UOP RUSSELL LLC
Tulsa, Oklahoma

JOB NO: J-447 **DATE:** 7/14/11
CLIENT: UOP Russell **BY:** JRG
SUBJECT: 60 MMscfd Cryo Plant

PLATE FIN EXCHANGER

SURFACE AREA: N/A ft^2 TOTAL DUTY: 2150 MBTU/hr
SERVICE: Demethanizer Reboiler TAG NO: E-204
Combined with E-205 P.O./S.O.#

		PROCESS DESIGN							
FLUID CIRCULATED:		Inlet Gas		Tower Liquid					
FLUID FLOW:	lb/hr	65428		70777					
FLUID DUTY:	MBTU/hr	2150							
STREAM NO:		153	5	204	206				
LIQUID		**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**
FLOWRATE:	lb/hr	2761	12190	70777	60167				
DENSITY:	lb/ft^3	27.88	26.88	31.45	31.35				
MOLECULAR WEIGHT:		38.25	33.88	37.07	38.27				
SPECIFIC HEAT:	BTU/lb-°F	0.6957	0.7204	0.6434	0.6483				
THERMAL COND:	BTU/hr.ft.°F	0.0500	0.0521	0.0604	0.0583				
VISCOSITY:	Cp	0.0850	0.0782	0.1077	0.1069				
VAPOR									
FLOWRATE:	lb/hr	62667	53238	0	10610				
DENSITY:	lb/ft^3	4.842	5.034		1.398				
MOLECULAR WEIGHT:		21.96	20.74		31.45				
SPECIFIC HEAT:	BTU/lb-°F	0.6918	0.7406		0.4450				
THERMAL COND:	BTU/hr.ft.°F	0.0204	0.0200		0.0113				
VISCOSITY:	Cp	0.0132	0.0128		0.0090				
OPER. TEMPERATURE:	°F	54.8	23.4	6.0	18.6				
INLET PRESSURE:	psia	880		190					
CORRECTED MTD:	°F	24.73							
UA	BTU/hr-°F	86,960 (88,600)							
ALLOW. PRESS. DROP:	psi	5		1					
FOULING RESISTANCE:	BTU/ft^2-°F	0.0005		0.0005					
MECHANICAL DESIGN									
DESIGN TEMPERATURE:	°F	150		150					
DESIGN PRESSURE:	psig	1100		400					
MDMT @ PRESSURE	°F / psig	-200 @ 1100		-200 @ 400					
CALC PRESSURE DROP:	psi	3.15		1.3					
PLATE / FIN MAT'L:		Aluminum		Aluminum					
NOZZLES									
SIZE:	inch	8"	-----	4"	6"				
TYPE / RATING:		600# RF	-----	300# RF	300# RF				
MATERIAL:		Aluminum		Aluminum					

DIMENSIONS

TOTAL NO. OF CORES: 1 in series 1 in parallel NO. OF ASSEMBLIES: 1
SHIPPING WEIGHT: 3,500 lbs LENGTH: 126" HEIGHT: 14.22" WIDTH: 24"
SUPPORT TYPE: Side Bar Angle INSULATION THICKNESS: 2.5" C

NOTES

(1) Add 10% to duty and flowrates for design.
(2) Equipment design shall satisfy design and alternate conditions.
(3) Minimum core stack height is preferred.
(4) Stacked with E-205
▲(5) Wind ASCE 7-10, 120mph, Exp. C, Cat III; Seismic ASCE 7-10, Site D, I=1.25, Ss=100%, S1=40%.
(6) Recov C1 GSP-1.hsc

REVISION	A		0		▲1			
ENGINEER/DATE	JRG	7/14/11	JRG	7/14/11	SHP	2/14/14		
ISSUED FOR	RFQ		Purchase		Revised			

UOP RUSSELL LLC
Tulsa, Oklahoma

JOB NO: J-447 **DATE:** 7/14/11
CLIENT: UOP Russell **BY:** JRG
SUBJECT: 60 MMscfd Cryo Plant

PLATE FIN EXCHANGER

SURFACE AREA: N/A ft^2 TOTAL DUTY: 3170 MBTU/hr
SERVICE: Demethanizer Side Heater TAG NO: E-205
Combined with E-204 P.O./S.O.#

		PROCESS DESIGN				Off Design - C2 Rejection			
FLUID CIRCULATED:		Inlet Gas		Tower Liquid		Inlet Gas		Tower Liquid	
FLUID FLOW:	lb/hr	65428		76285		61339		71348	
FLUID DUTY:	MBTU/hr	3170				2137			
STREAM NO:		5	155	201	202	5	155	201	202
LIQUID		**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**
FLOWRATE:	lb/hr	12190	27290	76285	66235	0	7155	71348	60138
DENSITY:	lb/ft^3	26.88	25.67	33.08	32.30		27.35	30.64	30.67
MOLECULAR WEIGHT:		33.88	29.09	34.99	36.84		35.78	37.83	39.11
SPECIFIC HEAT:	BTU/lb-°F	0.7204	0.7574	0.5877	0.6138		0.7086	0.6688	0.6710
THERMAL COND:	BTU/hr.ft.°F	0.0521	0.0537	0.0693	0.0641		0.0513	0.0566	0.0549
VISCOSITY:	Cp	0.0782	0.0707	0.1326	0.1193		0.0812	0.1002	0.1003
VAPOR									
FLOWRATE:	lb/hr	53238	38138	0	10050	61339	54184	0	11210
DENSITY:	lb/ft^3	5.034	5.434		1.189	4.522	4.894		1.618
MOLECULAR WEIGHT:		20.74	19.18		26.25	22.36	21.30		32.20
SPECIFIC HEAT:	BTU/lb-°F	0.7406	0.8562		0.4484	0.6574	0.7129		0.4671
THERMAL COND:	BTU/hr.ft.°F	0.0200	0.0197		0.0119	0.0208	0.0201		0.0119
VISCOSITY:	Cp	0.0128	0.0124		0.0090	0.0134	0.0130		0.0093
OPER. TEMPERATURE:	°F	23.4	-18.5	-50.7	-14.5	75.7	37.5	26.0	37.3
INLET PRESSURE:	psia	875		188.5		875		218.5	
CORRECTED MTD:	°F	32.96				20.53			
UA	BTU/hr-°F	96,190 (223,000)				104,100 (223,000)			
ALLOW. PRESS. DROP:	psi	5		1		5		1	
FOULING RESISTANCE:	BTU/ft^2-°F	0.0005		0.0005		0.0005		0.0005	
MECHANICAL DESIGN									
DESIGN TEMPERATURE:	°F	150		150					
DESIGN PRESSURE:	psig	1100		400					
MDMT @ PRESSURE	°F / psig	-200 @ 1100		-200 @ 400					
CALC PRESSURE DROP:	psi	3.15		1.3		6.2		0.9	
PLATE / FIN MAT'L:		Aluminum		Aluminum					
NOZZLES									
SIZE:	inch	-----	8"	6"	6"				
TYPE / RATING:		-----	600# RF	300# RF	300# RF				
MATERIAL:		Aluminum		Aluminum					

DIMENSIONS

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(3) Minimum core stack height is preferred.
(4) Stacked with E-204
▲(5) Wind ASCE 7-10, 120mph, Exp. C, Cat III; Seismic ASCE 7-10, Site D, I=1.25, Ss=100%, S1=40%.
(6) Design Case: Recov C1 GSP-1.hsc Off-Design: Reject C1.hsc

REVISION	A		0		▲1			
ENGINEER/DATE	JRG	7/14/11	JRG	7/14/11	SHP	2/14/14		
ISSUED FOR	RFQ		Purcahse		Revised			

UOP Russell, LLC

Final Documentation
P.O. # 4500748690
Item # E-204-205
Chart S.O. # 2968.2-2

INDEX

Section	Contents
1	Material Certificates & Traceability
2	Manufacturer's Data Reports (U-1/U-4 Forms)
3	Inspection and Test Reports
4	Hydrostatic / Pneumatic Test Charts
5	Nameplate Copies
6	Liquid Penetrant Test Report
7	As-Built Dimensional Report
8	Chart IOM Manual

HEAT EXCHANGER MATERIAL TRACEABILITY

SALES ORDER NO. 2968.2-2 **DRWG. NO.** 17769A

Nozzles:

Purpose	Dia. or Size	Material	Nozzle Thk. Nom.	Trace Code
B IN	4.500	SB-241-5083	0.237	T138C
B OUT & C IN&OUT	6.625	SB-241-5083	0.280	T178C
A IN&OUT	8.625	SB-241-5083	0.719	T183C

Headers:

Purpose	Material	Nom. Thk.	Trace Code
B IN	SB-209-5083	0.250	S618C
B OUT & C IN&OUT	SB-209-5083	0.375	S651C
A IN&OUT	SB-209-5083	1.250	S661C

End Pieces:

Purpose	Material	Nom. Thk.	Trace Code
B IN	SB-209-5083	0.375	S619C
B OUT & C IN	SB-209-5083	0.625	S644C
C OUT	SB-209-5083	1.000	S660C
A IN&OUT	SB-209-5083	1.250	S661C

Fittings:

Purpose	Description	ASTM or ASME Code	Trace Code
B IN	6061 4" 300# FLANGE	B247	W669E
B OUT & C IN&OUT	6061 6" 300# FLANGE	B247	W670E
A IN&OUT	6061 8" 600# FLANGE	B247	W671E

THE MATERIAL CERTIFICATION USED IN THE FABRICATION OF THE CORE OF THE ABOVE ASSEMBLY CONTAINS RESTRICTED INFORMATION.

THEREFORE IT IS COMPANY CONFIDENTIAL, AND CANNOT BE DIVULGED TO THE CUSTOMER OR ANY THIRD PARTY.

ALL MATERIALS USED MEET THE SPECIFICATIONS AND THE MANUFACTURING CODE AS STATED ON THE DRAWING.

Traci Leis

Traci A. Leis
Documentation Coordinator

ALUnna TUBES

Abnahmeprüfzeugnis 3.1 - DIN EN 10204:2005

Inspection Certificate 3.1 - DIN EN 10204:2005 / Certificat de Reception 3.1- DIN EN 10204:2005

Kunde: *Client:*

Zeugnisnummer: *Cert No.: / No. du certificat:* 43669/1

Bestellnummer: *Order No. / No. de commande* 29742

Produkt: *Product / Produit:* Rohre nahtlos gepresst / *Tubes seamless extruded*

Auftrag: *Our Reference/Notre Reference:* 43669/1

Spezifikation: *Specification:* ASME SB 241; BS - EN 755; - ✓

PO 3428042

LG# 7244-T-138C

Werkstoff: *Alloy/Alliage:* 5083

Zustand: *Temper/État* 0

Abmessung *Size / Dimension* 114,300 mm x 102,260 mm x 6,020 mm x 6000,000 mm
4" NB SCH 40

Kennzeichnung *Marking/Marquage:* AWU - 5083 - 0 - ASME - SB241 - 4" NB SCH40 - Cast No. ... - AAI

8/25/16

Lieferung: *Delivered Material / Matérial délivre:* pcs. 65 kgs 2088

1. Chemische Analyse — *Chemical Analysis / analyse chimique*

Charge/ Cast No.		Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Pb	Zr	Bi	Sn	Na
	min.				0,40	4,0	0,05							
	max.	0,40	0,40	0,10	1,0	4,9	0,25	0,25	0,15					
* 7244/12		0,195	0,331	0,066	0,593	4,823	0,070	0,025	0,024	0,002	0,0111	0,0001	0,0016	0,0001
Hydrogen content:			0,10		**ccm/100 g Al**									
7588/12		0,174	0,290	0,052	0,663	4,753	0,077	0,037	0,023	0,001	0,0128	0,0001	0,0016	0,0002
Hydrogen content:			0,10		**ccm/100 g Al**									

Elemente ohne Angabe < 0,01 % / Elements without indication < 0,01 %

2. Mechanische Eigenschaften — *Mechanical Properties / Valeurs Mécaniques*

Anforderungen Requirements	tensile (Rm) Ksi	yield (Rp0,2) Ksi	elongation 2" %	elongation A 5 %	Hardness HB	Cast No.
min.	39,0	16,0	14,0	12,0		
max.	51,0					
1	45,385	21,750	24,0	24,0		7588 - 20 pcs.
2	45,675	21,750	23,0	23,0		
3	44,950	21,750	22,0	22,0		7244 - 45 pcs.
4	44,225	21,895	23,0	23,0		
5	44,080	22,330	23,0	23,0		
6	44,515	20,880	22,0	22,0		

TEST CERTIFICATE CHECKED & VERIFIED

Ergebnis der Prüfungen: Es wird bestätigt, daß die Lieferung geprüft wurde und den Vereinbarungen bei der Bestellannahme entspricht

Test results: We confirm that the delivery has been tested and applies to the agreements made on receipt of the order

Resultats: Nous confirmons que la livraison a été controlée et correspond avec les conventions faites à la réception de la commande

08.05.2012 / merg

Certified acc. to DIN EN ISO 9001:2008 and DIN EN 9100:2003, valid until 2013-11-10
Cert.- Reg. No.: 001959 QM08;001959 AS1

ALUnna Abnahmebeauftragter

TW METALS TEST REPORTS OCT 21 2015 ACCEPTED BY

TW METALS TEST REPORTS OCT 19 2015 ACCEPTED BY

OK FOR PED

REVIEWED 9-1-16

AUG 25 2016

AI - Cmp 8/25/16

PO 34699305

T-178-C

4 2-17-17

Abnahmeprüfzeugnis 3.1 - DIN EN 10204:2005

ALUnna TUBES

Inspection Certificate 3.1 - DIN EN 10204:2005 / Certificat de Reception 3.1- DIN EN 10204:2005

Kunde: *Client:* TW Metals (MN)

14600 James Rd.
MN 55374 Rogers USA

Zeugnisnummer: *Cert No.: / No. du certificat:* 1664/15

Bestellnummer: *Order No. / No. de commande* M 49342799

Produkt: *Product / Produit:* Rohre nahtlos gepresst / *Tubes seamless extruded*

ALUnna Auftragsbest.-Nr.: *ALUnna Conf.-No.:/ conf. de commande:* 58912/100

Spezifikation: *Specification:* ASME SB 241 / ASME SB 241 - M 2013 Section II, Part B; -

Werkstoff: *Alloy/Alliage:* 5083

Zustand: *Temper/État* 0

Abmessung *Size / Dimension* 6,625 INCH x 6,065 INCH x 0,280 INCH x 20,000 FEET
51852

Kennzeichnung *Marking/Marquage:* ALUnna - Cert No. 1664/15 - 5083 - 0 - Cast No. 4241 - ASME - SB 241 - (2013) - 6.625" OD X 0,280 " Wall - 6,000 SCH 40 - Alunna Order Conf No. 58912/100 - 1 - CPB 300

Lieferung *Delivered Material / Matérial délivre:* pcs. 16 lbs 2116

Country of Manufacture: Germany

1. Chemische Analyse — *Chemical Analysis / analyse chimique*

		Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Pb	Zr	Bi	Sn	Ni	Na
Charge/ Cast No.	min.				0,40	4,0	0,05								
	max.	0,40	0,40	0,10	1,0	4,9	0,25	0,25	0,15						
4241/15		0,158	0,326	0,031	0,495	4,735	0,075	0,024	0,019	0,002	0,0038	0,0008	0,0017	0,0080	0,0002

Hydrogen content: 0,10 **ccm/100 g Al** Elements without indication < 0,01 % **country of melt manufacturer: Germany**

Products are in accordance with applicable RoHS

FAR BAA:	Cannot certify compliance
DFARS BAA:	Complies
FAR TAA:	Cannot certify compliance

CK FOR RED

REVIEWED
FEB 17 2017
2/17/17

2-23-17

TW METALS
TEST REPORTS
JAN 26 2016
ACCEPTED BY

Ergebnis der Prüfungen: Es wird bestätigt, daß das Material geprüft wurde und den Vereinbarungen bei der Bestellannahme entspricht

Test results: We confirm that the material has been tested and applies to the agreements made on receipt of the order

Resultats: Nous confirmons que le materiel a été controlée et correspond avec les conventions faites à la réception de la commande

07.12.2015

Zertifiziert nach DIN EN ISO 9001:2008 und DIN EN 9100:2009
gültig bis 2016-11-10
Zertifikat- Register- Nr.: 001959 QM08; 001959 ASH 09-1

released by
Holmann

Aluminiumwerk Unna AG Uelzener Weg 36 59425 Unna, Germany

T-178-C

Abnahmeprüfzeugnis 3.1 - DIN EN 10204:2005

ALUnna TUBES

Inspection Certificate 3.1 - DIN EN 10204:2005 / Certificat de Reception 3.1- DIN EN 10204:2005

Kunde: *Client:* TW Metals (MN)

14600 James Rd.
MN 55374 Rogers USA

Zeugnisnummer: *Cert No.: / No. du certificat:* 1664/15

Bestellnummer: *Order No. / No. de commande* M 49342799

ALUnna Auftragsbest.-Nr: *ALUnna Order Conf.No.:* 58912/100

Kennzeichnung *Marking/Marquage:* ALUnna - Cert No. 1664/15 - 5083 - 0 - Cast No. 4241 - ASME - SB 241 - (2013) - 6.625" OD X 0,280 " Wall - 6,000 SCH 40 - Alunna Order Conf No. 58912/100 - 1 - CPB 300

Lieferung *Delivered Material / Matérial délivre:* pcs. 16 lbs 2116

Country of Manufacture: Germany

2. Mechanische Eigenschaften — Mechanical Properties / Valeurs Mécaniques

Anforderungen Requirements	tensile (Rm) ksi	yield (Rp0,2) ksi	elongation 2" %	elongation A %	Hardness HB
ASME SB 241	39,0 51,0	16,0	14,0		
1	44,950	23,345	23,0		
2	44,225	23,200	23,0		
3	44,660	22,910	22,0		

CUT FOR RED

REVIEWED
FEB 17 2017

2-23-17
AJ 40A
2/17/17

TW METALS
TEST RECEIVED
JAN 26 2016
ACCEPTED BY

Ergebnis der Prüfungen: Es wird bestätigt, daß das Material geprüft wurde und den Vereinbarungen bei der Bestellannahme entspricht

Test results: We confirm that the material has been tested and applies to the agreements made on receipt of the order

Resultats: Nous confirmons que le materiel a été controlée et correspond avec les conventions faites à la réception de la commande

07.12.2015

Zertifiziert nach DIN EN ISO 9001:2008 und DIN EN 9100:2009
gültig bis 2016-11-10
Zertifikat- Register- Nr.: 001959 QM08; 001959 ASH 09-1

released by
Hollmann

ALUnna AG, Holzener Weg 36, 59425 Unna, Germany

Aleris
Extruded Products
Friedrich-Wöhler-Str. 2
53117 Bonn
Tel.: 0228 / 558-2876
Fax.: 0228 / 558-2784

