS, I NOT

ENBAYO / TEST	SCONTROL / TEST RATE	REQUISITOS / REQUIREMENTA	RESULTADO / Presinct	
MENNY & CHRUMONAY HAS	.100%		Ø.k	_
P.HIDROSTATICA- HYUMOTEST	100%	2.500.0 PS) 5 SEC.	oĸ	-
INSP. POR PASO DE ANILLO NINO DAJOS INSPECTIÓN	100%		OK.	

#### ENRAYOR TECNOL DOLCORY METAL LIEGICOR / TECHNOLOGICAL AND METALLIEGICAL TEST

DOBLADO

ACI AISASJISA 108/SL -OK

AMURRIO 02 02 2011

Rick Windell

. WITNESS

3176869100 P 13/31



# TUBOS REUNIDOS INDUSTRIAL, S.L.U Barrio Sagarribai, 2 - 01470 AMURRIO (Spain)

EN 10204:2004 / 3.1

CERTIFICADO DE CALIDAD MILL TEST CERTIFICATE



PAG. 314

Nº 0000300368/1 Rev. 000

#### ANALISIS DE PRODUCTO / PRODUCTANALYSIS

	Ç	Mn	Sı	P	5	Cr.	Ni	Mo	Cu	V	AJ	· Yia	Nb		B CE.
MIN		0,78	0,10												
MAX.	0,27	1,06		0.030	0,030	0,400	0.400	0,150	0,400	0,080	0,080	0,050	0,020	,1	0.0001 6,41
105875	Q.21	0,84	0,25	0,011	0,001	0,100	0,110	<u>,010</u>	0,320	0.001	0,002	0,001	0,001		0.0001 0,41
105825	0,20	0,63	0,23	0,010	0,001	0,100	0.110	0,040	0,320	0.001	0.001	0,001	0,001		0,40

#### FORMULAR

MIN	(01)	(02)		•	
MAX. 105825	1,000	0.150			
105825	0,670	0.010			

COLADA	(i)	(2)	CINA ( in	ENSION ches)	LELAST. YIELD POINT ( Pei ) (3)	N.TRACC.	ALARG.	DUREZA HARDHESS (HRB)	,	 	 	 
					39 900	70 300		59				
105625	<u> </u>	P	0.697	# 0.394	50 668 50 481	81 801	32 32	65 A5				

- (1) L + LONGITUDINAL II T = TRANSVERBAL
- (2) T = Full subs tube If P = Strip spacemen
- (3) yeld point (0.2%)
- (4) La + 2" (50,8 mm)

11

ANEXOS L AUNEX

"Billets are produced at our amurrio steel plant (Spain), which is also certified to 180 9001, the same as our tube plant".

- · Mercury free · No weld repair · "Lacquer free of Leaq"

AMURRIO 02 02 2011

CONTROL DE CAL

WITNESS

Rick Windell

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#### TUBOS REUNIDOS INDUSTRIAL, S.L.U Barrio Sagarribai, 2 - 01470 AMURRIO (Spain)

EN 10204:2004 / 3.1

CERTIFICADO DE CALIDAD MILL TEST CERTIFICATE

TLW

N° 0000300368/1 Rev. 000

ANEXOS / APHEL

\* TOLERANCES IN ACCORDANCE WITH ASTMASME AISASID.

t.g. s.a. has a qualymamedement system approved by again in agreement with coldiname as this the presence AENOR EN CONST.

PAG. 474

FEDERAL S. LEL SUPPLY
OA APPROVED

BY MB 24/11

AMURRIO 02.02.2011

CONTROL DE CALIDAD DE TUBOS REUNIDOS TUBOS REUNIDOS INGUESTRAS PREUNTO CONTROL)

Munley

Rick Windell

WITNESS

#### INSPECTION CERTIFICATE DIN EN 10204: 2005-01 3.1 / № 1-0202 /

Quality management system has been certified according to ISO 9001:2008 by Bureau Veritas Certification (Certificate Number UA 226868/1) Environmental management system has been certified according to ISO 14001:2004 by Bureau Veritas Certification (Certificate Number UA 226869) Occupational health and safety management system has been certified according to OHSAS 18001:2007 by Bureau Veritas Certification (Certificate Number UA 226339)



Open Joint-Stock Company "Byelorussian Steel Works - management company of "Byelorussian Metallurgical Company" holding" 37, Promyshlennava street 247210 Zhlobin -- Belarus Tel. +375 (2334) 5-41-29, Fax +375 (2334) 5-60-42 www.belsteel.com qualdir@bmz.gomel.by

Description of the goods: Hot strained seamless pipes for oil-and-gas

Описание товара: Трубы бесшовные горячедеформированные для нефте- и газопроводов.

Final application: For pipeline transportation systems for petroleum and natural gas industries.

Конечное назначения: Для трубопроводных транспортных систем для нефтяной и газовой

Delivery Conditional: Normalized

Условие поставки: Нормализована

Contract No 12025764 appendix 2

Контракт не PO number 10P5586SHE

Wagon Nº 66401902

Country of destination: USA

Kelly Pipe Co., LLC Consignes:

11680 Bloomfield Ave.

CA 90670 Santa Fe Springs

Ne pos. He flee.	Number of heat House ansum	Number of lot Homep партии	Grade steel /Standard Mapus crauw/Crawpapr	Chemical composition, % Xummerscanil cocras, %	С	81	Mn	P	8	Cr	N	Cu	π	Мо	٧	Al	NB	Nb+V	MD+11	Cr+NI+ Mo +Cu+V	CEV	Steel making- process:
		•	B/C acc. to ASTM A168-2011 B/C acc. to ASME SA106-2001	Norm/норма	max .30	min 10	.29 - 1.06	.035	max .035	max .40	max .40	max .40		max .15	.08					max 1,00		
1	336364 🗸	130253	NACE MR 0175-2:2003, ISO 15156-2:2003 and PED 97/23/EC, NACE MR 0103-2010	Ladie (fact) xoeween (факт)	.24	.26	.57	.015	.014	.07	.13	.28		,02	.016					.52	.38	E+AOD

Musick Windell SG REVIEW RICK WINDER SAU613

#### INSPECTION CERTIFICATE DIN EN 10204: 2005-01 3.1 / № 1-0202 /

Quality management system has been certified according to ISO 9001:2008 by Bureau Veritas Certification (Certificate Number UA 225978)
Environmental management system has been certified according to ISO 14001:2004 by Bureau Veritas Certification (Certificate Number UA 225979)

Occupational health and safety management system has been certified according to OHSAS 18001:2007 by Bureau Veritas Certification (Certificate Number UA 226339)

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															min 70000	min 40000	min 21				Средн.	
	1	73.0	2.875	5.16	0.203	6.40 (-0/+0.10)	21,0 (-0/+0,33)	7	308	17346	17374	1991.53	6533.9	160 16	81200	56500	35					
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NDT / Метод испытаний:	
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NDT / Метод испытаний: Eddy current test / инфиналы вы ASTM E309	ОК Резупь

- it is hereby certified that products covered by this certificate has been tested and is compiled with the requirements of the contract.
- -Подтверждаем, что продукция, указанная в настоящем сертификате, испытана и соответствует условиям контракта.
- -Visually measuring test was performed with satisfactory result.
- Визуально- измерительный контроль проведен с удовлетворительным результатом.
- No weld repair. Free of mercury and mercury containing compounds.
- Без следов эвреслом сверкой. Без ртути и ртутьсодержащих аламентов.