Abnahmeprüfzeugnis DIN EN 10204-3.1

Inspection Certificate / Certificat de Reception

Aleris Aluminum Bonn GmbH • Postfach 420216 • 53054 Bonn

Po 3032878
Lot 114131
T-183-C
4-31417

CHART ENERGY AND
CHEMICALS, INC.
2191 WARD AVENUE
USA LA CROSSE WI 54601

edith.berkenkopf@aleris.com;richard.lalande@aleris.com

Nummer / No / Nr.	LS00147586-0010
Unser Auftrag / Our Commission / Notre Confirmation	15116399-0050
Lieferung vom / Or do	24.02.12
Ihre Bestellung / Your Order / Ident nb / Votre ordre	3032878 dated 02.09.2011 (Jeff Haldeman)
Sachbearbeiter / Sales Contact / Compétent	Herr B. Müller
Herstellungs- Nr.(FA) / Factory no / Fabrications numéro	Pr: 45 x 356503-00
	Pk. 45 x 356503-00

Produktbeschreibung-Description of Product-Description de produit — *Liefermenge / Quantity / Quantité*

seamless tubes extruded, as per EN 755-7 (*) — 6.000,0 Kg
in alloy as per EN AW 5083 H112 die no.: 219018 31,11 kg/m
DIA. 219.075 x 18.26 MM (PIPE 8 NPS .719W)
length: 4200 mm (165.35")
(*) = SES 4-1.87 / ASME SB 241 / ANSI H35.1/.2
tolerances as per drawing

Prüf-Nr. / Identification No / No	Chargen-Nr. / Cast No / Coulee N°	Rp 0,2	Rm	A50 % / A2"	HB	Leitfähigk. MS/m	Bemerkungen / Notes / Remarques
Sollwerte / Values / Valeurs		110 Mpa 16 ksi	270 Mpa 39 ksi	12,0 12,0			ASME SB 241 ✓
	01/114131	192,9 Mpa	307,0 Mpa	21,6 %			
	01/114131	192,2 Mpa	307,2 Mpa	21,7%			
	01/114131	189,6 MPa	310,3 Mpa	23,6 %			
	01/114131	172,4 Mpa	307,0 MPa	24,7 %			
	01/114131	168,2 Mpa	303,7 Mpa	23,7 %			
	01/114131	177,2 Mpa	305,4 Mpa	23,6 %			
	01/114131	28,0 ksi	44,5 ksi	24,0 %			
	01/114131	27,9 ksi	44,6 ksi	24,4%			
	01/114131	27,5 ksi	45,0 ksi	23,6%			
	01/114131	25,0 ksi	44,5 ksi	25,0 %			
	01/114131	24,4 ksi	44,0 ksi	25,2 %			
	01/114131	25,7 ksi	44,3 ksi	24,4 %			

OK FOR PED

3-16-17
REVIEWED
MAR 14 2017
AF=4 3/14/17

Sollwerte / Values / Valeurs	Si %	Fe %	Cu %	Mn %	Mg %	Cr %	Zn %	Ti %	%	%
Chargen-Nr. / Cast No. / Coulee N°	0,40	0,40	0,10	1,00	4,90	0,25	0,25	0,15		
	0,00	0,00	0,00	0,40	4,00	0,05	0,00	0,00		
01/114131	0,15	0,27	0,06	0,71	4,56	0,07	0,02	0,01		

S. Jost
Leiter Werkstoffprüfung / Expert

Dieses Dokument wurde elektronisch erstellt und ist ohne Unterschrift und Stempel gültig.
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Bonn, den 01.03.12 10:15:46

Exh 01

PO 3185340
S-618-C

AMAG ROLLING

Abnahmeprüfzeugnis 3.1 (EN 10204)
inspection certificate - mill certificate 11/1/16

Nr.: 85220799 **02 / 3**
Rev.: 0
Seite / page: 1 von / of 2
Datum / date: 2014 01 07

Zertifiziert nach / certified to ISO 9001, ISO/TS 16949, EN/AS 9100, ISO 14001, NADCAP

Auftraggeber / customer: TW METALS, INC 760 CONSTITUTION DR EXTON PA 19341 USA	Bestell Nr. / order no.: M 49302619 Datum / date: 2013 09 20
	Auftragsbest. Nr. / order confirm no.: 663678 Datum / date: 2013 09 25
Warenempfänger / consignee: TW Metals - Rogers 14600 James Road ROGERS MN 55374 USA	Lieferschein Nr. / delivery note: 85220799 Datum / date: 2014 01 31

Produktspezifikation	Bedingungen / terms
Form / form: Sheet Werkstoff / material: 5083 Zustand / temper: O Dim. / dim.: [inch]: 0,250x60,00x144,00 Kundenartikel Nr. / cust. article no.: 12702	Technische Lieferbedingungen / techn. spec.: ASTM B 209 - 10 ASME SB-209, 2011a ✓ Sondervorschrift / special terms:

AB-Pos. ord. item	BNr/Los/Teilos Lot/No. Part	Guss-Nr. cast no.	Werkstoff material	Kolli packing	Gewicht netto weight net	Stk pcs.
07	16673/02/00	01/0059307/3	5083	6636780047	3333,333 lbs	16
07	16673/02/00	01/0059307/3	5083	6636780048	3333,333 lbs	16

Chemische Zusammensetzung (%) (Gewichtsanteile) / Chemical composition (%) weight proportion (OES)

Guss Nr. / cast no.	material	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others Each	Others Total
01/0059307/3	5083										
	spec. min.	-	-	-	0,40	4,0	0,05	-	-	-	-
	spec. max.	0,40	0,40	0,10	1,0	4,9	0,25	0,25	0,15	0,05	0,15
	actual	0,24	0,35	0,06	0,61	4,8	0,10	0,05	0,03	0,02	0,04

Zugprüfung L / tensile test L

BNr/Los Lot/No.	Zustand temper	Richtung direction	Tests		UTS [ksi]	YS [ksi]	A2" [%]			
				spec.min.	40,0	18,0	16			
				spec.max.	51,0	29,0	-			
16673/02	O	L	3	from	44,8	24,9	20			
16673/02	O	L		to	46,4	28,9	22			

Sonstige Prüfungen / other tests:
Maßkontrolle: OK. / Dimensional Check: OK.

TW METALS
FEB 24 2014
ACCEPTED BY:

REVIEWED
NOV 01 2016
AJ=Cmp 11/1/16

FOR PED
11-1-16

S-618C

AMAG_
ROLLING

Abnahmeprüfzeugnis 3.1 (EN 10204)
inspection certificate - mill certificate

Nr.: 85220799 02 / 3
Rev.: 0
Seite / page: 2 von / of 2
Datum / date: 2014 01 07

Zertifiziert nach / certified to ISO 9001, ISO/TS 16949, EN/AS 9100, ISO 14001, NADCAP

Es wird bestätigt, dass die Lieferung geprüft wurde und den Vereinbarungen bei der Bestellung entspricht.
We hereby certify that the material described above has been tested and complies with the terms of the order contract.

Werksachverständiger / factory specialist	E-Mail / email
Josef Klampfer	josef.klampfer@amag.at

Herstellerland: Österreich / goods origin: The goods are of Austrian origin.
Maschinell erstellt - Gültig ohne Unterschrift / Automated - valid without being signed.

OK FOR PED

REVIEWED
NOV 01 2016

11-1-16

AJ-CVP 11/1/16

TW [illegible]
TEST
FEB 24 2014
APPROVED BY

CERTIFIED INSPECTION REPORT

Arconic DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

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Per:

Rob d. Woodall
Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

Ship From: RIVERDALE, IA.

3079585 Ship Date	0 B.L. No.	Invoice No.	Arconic No.	
2016-11-29	11125395	00000	1000864455-1	DP-64455-01-1
P.O. No./Govt Contract No.	Item	Customer	Arconic Item	
M49359332 Ln#: 001		TW METALS-EXTON	G041147946R01	

PO 3472447
S-651-C
4K3117

Ship To: TW METALS INC
14600 JAMES RD
ROGERS 55374 MN

Item Description
0.375 IN TK (+.020 -.020) X 60.0 IN W (+.375 -
0.000) X 144.0 IN LN (+.5 -0.0) CAT X 11452 (N) A/T 5083-
O STORAGE TANK & CRYOGENIC PLATE MILL FINISH 11452. ASME-SB-
209 REV 15 EXC_MRK ASTMB209 REV 14 EN10204 REV
2004 ((MARKED)) NOT INTERLEAVED MAX
GROSS SKID WGT: 4500 LB QUAN TOL +/-40 %
CQR 0254443 REV 01 CUST REQ 16-11-
27 *** W/E 16-12-03 ***

Num	Package Ticket	Lot	Weight	Quantity	UOM	Inspector Clock Numbers
1	307833	499611	4100	13	PC	47274 47029
2	307913	499611	4092	13	PC	47274 47029
3	307955	499611	4088	13	PC	47274 47029
4	307958	499611	1578	5	PC	47274 47029
5	307994	499611	1264	4	PC	47274 47029
			15122	48		

Notes for CQR: 0254443.1
CERTIFICATE 3.1 AS IN EN10204.

CQR: 0254443.1 -Specification Limits

Tmpr	Dir		UTS KSI	TYS KSI	EL4D PCT
O	Longitudinal	Max	51.0	29.0	
		Min	40.0	18.0	16

Chemical Composition		SI	FE	CU	MN	MG	CR	ZN	TI	Other Each	Other Total	Aluminum
	Max	0.40	0.40	0.10	1.0	4.9	0.25	0.25	0.15	0.05	0.15	
Alloy 5083	Min				0.40	4.0	0.05					REMAIN

REVIEWED
MAR 01 2017

AI 3/1/17

3-16-17 OK FOR RED

TW METALS TEST REPORTS
DEC 05 2016
ACCEPTED BY

CERTIFIED INSPECTION REPORT

Arconic

DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

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Per

Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

3079585 Ship Date	0 B.L. No.	Invoice No.	Arconic No.	
2016-11-29	11125395	00000	1000864455-1	DP-64455-01-1
P.O. No./Govt Contract No.	Item Customer		Arconic Item	
M49359332 Ln#: 001		TW METALS-EXTON	G041147946R01	

S-651-C

CQR: 0254443.1 -Specification Limits (cont.) ----------

Lot: 499611 - Mechanical, Physical, Metallography, Quantometer Results ----------

Tmpr	Dir	No-> Test	UTS KSI	TYS KSI	EL4D PCT
O	Longitudinal	4	44.9	24.1	24.9
			45.3	23.9	23.8
			44.8	24.2	24.9
			45.1	23.9	25.6

Cast Number	Chemical - OES	SI	FE	CU	MN	MG	CR	ZN	TI	Other Each	Other Total
H343101E	Actuals	0.10	0.19	0.02	0.65	4.5	0.09	0.15	0.02	< 0.05	< 0.15

This material was melted in the United States or a Qualifying Country [REF DFARS 225.872.1(a)]; it was manufactured in the United States

REVIEWED
MAR 01 2017

3/1/17

3-16-17

OK FOR USE

GERTIFIED INSPECTION REPORT

Arconic DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

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Per

Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

Ship Date	B.L. No.	Invoice No.	Arconic No.	
3136413	0			
2017-02-14	11210474	00000	1000880851-1	DP-80851-1

P.O. No./Govt Contract No.	Item	Customer	Arconic Item
M49362607 Ln#: 001		TW METALS-ROGERS	G041146061R01

PO# 3478253
5.661C
4-3-2217

Ship To: TW METALS INC
14600 JAMES RD
ROGERS 55374 MN

Item Description
1.25 IN TK (+.047 -.047) X 60.0 IN W (+.3125 - 0.000) X 144.0 IN LN (+.5 -0.0) CAT X 16767 (N) A/T 5083-O STORAGE TANK & CRYOGENIC PLATE MILL FINISH, SAWED 16767. ASME-SB-209 REV 15 EXC_MRK ASTMB209 REV 14 EN10204 REV 2004 ((MARKED)) NOT INTERLEAVED MAX GROSS SKID WGT: 6000 LB QUAN TOL +/- 40 % CQR 0252840 REV 01 CUST REQ 17-02-05 *** W/E 17-02-11 ***

Num	Package Ticket	Lot	Weight	Quantity	UOM	Inspector Clock Numbers
1	330460	567481	5260	5	PC	47275
2	330461	567481	2114	2	PC	47275
3	330462	567481	5268	5	PC	47275
			12642	12		

Notes for CQR: 0252840.1
CERTIFICATE 3.1 AS IN EN10204.

CQR: 0252840.1 -Specification Limits

Tmpr	Dir		UTS KSI	TYS KSI	EL4D PCT
O	Longitudinal	Max	51.0	29.0	
		Min	40.0	18.0	16

Chemical Composition		SI	FE	CU	MN	MG	CR	ZN	TI	Other Each	Other Total	Aluminum
	Max	0.40	0.40	0.10	1.0	4.9	0.25	0.25	0.15	0.05	0.15	
Alloy 5083	Min				0.40	4.0	0.05					REMAIN

REVIEWED
MAR 22 2017
3-30-17
AI=40 3/22/17

OK FOR PED

TW METALS
TEST REPORTS
FEB 20 2017
ACCEPTED BY

CERTIFIED INSPECTION REPORT

Arconic DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

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Per

Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

Ship Date	B.L. No.	Invoice No.	Arconic No.	
3136413	0			
2017-02-14	11210474	00000	1000880851-1	DP-80851-1
P.O. No./Govt Contract No.	Item	Customer	Arconic Item	
M49362607 Ln#: 001		TW METALS-ROGERS	G041146061R01	

5 bdl C

CQR: 0252840.1 -Specification Limits (cont.)
Lot: 567481 - Mechanical, Physical, Metallography, Quantometer Results

Tmpr	Dir	No-> Test	UTS KSI	TYS KSI	EL4D PCT
O	Longitudinal	4	44.3	25.7	19.9
			44.4	25.6	19.6
			44.9	26	19.9
			44.6	25.2	19.2

Cast Number	Chemical	OES	SI	FE	CU	MN	MG	CR	ZN	TI	Other Each	Other Total
H3512021	Actuals		0.09	0.20	0.03	0.58	4.4	0.09	0.18	0.02	< 0.05	< 0.15

This material was melted in the United States or a Qualifying Country [REF DFARS 225.872.1(a)]; it was manufactured in the United States

REVIEWED
MAR 22 2017
3-30-17
AI > 4P 3/22/17
OK FOR RLD

CERTIFIED INSPECTION REPORT

Alcoa Inc. DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

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Per:

Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

2866942 Ship Date	0 B.L. No.	Invoice No.	Alcoa No. Item	
2016-02-11	10615237	00000	1000693487-1	DP-93487-01-1
P.O. No./Govt Contract No.	Customer	Alcoa Item		
M49331622 Ln#: 001	TW METALS-EXTON	G041134226R03		

PO# 3447504

S-619-C

4/11/16

Ship To: TW METALS INC
7640 REINHOLD DRIVE
CINCINNATI 45237 OH

Item Description
0.375 IN TK (+.0228 -.0228) X 96.0 IN W (+.375 - 0.000) X 240.0 IN LN (+.5 -0.0) CAT X 06308 (N) A/T 5083-O STORAGE TANK & CRYOGENIC PLATE MILL FINISH 06308. EXC_MRK AMS4056 REV G IS 2010 ANSIH35.2(M) REV 2013 ASME-SB-209 REV 11 EXC_MRK ASTMB209 REV 14 ((MARKED)) NOT INTERLEAVED MAX GROSS SKID WGT: 5000 LB QUAN TOL +/- 40 % CQR 0242949 REV 03 CUST REQ 15-12-15 *** W/E 15-12-26 ***

Num	Package Ticket	Lot	Weight	Quantity	UOM	Inspector Clock Numbers
1	222386	664871	4358	5	PC	46819
2	222389	664871	4324	5	PC	46819
3	222392	664871	4348	5	PC	46819
			13030	15		

Notes for CQR: 0242949.3
PRODUCT PRODUCED TO THE REQUIREMENTS OF AMS4056 REV G RE-A FFIRMED 11-01-2010 ALSO MEET THE REQUIREMENTS OF AMS-QQ-A- 250_6 REV B DATED 03-01-2012.

CQR: 0242949.3 -Specification Limits

Tmpr	Dir		UTS KSI	TYS KSI	EL4D PCT
O	Longitudinal	Max	51.0	29.0	
		Min	40.0	18.0	16

11-17-16 OK FOR RED

Chemical Composition		SI	FE	CU	MN	MG	CR	ZN	TI	Other Each	Other Total	Aluminum
	Max	0.40	0.40	0.10	1.0	4.9	0.25	0.25	0.15	0.05	0.15	
Alloy 5083	Min				0.40	4.0	0.05					REMAIN

REVIEWED
NOV 10 2016
AT = CMP 11/11/16

TW METALS
INW033116228
FEB 16 16
ACCEPTED BY

CERTIFIED INSPECTION REPORT

Alcoa Inc. DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

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Per:

Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

Ship Date	B.L. No.	Invoice No.	Alcoa No. Item	
2866942	0			
2016-02-11	10615237	00000	1000693487-1	DP-93487-01-1
P.O. No./Govt Contract No.		Customer	Alcoa Item	
M49331622 Ln#: 001		TW METALS-EXTON	G041134226R03	

S-619-C

CQR: 0242949.3 -Specification Limits (cont.) ----------

Lot: 664871 - Mechanical, Physical, Metallography, Quantometer Results ----------

Tmpr	Dir	No-> Test	UTS KSI	TYS KSI	EL4D PCT
O	Longitudinal	4	42.7	20.7	28.8
			42.5	20.5	29.3
			43.6	21	28.2
			42.3	20.8	28.9

Cast Number	Chemical - OES	SI	FE	CU	MN	MG	CR	ZN	TI
H309001C	Actuals	0.08	0.20	0.04	0.57	4.4	0.09	0.18	0.02

This material was melted in the United States or a Qualifying Country [REF DFARS 225.872.1(a)]; it was manufactured in the United States

REVIEWED
NOV 10 2016

11-17-16 OK FOR PAY

AJ=CMP 11/11/16

TW METALS
MU49331622
TEST REPORTS
FEB 16 16
ACCEPTED BY

CERTIFIED INSPECTION REPORT

Alcoa Inc. DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

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Per:

Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

2897343 Ship Date	0 B.L. No.	Invoice No.	Alcoa No. Item	
2016-03-24	10706315	00000	1000790411-1	DP-90411-01-1
P.O. No./Govt Contract No.	Customer	Alcoa Item		
M49346511 Ln#: 001	TW METALS-ROGERS G041144437R01			

PO 3464535
S-644-C
4/22-17

Ship To: TW METALS INC
14600 JAMES RD
ROGERS 55374 MN

Item Description
0.625 IN TK (+.027 -.027) X 60.0 IN W (+.3125 - 0.000) X 144.0 IN LN (+.5 -0.0) CAT X 11453 (N) A/T 5083-O STORAGE TANK & CRYOGENIC PLATE MILL FINISH, SAWED 11453. ANSIH35.2 REV 2013 ASME-SB-209 ✓ REV 15 EXC MRK ASTMB209 REV 14 EN10204 REV 2004 ((MARKED)) NOT INTERLEAVED MAX GROSS SKID WGT: 6000 LB QUAN TOL +/-30 % CQR 0251524 REV 01 CUST REQ 16-03-20 *** W/E 16-03-26 ***

Num	Package Ticket	Lot	Weight	Quantity	UOM	Inspector Clock Numbers
1	235491	717142	5295	10	PC	47042 47396
2	235582	717142	5299	10	PC	47042 47396
3	235584	717142	5297	10	PC	47042 47396
4	235626	717142	5297	10	PC	47042 47396
5	235651	717142	1587	3	PC	47042 47396
			22775	43		

Notes for CQR: 0251524.1
CERTIFICATE 3.1 AS IN EN10204.

CQR: 0251524.1 -Specification Limits

Tmpr	Dir		UTS KSI	TYS KSI	EL4D PCT
O	Longitudinal	Max	51.0	29.0	
		Min	40.0	18.0	16

REVIEWED
FEB 02 2017

2-3-17 OK FOR PED

AI = 4 2/2/17

TW METALS
TEST REPORTS
APR 08 2016
ACCEPTED BY

CERTIFIED INSPECTION REPORT

Alcoa Inc. DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

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Per:

Rob d. Woodall
Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

2897343	0			
Ship Date	B.L. No.	Invoice No.	Alcoa No. Item	
2016-03-24	10706315	00000	1000790411-1	DP-90411-01-1
P.O. No./Govt Contract No.	Customer		Alcoa Item	
M49346511 Ln#: 001	TW METALS-ROGERS G041144437R01			

S-644-C

CQR: 0251524.1 -Specification Limits (cont.) ----------

Chemical Composition		SI	FE	CU	MN	MG	CR	ZN	TI	Other Each	Other Total	Aluminum
	Max	0.40	0.40	0.10	1.0	4.9	0.25	0.25	0.15	0.05	0.15	
Alloy 5083	Min				0.40	4.0	0.05					REMAIN

Lot: 717142 - Mechanical, Physical, Metallography, Quantometer Results ----------

Tmpr	Dir	No->	UTS	TYS	EL4D
		Test	KSI	KSI	PCT
O	Longitudinal	6	42.9	21.8	23.6
			42.5	21.5	24.2
			42.8	22.8	24.8
			43.9	22.1	22.8
			43	21.4	24.9
			42.9	21.3	25

Cast Number	Chemical - OES	SI	FE	CU	MN	MG	CR	ZN	TI
H3156014	Actuals	0.11	0.22	0.04	0.60	4.4	0.09	0.17	0.02

This material was melted in the United States or a Qualifying Country [REF DFARS 225.872.1(a)]; it was manufactured in the United States

REVIEWED
FEB 02 2017

2-3-17 OK FOR USE

AI 2/2/17

TW METALS TEST REPORTS
APR 08 2016
ACCEPTED BY

CERTIFIED INSPECTION REPORT

Arconic DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

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Per

Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

Ship From: RIVERDALE, IA.

Ship Date	B.L. No.	Invoice No.	Arconic No.	
3121890	0			
2017-01-27	11190477	00000	1000880839-1	DP-80839-01-1

P.O. No./Govt Contract No.	Item	Customer	Arconic Item
M49362604 Ln#: 001		TW METALS-CINCINN	G041145142R02

PO 34782253
5-660-C
4432217

Ship To: TW METALS INC
14600 JAMES RD
ROGERS 55374 MN

Item Description
1.0 IN TK (+.047 -.047) X 60.0 IN W (+.3125 -
0.000) X 144.0 IN LN (+.5 -0.0) CAT X 11451 (N) A/T 5083-
O STORAGE TANK & CRYOGENIC PLATE MILL FINISH, SAWED 11451. ASME-SB-209 REV 15 EXC MRK ASTMB209 REV 14 EN10204
REV 2004 ((MARKED)) NOT
INTERLEAVED MAX GROSS SKID WGT: 6000 LB QUAN TOL +/-
40 % CQR 0252111 REV 02 CUST REQ 17-01-
22 *** W/E 17-01-28 ***

Num	Package Ticket	Lot	Weight	Quantity	UOM	Inspector Clock Numbers
1	325702	581583	3323	4	PC	47431
2	325703	581583	4977	6	PC	47431
3	325704	581583	4983	6	PC	47431
			13283	16		

Notes for CQR: 0252111.2
CERTIFICATE 3.1 AS IN EN10204.

CQR: 0252111.2 -Specification Limits

Tmpr	Dir		UTS KSI	TYS KSI	EL4D PCT
O	Longitudinal	Max	51.0	29.0	
		Min	40.0	18.0	16

Chemical Composition		SI	FE	CU	MN	MG	CR	ZN	TI	Other Each	Other Total	Aluminum
	Max	0.40	0.40	0.10	1.0	4.9	0.25	0.25	0.15	0.05	0.15	
Alloy 5083	Min				0.40	4.0	0.05					REMAIN

REVIEWED
MAR 22 2017
3-30-17
OK FOR FED
AI > 40 3/22/17

TW METALS
TEST REPORTS
JAN 30 2017
ACCEPTED BY

CERTIFIED INSPECTION REPORT

Arconic

DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

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Per:

Rob Woodall
Director of Manufacturing Davenport Works

Terrence Thom
Quality Assurance Manager

Ship Date	B.L. No.	Invoice No.	Arconic No.	
3121890	0			
2017-01-27	11190477	00000	1000880839-1	DP-80839-01-1

P.O. No./Govt Contract No.	Item	Customer	Arconic Item
M49362604 Ln#: 001		TW METALS-C1NCINN	G041145142R02

S-660-C

CQR: 0252111.2 -Specification Limits (cont.)

Lot: 581583 - Mechanical, Physical, Metallography, Quantometer Results

Tmpr	Dir	No->	UTS	TYS	EL4D
		Test	KSI	KSI	PCT
O	Longitudinal	4	44	26.2	20
			44.2	26.5	18.7
			44.9	27.4	19.6
			44.9	26.4	20.8

Cast Number	Chemical - OES	SI	FE	CU	MN	MG	CR	ZN	TI	Other Each	Other Total
H351202B	Actuals	0.09	0.20	0.03	0.58	4.4	0.09	0.18	0.02	< 0.05	< 0.15

This material was melted in the United States or a Qualifying Country [REF DFARS 225.872.1(a)]; it was manufactured in the United States

REVIEWED
MAR 22 2017
3-30-17
AI = QP 3/22/17
OK FOR [illegible]

WESTERN FORGE & FLANGE CO.

687 COUNTY ROAD 2201
CLEVELAND, TX 77327
PH (281) 727-7000 FAX (281) 727-7062

4k31417

CERTIFIED MATERIAL TEST REPORT

CERTIFIED IAW EN10204 3.1 (MADE IN USA)

TO:	**CHART ENERGY & CHEMICALS INC.**	**WFF SO NO:**	**31144-1**
PO:	**3467775**	**HEAT NO:**	**E5M0293A**
SPECIFICATIONS:	ASTM B247-09 6061-T6 ALUMINUM 125RMS ALL OVER PER SES 4-8.45		

QTY	ITEM DESCRIPTION
1	4" 300# WN RF 125/250RMS
	.237" WALL; DWG# 16200074-315 (W-668-E)

TYPE	CU	FE	SI	MN	MG	ZN	AL	CR	TI
ALUM 6061	.23	.18	.58	.02	.93	.00	Bal	.07	.01
MILL									

HEAT NO.	YIELD .2% OFF-PSI	TENSILE-PSI	% ELONG	% RED AREA	HARDNESS	GRAIN SIZE (ASTM)
E5M0293A	42,190	46,170	20.7		67 HRB	

- NO WELDING PERFORMED ON THE FORGINGS OF THIS ORDER.
- MATERIAL HEREIN IS CERTIFIED FREE FROM ANY FORM OF MERCURY, RADIUM OR ALPHA PARTICLE CONTAMINATION THROUGHOUT ALL PHASES OF MANUFACTURE AND SHIPMENT.
- THE FORGINGS ON THIS ORDER CONFORM TO THE SPECIFIED DIMENSIONAL REQUIREMENTS.
- MATERIAL MANUFACTURED IAW WFF QA PROGRAM QMS-WF08-10.
- FORGED & HEAT TREATED BEFORE MACHINING.

WE CERTIFY AND AFFIRM THAT CONTENTS OF THE REPORT ARE CORRECT AND ACCURATE AND THAT ALL TEST RESULTS AND OPERATIONS PERFORMED BY WESTERN FORGE OR ITS SUBCONTRACTORS ARE IN COMPLIANCE WITH THE APPLICABLE SPECIFICATIONS. THE MATERIAL DESCRIBED HEREIN MEETS ALL THE REQUIREMENTS OF ABOVE PURCHASE ORDER AND REFERENCED SPECIFICATIONS..

REVIEWED
MAR 14 2017

Rose Kay

03/10/2017
DATE

ROSE KAY, QUALITY ASSURANCE ASSISTANT
WESTERN FORGE & FLANGE CO.

WESTERN FORGE & FLANGE CO.

687 COUNTY ROAD 2201
CLEVELAND, TX 77327
PH (281) 727-7000 FAX (281) 727-7062

4c 3-14-17

CERTIFIED MATERIAL TEST REPORT

CERTIFIED IAW EN10204 3.1 (MADE IN USA)

TO:	CHART ENERGY & CHEMICALS INC.	WFF SO NO:	31144-2
PO:	3467775	HEAT NO:	E5M0293A
SPECIFICATIONS:	ASTM B247-09 6061-T6 ALUMINUM 125RMS ALL OVER PER SES 4-8.45		

QTY	ITEM DESCRIPTION
3	6" 300# WN RF 125/250RMS
	.280" WALL; DWG# 16200074-319 (W-670E)

TYPE	CU	FE	SI	MN	MG	ZN	AL	CR	TI
ALUM 6061	.23	.18	.58	.02	.93	.00	Bal	.07	.01
MILL									

HEAT NO.	YIELD .2% OFF-PSI	TENSILE-PSI	% ELONG	% RED AREA	HARDNESS	GRAIN SIZE (ASTM)
E5M0293A	42,190	46,170	20.7		67 HRB	

- NO WELDING PERFORMED ON THE FORGINGS OF THIS ORDER.
- MATERIAL HEREIN IS CERTIFIED FREE FROM ANY FORM OF MERCURY, RADIUM OR ALPHA PARTICLE CONTAMINATION THROUGHOUT ALL PHASES OF MANUFACTURE AND SHIPMENT.
- THE FORGINGS ON THIS ORDER CONFORM TO THE SPECIFIED DIMENSIONAL REQUIREMENTS.
- MATERIAL MANUFACTURED IAW WFF QA PROGRAM QMS-WF08-10.
- FORGED & HEAT TREATED BEFORE MACHINING.

WE CERTIFY AND AFFIRM THAT CONTENTS OF THE REPORT ARE CORRECT AND ACCURATE AND THAT ALL TEST RESULTS AND OPERATIONS PERFORMED BY WESTERN FORGE OR ITS SUBCONTRACTORS ARE IN COMPLIANCE WITH THE APPLICABLE SPECIFICATIONS. THE MATERIAL DESCRIBED HEREIN MEETS ALL THE REQUIREMENTS OF ABOVE PURCHASE ORDER AND REFERENCED SPECIFICATIONS..

REVIEWED
MAR 14 2017

Rose Kay

03/10/2017
DATE

ROSE KAY, QUALITY ASSURANCE ASSISTANT
WESTERN FORGE & FLANGE CO.

WESTERN FORGE & FLANGE CO.

687 COUNTY ROAD 2201
CLEVELAND, TX 77327
PH (281) 727-7000 FAX (281) 727-7062

4/3/1417

CERTIFIED MATERIAL TEST REPORT

CERTIFIED IAW EN10204 3.1 (MADE IN USA)

TO:	CHART ENERGY & CHEMICALS INC.	WFF SO NO:	31144-3
PO:	3467775	HEAT NO:	E5F1421A
SPECIFICATIONS:	ASTM B247-09 6061-T6 ALUMINUM 125RMS ALL OVER PER SES 4-8.45		

QTY	ITEM DESCRIPTION
2	8" 600# WN RF 125/250RMS
	.719" WALL; DWG# 16200074-671 (2-671F)

TYPE	CU	FE	SI	MN	MG	ZN	AL	CR	TI
ALUM 6061	.23	.18	.59	.03	.95	<.01	Bal	.06	.010
MILL									

HEAT NO.	YIELD .2% OFF-PSI	TENSILE-PSI	% ELONG	% RED AREA	HARDNESS	GRAIN SIZE (ASTM)
E5F1421A	41,620	45,920	18.6		64 HRB	

- NO WELDING PERFORMED ON THE FORGINGS OF THIS ORDER.
- MATERIAL HEREIN IS CERTIFIED FREE FROM ANY FORM OF MERCURY, RADIUM OR ALPHA PARTICLE CONTAMINATION THROUGHOUT ALL PHASES OF MANUFACTURE AND SHIPMENT.
- THE FORGINGS ON THIS ORDER CONFORM TO THE SPECIFIED DIMENSIONAL REQUIREMENTS.
- MATERIAL MANUFACTURED IAW WFF QA PROGRAM QMS-WF08-10.
- FORGED & HEAT TREATED BEFORE MACHINING.

WE CERTIFY AND AFFIRM THAT CONTENTS OF THE REPORT ARE CORRECT AND ACCURATE AND THAT ALL TEST RESULTS AND OPERATIONS PERFORMED BY WESTERN FORGE OR ITS SUBCONTRACTORS ARE IN COMPLIANCE WITH THE APPLICABLE SPECIFICATIONS. THE MATERIAL DESCRIBED HEREIN MEETS ALL THE REQUIREMENTS OF ABOVE PURCHASE ORDER AND REFERENCED SPECIFICATIONS..

REVIEWED
MAR 14 2017

03/10/2017
DATE

Rose Kay
ROSE KAY, QUALITY ASSURANCE ASSISTANT
WESTERN FORGE & FLANGE CO.

National Board Number: 9433

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

1. Manufactured and certified by Chart Energy & Chemicals, Inc. 2191 Ward Avenue La Crosse, WI, USA 54601
(Name and address of Manufacturer)

2. Manufactured for UOP RUSSEL, LLC.
(Name and address of Purchaser)

3. Location of installation UNKNOWN
(Name and address)

4. Type: VERT. (Horizontal, vertical, or sphere) | HEAT EXCHANGER (Tank, separator, jkt. vessel, heat exch., etc.) | 2968.2-2 (Manufacturer's serial number)

(CRN) | 17769A REV. J (Drawing number) | 9433 (National Board Number) | 2017 (Year built)

5. ASME Code, Section VIII, Div. 1 | 2015 [Edition and Addenda, if applicable (date)] | 2351, 2774 (Code Case Number) | NONE [Special service per UG-120(d)]

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

6. Shell (a) No. of course(s) N/A (b) Overall length

Course(s)			Material	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B, & C)			Heat Treatment	
No.	Diameter	Length	Spec./Grade or Type	Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time

Body Flanges on Shells

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

7. Heads: (a) N/A (Material spec. number, grade or type) (H.T. — time and temp.) (b) (Material spec. number, grade or type) (H.T. — time and temp.)

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

Body Flanges on Heads

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

8. Type of jacket N/A Jacket closure N/A (Describe as ogee and weld, bar, etc.)

If bar, give dimensions N/A If bolted, describe or sketch.

9. MAWP SEE U-4 (Internal) SEE U-4 (External) psi at max. temp. SEE U-4 (Internal) SEE U-4 (External) °F Min. design metal temp. SEE U-4 °F at SEE U-4 psi.

10. Impact test NO, UNF-65 [Indicate *yes* or *no* and the component(s) impact tested] at test temperature of .

11. Hydro., pneu., or comb. test press. SEE U-4 FORM Proof test

Items 12 and 13 to be completed for tube sections.

12. Tubesheet: N/A [Stationary (Material spec. no.)] | [Diameter (subject to press.)] | (Nominal thickness) | (Corr. allow.) | [Attachment (welded or bolted)]

[Floating (Material spec. no.)] | (Diameter) | (Nominal thickness) | (Corr. allow.) | (Attachment)

13. Tubes: N/A (Material spec. number, grade or type) | (O.D.) | (Nominal thickness) | (Number) | [Type (straight or U)]

Mfg. Representative: Date: 5-15-17

Authorized Inspector: Date: 5/15/17

(07/13)

National Board Number: 9433

FORM U-1 (Cont'd)

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

14. Shell (a) No. of course(s) N/A (b) Overall length

Course(s)			Material	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B, & C)			Heat Treatment	
No.	Diameter	Length	Spec./Grade or Type	Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time

Body Flanges on Shells

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

15. Heads: (a) N/A (b)
(Material spec. number, grade or type) (H.T. — time and temp.) (Material spec. number, grade or type) (H.T. — time and temp.)

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

Body Flanges on Heads

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

16. MAWP N/A (Internal) (External) at max. temp. (Internal) (External) Min. design metal temp. at .

17. Impact test N/A at test temperature of .
[Indicate *yes* or *no* and the component(s) impact tested]

18. Hydro., pneu., or comb. test press. SEE U-4 FORM Proof test

19. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Type	Material		Nozzle Thickness		Reinforcement Material	How Attached		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
A IN, A OUT	2	8.625	N/A	SB2415083	N/A	0.719	N/A	N/A	UW-16.1(a)	N/A	N/A
B IN	1	4.500	"	"	"	0.237	"	"	"	"	"
B OUT, C IN, C OUT	3	6.625	"	"	"	0.280	"	"	"	"	"

20. Supports: Skirt NO (Yes or no) Lugs N/A (Number) Legs N/A (Number) Others A NGLES (2) (Describe) Attached SIDES, WELDED (Where and how)

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

22. Remarks: MULTI STREAM (CHAMBER) VESSEL OF PLATE FINS CONSTRUCTION FOR NON-CORROSIVE SERVICE. SEE U-4 FORM FOR ITEMS 9&11 & OTHER DESIGN DETAILS (ITEM 22). CODE JURISDICTION ENDS AT THE NOZZLE TRIM LINE OR FIRST WELD PREP TO AN ATTACHED PIPE FITTING (ELBOW, FLANGE, REDUCER, ETC.) EXEMPTED FROM IMPACT TESTING PER UNF-65. PRESSURE RELIEF VALVES ARE NOT INSTALLED BY Chart Energy & Chemicals, Inc., BUT ARE THE RESPONSIBILITY OF THE CUSTOMER OR THE INSTALLER.