TRJ

Technical Control Inspectors

Babonymsking Stock Company of Byglorusais Sto
Organ (2007) Technical Company of Byglorusais
Organ (2007) Technical Company of Byglorusais

On Behalf of BNZ Zhiobia NTRO

FOR CERTIFICA 8 01 2013 12:40:59

Date: 28.01.2013 12:4

Rick Windell SG REVIEW DEL

CERTIFIED TEST REPORT SHIP TO SHIP FROM US STEEL , LLC MCJUNKIN CORP USS DIVISION MCJUNKIN ROAD WV251430513 PITTSBUGH PA15219 NITRO MANUFACTURER MANUFACTURING PLANT US STEEL , LLC US STEEL LLC USS DIVISION USS DIVISION P.O. BOX 3180 PITTSBUGH PA15219 PA152194776 PITTSBURGH **HEAT # A82443** MCJUNKIN PO NUMBER S002633048 PART # 0320-0216 LINE # 01 SHIPPED 04/07/16 VENDOR ORDER NUMBER DR2549601 \*-\* SPECIFICATIONS \*-\* PIPE CARBON SMLS STD PIPE API 5L- 42ND EDITION DATED 1/00 PS L-1 GRADE B AND GRADE X42 AS TM A53- 01 ASTM A106- 99 GRADE B OUAD STENCIL ASME SA53 - 2001 EDITION ASME SA106 - 2001 EDITION GRADE B CARBON EQUIV ALENT .43 MAX TO SR18 BLK REG MILL COAT PE BEV 30 DEG MEETIN G ALL THE APPLICABLE REQUIREME NTS OF NACE STANDARD MR-01-75 2002 MANUFACTURED IN THE USA. NO REPAIRS BY WELDING. NO MERCURY OR MERCURY COMPOUNDS ARE ADDED TO THE STEEL AND ALL MERCURY BEARING EQUIPMENT \*-\*-\* NOTES \*-\*-\* 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: S.ANADELL MGR. Q.A. USS TUBULAR PRODUCTS \*-\*-\* DESCRIPTION \*-\*-\* 2.8750 INCH OD X 0.2030 INCH WALL GRADE B SML CHEMISTRY CHEMICAL ANALYSIS-PRODUCT C CU CB CR ALMO 0.001 0.09 0.036 0.22 0.02 1.09 P S SI NI . 17 0.012 0.006 0.002 0.02 0.18 CHEMISTRY CHEMICAL ANALYSIS-HEAT С CB CR CU MIN MO AL0.038 0.19 0.001 1.06 0.12 0.02 0.01 NI P S SI V 0.003 0.012 0.18 0.001 0.03 CARBON EQUIVALENT 0.40 PHYSICAL YIELD STRENGTH YIELD PSI ULTIMATE STRENGTH TENSILE PERCENT-ELONGATION ELONGATION FLATNESS

\*-\* CONTINUED \*-\*

ROCKWELL B

But 8-15-06

Rick Wandell

CERTIFIED TEST REPORT HEAT # A82443

PAGE

HYDROTEST PRESSURE HYDROTEST DURATION

HYDRO PRESSURE HYDRO PRESSURE

3000

5

PSI SEC

QUALITY ASSURANCE CONTACT

S. ANADELL

US STEEL LLC

THIS INFORMATION WAS RECEIVED ELECTRONICALLY FROM THE MANUFACTURER IDENTIFIED ABOVE.

\*-\* END OF REPORT \*-\*

MPX

Rick Windell 56 TREVIEW





### ADZ Inspection certificate "3.1" (EN 10 204)

AOS	Document N	lo.: 418	/07/BP													
AOT	Customer's								A08	Manufa	cturer's \					
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BEA 1-7-08

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THESE TEST REPORTS APPLY TOS  YOUR P. O. #	
INSPECTION CERTIFICATE    Number / Número:   Page / Página:   Septembris   Septembr	
Customer / Clienter FEDERAL STEEL SUPPLY, INC.  Customer's Order Item:   Customer's Returnos / Ref. de Character's Wents Order N° / Confermation de Versignal Supplication    Manufacturery Receives / Process de Manufacture:   Product Type / Type de Producto    Manufacturery Receives / Process de Manufacture:   Product Type / Type de Producto    Surface / Supplication    Surface /	
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FEDERAL STEEL SUPPLY, INC.

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Rick Windell

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	MILL TEST GERTIFICATE ACCOR	DING TO EN 18284 3.1	PAGE I of 2
	P1-001/77 Clustomer POS 027978-1 TMK IPSCO POS 071594		CERTIFICATE Me: 2129 DATE OF ISSUE: 10.05,201
MANUPACTURER: VOLZHSKY PIPE PLANT (JISC #4119, VOLZHSKY	GOODS: Hat finished seamless tubes according to ASTM ASIS-06, ASTM A 106/A106M-11, ASME SA106-10. Hardaces per NACE MR 0175/ISO (\$156-2:200).	Consigned:  *TMK IPSCO INTERNATIONAL, L.L.C.»  Delaware Secretary of State File No.  \$649767, 2659 Warrenville Road, Saite 700,  Donziers Grove, Hiliants, 60515 U.S.A.	}
VOLGOGRAD REGION RUSSIA	Tubes shall conform to ASTM A 105-11 / ASME SA105-07 (only for chemical regularments).		
	Produced and certified to the latest edisjon/revisions to all foregoing standards.  GRADE: 1026 as per ASTM AS19/B, C as per ASTM AT06/ASME SAIN6.		

HEAT M	PARTY M	BUNDLEM	SIZE, MCH (	ma)	NUMBER OF PIECES		NET WEIGHT
	A		OD	Wi		LENOTH, FT	TR.
221868	2885	18789	4.250 (107,95)	1.000 (25,4)	8	187,40	6415,39
		18790		, , , , ,	6	140,29	4806,03
. 4	l I	18791			. 8	184,81	6393,34
	1	18792	8	4 1	8	180,25	6194,93
		18906		1	2	45,60	1565,27
f				1			Language of the
				TOTAL	32	738,35	25374,96

CHEMICAL COMPOSITION. %

	HEAT >		C	Si	Mn	P	S	O-	N	CX	Ma	Y	į.
	221868	Ladle	0,23	0,22	0,61	0,006	0,607	0,07	0,10	0,16	0,02	0	ŀ
,	221868	PI	0,25	0,22	0,61	0,007	0,008	0,07	0,10	0.17	0,03	0	İ
1	221868	P 2	0,26	0,22	0,62	0,007	0,010	0,07	0.10	0,17	0,03	0	ľ

PARTY			TENSILE	TEST		Control of the State	ULTRA	SOME	Hardness	Metallographic
Me	ORIEN-	TEST	UTS. psi	YS. psi	EL, %	Reduction	717	ST	tost	Analysis
	TATION	SPECIMEN		. 1		of secs.	<b>1</b>	aí	HKC < 22	Grain Sizo, score
	1+	2*					1* (3*)	1* (3*)		
2885	L	R	73240	49310	26	58	1. (10)	1.(10)	9	6
		1					T(10)	T(10)		7

Rick Windell St REVIEW BLH 5-15-13 Rus Pus

Flatening test:

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PAGE 2 of 2

CERTIFICATE M: 2129 DATE OF ISSUE: 10.05.2012

WE CONFIRM THAT THE PIPES COVERED BY THIS CERTIFICATE ARE MANUFACTURED, TESTED AND INSPERTED IN ACCORDANCE WITH TERMS OF THE CONTRACT

PIPES BY WORKSHOP ROLLING MEE AO A THE CONTRACT

FREEDOM OF MILL SHIRYAEV V.K. GREEF OF CODAREA BERLINGVA

RESPECTORVOLZESKY PIPE PLANT

GOVERNOVA M.A.

CODE OF CODAREA BERLINGVA

COLZESKY PIPE PLANT

GOVERNOVA M.A.