Mfg. Representative: Date: 5-15-17

Authorized Inspector: Date: 5/15/17

(07/13)

National Board Number: 9433

FORM U-1 (Cont'd)

CERTIFICATE OF SHOP COMPLIANCE

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

U Certificate of Authorization No. 20,954 Expires JANUARY 6, 2019

Date 5-15-17 Name Chart Energy & Chemicals, Inc. (Manufacturer) Signed _____ (Representative)

CERTIFICATE OF SHOP INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by OneCIS Insurance Company of LYNN, MA have inspected the pressure vessel described in this Manufacturer's Data Report on 5/11/2017, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the Inspector nor his/her employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's' Data Report. Furthermore, neither the Inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date 5/15/2017 Signed Craig Pollack (Authorized Inspector) Commissions NB15055 [National Board (incl. endorsements)]

CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE

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

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

CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by _____ of _____, have compared the statements in this Manufacturer's Data Report with the described pressure vessel and state that parts referred to as data items _____, not included in the certificate of shop inspection, have been inspected by me and to the best of my knowledge and belief, the Manufacturer has constructed and assembled this pressure vessel in accordance with the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. The described vessel was inspected and subjected to a hydrostatic test of _____.

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

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

(07/13)

FORM U-4 MANUFACTURER'S DATA REPORT SUPPLEMENTARY SHEET
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by Chart Energy & Chemicals, Inc. 2191 Ward Avenue La Crosse, WI, USA 54601
(Name and address of Manufacturer)

2. Manufactured for UOP RUSSELL, LLC.
(Name and address of Purchaser)

3. Location of installation UNKNOWN
(Name and address)

4. Type: VERT. (Horizontal, vertical, or sphere) | HEAT EXCHANGER (Tank, separator, heat exch., etc.) | 2968.2-2 (Manufacturer's serial number)

(CRN)	17769A REV. J (Drawing number)	9433 (National Board number)	2017 (Year built)

9. / 11. Working/test conditions: Working Temp. +150 °F Max -320 °F Min.

Stream/Chamber	MAWP (P.S.I.)	(All Streams/Chambers horizontally tested) Hydro, Pneu, or Combination Test Pressure (P.S.I.)
A	1100	1210
B, C	400	440

22. (a) Heat Exchanger for ETHANE/LPG RECOVERY Service:
(b) Parting Sheets: Material SB-209-3003 Nominal Thickness 0.079 Width 24.00 Length 126.00
(c) Outside Sheets: Material SB-209-3003 Nominal Thickness 0.250 Width 24.00 Length 126.00
(d) Core Joints: Type: VACUUM Brazed Longitudinal Length 126.00 Girth Length 24.00 Height 13.23
Side/End Bars: Material SB-221-3003 Nominal Width 1.50 / 2.75
(e) Fins: Material SB-209-3003
(f) Headers (Half Cylinders) (g) Header Ends

Stream/Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Material	Nominal Thickness	End Type	Nominal Thickness	End Material	End Bracing Size/Type	End Bracing Material
A IN, A OUT	2	15.276	SB2095083	1.250	MITER	1.250	SB2095083	N/A	N/A
B IN	1	4.500	"	0.250	FLAT	0.375	"	"	"
B OUT, C IN	2	6.875	"	0.375	"	0.625	"	"	"
C OUT	1	10.750	"	0.375	"	1.000	"	"	"

(h) Nozzle Permanent End Closures

Stream/Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Type	Material	Nominal Thickness

Headers, Ends, End Bracing and Nozzle Permanent End Closures Attached by Welding

(i) Remarks: A IN & A OUT HEADER BODY TO END PIECE BUTT WELD JOINTS 100% RADIOGRAPH INSPECTED.

Certificate of Authorization: Type 'U' No. 20,954 Expires JANUARY 6, 2019

Date 5-15-17 Name Chart Energy & Chemicals, Inc. (Manufacturer) Signed (Representative)

Date 5/15/2017 Name Craig Pollack (Authorized Inspector) Commission NB13055 [National Board (incl. endorsements)]

(07/13)

Chart Energy & Chemicals, Inc.
Inspection & Test Report

Stacking & Brazing **(Cores < 100 Layers)**

Cell 4

Sales Order # 2968.2-2 Module # _____ Manufacturing # 17769B

Operation	Instruction	Operator Clock #	Date & Inspector Initials	W/H Points Int & Date
1. STACKING ASSEMBLY	WI9-040-002			
1 Layer B/C	WI10-02	102983-102980	4-19-17 TO	
2 Layer A	WI10-02	102983-102980	4-19-17 TO	
Layer	WI10-02			
Layer	WI10-02			
Layer	WI10-02			
Layer	WI10-02			
Layer	WI10-02			
Layer	WI10-02			
Layer	WI10-02			
Layer	WI10-02			
Primary Stacking & Squareness	WI10-02	102966/103192	BRD 4-19-17	
Compression & Dimensional Record		102966/103192		
Braze Core (signed by heat off operator)	Date 04/20/17	102966		
Fixture Removal / Dimensional After Brazing	Date 4/21/17	46414		

Header Inspection Log

			Sales Order #			2968.2-2			
Header Assy. Item #	Stream Identification	Header Body Trace	End Piece Trace	Nozzle Trace	Misc. Material Trace	In Process and Final Insp. Initials & Dates	X-Ray Initials & Date	X-Ray #	A.I. Review Initials & Date
6502	A-IN	S661C	S661C	T183C		FINAL OK MB 4/25/2017	jb 4-26-2017	b733	JA 4/26/17
6503	A-OUT	S661C	S661C	T183C		KL 4/26/17	JJ 4-26-2017	B734	JA 4/26/17
6504	B-IN	S618C	S619C	T138C		FINAL OK MB 4/25/2017			JA 4/25/17
6505	B-OUT	S651C	S644C	T178C		FINAL OK MB 4/25/2017			JA 4/25/17
6506	C-IN	S651C	S644C	T178C		KL 4/26/17			JA 4/26/17
6507	C-OUT	S651C	S660C	T178C		KL 4/26/17			JA 4/26/17

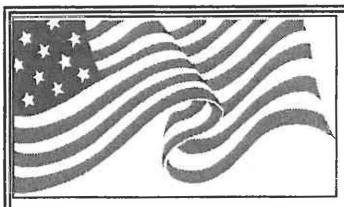


Chart Energy & Chemicals, Inc.

La Crosse WI

Post Braze
Inspection and Test Report

National Board Number:

9433

Job Number/Serial Number 2968.3-3

Drawing Number: **17769A**

Mfg. Number: **17769B**

Review of Design Calculations, Assembly Drawings and I&T Report

QC Review and approval of ITR: MD

Date: 3-9-17

AI: Craig Pollack

Date: 3/9/17

General Documentation

	QC Inspection	Date	Authorized Inspector	Date
Nameplate Verification	MB	5-11-17	CP	5/11/17

General Operations

	Emp #	Date	QC Insp	Date	AI Init & Date
Centerline Layout	102940	5/2/17			
Weld and Inspect Port Posting	NA	—			

Header Fit-up and Inspection

Header	AI Hold (H)	Clean Check / Header Fit-up (Stamp # & Date)										
		Visual Inspection before fit-up										
A-In	N/A	5-2-17										
A-Out		"										
B-In		"										
B-Out		"										
C-In		"										
C-Out	✓	"										

A.I Notes:

Flange/Piping Fit-up and Inspection per B31.3 Par 344.7
(Welder Stamp & Date Required)

Header	Joint Prep/Cleanliness/Fit-Up (Welder/Inspector)	Pre Heat (Welder)	Filler Metal Verification (Welder)	Root Pass Inspection (Welder)	Interpass Inspection (Welder)				Final Inspection (Inspector)	Header Clean Check Prior to Blind (Tester)	Trace Codes (Turn in when done-Inspector)
A-In	16 5-4-17	27	27	27	27					42	W691E
A-Out	46 5-4-17	27	27	27	27					42	W671E
B-In	46 5-4-17	1	1	1	1					42	W669E
B-Out	16 5/4/17 5-4-17	1	1	1	1					42	W670E
C-In	46 5-4-17	51	51	51	31					42	W670E
C-Out	16 5/4/17 5-4-17	1	1	1	1					42	W670E

Pre-hydro Inspection and Tests

	Emp #	Date	Quality	QC Insp	Date	AI Init & Date
Verify Completion of Header Inspection Log				[illegible]	5-5-17	
Fitting Trace Codes turned in to Documentation				[illegible]	5-5-17	
1st Air Test	1	5-5-17				
Support angle fit-up	1	5-5-17				
RT complete per drawing requirement **Code Required**				[illegible]	5/5/17	[illegible] 5/5/17
Visual Inspection, final welds (Weld Check)				[illegible]	5-5-17	[illegible] 5/5/17
Dimension Check	Ref. Dim. Worksheet			[illegible]	5-5-17	

Pre-Test with Water

Stream Identification	Stream Test Pressure (PSIG)	Supervisor Initial and Date	Tester Employee # & Date	
A	1430	DL 5-8-17	102944 5-8-17	
B	520	DL 5-8-17	102944 5-8-17	
C	520	DL 5-8-17	102944 5-8-17	

Gauge No. 3000 KG / 1000 CC

Core Drain and Dry

		Emp #	Date
Drying Procedure: Manual **(M)** or Automatic **(A)**	M		
Verification of core dryness.		103002	5 9 17

Prior to Pneumatic and Leak Test

Visual Inspection of Bottom Cap Sheet	QC Insp	Date
	MO	5-11-17

Pneumatic and Leak Test

Stream Identification	Stream & Pressure Verification Tester Emp # and Date	Stream & Pressure Verification Inspector Emp # and Date	Stream & Pressure Verification Supervisor Emp # and Date	Pneumatic Test Pressure (PSIG)	Leak Test Pressure (PSIG)	Tester Emp # and Date	Inspector or 2nd Tester Emp# and Date	Internal Leak Test (OK)	External Leak Test (OK)	AI Hold Point Init & Date
A	46483 5-11-17	JW 5/11/17	MJ 5-11-17	1210	1100	46483 5-11-17	N/A	Vok	Vok	(H2) CMP 5/11/17
B	46483 5-11-17	JW 5/11/17	DL 5-11-17	440	400	46483 5-11-17	↓	Vok	Vok	(H2) CMP 5/11/17
C	46483 5-11-17	MB 5-11-17	DL 5-11-17	440	400	46483 5-11-17	↓	Vok	Vok	(H2) CMP 5/11/17

Final Inspection

	Emp #	Date	QC Insp	Date	
Header clean check inspection	75789	5-11-17	MB	5-11-17	
Shipping pressure and labeling	75789	5-11-17			
Final Inspection			MB	5-11-17	
Lead or 2nd Person Final Inspection			SL	5-2017	
Crate check(Tester)	75789	5-11-17			
Loose parts verification	75789	5-11-17			
ITR review and return to QC Office					

Sales Order: 2968.2-2

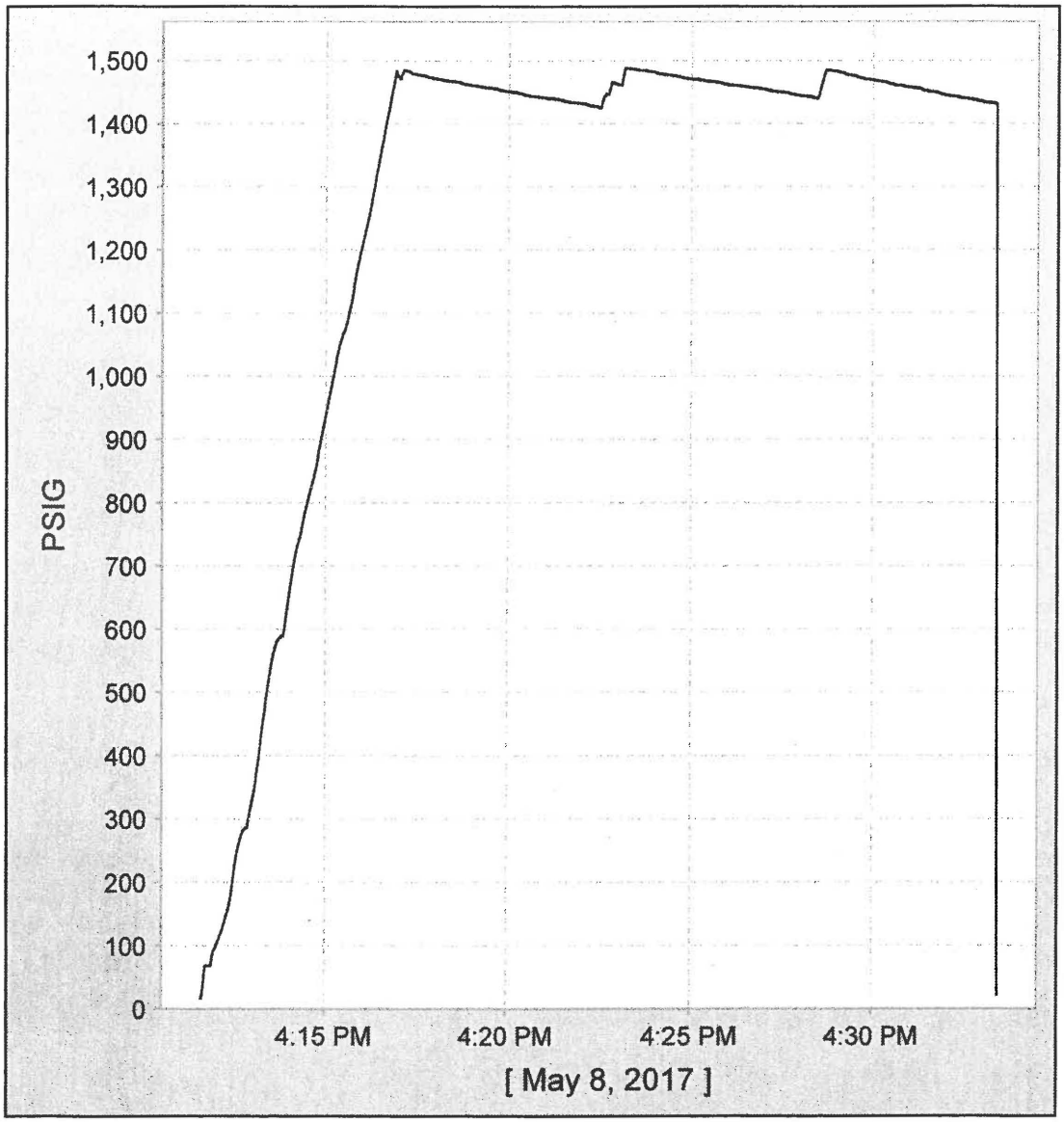
Tester ID: Chart Hydro Tester 3

Gauge Number	Item Number
3000 AG	E-204-205

Supervisor ID	216561
Inspector ID	103178
Operator ID	102944

Comments:

Stream Name	Pressure (in PSIG)	Time (in Mins)
a	1430 PSIG	10.1 min.



Time	PSI
4:23:14 PM	1487.9
4:23:44 PM	1484.3
4:24:14 PM	1478.4
4:24:45 PM	1473.2
4:25:15 PM	1468.9
4:25:45 PM	1465.1
4:26:16 PM	1460.2
4:26:46 PM	1456.7
4:27:16 PM	1451.0
4:27:47 PM	1446.3
4:28:17 PM	1442.3
4:28:47 PM	1484.2
4:29:18 PM	1477.7
4:29:48 PM	1470.7
4:30:18 PM	1466.0
4:30:48 PM	1460.0
4:31:19 PM	1455.2
4:31:49 PM	1448.4
4:32:19 PM	1442.9
4:32:50 PM	1437.7
4:33:20 PM	1432.5

CHART

Sales Order: 2968.2-2

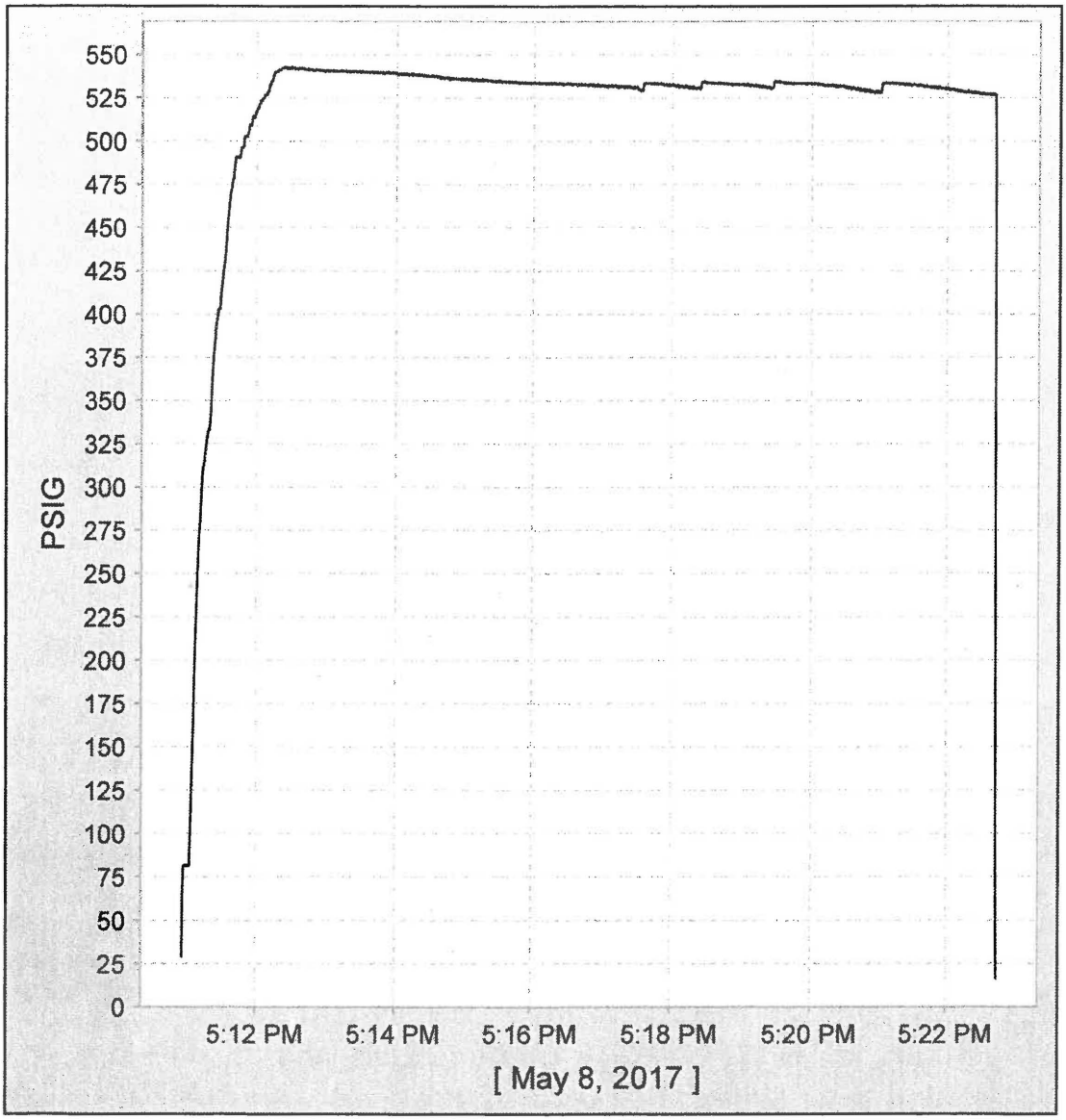
Tester ID: Chart Hydro Tester 3

Gauge Number	Item Number
1000 cc	E-204-205

Supervisor ID	216561
Inspector ID	103178
Operator ID	102944

Comments:

Stream Name	Pressure (in PSIG)	Time (in Mins)
b	520 PSIG	10.1 min.



Time	PSI
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5:12:54 PM	541.0
5:13:24 PM	540.3
5:13:54 PM	539.7
5:14:24 PM	537.9
5:14:55 PM	536.2
5:15:25 PM	534.8
5:15:56 PM	533.8
5:16:26 PM	533.0
5:16:56 PM	532.4
5:17:26 PM	531.0
5:17:56 PM	532.9
5:18:27 PM	534.5
5:18:57 PM	533.0
5:19:28 PM	534.5
5:19:58 PM	533.5
5:20:28 PM	531.4
5:20:58 PM	528.3
5:21:28 PM	532.8
5:21:59 PM	530.6
5:22:30 PM	527.4

Sales Order: 2968.2-2

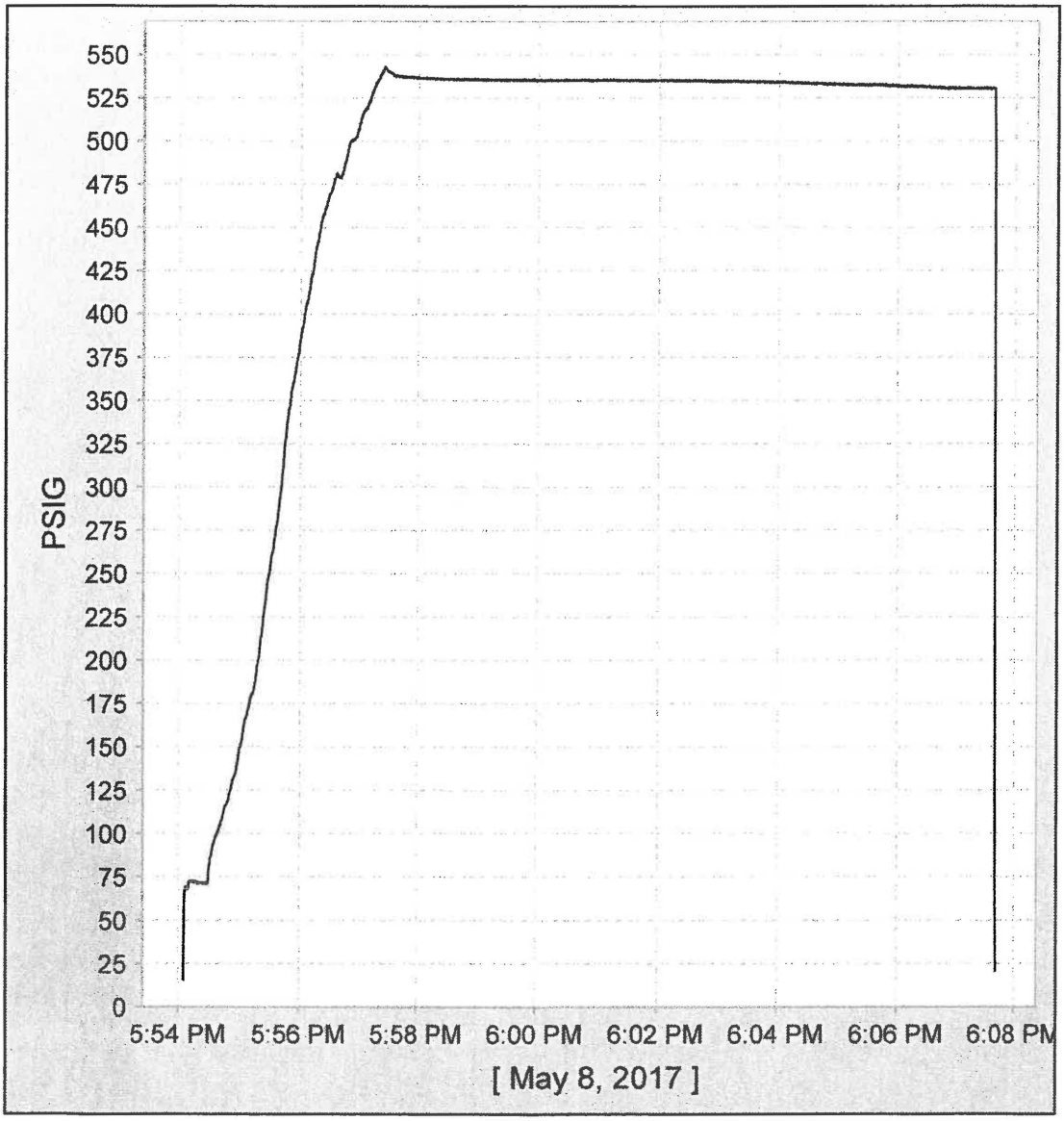
Tester ID: Chart Hydro Tester 3

Gauge Number	Item Number
1000 c c	E204-205

Supervisor ID	216561
Inspector ID	103178
Operator ID	102944

Comments:

Stream Name	Pressure (in PSIG)	Time (in Mins)
c	520 PSIG	10.1 min.



Time	PSI
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5:58:28 PM	536.1
5:58:58 PM	535.7
5:59:28 PM	535.5
5:59:58 PM	535.3
6:00:28 PM	535.3
6:00:59 PM	535.3
6:01:29 PM	535.3
6:02:00 PM	535.2
6:02:30 PM	535.1
6:03:00 PM	534.8
6:03:30 PM	534.8
6:04:01 PM	534.2
6:04:31 PM	533.2
6:05:01 PM	532.7
6:05:32 PM	532.4
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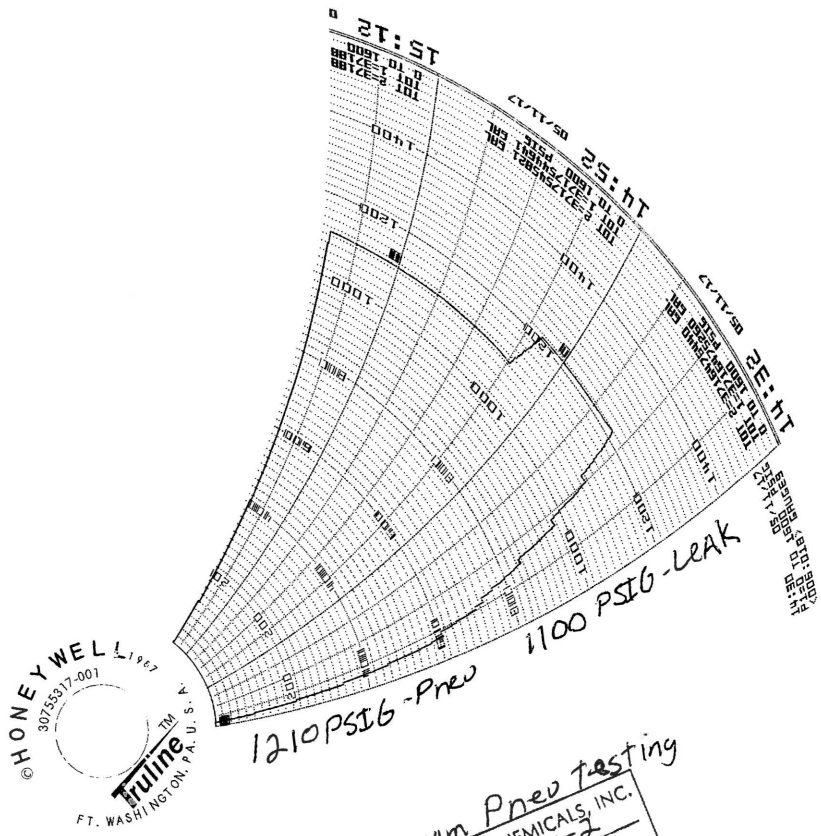
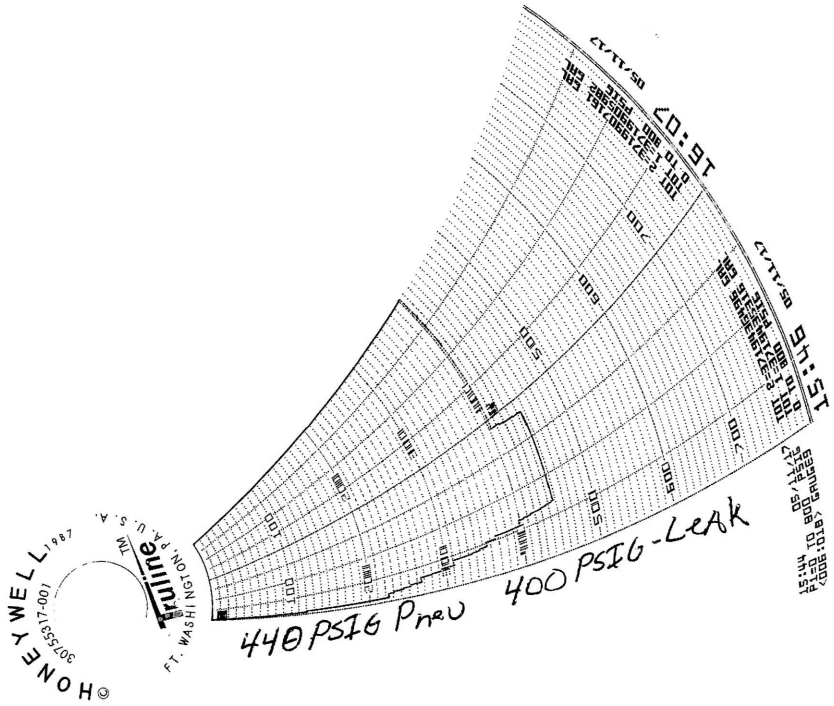
6:06:32 PM	531.2
6:07:02 PM	530.4
6:07:33 PM	530.6



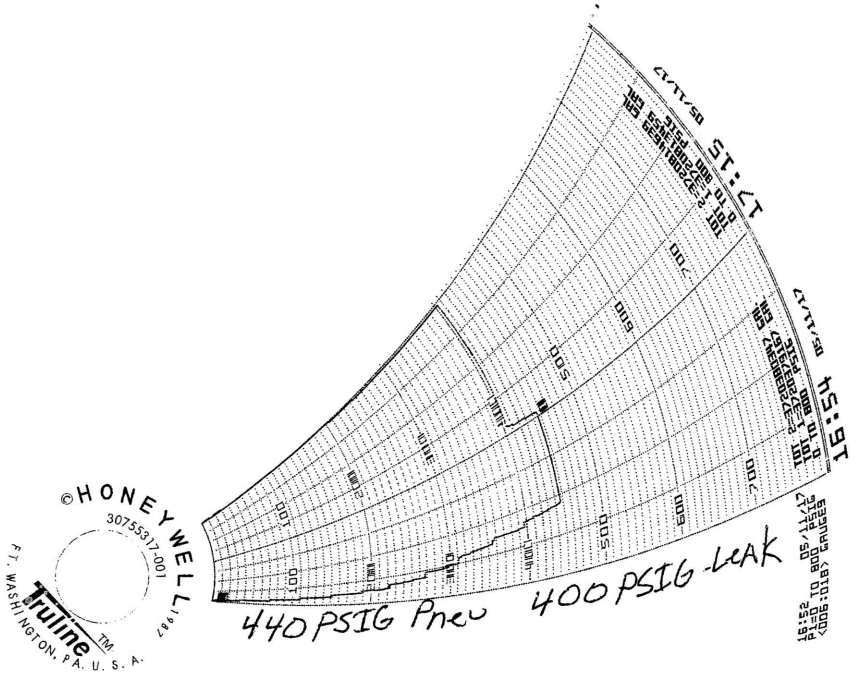
A-Stream Prev testing

CHART ENERGY & CHEMICALS, INC.
SALES ORDER 2968.2-2
ITEM NO. E-204-205
GAUGE NO. 2000 BB
OPER./INSPECTOR 46483



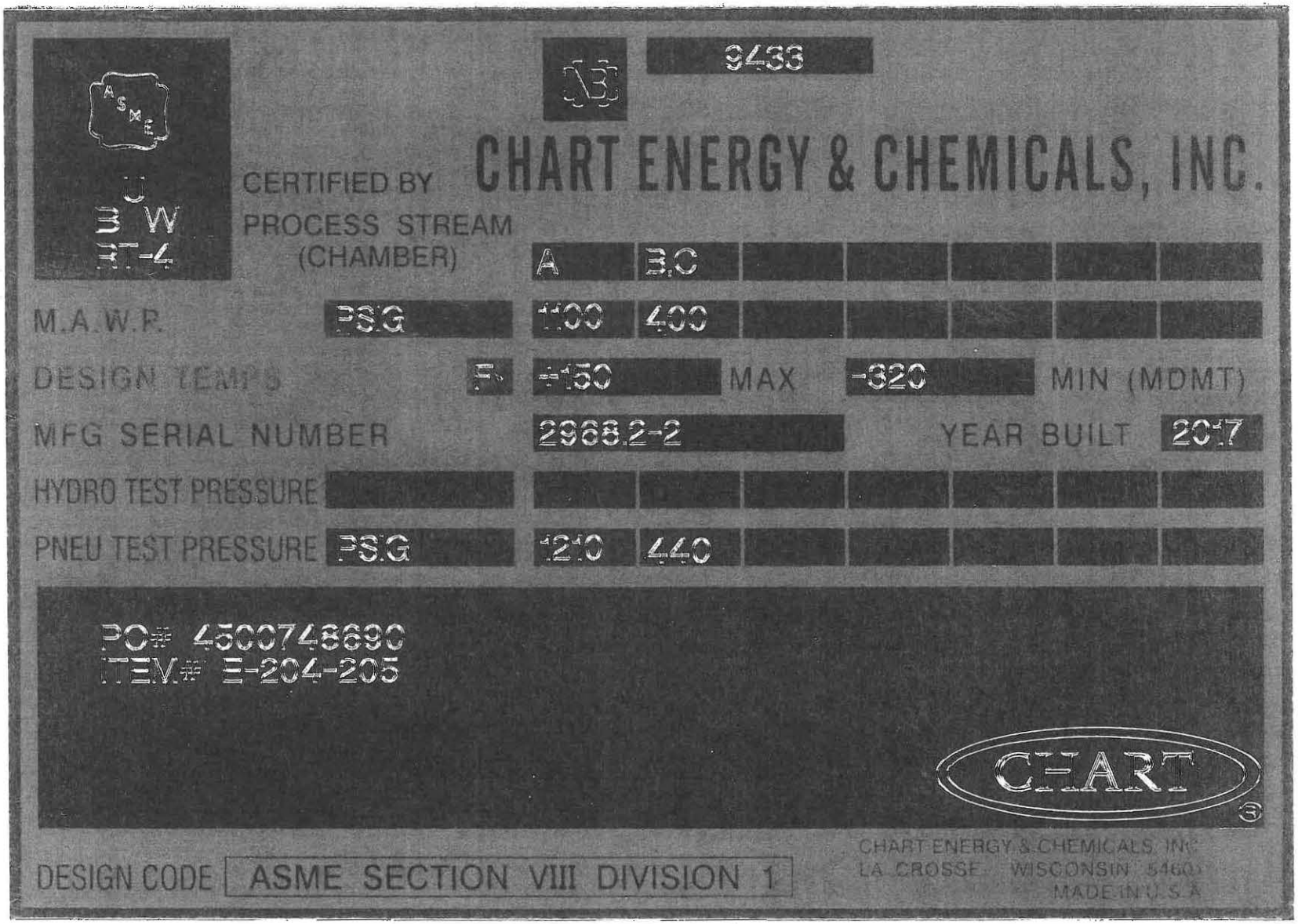
B-Stream Pneu Testing

CHART ENERGY & CHEMICALS, INC.
SALES ORDER 2968.2-2
ITEM NO. E-204-205
GAUGE NO. 1000-EE
OPER./INSPECTOR 46483



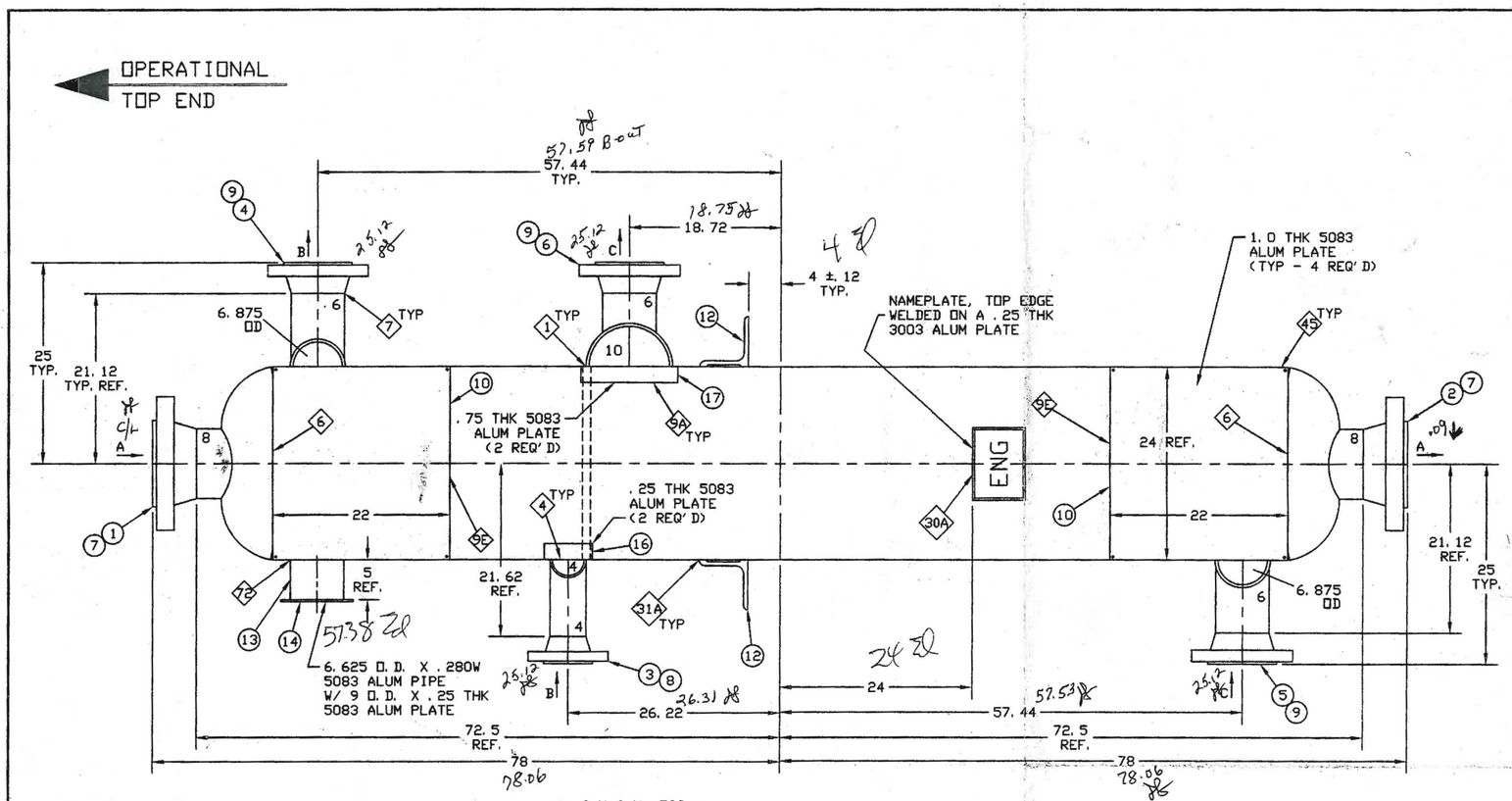
C-stream Pneu Testing

CHART ENERGY & CHEMICALS, INC.
SALES ORDER 2968.2-2
ITEM NO. E-204-205
GAUGE NO. 1000-EE
OPER./INSPECTOR 46483


9436
CHART ENERGY & CHEMICALS, INC.
U
B W
RT-4
CERTIFIED BY
PROCESS STREAM
(CHAMBER)
A
B,C
M.A.W.P.
PSIG
100
400
DESIGN TEMPS
F
-150
MAX
-320
MIN (MDMT)
MFG SERIAL NUMBER
29682-2
YEAR BUILT
2017
HYDRO TEST PRESSURE
PNEU TEST PRESSURE
PSIG
210
440
PO# 4500748690
ITEM# E-204-205
CHART
DESIGN CODE
ASME SECTION VIII DIVISION 1
CHART ENERGY & CHEMICALS, INC.
LA CROSSE, WISCONSIN 54601
MADE IN U.S.A.