CODE OF CODAREA BERLINGVA

TLZ

Rick Windell SG REVIEW SAUGIS

STEEL



## **Test Certificate**

Form TC1: Revision 1: Date 31 Oct 2000

13609 Industrial Road, Houston, TX 77015

Customer: AMERICAN ALLOY STEEL 6230 NORTH HOUSTON ROSSLYN RD P.O. BOX 40469 HOUSTON TX 77240 0469

Shipping Manifest: HT047095 Mill Order No.: 41-199629-02 Customer P.O. No.: 73374 Product Description: ASTM A516-70(06)/ASME SA516-70(04ED.)

Ship Date: 10 Jan 08 Cert Date: 10 Jan 08

Cert No: 031075465 (Page 1 of 1)

Size: 0.250 X 96.00 X 360.0 (IN)

	Tested Piece	S			Tensik	ess.							Chi	upy	Impa	ct Te	 		 	
Heat Id	Piece Id		- 1	•	(PSI)		Elon 2in	g % I 8in I		 Abs 1	2	rgy(	FTLB) Avg	1	% S 2	hear 3	Tst Tmp	Tst Dir	BDW Tmp	
W7K692	0574	0.250 X 96.00 (T.L.C)	LCT	63000 54000 54000	84000 74000 74000		25 24 25		T T T											

Heat	,								Chem	ical Ana	lysis					
Id /	C	Mn	P	<b>S</b>	Si	Tot Al	Sol Al	Cu	Ni	Ст	Mo	Съ		Ti	CEV	ORGN
W7K692 ✓	.18	1.06	.009	.003	.21	.031	.030	.34	.17	.10	.05	.007	.006	.025	.43	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)/15MATERIAL MARKED WITH AN ASTERISK IS PRODUCED FROM COIL 100% MELTED AND MANUFACTURED IN THE U.S.A. \* W7K692 0574 PCES: 7, WGT: 17152

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

Rick Windell

6-17-08

Cust Part #: 73374

WE HEREBY CERTIFY THAT THIS MATERIAL WAS TESTED IN ACCORDANCE WITH THE APPROPRIATE SPECIFICATION

Jason Thomas CHBCKED BY

(P)



## METALLURGICAL TEST REPORT

6870 Highway 42 East Ghent, KY 41045-9615 (502) 347-6000

Certificate: 442736 02 Customer: 2830 023

Mail To:

ROLLED ALLOYS

6555 SOUTH 57TH WEST AVENUE

TULSA, OK 74131

Ship To: ROLLED ALLOYS

6555 SOUTH 57TH WEST AVENUE

TULSA, OK 74131

Date: 12/19/2008

Page: 1

Steel: 304/304L

Finish: ERAP

Your Order: S01065

NAS Order: AN 0409547 04

Corrosion: ASTM A262/02aE;180Bend-OR

PRODUCT DESCRIPTION:

STAINLESS STEEL PLATE, HRAP; UNS 30400/30403

ASTM A240/08,A480/08a,A666/03; ASME SA240/07,SA480/07,SA666/07

CHEM ONLY ON FOLLOWING ASTM: A276/06a, A479/06a, A484/06b, A312/07

CHEM ONLY ON FOLLOWING ASME: SA312/07, SA479/07

AMS5511H/5513H XMRK; MIL-S-5059D AMD3(X CRN MEAS); MIL-S-4043B

NACE MR0175/01, MR0103/07; QQS766D-A X MAG PERM

MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.

EN 10204:2004 3.1; QQ8763F Cond A; RoHS Compliant

Material is Free of Radioactive Contamination

NAS Steel Making Process: EAF, AOD, & Cont. Casting Product Mfg.by a Quality Mgt.Sys. in Conf. w/ISO 9001:2000

\*Melted & Manufactured in the USA; Mat'l is DFARs Compliant

EN 10204 3.1.B/DIN 50049

Skid #	Prod #	Thickness	Width	Weight		-Length	Mark	Pieces	
P76436	* 044TJ4	.3750	60.0000	7,835	PLATE	240.00		5	

#### CHEMICAL ANALYSIS CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan)

HEAT	CM	С	CO	CR	CU	MN	MO	N	NI	P	
4TJ4	US	.0230	.1720	18.2225	. 4825	1.7675	.4250	.0708	8.3305	.0360	
		s	SI					11111			
		.0010	.2880								
<u> </u>						TRA	CER# 1808	32 t	TRF	CER# 180821	

#### MECHANICAL PROPERTIES

s	Skid #	Prod #	0 0	d i r	UTS KSI	.2% YS KSI	ELONG %-2"	Hard RB	R of A	
P	76436	044TJ4	F	T	82.89	34.56	57.93	81.50	70.32	
i					(   <b>         </b>		MARI 1191 1834			DOLLED ALL GVOLGHALITY AGOLIDANGE

TRACER# 180821

TRACER# 180821

TRACER# 180821

NAS hereby certifies that the analysis on this certification is correct and the material meets the specifications stated.

OC ENGINEER

12/19/2008

ERIC HESS

**Rick Windell** 

12/11/2008 From: AMERICAN ALLOY STEEL

Item :2 (1 PC) 1/2" X 60" X 120" :TAG: (2) 3952C, (1) 3952E 10: 1

TO: HEAT EXCHANGER DESIGN, INC.

P O.#:5631-AAS-14627

5.0.#:337319

AA PL#:5908507

PFF

.

TEST CERTIFICATE

SHIP TO:
AMERICAN ALLOY STEEL
6230 N HOUSTON ROSSLYN RD
NORTH HOUSTON TX 77091

PAGE NO: 01 OF 02 FILE NO: 0284-01-32 MILL ORDER NO: 20619-003 MELT NO: R0473

LAB NO: 11AB / DATE: 09/30/08

SOLD TO:
AMERICAN ALLOY STEEL, INC
P. O. BOX 40469
HOUSTON TX 77240-0469

SEND TO:

01-C

PLATE DIMENSIONS / DESCRIPTION

TOTAL PIECE OTY GAUGE WIDTH LENGTH DESCRIPTION WEIGHT

1 .5" 120" 480" RECTANGLE 8168#

CUSTOMER INFORMATION CUSTOMER PO: 76647 Certified a true copy of the original, retained in our file.

AMERICAN ALLOY STEEL

SPECIFICATION (S)

THIS MATERIAL HAS BEEN MANUFACTURED AND TESTED IN ACCORDANCE WITH PURCHASE ORDER REQUIREMENTS AND SPECIFICATION(S).

AM ALLOY-TUF-37 REV 8 YR 06
ASME SA516 GR 60
ASME SA516 ED 04 GRADES 60/65/70 06 ADDENDA
MATERIAL PRODUCED UNDER A CERTIFIED QUALITY MGMT SYSTEM COMPLYING WITH
ISO 9001 ABS-QE CERT. NO. 30130

CHEMICAL COMPOSITION

MELT:R0473 C MN P S CU SI NI CR MO
.19 .98 .005 .001 .04 .35 .25 .06 .01

MELT:R0473 V TI B AL CB SB AS SN CEF
.001 .004 .0003 .030 .001 .0010 .0030 .004 .39

CARBON EQUIVALENT FORMULA (CEF)
CEF = C + (MN \* .1667) + ((CR + MO + V) \* .2000) + ((CU + NI) \* .0667)

MANUFACTURE

FINELINE - VACUUM DEGASSED - MCQUAID-EHN GRAIN SIZE PER E112 - 7-8

HEAT TREAT CONDITION

OR HEAT TREAT NOM HOLD COOL Rick Windell TEST DESCRIPTION TEMP MINS MTHD

WITNESS

REVIEW

TENSILE PROPERTIES

ELONGATION SLAB STRENGTH PSI X 100 STRENGTH PSI X 100 NO. LOC DTR &R.A. 11AB BOT. 519 735 TRANS. 8.00" 25.0 68.0

WANI

WE HEREBY CERTIFY THE ABOVE INFORMATION IS CORRECT:

QUALITY ASSURANCE LABORATORY COATESVILLE, PA 19320

SUPERVISOR - TEST REPORTING
ELINORE ZAPLITNY

12/31/2008 From: AMERICAN ALLOY STEEL

S.O.# :337319

To: HEAT EXCHANGER DESIGN, INC. AA PL#:5908507

P.O.# :5631-AAS-14627 Item :2 (1 PC) 1/2" X 60" X 120"

:TAG: (2) 3952C, (1) 3952E

TEST

CERTIFICATE

PAGE NO: 02 OF 02

FILE NO: 0284-01-32

MILL ORDER NO: 20619-003

MELT NO: R0473

SLAB NO: 11AB

DATE: 09/30/08

#### GENERAL INFORMATION

ALL STEEL HAS BEEN MELTED AND MANUFACTURED IN THE U.S.A. MATERIAL HAS BEEN VACUUM DEGASSED AND CALCIUM TREATED FOR SULFIDE SHAPE CONTROL. FINELINE MOD FOR SULPHUR TEST CERTS. ARE PREPARED IN ACCORD. WITH PROCEDURES OUTLINED IN EN 10204:2004 PARA 3.1 B/L #49724 TTJX 81022

Rick Windell

WITNESS

REVIEW

ELINORE ZAPLITNY

WE HEREBY CERTIFY THE ABOVE **INFORMATION IS CORRECT:** 

**QUALITY ASSURANCE LABORATORY** COATESVILLE, PA 19320

1, Laponsky st., Markspoll, Brildo, Lifet Amer, Inn. 2010 (470) 62-70-50 A views 2 5 7 Chemical composition, % 2 OT 27.08.2011 Sheet > £ Test results £ F We hereby conform that the products specified in this guality confidents have been toxed and comply with contract regularization. Instrumentations, and prodictionally prospected is watcomilian captricipation interaction, actuations a connectivities by connectivities yourseless contributions. g Africa parties 2 **8 8 8** TOTAL HOUSE 3 2 2 1 ₫ 100 112 24 3 12 6 23 20 112 24 3 12 6 23 20 112 24 3 12 8 23 j Z CEPTMONKAT KANECTRA Nº 09-20410 QUALITY CERTIFICATE Nº 5% 674 SP6 99e 10 1.81 828 2 8085359-Химический состав, % BLA 6-12-12 PROFITETIL MOTESTERNIR 150 0-3 020 020 □ Witnes@ed Reviewed 0.39 0.39 4 Signature 85.0 8.0 4 8 Transport ## Especify # Secretarile Will restration of Area? Off trubory lost pay? C 2 6 4 9 B776 2 B778 TAO «NK «AJOBCTANЬ» PJEC «AZOVSTAL IROM & STEEL WORKS» UA BU BU 1688 T Q.S houghen Note of section 18.647 8.815 8.915 9.632 8.63 Meace, 1(TW) 400711-0735 Mapinepons STB-COX (64, Pic. #Days, LOT 4(10), RET NOLESTS, REW CHLANS, NOME CONTROL (2002) OF STBC. WEST, T (2004) OF STBC. W ASHE SASIA/SASIAN-2010 ASHE ASIA/ASHE 100 ASHE SASIA/SASH-2010 IN BH 10/16/2-2-2013 class B-3 So per customer's specification £1015 8.632 EN X0204-3.1 N HOWEL/RI-CLASS SEPONDENCH Senso Ma LOT 4(10) Manufacturen's production order No Width Langth Konnectuo touspa, are. Quantity of goods, pos ģ 312 na, c.Maranymon, 87800, 91894419, drawz 880 (628) 52-70-00 Paziverbu, godiu Dimensions, inch 120 2 dopos netvenect offereurings. Hopesements Aoryment Normalive document Nonepreparty croud reprosquare Nade by the BOF Process Opowar Toucroniscrosofi Heavy plates Tonumer 11/2 N Actentic No. N. 7675, REF NO. 85579 METINVEST. Овидетельство о прясмечици испытанних Hauseston author trenspa (Tookar vous Description of goods Heavy plate: Mapta, crass ASPRE/ASTN Grade of Steel SV/AS 16-70 MT LTV Прртия Net Изделив Ne Test No/ Product No 54765573 79870 12670 Состанна поставия Вейчегу совейбов napection certificate Steelmaking process Charte # 8778 8778 Saraw Xa RW - Car No Contract No Jakaship Application of the second Nosesen Kem No 10.2 = 1 2 Paciding List 27841-1 (5/29/2012) Img No 13110 (5/30/2012) Your Order 8085358 Our Order 23422-1-1

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REVIEW

Rick Wingelt /

05/08/2013 From: AMERICAN ALLOY STEEL To: HEAT EXCHANGER DESIGN, INC. S.O.# :449980 AA PL#:5130237 P.O.# :003408-00 Item :3 (1 PC) 3-1/4° X 24.13° OD :TAG 00831-0000

ARCELORMITTAL PLATE LLC

MERICAN ALLOY STEEL INC

TEST CERTIFICATE TE: 02/05/13

SOLD TO: AMERICAN ALLOY STEEL, INC P. O. BOX 40469 HOUSTON TX 77240-0469

SEND TO:

01-C

Certified a true copy of the

PLATE DIMENSIONS

GALIGE MIDTH DESCRIPTION 3.25° 96" 240" RECTANGLE 21236#

CUSTOMER INFORMATION .....

CUSTOMER PO: 93229-NY

PART NO. 8

SPECIFICATION (S)

THIS MATERIAL HAS BEEN MANUFACTURED AND TESTED IN ACCORDANCE WITH PURCHASE ORDER REQUIREMENTS AND SPECIFICATION(S).

SA516 REV ED YR 10 GR 70 11A SA516 REV ED YR 10 GR 65 11A A516 10 GR. 70 A516 10 GR. 65

MANAGEMENT SYSTEMS FOR MANUFACTURE OF THIS PRODUCT ARE CERTIFIED 180 9001:2008 (CERTIFICATE NO. 30130) AND ISO 14001 (CERTIFICATE 009496).

COMPOSITION CHEMICAL

MN P S CU .94 .012 .004 .25 31 .21 NI .15 MELT: C5506 V

V TI B AL CB MELT: C5506

HEAT TREAT CONDITION

original, retained in our file. AMERICAN ALLOY STEEL Reviewed By: AIR COOL PL/TEST NORMALIZE 1650F 79

TENSILE PROPERTIES

> ELONGATION GAGE SLAB NO. LOC DIR 5 BOT. 535 TRANS. 824 2.00" 26.0

WE HEREBY CERTIFY THE ABOVE INFORMATION IS CORRECT:

ARCELORMITTAL PLATE LLC QUALITY ASSURANCE LABORATORY 139 MODENA ROAD COATESVILLE, PA 19320

ELINORE ZAPLITNY

TIEWED WITNESS Rick Windell

05/08/2013 From: AMERICAN ALLOY STEEL

P.O.# :003408-00

S.O.# :449980

To: HEAT EXCHANGER DESIGN, INC.

AA PL#:5130237

Item :3 (1 PC) 3-1/4" X 24.13" OD

:TAG 00831-0000

CERTIFICATE

CHARPY V-NOTCH IMPACT RESULTS

5

SLAB **LOC**  DIR

TEMP

SIZE

FT. LBS.