Liquid Penetrant Test Report

N/A



NOTES: 2968.2-2

1. REFER TO BRAL-IOM FOR INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS. ASSURE COMPLIANCE WITH REQUIREMENTS PARTICULARLY OPERATING CONDITIONS TO PREVENT OVER PRESSURIZATION, THERMAL SHOCK, PLUGGING/FOULING AND OPERATION OUTSIDE DESIGN TEMPERATURE RANGE. REFER TO DRAWING 917-7795 FOR UNCRATED HEAT EXCHANGER LIFTING INSTRUCTIONS AND DRAWING 918-6671 FOR INSTRUCTIONS ON ROLLING HEAT EXCHANGER TO SIDE OTHER THAN SHIPPING SURFACE.
2. CUSTOMER TO DRILL APPROPRIATE HOLES OR SLOTS IN SUPPORT ANGLES FOR MOUNTING HEAT EXCHANGER AS DESCRIBED IN BRAL-IOM.
3. HEAT EXCHANGER DESIGNED, CONSTRUCTED, AND STAMPED PER THE LATEST MANDATORY EDITION AND ADDENDA OF THE ASME PRESSURE VESSEL CODE; SECTION VIII, DIV. 1 AND REGISTERED WITH THE NATIONAL BOARD. CODE CASES 2351 AND 2774 HAVE BEEN APPLIED. CODE JURISDICTION ENDS AT THE NOZZLE TRIM LINE OR FIRST WELD PREP TO AN ATTACHED PIPE FITTING. IN PROCESS EXAMINATION PER PARAGRAPH 344.7 IS CONDUCTED ON CIRCUMFERENTIAL PIPE WELDS UNDER ASME B31.3 JURISDICTION.
4. ALL FLANGES ARE RAISED FACE WELD NECK 6061-T6 ALUMINUM PER ASME B31.3 APPENDIX L. GEOMETRY IS EQUIVALENT TO ASME B16.5. BOLT HOLE PATTERN TO STRADDLE CENTERLINE. MAXIMUM ROTATION OF BOLT HOLE PATTERN OFF CENTERLINE IS 1 DEGREE BUT NOT MORE THAN .19 INCH AT BOLT CIRCLE.

   'B' & 'C' STREAM FLANGES ARE CLASS 300
   'A' STREAM FLANGES ARE CLASS 600
   FLANGE FACING 125 TO 250 RMS

5. CORROSION ALLOWANCE: ALUMINUM = 0.0000 INCHES
6. SEE DRAWING 17769C FOR MAXIMUM ALLOWABLE PIPE LOADS.
7. THE HEADERS AND NOZZLES ARE LABELED ON THE DRAWING WITH THEIR NOMINAL PIPE SIZE (NPS). IF A STANDARD SIZE IS NOT USED THE PIPING IS LISTED AT ITS ACTUAL OUTSIDE DIAMETER AND LABELED "OD". UNLESS SHOWN OTHERWISE ALL NOZZLES ARE ON THE HEAT EXCHANGER CENTERLINE.
8. TOLERANCE ON ALL DIMENSIONS IS +/- .25 INCH UNLESS OTHERWISE NOTED. ANGULAR TOLERANCE ON FLANGE FACES TO DESIGN PLANE IS +/- .06 INCH/FOOT, MAXIMUM OF .19 INCH AT FLANGE PERIPHERY.
9. STREAM

	A	B	C
MAWP (PSIG)	1100	400	400
DESIGN TEMP DEG. F	+150 MAX.	-320 MIN.	

10. TESTING INFORMATION:

STREAM	A	B	C
FIRST AIR (PSIG)	30	30	30
PRETEST W/WATER (PSIG)	1430	520	520
PNEU (PSIG)	1210	440	440
LEAK (PSIG)	1100	400	400

11. UNIT TO SHIP WITH AIR AT 15 PSIG IN ALL STREAMS. GAUGES ARE PROVIDED.
12. ESTIMATED WEIGHT = 2,900 LBS. (DRY)
    3,400 LBS. (OPERATING)
    3,900 LBS. (FILLED WITH WATER)
    (WARNING: DO NOT HYDRO TEST IN FIELD WITH WATER)
13. STREAM VOLUME:

STREAM	A	B	C
CU. FT.	6.1	2.8	6.4

14. CUSTOMER NOTE:
    A. ESTIMATED BRAZED HEIGHT. ACTUAL BRAZE HEIGHT MAY VARY +/- .12 PER FOOT OF BRAZE HEIGHT. MAX DIMENSION INCLUDES TOLERANCE ON BRAZE HEIGHT PLUS HEADER ATTACHMENT PLATES.
15. CODE REQUIRED NDE:
    A. BUTT WELD PORTION OF 'A' STREAM, HDR. BODY TO END PIECE JOINTS TO BE 100% RADIOGRAPH INSPECTED PER ASME PRESSURE VESSEL CODE, SECT. VIII, DIV. 1, PAR. UW-51.

HEADER / NOZZLE CHART

STREAM ID	HEADER OD X WALL	END PIECE STYLE / THK	NOZZLE OD X WALL
A IN (153-155)	15.276 X 1.250	MITER/1.250	8.625 X 0.719
A OUT (153-155)	15.276 X 1.250	MITER/1.250	8.625 X 0.719
B IN (204-206)	4.500 X 0.250	FLAT/0.375	4.500 X 0.237
B OUT (204-206)	6.875 X 0.375	FLAT/0.625	6.625 X 0.280
C IN (201-202)	6.875 X 0.375	FLAT/0.625	6.625 X 0.280
C OUT (201-202)	10.750 X 0.375	FLAT/1.000	6.625 X 0.280

ALL MATERIAL IN TABLE ABOVE IS 5083 ALUMINUM

AS BUILT
CHART ENERGY & CHEMICALS, INC.
La Crosse, WI

CHART SALES ORDER	JOB NO.	P.O. NO.
2968.2 (1) 1/17	J447	4500748690
2905.2 (1) 10/16	TRJ-445	4500732884
2807.2 (1) 3/16	J441XX	4500701785
2636.2 (1) 2/15	J419XX	4500622592
2577.2 (1) 10/14	401	401-2
2576.2 (1) 10/14	409	409-2
2552.2 (1) 9/14	395	395-2
2364.2 (1) 10/13	361	361
2349.2 (1) 10/13	357	357
2172.2 (1) 8/12	315	315-2
2126.2 (1) 7/12	293	293
2060.2 (1) 2/12	289	289
2034.2 (1) 2/12	286	286
1983.2 (1) 2/12	265	265
1917.2 (1) 2/12	258	258-2
1776.2 (1) 1/11		
1761.2 (1) 12/10		

REVISION RECORD	
G	REMOVED TIE DOWN CLIPS — RLM PAYNE 9-24-14
H	TOOK FLANGES OFF HEADER ASSEMBLIES AND PUT BALLOONS BACK ON THE DRAWING. — RLM 2-11-15
J	FIRST AIR TEST PRESSURE WAS 50 PSIG. ADDED IN PROCESS EXAMINATION NOTE TO NOTE 3 BALLOON 14 WAS 8" O.D. — MENDELL EAB STARK 3-7-16

DR	SWIGGUM	
DATE	6-30-11	
CHKD	WUOLLE	
DATE	6-30-11	
PROD ENG	MARTY	
DATE	7-5-11	
MFG ENG		
DATE		
WELD ENG		
DATE		

STD ENGR SPEC 11-6.00
NOTE 10: SES 9-8.01 PARA 1, 2, 1, 3.1 & 4.1

THIRD ANGLE PROJECTION

UNLESS NOTED: DIMENSIONS IN INCHES OR INCHES [MM]

LEGEND
- ○ PART NUMBER (PRODUCTION USE ONLY)
- ◇ JOINT DETAIL-REF.(PRODUCTION USE ONLY)
- □ FIN DATA INFORMATION
- △ DIMENSIONAL REVISION
- ⬡ SPECIAL NOTATION

Chart Energy & Chemicals, Inc.
2191 Ward Ave., La Crosse, WI 54601 USA

BRAZED ALUMINUM HEAT EXCHANGER 3 STREAM PLATE/FIN

ITEM NO. E-204-205

SIZE C | DWG. NO. 17769A | REV. J

INSTALLATION, OPERATION, AND MAINTENANCE MANUAL

for Chart Brazed Aluminum Heat Exchangers (BAHX) and Core-in-Kettle® Assemblies.

CHART®

Innovation. Experience. Performance.®

JANUARY 2017

ARRIVAL, INSTALLATION, AND STARTUP CHECKLISTS

The following checklists are for reference only, and are not intended to be comprehensive for all situations.

Serial Number:	
Plant Item Number:	

BAHX Arrival	**Relevant IOM Section**	**Checked By / Date**
1. Verify nameplate and record serial number	II. A.	
2. Check for external damage	II. A.	
3. Verify shipping stream pressure (typically 15 psig, if applicable)	II. A.	
4. Store per IOM instructions	II. B.	

BAHX Installation		
1. Verify nameplate serial number		
2. Lift into position following general lifting instructions in IOM and specific instructions supplied with unit (if applicable)	II. C.	
3. Verify correct BAHX orientation and nozzle locations	II. D. 1.	
4. Install Micarta® or equivalent insulation between support angle mounts and mating support surfaces (if applicable)	II. D. 1. c.	
5. Tighten bolted support connections to finger tight only (does not apply to bolted flange pipe connections)	II. D. 1. e.	
6. Verify no water or debris trapped in field piping to be attached to BAHX.	III. B. 1.	
7. Connect all nozzles to pipes	II. E.	
8. Remove all temporary shipping supports	II. D. 1. a.	
9. Remove all vent plugs (if applicable)	II. F.	
10. Perform piping system leak / proof test	III. A., IV. A.	
11. Install insulation	II. G.	

BAHX Initial Startup		
1. Verify overpressure protection for all streams	III. C. 2.	
2. Verify filters installed for all applicable streams	III. B. 1.	
3. Verify no water trapped in or upstream of BAHX	III. C. 1.	
4. Bring to operation conditions following IOM instructions, **with special attention to temperature rate of change guidelines**	III. C. 3.	

QUESTIONS?

CHART LIFECYCLE IS HERE TO HELP!

Chart Lifecycle provides plant stakeholders, from process and mechanical engineers through to operation and maintenance personnel, with best practices for the maintenance and management of Chart proprietary equipment for optimized performance and lifespan. Chart Lifecycle, Inc., is also your 24/7 single point of contact for spares, repairs, warranties, technical expertise, project development, field services, and training. Other services include:

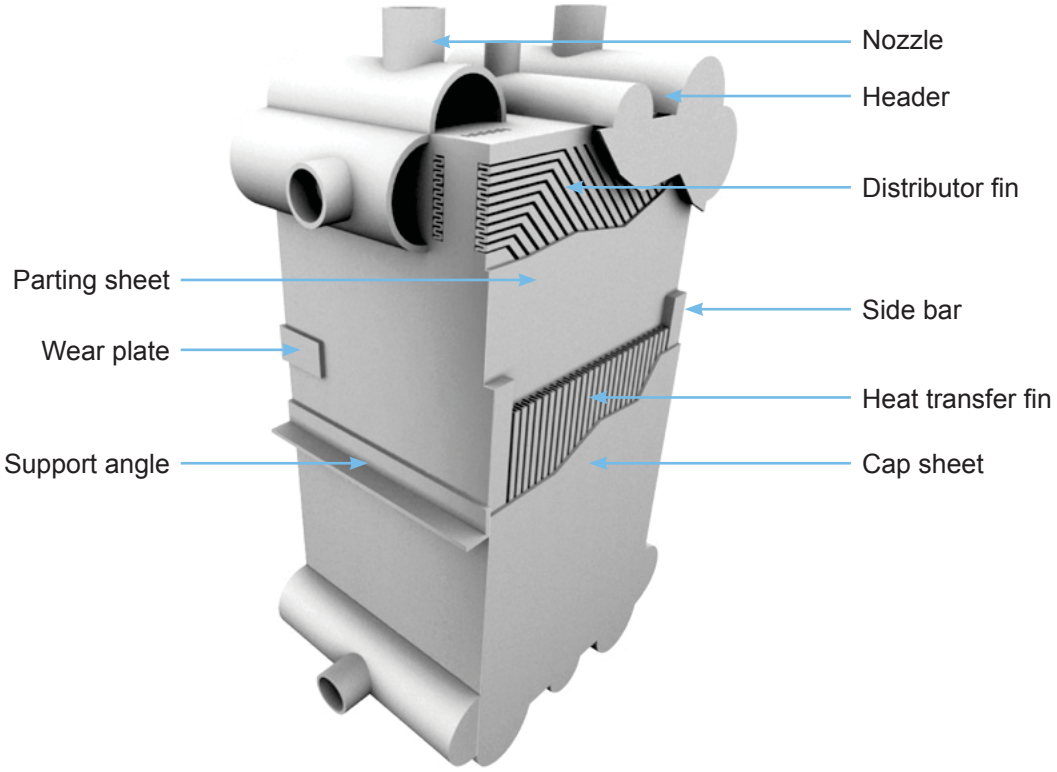
- Extended warranties
- Predictive maintenance analysis
- Customized operating solutions and best practices
- Performance improvement consulting services

Tel: 1-844-GTLS-911 (1-844-485-7911)
E-mail: info@ChartLifecycle.com
www.ChartLifecycle.com

CHART®
Chart Lifecycle, Inc.

FIGURE I

Basic Components of a Chart Brazed Aluminum Heat Exchanger (BAHX)



The Chart Energy & Chemicals, Inc. ("Chart") brazed aluminum heat exchanger (BAHX) business began in 1985 with the acquisition of The Trane Company's BAHX operation in La Crosse, Wisconsin. Chart is a recognized global leader in the design and manufacture of large BAHX, battery assemblies, and cold boxes for cryogenic applications.

Chart incorporates the former Altec and Marston BAHX brands and consequently all rights to engineering and equipment produced by these companies.

"Core-in-Kettle" is a registered trademark of Chart Energy & Chemicals, Inc.

"Chart", the Chart logo, and the *Innovation. Experience. Performance.*® tagline are registered trademarks of Chart Inc.

Brazed aluminum heat exchangers are also referred to as plate fin heat exchangers and abbreviated to PFHE within the industry.

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FOREWORD

This manual includes Chart's instructions, practices, and procedures regarding installation, operation, and maintenance of Chart BAHX, assemblies, and Core-in-Kettle® assemblies.

This manual is based on extensive experience, including more than 60 years in the design and manufacture of BAHX for low temperature applications, including air separation and liquefaction, natural gas processing and liquefaction, helium liquefaction, and hydrogen, ethylene, and other light hydrocarbon product recoveries.

THROUGHOUT THIS MANUAL, SAFETY ITEMS ARE HIGHLIGHTED IN CAPITAL LETTERS AND LABELED WITH THE CAUTION MARK SHOWN HERE.

This manual is updated periodically. Before attempting any procedure you should verify with Chart that you are using the current version.

This manual cannot cover all possible variations in equipment design or provide answers to all specific installation, operation, and maintenance questions that may arise. If for any reason, any variations or questions arise that are not addressed in this manual, or any of these instructions, practices, and procedures cannot be followed, the contractor or owner must contact Chart for further information, interpretation, and guidance. Failure to follow the instructions, practices, and procedures may result in serious bodily injury or death, property damage, irreparable damage to the Chart equipment, and the voiding of any warranties applicable to the equipment.

When these instructions, practices, and procedures are followed, extended and reliable service from BAHX and Core-in-Kettle® assemblies can be expected.

THESE ITEMS SHOULD BE READ WITH EXTREME CARE AND THOROUGHLY UNDERSTOOD BEFORE COMMENCING ANY INSTALLATION, OPERATION, OR MAINTENANCE OF CHART EQUIPMENT. FAILURE TO PROPERLY FOLLOW INSTRUCTIONS SO DESIGNATED COULD RESULT IN RUPTURES OR EXPLOSIONS OR OTHER DANGEROUS SITUATIONS WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

DO NOT MODIFY THE EQUIPMENT OR DEVIATE FROM THE INSTRUCTIONS, PRACTICES, AND PROCEDURES IN THIS MANUAL.