BOT. LONG. -20F FULL 18 24 31

GENERAL INFORMATION

ALL STEEL HAS BEEN MELTED AND MANUFACTURED IN THE U.S.A. TEST CERTS. ARE PREPARED IN ACCORD. WITH PROCEDURES OUTLINED IN EN 10204:2004 TYPE 3.1. ACID SOLUBLE ALIMINUM FOR MORE INFORMATION AND PROCESSING GUIDELINES, REFER TO WWW.ARCELORMITTAL.COM/PLATEINFORMATION

B/L #13647 BVRY 63011

WITNESS

Rick Windell

WE HEREBY CERTIFY THE ABOVE INFORMATION IS CORRECT:

ARCELORMITTAL PLATE LLC QUALITY ASSURANCE LABORATORY 139 MODENA ROAD COATESVELE, PA 19320

ELINORE ZAPLITNY

## **SECTION 17**

# Installation/Operation and Maintenance Manual

Musik SG REVIEW 25 SD13

Installation, Operation & Maintenance Manual

#### T HEAT EXCHANGER PERFORMANCE

Satisfactory operation of heat exchangers can be obtained only from units which are properly designed and have built-in quality. Correct installation and preventive maintenance are user responsibilities.

#### A POSSIBLE PERFORMANCE FAILURES

The failure of heat exchanger equipment to perform satisfactorily may be caused by one or more factors, such as:

- Excessive fouling
- Air or gas binding resulting from improper piping
- Operating conditions differing from design conditions.
- · Poor flow distribution in the unit.
- Excessive clearances between the baffles and shell and/or tubes, due to corrosion.
- Improper thermal design

The user's best assurance of satisfactory performance lies in dependence upon manufacturers competent in the design and fabrication of heat transfer equipment.

#### HEAT EXCHANGER INSTALLATION

### **HEAT EXCHANGER SETTINGS**

#### **CLEARANCES** 1

For straight tube exchangers with removable bundles, provide adequate clearance at the stationary head end to permit removal of the bundle from the shell and provide sufficient space beyond the rear head to permit removal of the shell cover and/or floating head cover.

For fixed tubesheet exchangers, provide adequate 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 adequate clearance at the stationary head end to permit withdrawal of the tube bundle, or at the opposite end to permit removal of the shell.

#### **FOUNDATIONS**

Foundations must be sufficient to negate or eliminate settling of, or 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.

#### 3 MOUNTING BOLTS

Mounting bolts should be loosened at one end of unit to allow free expansion of shells. Slotted holes in supports are provided for this purpose.

Biekhwindell Sol Review S.O.#: 4474

Client: Cenovus Energy, Inc.

P.O.#: 1083-BC-4006

#### Installation, Operation & Maintenance Manual

#### 4 LEVELING

Exchangers must be set level and square so that pipe connections may be made without forcing.

#### **B** CLEANLINESS PROVISIONS

#### 1 CONNECTION PROTECTORS

All exchanger openings should be inspected for foreign material. Protective plugs and covers should not be removed until just prior to installation.

#### 2 PARTICULATE MATTER REMOVAL

The entire system should be clean before start-up. Under some conditions strainers in the supply side piping may be required.

#### 3 CLEANING FACILITIES

Convenient means should be provided for cleaning the unit as suggested under "Heat Exchanger Maintenance" (Paragraph IV).

## C FITTINGS AND PIPING

#### 1 BY-PASS VALVES

It may be desirable to provide valves and/or by-passes in the piping system to permit inspection and/or repairs.

#### 2 TEST CONNECTIONS

When not integral with the exchanger nozzles, thermometer well and pressure gage connections should be installed close to the exchanger in the inlet and outlet piping.

#### 3 VENTS

Vent valves should be provided so units can be purged to prevent vapor or gas binding. Special consideration must be given to discharge of hazardous of toxic fluids.

#### 4 DRAINS

Drains may discharge to atmosphere, if permissible, or into a vessel at lower pressure. They should not be piped to a common closed manifold.

#### 5 PULSATION AND VIBRATION

In all installations, care should be taken to negate or eliminate transmissions of fluid pulsations and physical vibrations to the heat exchangers.

#### 6 SAFETY RELIEF DEVICES

The ASME Code defines the requirements for safety relief devices. When specified by the purchaser, the manufacturer will provide the necessary connections for the safety relief devices. The size and type of the required connections will be specified by the purchaser. The purchaser will provide and install the required relief devices.

Client: Cenovus Energy, Inc. P.O.#: 1083-BC-4006 Item#: BL-E-301 S.O.#: 4474



Installation, Operation & Maintenance Manual

#### III OPERATION OF HEAT EXCHANGERS

#### A DESIGN AND OPERATING CONDITIONS

Equipment must not be operated beyond the conditions listed on vessel nameplate(s).

#### **B** OPERATING PROCEDURES

Reference should be made to the exchanger drawings, specification sheet(s) and name plate(s) for any special instructions before placing exchanger in operation. Jurisdictional 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.

#### 1 START-UP OPERATION

Exchangers shall be placed in service by first establishing circulation of the colder medium, followed by the gradual introduction of the hotter medium. During start-up all vents 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.

#### 2 SHUT-DOWN OPERATION

For exchangers with removable bundles, the units shall shut down by first gradually stopping the flow of the hotter medium and then stopping the flow of the colder medium. If it is necessary to stop the flow of colder medium, the circulation of hotter 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. 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.

#### 3 TEMPERATURE SHOCK

Exchangers shall not be subjected to abrupt temperature fluctuations. Hot fluid must not be suddenly introduced when the unit is cold, nor cold fluid suddenly introduced when the unit is hot.

#### 4 BOLTED JOINTS

Heat exchangers are pressure tested before leaving the manufacturer's shop in accordance with ASME Code requirements. However, normal relaxing of the gasketed joints may occur the interval between testing in the manufacturer's shop and installation at the job site. Therefore, all external bolted joints may require tightening after installation and, if necessary, after the exchanger has reached operating temperature.

Client: Cenovus Energy, Inc. P.O.#: 1083-BC-4006 Item#: BL-E-301 S.O.#: 4474



Installation, Operation & Maintenance Manual

#### 5 RECOMMENDED BOLT TIGHTENING PROCEDURE

It is important that all bolted joints be tightened sequentially & uniformly in a diametrically staggered pattern, except for special high pressure closures when the instructions of the manufacturer should be followed

#### IV HEAT EXCHANGER MAINTENANCE

#### A INSPECTION OF UNIT

Regular periodic examination should be made of 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.

#### 1 INDICATIONS OF FOULING

Exchangers subject to scaling or fouling should be cleaned periodically. A light sludge or scale coating on the tubes greatly reduce their 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 cleaning should not be excessive.

#### 2 INSPECTION OR CLEANING DISASSEMBLY

Before disassembly, the user must be assured that the unit has been depressurized, vented and drained, neutralized and/or purged of hazardous material.

To inspect the inside of the tubes and also make them accessible for cleaning, the following procedures should be used:

- a) Stationary Head End
  - i) TEMA Type A, C, D & N remove cover only
  - ii) TEMA Type B, remove bonnet
- b) Rear Head End
  - i) TEMA Type L, N & P, remove cover only
  - ii) TEMA Type M, remove bonnet
  - iii) TEMA S & T, remove shell cover and floating head cover
  - iv) TEMA Type W, remove channel cover or bonnet

#### 3 LOCATING TUBE LEAKS

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.