THE CONTRACTOR OR OWNER INSTALLING CHART EQUIPMENT MUST COMPLY WITH THESE INSTRUCTIONS, PRACTICES, AND PROCEDURES ALONG WITH ANY LIFTING AND HANDLING AND OTHER INSTRUCTIONS, PRACTICES, AND PROCEDURES PROVIDED WITH INDIVIDUAL UNITS.

I. INTRODUCTION

A. Configuration

B. Codes and Materials of Construction

A. CONFIGURATION

I. A. Configuration (see Figure I, inside cover)
Chart BAHX are constructed of aluminum. The basic construction consists of layers of corrugated fins which are furnace brazed between parting sheets. The BAHX dimension created by this stack of layers is referred to as the stack height dimension of the BAHX.

The rectangular plate-fin "block" created by this stack of layers is also referred to as a "core" and is normally specified by its outside block dimensions of "W" (width) times "H" (stack height) times "L" (length). A BAHX's size, number of layers, type of fins, stacking arrangement, and stream circuiting will vary depending on the application requirements.

The basic components of a brazed aluminum heat exchanger are described below in sections I. A. 1 through 1. A. 10. Sections I. A. 11 through I. A. 15 define the terminology used to describe the Chart heat exchanger assemblies and associated piping.

I. A. 1. Nozzles
Nozzles are the pipe sections used to connect the BAHX headers to the customer piping.

I. A. 2. Headers
Headers are the half cylinders that provide for the distribution of fluid between the nozzles and the ports of each appropriate layer within the BAHX.

I. A. 3. Ports
Ports are the openings in either the side bar or the end bar, located under the headers, through which the fluids enter or leave individual layers.

I. A. 4. Distributor Fins
Distributor fins distribute the fluid between the port and the heat transfer fins. The distributor fin used adjacent to a port is called a port fin. The distributor fin used between a port fin and a heat transfer fin is called a turning fin.

I. A. 5. Heat Transfer Fins
Heat transfer fins provide an extended heat transfer surface. All fins, both heat transfer and distributor, provide a connecting structure between the parting sheets, thereby creating the essential structural and pressure holding integrity of the BAHX.

I. A. 6. Parting Sheets
Parting sheets (sometimes referred to as separator sheets) contain the fluids within individual layers in the BAHX and also serve as the primary heat transfer surface.

I. A. 7. Outside Sheets
Outside sheets (sometimes referred to as cap sheets) are the outermost parting sheets. They serve as the outer protective surface of the BAHX as well as a land for weld attachment of the headers.

I. A. 8. Side and End Bars
Side and end bars enclose individual layers and form the protective perimeter of the BAHX.

A. CONFIGURATION

I. A. 9. Support Angles

Support angles are typically 90° extruded aluminum angles welded to the BAHX bar face for the purpose of supporting or securing a BAHX in its installed position. Other support configurations, such as pedestal bases, are also available (see Figure X).

I. A. 10. Lifting Lugs

Lifting lugs are lift attachment points strategically located and welded to the BAHX bar face or a header/nozzle assembly for the specific purpose of lifting the BAHX into its installed position.

I. A. 11. Modular BAHX Assembly

A modular BAHX assembly consists of two or more individually brazed BAHX blocks that are welded together prior to attaching the headers to form a single piece BAHX. This form of construction is used when the customer's heat exchange requirements exceed the maximum block size that can be furnace brazed. Modular construction eliminates the need for costly piping to interconnect separate, individual BAHX.

I. A. 12. Multiple BAHX Assembly

A multiple BAHX assembly, often referred to as a "battery," consists of two or more BAHX piped or manifolded together into a single assembly with the individual BAHX arranged either in a parallel, series, or combination parallel series arrangement. Multiple BAHX assemblies are used when the customer's heat transfer requirements are too large for either single piece or modular BAHX construction.

I. A. 13. Cold Box

A cold box consists of a welded airtight carbon steel casing, usually rectangular in shape, which supports and houses BAHX, piping, other related cryogenic equipment, and insulation material. More information can be found in the Cold Box Installation, Operation, and Maintenance Manual.

I. A. 14. Transition Joint

A transition joint is a bimetallic coupling used to make the transition from aluminum to stainless steel piping. Transition joints are available in various configurations.

I. A. 15. Core-in-Kettle® Assembly

A Core-in-Kettle® assembly consists of a cylindrical pressure vessel, usually carbon or stainless steel, which contains and supports one or more BAHX and associated piping including transition joints. In operation, one fluid is piped through the headered stream of the BAHX and the other partially fills the vessel and communicates with the open (unheadered) stream of the BAHX.

B. CODES AND MATERIALS OF CONSTRUCTION

I. B. Codes and Materials of Construction

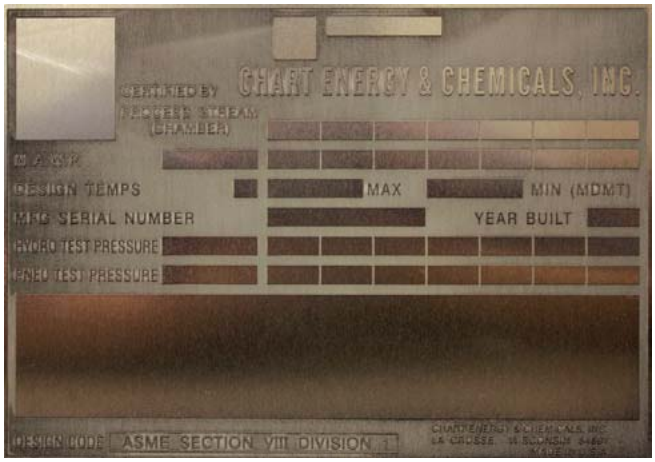
Chart BAHX are normally designed and manufactured in accordance with Section VIII, Division I of the ASME Pressure Vessel Code, carry the "U" stamp, and are registered with the National Board of Boiler and Pressure Vessel Inspectors. Associated piping is normally designed and manufactured in accordance with the ASME B31.3 Piping Code. The ASME pressure vessel and piping code boundaries are indicated on the Chart drawing.

Chart BAHX and piping are sometimes designed and manufactured to other (international) codes. The governing international code is specified on the Chart drawing and BAHX nameplate.

The following table indicates the typical materials of construction for the BAHX components.

FIGURE II

Typical BAHX Nameplate



COMPONENT	TYPICAL MATERIALS (Aluminum Alloy)
Outside Sheets	3003
Parting Sheets	3003
Side and End Bars	3003
Heat Transfer Fins	3003
Distributor Fins	3003
Headers & Nozzles	5083*
Flanges	6061-T6*
Support Angles	6061-T6*
Lifting Lugs	5083*

*Actual materials may differ and are specified on the Chart assembly drawing.

II. INSTALLATION

A. Arrival Inspection

B. Storage

C. Lifting and Handling

1. Single BAHX
2. Multiple BAHX Assemblies
3. Core-in-Kettle® Assemblies

D. Mounting, Bracing, and Shipping Support

1. Support Angle Mounting System
2. Pedestal Base Mounting System
3. Core-in-Kettle® Assemblies

E. Pipe Connections

1. Pipe Loads
2. Connection Configurations
3. Transition Joints

F. Venting

G. Insulation

A. ARRIVAL INSPECTION

II. A. Arrival Inspection

Upon arrival, verify the nameplate matches the purchase order. The BAHX should be inspected for shipping damage and contamination. Closely examine all units for external damage. For units shipped unpressurized, check under the shipping covers for contamination of the port openings. For units shipped pressurized (normally to 15 psig [1 barg]) with dry air or nitrogen, each headered or manifolded stream is provided with a valve and coupling to which a pressure gauge can be mounted (see Figure XI). A positive pressure should be indicated on the gauge when the valves are opened. If a stream does not indicate a positive pressure and the valve and coupling connections have been checked for leakage, it should be repressurized with dry air or nitrogen to 15 psig (1 barg). If a leak in the BAHX, shipping damage, or internal shipping contamination is confirmed, contact Chart for further direction.

B. STORAGE

II. B. Storage

An indoor storage area away from any main work area is recommended. Indoor storage is required for BAHX having open layers or nozzles not covered with welded or bolted covers. Any ingress of moisture into these open layers should be avoided. In all storage areas, the following additional recommendations should be followed.

II. B. 1.

BAHX are typically shipped on wood or steel channel skids. Skidded BAHX may also be packaged in a wooden crate or metal shipping container. Do not stack skidded or crated BAHX.

BAHX should be stored in the original packaging, which is generally suitable for three years. For longer term storage, consideration should be given to special packaging. Consult Chart for packaging options.

II. B. 2.

The storage area should provide level, uniform support with good drainage.

If the BAHX has been removed from its packaging, it should be laid on wooden sleepers in a horizontal position on the outside sheet face of the BAHX. The wooden sleepers should be at least 6 inches (152 mm) wide and extend beyond the edges of the BAHX. Failure to extend sleepers beyond the edges of the BAHX can result in internal damage to the outside layers. Use only two sleepers – one near each end of the BAHX – at a distance from each end that is approximately one fourth the BAHX's length. Avoid positioning the sleepers under any headers. Use a soft, resilient material such as fiber board as a buffer between the sleeper and the BAHX.

II. B. 3.

The storage area should be located where the BAHX is not subjected to fluids or atmospheres that are corrosive to aluminum.

II. B. 4.

The storage area should be located where the BAHX is not subjected to vibration.

II. B. 5.

Avoid a location where other work activity or falling objects will be in the vicinity of the stored BAHX. External denting of the BAHX can damage the internal matrix of the BAHX and cause leakage.

II. B. 6.

Avoid a location that is subject to large fluctuations in temperature (especially below 32 °F [0° C]), or high humidity when the BAHX is not sealed and weather-proofed, as this can cause condensed water to accumulate in the BAHX and freeze when the BAHX is placed in storage or operation. Water freezing inside the BAHX can damage its internal matrix.

NEVER STACK BAHX. STACKING OF BAHX COULD RESULT IN A BAHX FALLING FROM ITS STACKED POSITION WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

B. STORAGE

II. B. 7.

BAHX must be properly covered and sealed in such a manner that dirt, sand, water, or foreign materials cannot enter open nozzles, ports, or through any other access into the BAHX. For BAHX that are shipped pressurized, dry air or nitrogen with a dew point of 32 °F (0 °C) or less should be sealed in each stream during storage. The dry air or nitrogen pressure should be 15 psig (1 barg), or one third the stream design pressure, whichever is less. The BAHX should be checked periodically to ensure that the pressure is maintained.

For BAHX that are not shipped with pressure and do not have welded shipping covers on the nozzles, all nozzle openings on the BAHX should be covered and sealed while the unit is in a dry condition.

FAMILIARIZATION WITH ALL APPLICABLE CHART DRAWINGS IS REQUIRED BEFORE ANY INSTALLATION WORK PROCEEDS. PARTICULAR CARE SHOULD BE TAKEN WHENEVER OFF-LOADING, MOVING, OR LIFTING THE BAHX.

FAILURE TO HANDLE EQUIPMENT PROPERLY COULD RESULT IN THE BAHX BEING DROPPED OR SOME OTHER EQUIPMENT ACCIDENT WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

C. LIFTING AND HANDLING

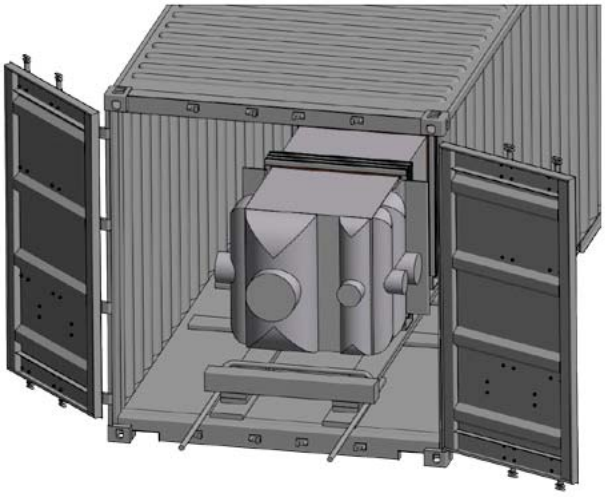
II. C. Lifting and Handling

Review lifting drawings that ship with each unit. Confirm the weight, dimensions, and lift connection locations of the BAHX. Select the appropriate hoisting machines, spreader bars, slings, shackles, and other material handling tools in consideration of the height, the BAHX weight, and the angle and direction of the hoisting. Care should be taken to avoid impacts to the BAHX. Rough or improper handling can cause damage to the internal matrix of the BAHX.

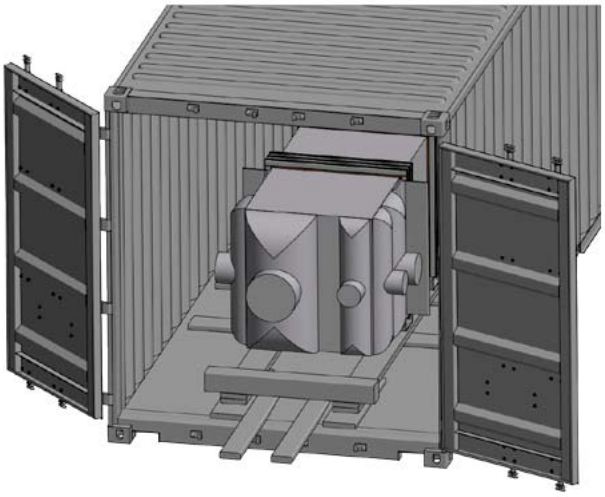
BAHX may be removed from metal shipping containers by towing with a chain, cable, or fork lift (see Figure III). Only tow from the indicated end of the skid, do not tow from any part of the BAHX.

FIGURE III

Removing BAHX from metal shipping containers



Chain or cable method



Fork lift method

C. LIFTING AND HANDLING

II. C. 1. Single BAHX

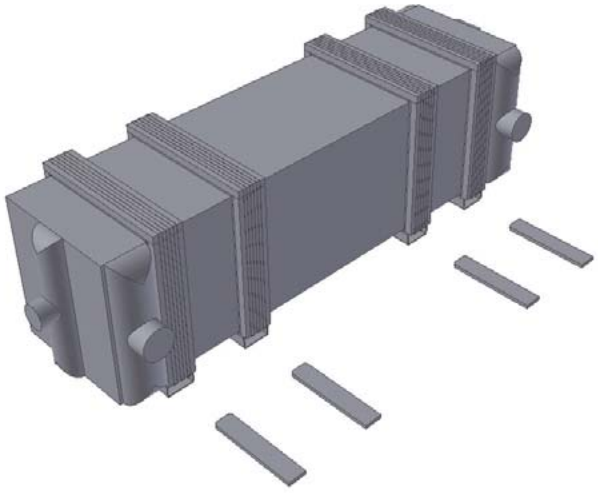
II. C. 1. a. Crated or Skidded (Lifting and Moving in a Horizontal Position)

Crated or skidded BAHX can be lifted with a fork truck or with a crane by using slings and a spreader bar (see Figure IV). When lifting with fork trucks have the forks horizontal. Do not ram BAHX.

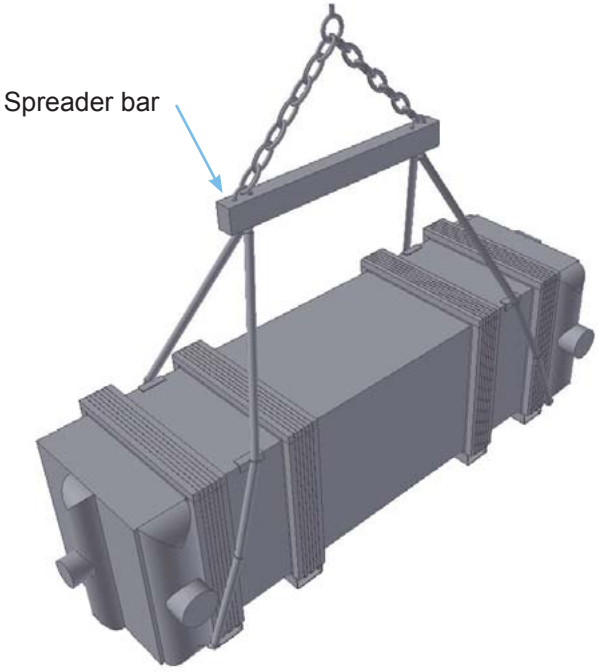
Wood skidded or crated BAHX can be towed with a fork truck, but do not tow steel channel skidded BAHX.

FIGURE IV

Horizontal lifting and moving instructions
(Steel channel skidded BAHX)
***Skidded BAHX furnished with single or dual fork lift provisions depending on unit length**



Fork lift method

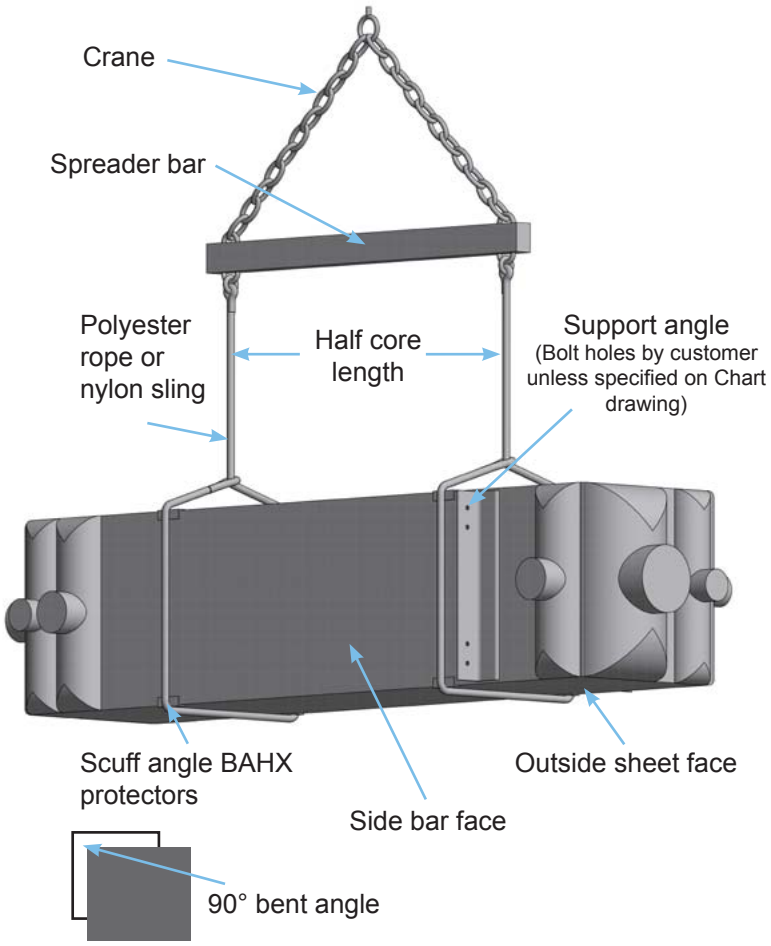


Sling method

C. LIFTING AND HANDLING

FIGURE V

Horizontal lifting and moving instructions (Unpackaged BAHX)



II. C. 1. b. Unpackaged (Lifting and Moving in a Horizontal Position)

Use nylon slings or polyester rope with scuff angles to protect the exterior of the BAHX (see Figure V). Do not use cables directly on the exterior of the BAHX as they can dent or cut into the exterior of the BAHX and cause damage to its internal matrix. Scuff angles are 90° angles placed on the corners of the BAHX under the sling or belt.