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Installation, Operation & Maintenance Manual

- a) Units with removable channel cover: Remove channel cover and apply hydraulic pressure in the shell.
- b) Units with bonnet type head: For fixed tubesheet units where tubesheets are an integral part of the shell, remove bonnet and apply hydraulic pressure in the shell. For fixed tubesheet units where tubesheets are not an integral part of the shell and for units with removable bundles, remove bonnet, re-bolt tubesheet to shell or install test flange or gland, as applicable, and apply hydraulic pressure in the shell.
- c) Units with TEMA Type S or T floating head: Remove channel cover or bonnet, shell cover and floating head cover. Install a suitable test ring and bolt in place with gasket and packing. Apply hydraulic pressure in the shell. 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. Care must be exercised when testing partially assembled exchangers to prevent over extension of expansion joints or overloading of tubes and/or tube-to-tubesheets joints.
- d) Hydrostatic test should be performed so that the temperature of the metal is over 60 F. unless the materials of construction have a lower nil-ductility transition temperature.

#### B TUBE BUNDLE REMOVAL AND HANDLING

To avoid possible damage during removal of a tube bundle from a shell, a pulling device should be attached to eye bolts screwed into the tubesheets. If the tubesheet does not have tapped holes for eye bolts, steel rods or cables inserted through tubes and attached to bearing plates may be used. The bundle should be supported on the tube baffles, supports or tubesheets to prevent damage to the tubes.

Gasket and packing contact surfaces should be protected.

#### C CLEANING TUBE BUNDLES

#### 1 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:

- Circulating hot wash oil or light distillate through tubes or shell at high velocity may effectively remove sludge or similar soft deposits.
- Some salt deposits may be washed out by circulating hot fresh water.

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## Installation, Operation & Maintenance Manual

- 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.
- High pressure water jet cleaning.
- Scrapers, rotating wire brushes, and other mechanical means for removing hard scale, coke, or other deposits.
- 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.

## 2 CLEANING PRECAUTIONS

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-tubesheet joint

When mechanically cleaning a tube bundle, care should be exercised to avoid damaging the tubes.

Cleaning compounds must be compatible with the metallurgy of the exchanger.

#### D 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.

#### **E GASKET REPLACEMENT**

Gaskets and gasket surfaces should be thoroughly cleaned and should be free of scratches and other defects. Gaskets should be properly positioned before attempting to tighten 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.



Installation, Operation & Maintenance Manual

Metal jacketed type gaskets are widely used. When these 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.

#### F SPARE AND REPLACEMENT PARTS

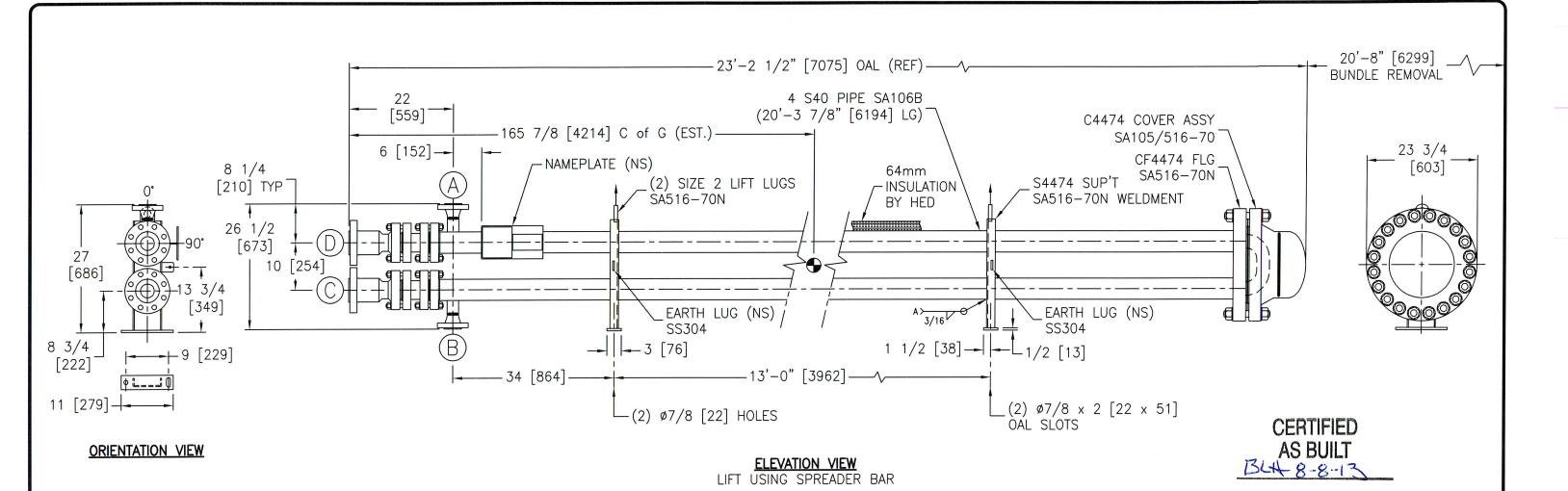
Client: Cenovus Energy, Inc.

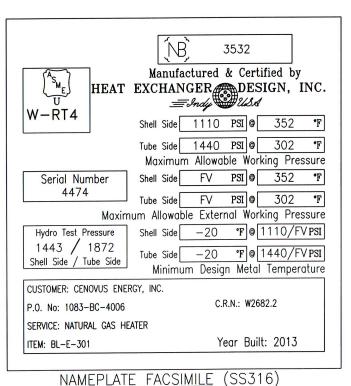
The procurement of spare or replacement parts from the manufacturer will be facilitated if the correct name for the part, is given together with the serial number, type, size, and other information from the name plate. Replacement parts should be purchased from the original manufacturer.



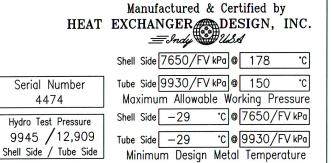
# SECTION 18 Full Size as Built Drawings

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MTD ON 4" SA516-70 STAND OFF BKT



MISC CONSTRUCTION NOTATION

1) FOR MECHANICAL CALCULATIONS SEE CC4474 (& RELATED)

2) DIMENSIONS ARE IN INCHES (mm) & SYMM UNLESS NOTED OTHERWISE

3) FOR BOLTING qv BOM4474 (SA193 B7/194 2H)

4) FOR GASKETS QV BOM4474 (KAMMPROFILE TYPE CS/GRAPHITE)

5) CORROSION ALLOWANCE SHALL NOT BE APPLIED TO INNER PIPE

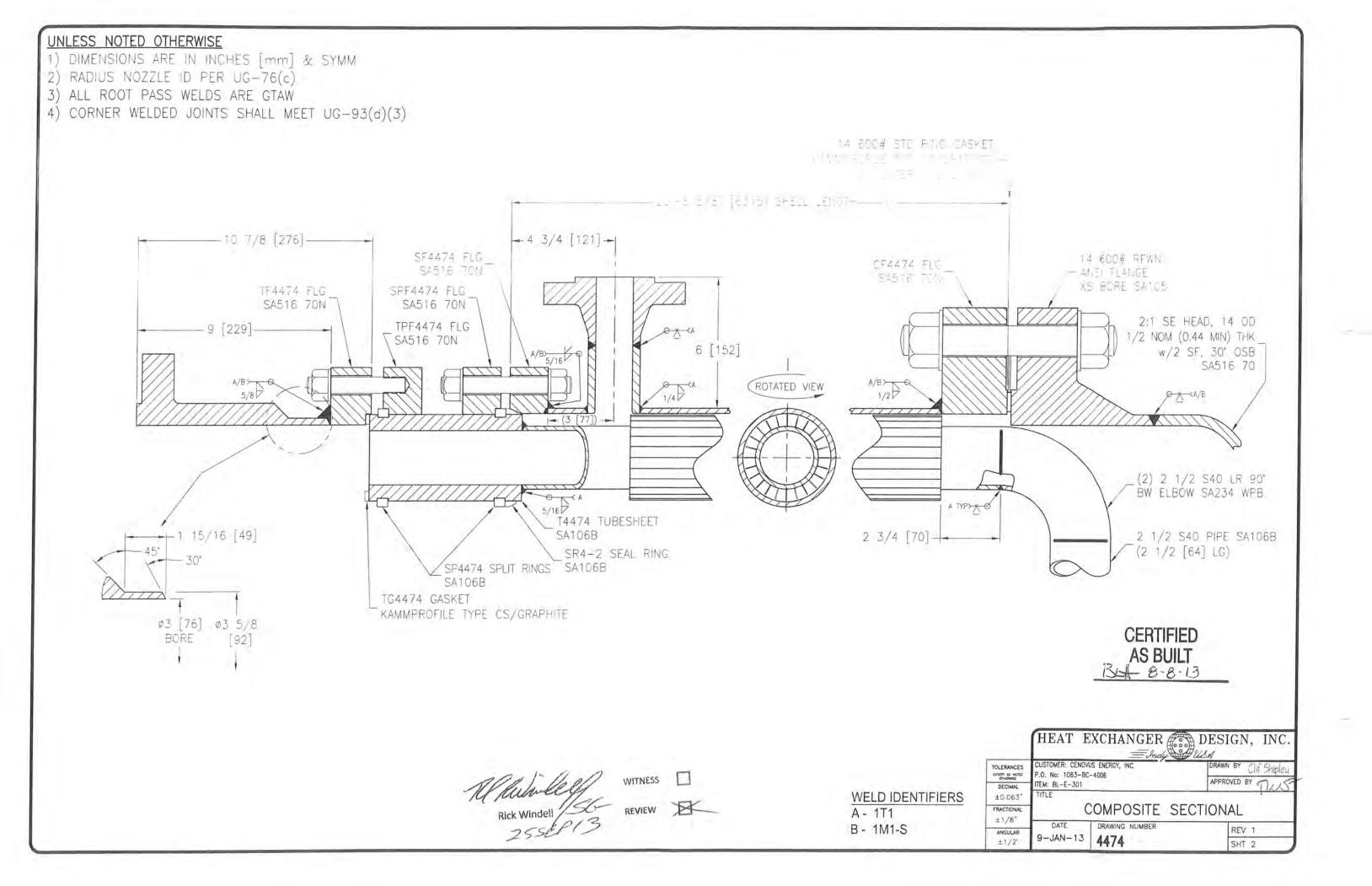
6) (1) HOUR CHARTED HYDROTEST REQUIRED

7) INSULATION SHALL BE HED SUPPLIED AND INSTALLED (SEE TABLE 1g)

8) SHIPPPING CRATE SHALL BE SUPPLIED

*WEIGHT TABLE						
TOTAL UNIT	1879# (852.3)					
FILLED w/WATER	2031# (921.25)					
TUBE BUNDLE	332.05# (150.62)					
REMOVAL LOAD	498.08# (225.93)					

		NOZZLE SO	CHEDULE		TUBE DATA	DESIGN C	ONDITIO	NS	S	PECIAL DATA		CU	STOMER DATA		
	NOZ.	SIZE / RATING	SERVICE	INNER PIPE	2 1/2 PIPE S40		SHELLSIDE	TUBESIDE	ASME SE	CTION VIII, DIV 1, 2010 ED., A11	CUSTOMER: CEN	iowus energy, ii	NC. P.O.	. No: 1083-BC-4	4006
	Α	2" 600# RFWN (S160)	SHELL IN (SA105/106B)		247 3/4 [6293] LONG	PSI DESIGN PRESSURE (kPa)	1110 (7650)/FV	1440 (9930)/FV	TEMA CLAS	S R (AS APPLICABLE)	USER:		ITEM	4: BL-E-301	
	В	2" 600# RFWN (S160)	SHELL OUT (SA105/106B)	MATERIAL	SA106B/234 WPB, C-STL FINS	*F DESIGN TEMPERATURE (*C)	352 (178)	302 (150)	CLIENT INS	P. AS REQUIRED	SERVICE: NATUR	AL GAS HEATER	SIZE	E: SH4K1-20-00-	-24UV-2C3D
	С	3" 900# RFLWN (MOD)	TUBE IN (SA105)	LONG FINS	(24) 1/2 HI, 0.035 THK	CORROSION ALLOWANCE (mm)	1/16 (1.6)	1/16 (1.6)	WEIGHT (K	1088# (493.5)	TOLERANCES	HEAT	EXCHANGER #	DESIGN,	INC.
	D	3" 900# RFLWN (MOD)	TUBE OUT (SA105)		20'-0" LG (2 3/4 & 5 BARE)	PSI HYDROTEST (kPa)	1443 (9945)	1872 (12,909)	SQ' AREA	(M <sup>2</sup> ) 109 (10.1)	EXCEPT AS NOTED OTHERWISE		<i>≡</i> Indy	2681	
l '	NAME OF TAXABLE PARTY.			TUBESHEET	SA106B	RADIOGRAPHY	UW-11(a)(5)(b)	UW-11(a)(5)(b)	SURFACE F	REP Sp-10			NED DOUBLE PIPE TYPE	DRAWN BY	Clif Shipley
						'F MINIMUM TEMPERATURE ('C)	-20 (-29)	-20 (-29)	PAINTING S	PEC. CARBOZINC 11 (2-3 mils DFT)		COUNTERFLOW	GER SINGLE PASS,	APPROVED F	BYTWF
						POST WELD HEAT TREAT	NO	NO	F	REVISION LOG	FRACTIONAL	TITLE	SCHOOL ADDAM		
						IMPACT TEST EXEMPTION	UG-20(f), UCS-66	UG-20(f), UCS-66	NO. DATE	COMMENT	±1/4"	(·	SENERAL ARRAN	GEMENT	
						WIND	97 ki	m/hr	1 21-FEB	FABRICATION DWG RELEASE	ANGULAR	DATE	DRAWING NUMBER		REV 1
						SEISMIC	SITE CL	ASS D	A 9-JAN	APPROVAL DWG RELEASE	±1/2°	9-JAN-13	4474		SHT 1



# SECTION 19 Inspection & Test Plan

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BANTREL	JOB VP NO.						
VENDOR PRINT	10	1083-BC-4064-0017					
EQUIPMENT NUMBER	F	bL-E-301					
CLIENT CROSS REF							
Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve the supplier from full compliance with contractual obligations.  1. Work may proceed. 2. Revise and resubmit. Work may proceed subject to incorporation of changes indicated. 3. Revise and resubmit. Work SHALL NOT proceed. 4. Reviewnot required. Work may proceed.  BY:  DATE Wine 11, 701							

Multiless D Rick Windell SG REVIEW D 8-8-13

Heat Exchanger Design, Inc. P. O. Box 524 Indianapolis, IN 46206-0524 USA Phone: (317)686-9000 - Fax: (317)686-9100



	Inspection and Test Pla	an	
Revision 1	•		28-May-2013
Customer: Cenovus Energy, Inc.	P.O. #: 1083-BC-4006	Item #: BL-E-301	
Description: Natural Gas Heater		Work Order #: 4474	

			ORMED Y:		
NO.	ACTIVITY	Vendor	Client	REMARKS	
1	Inspection of raw material: Qty, Markings, MTR's etc. All pressure bo	undary materials	P		
	and welded attachments are in accordance with A.S.M.E. Sections II Codes.	BER			
2	Inspection of machined parts.	BCH	- P		
3	In process fabrication inspection:	BLH	P		
	a) verification of WPS/PQR(s)	BOH	- P		
	b) verification of filler metal	344	P		
	c) verification of welder's qualifications	BLA	P		
	d) inspection of weld joint preparations and fit-ups	BLH	P		
	e) inspection of root pass and final welds	BUN	- P		
	f) verification of appurtenance layout	Bet	- P		
4	Confirmation of valid NDE personnel qualifications & proper NDE pro	cedures. BLA	- P	ew	
5	Perform PT examination of:	Bill		-	
	a) areas as required by A.S.M.E. Sec.VIII, Div.1 Code	BLA	P	Rh	$\nu_{l}$
	b) lift lug final welds	BiH	P	RA	$\mathcal{V}$
6	Final visual inspection of welds, dimensions and orientations.	BUN	- P	No.	
7	Perform Spot RT of shell and tube sides. Verify film and review reader			1/	Subcontracted
8	Perform hydrostatic testing w/potable water per ASME Code @ pressure in each chamber individually for I hour using chart recorder.	50°F min. Hold BLN	P	на	V
9	Perform blast and paint per client specification TR-43-SPC manufacturer's recommendations. Each sub-assembly shall be treated to final assembly to insure flange faces and bolts holes are coated preparation & verify blast profile and coating thickness & appearance. SP10 and prime 2-3 mils DFT Carbozinc 11.	individually prior . Inspect surface	P		
10	Confirm Canadian Registration (CRN) through province of Alberta is r			100	/
11	Verification of nameplate stamping.	DLH		w	1
12	Verify insulation installed per client specification TR-43-SPC-00-021-02	2. 304	R	M	Subcontracted – certification supplied by installer
13	Inspection of shipment preparation. Blow completely dry, oil flange facovers & plastic wrap. Verify one(1) set of spare gaskets is included.	nces, bolted wood BL <del>U</del>			Client perform final inspection
14	Acquire Inspection / Shipping Release from client.	But	P	н	Client provide after final irrspection
15	Review of Manufacturer's Equipment Record Book & Dispatch Dossie		P	R	J
			<u> </u>		
"Vend		R-	- Perform - Review		
"Clien	refers to Cenovus Energy or their assigned Third Party Inspector	H-		s nust be pre m Inspectio	
	Whitelell	WITNE		]	

REVIEW



# **SECTION 20**

# **Short / Long Term Storage Procedure**

Mulabell WITNESS D Rick Windell 156 REVIEW 255813

## Heat Exchanger Design, Inc.

P. O. Box 524

Indianapolis, IN 46206-0524 USA

Phone: (317)686-9000 • Fax: (317)686-9100



The list below is not meant to cover every possible scenario and is only a general list of procedures that can be incorporated to reduce the amount of corrosion until the exchangers/vessels are placed into service. If an area is not addressed adequate measures should be put in place to address the possibility for corrosion.

#### Short-Term and Long -Term Storage for Pressure Vessels & Heat Exchangers

- 1.) Internal surfaces may be protected against corrosion by the use of a desiccant, a rust inhibitor or blanketing with an inert gas (pressure up to 5 psig)
- 2.) If left un-blanketed all machined surfaces to be coated with rust inhibitor.
- 3.) Un-painted exterior surfaces should be treated with rust inhibitor, insulated or covered to reduce moisture and corrosion.
- 4.) If left un-blanketed internal surfaces should be visually inspected and/or flushed to remove any residue prior to start-up.
- 5.) All machined surfaces should be cleaned and gaskets visually inspected prior to start-up.
- 6.) Random inspections should be incorporated based on climate and environmental conditions to insure that adequate measures are in place and functioning to reduce corrosion.

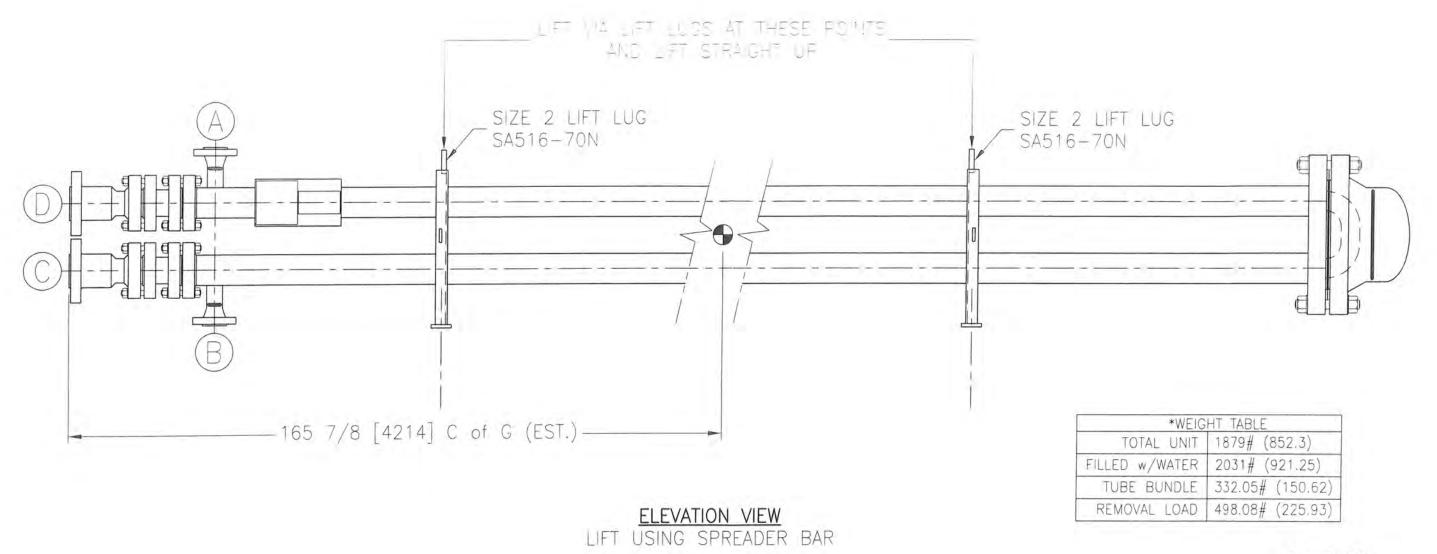
BANTREL	JOB	VP NO.	REV				
VENDOR PRINT	1083-186-4006-6018 O						
EQUIPMENT NUMBER	Y	5L-E-301					
CLIENT CROSS REF							
Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve the supplier from full compliance with contractual obligations.							
Work may proceed.     Revise and resubmit. Work may proceed subject to incorporation							
of changes indicated.  3. Revise and resubmit, Work SHALL NOT proceed.							
4. Review/not required. Work may proceed.							
BY: DATE:							

Serving Petroleum, Petrochemical, Power, Food, and Industrial on Heat Transfer Equipments

# **SECTION 21**

# Sling / Lifting Arrangement Drawing

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CERTIFIED

AS BUILT

BLH 88-13

Rick Windell 156-25 Sep 13

WITNESS [

	-	CL	ISTOMER DA	TA			
L	LOSTOMER: CE	NOVUS ENERGY, I	NC.	P.O. No: 1083-BC-4006			
	USER:			ITEM: BL-E-301 SIZE: SH4K1-20-00-24UV-2C3D			
F	SERVICE: NATU	RAL GAS HEATER					
	TOLERANCES EXCEPT AS MOTED OTHERWISE	HEAT	EXCHANGER	DESIG	N, INC.		
	DECIMAL ±0.125"	A 1.114 D. W. C. C. C. C. C. C.	GER SINGLE PASS,	TYPE DRAWN BY CLIF Shiples			
	FRACTIONAL ±1/4"	TITLE	LIFTING ARRA	NGEMENT	1000		
	±1/2	B-AUG-13	DRAWING NUMBER		REV 1		