II. C. 1. c. Rolling to Alternate Side

Rolling of the BAHX from the shipping attitude is permitted when specified on the Chart assembly drawing. When permitted, a rolling instruction is shipped with the BAHX.

II. C. 1. d. Rotating and Lifting to a Vertical Position

The method for lifting a BAHX from its horizontal shipping position to the vertical installation position will depend upon BAHX configuration and weight. Lifting instructions are provided on the Chart drawings shipped with the unit.

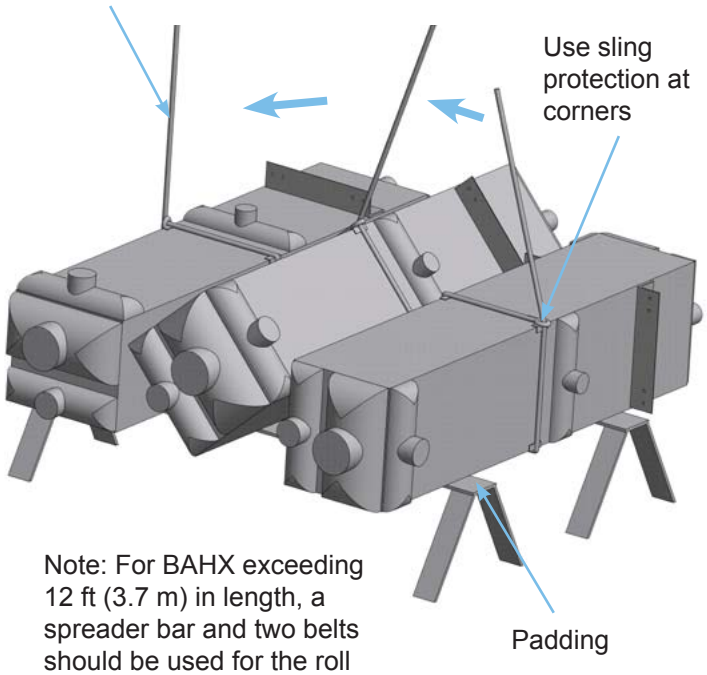
LIFT DIRECTLY FROM THE BAHX BLOCK ITSELF. DO NOT LIFT FROM ANY HEADER, NOZZLE, OR PIPING UNLESS SPECIFICALLY INDICATED ON THE CHART DRAWING.

FAILURE TO HANDLE EQUIPMENT PROPERLY COULD RESULT IN THE BAHX BEING DROPPED OR SOME OTHER EQUIPMENT ACCIDENT WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

C. LIFTING AND HANDLING

FIGURE VI

Typical method for rolling BAHX from shipping attitude to alternate sides (Unpackaged BAHX)
Use only when authorized on Chart assembly drawing.



Note: For BAHX exceeding 12 ft (3.7 m) in length, a spreader bar and two belts should be used for the roll

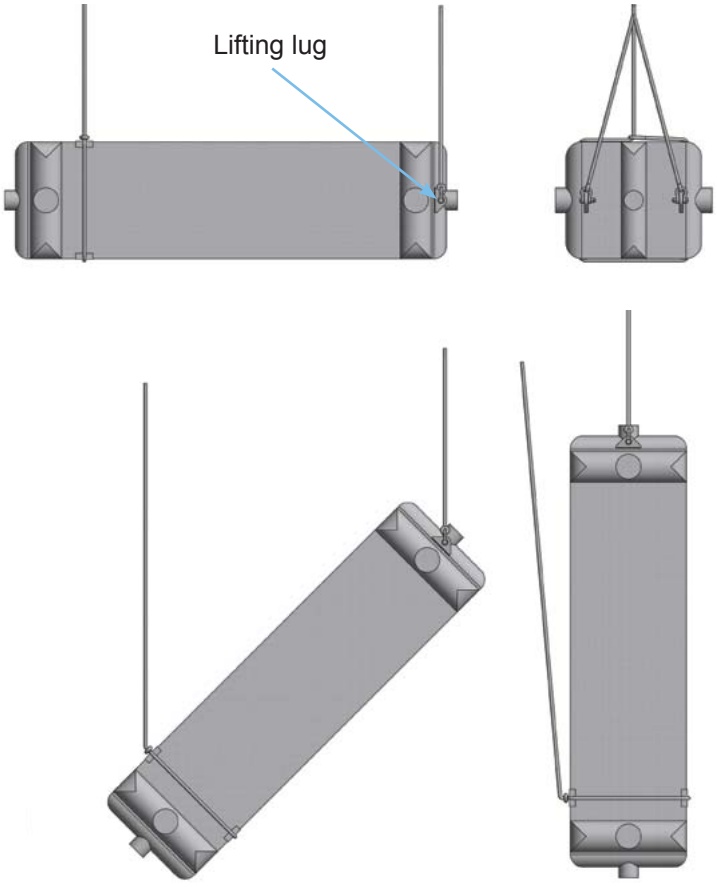
IF LIFTING LUGS ARE PROVIDED, THEY SHOULD BE USED AS THE ATTACHMENT LIFTING POINT. IF LIFTING LUGS ARE NOT PROVIDED, AND SPECIFIC LIFTING INSTRUCTIONS FOR THE UNIT ARE NOT AVAILABLE, CONTACT CHART. DO NOT LIFT USING THE NOZZLES OR ANY OTHER PIPING UNLESS SPECIFICALLY SHOWN IN THE CHART DRAWING FOR THE UNIT.

There are two basic methods for lifting to the vertical position. Other methods are approved only if specified on the Chart drawing for the unit. Both methods are similar except for the point of lifting attachment.

One method involves the use of lifting lugs provided with the Chart unit (see Figure VII).

FIGURE VII

Typical method lifting BAHX to vertical position using provided lifting lugs.

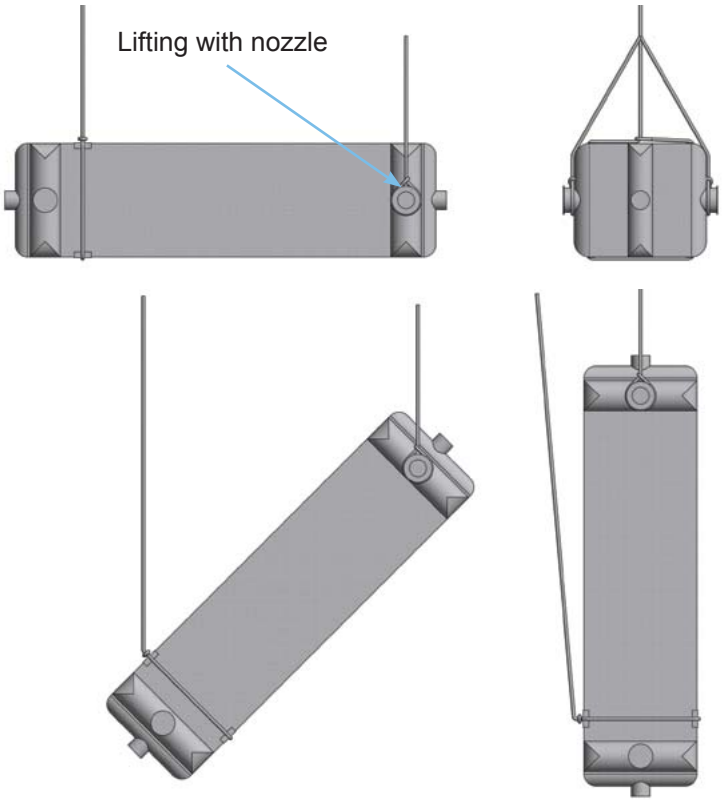


C. LIFTING AND HANDLING

The other method involves lifting using the BAHX nozzles (see Figure VIII). These lifting methods are used for both support angle mounting and pedestal base mounting of BAHX.

FIGURE VIII

Typical method lifting BAHX to vertical position using nozzles on the BAHX



II. C. 2. Multiple BAHX Assemblies

Considering the numerous possible variations in BAHX and piping assembly configurations, size, and weight, a single lifting, handling, and erection procedure for multiple BAHX assemblies is not possible.

For these assemblies, lifting instructions are included on the Chart assembly drawing or on a separate erection drawing. Multiple BAHX assemblies should be handled with the same care afforded individual BAHX.

II. C. 3. Core-in-Kettle® Assemblies

Core-in-Kettle® assemblies are either provided with appropriate lifting lugs on the kettle or instructions as to where to sling around the assembly.

WHEN LIFTING LUGS ARE PROVIDED ON CHART CORE-IN-KETTLE® ASSEMBLIES FOR LIFTING AND HANDLING THEY SHOULD BE USED WHENEVER MOVING THE CORE-IN-KETTLE® ASSEMBLY.

FAILURE TO HANDLE EQUIPMENT PROPERLY COULD RESULT IN THE BAHX BEING DROPPED OR SOME OTHER EQUIPMENT ACCIDENT WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

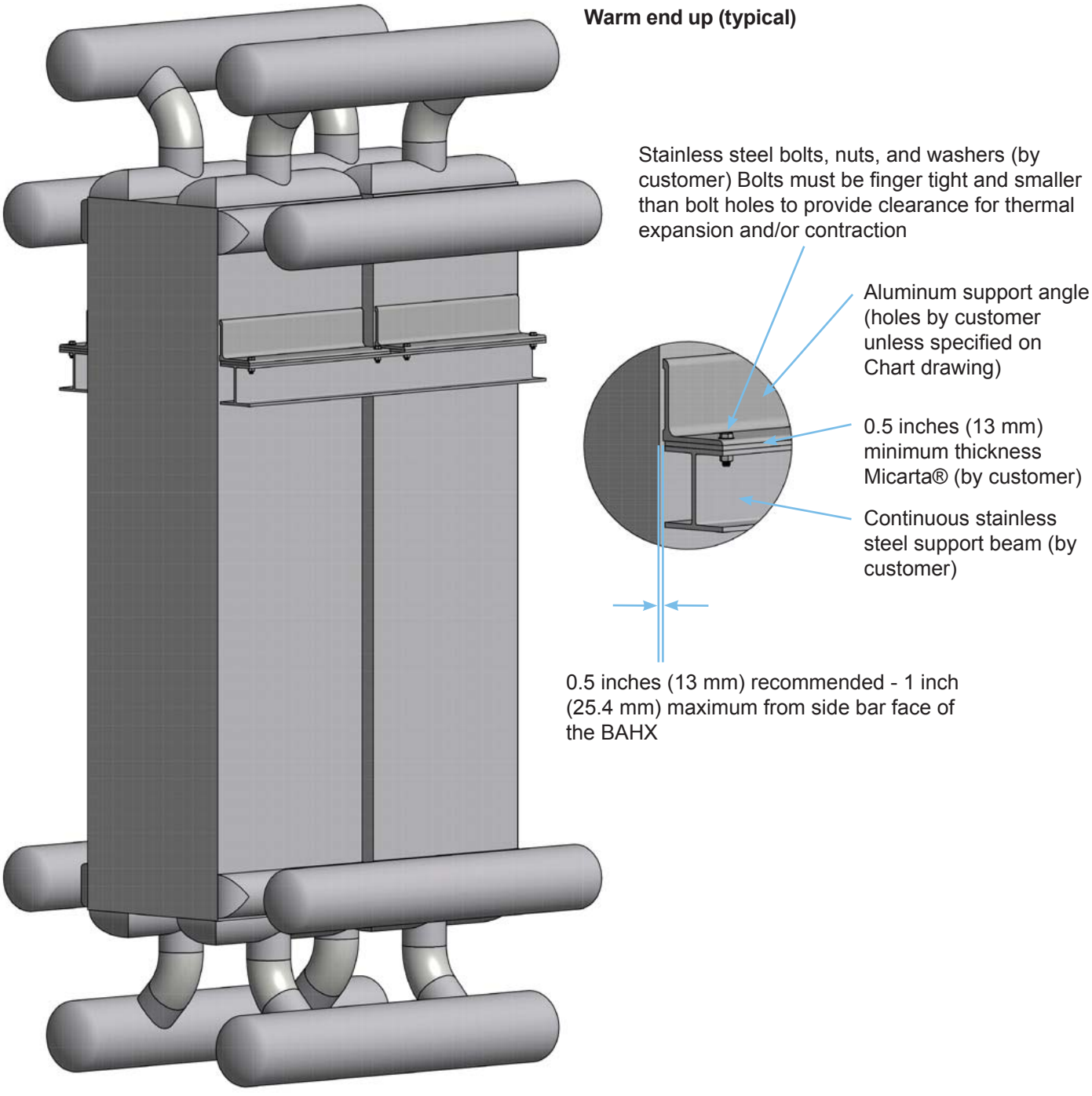
C. LIFTING AND HANDLING

FIGURE IX

Typical support angle mounting system

(Single or multiple BAHX assemblies)

Warm end up (typical)



D. MOUNTING, BRACING, AND SHIPPING SUPPORT

II. D. Mounting, Bracing, and Shipping Support

II. D. 1. Support Angle Mounting System (Single or Multiple BAHX Assemblies)

Chart BAHX are normally installed vertically with the warm end up (see Figure IX). Other orientations are permissible only if specified on the Chart assembly drawing. Chart BAHX are normally provided with aluminum support angles welded directly to the side bar face of the BAHX for mounting purposes.

The following are general mounting recommendations for both single BAHX and for multiple BAHX assemblies utilizing support angle mounting systems (see Figure IX).

II. D. 1. a.

All shipping supports should be removed as shown on the Chart drawings. Extreme care should be taken to keep all steel working torches and flame-cutting tools at a proper distance from the aluminum BAHX in order to prevent severe damage to brazed joints and to the internal matrix.

II. D. 1. b.

The support angle surfaces on the BAHX are in plane within 0.06 inches/foot (0.5%). The mating support surface (by customer) should be a continuous member and be in plane to this same standard. Shimming is acceptable but is not preferred.

II. D. 1. c.

Since these BAHX are normally installed in cryogenic services, some method of insulating between the Chart aluminum support angles and the customer mating support surface is recommended.

A minimum of 0.5 inch (13 mm) thick piece of Micarta® (phenolic canvas base laminate) block is recommended for this purpose. The insulation material thickness should be sufficient to minimize heat leak and prevent frost spots from developing on the supports or cold box walls during operating conditions.

II. D. 1. d.

Provisions for thermal expansion and contraction of the BAHX in the horizontal plane at the support location must be provided.

The expected thermal movement should be calculated in both horizontal directions by the following equation:

$$D=12.6 \times 10^{-6} \times L \times \Delta T$$

where L is the distance in inches between extreme bolts in the direction under consideration, ΔT is the change in temperature in °F at the support location from the installed (ambient) temperature to the coldest possible operating temperature, and D is the expected thermal movement in inches which will result from this calculation.

D. MOUNTING, BRACING, AND SHIPPING SUPPORT

If the expected thermal movement in both directions is 0.5 inches (13 mm) or less, the bolt hole diameters in the aluminum support angles should be oversized by adding the maximum expected thermal movement to the bolt diameter.

If the expected thermal movement exceeds 0.5 inches (13 mm) in one of the horizontal directions, a slotted hole should be used with a slot length equal to the bolt diameter plus the maximum expected thermal movement, and a slot width equal to the bolt diameter plus the expected thermal movement in the other direction.

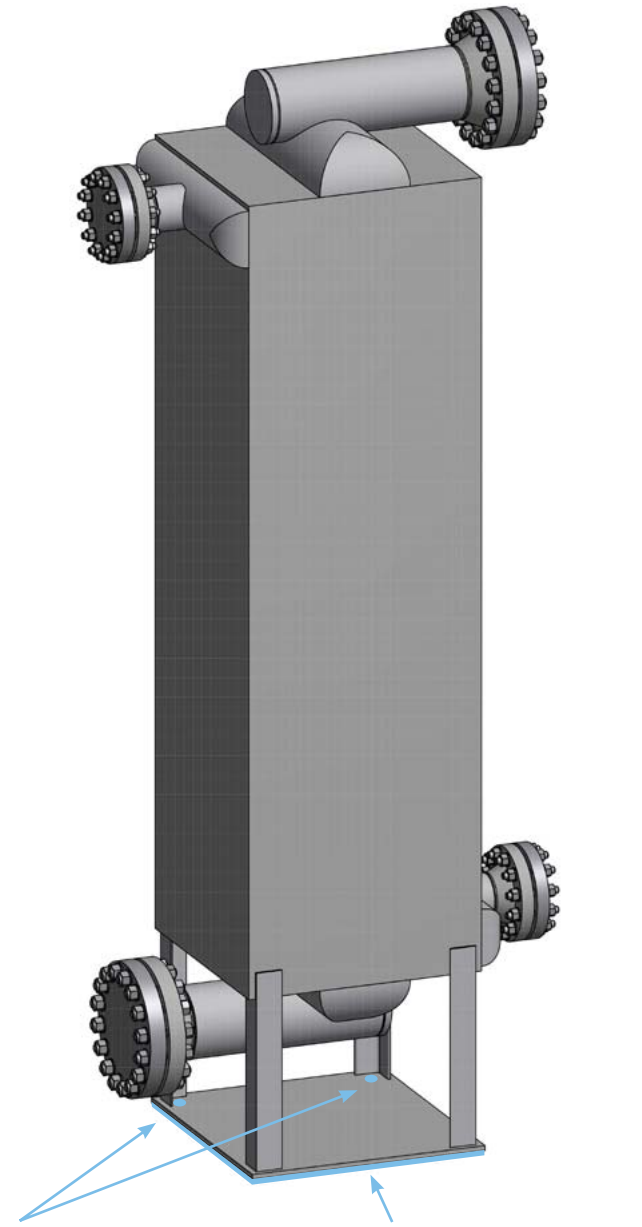
If the expected movement exceeds 0.5 inches (13 mm) in both directions, the holes in the aluminum support angles should be slotted as per above in one direction and the holes in the stainless steel support beam should be slotted as per above in the other direction with slot widths equal to the bolt diameter plus 0.12 inches (3 mm).

II. D. 1. e.

Bolts employed to secure the BAHX to the supporting surface must be finger tight only (this requirement applies to both angle type and pedestal base type mounting systems). Do not use lock washers. Use a double nut or interrupt the bolt threads to prevent the nut from working loose. Wrench tightening the bolts could allow relatively small horizontal pipe loads applied to either end of the BAHX to develop bending moments on the BAHX which may produce unacceptable stress concentrations at the support angles.

FIGURE X

Typical pedestal base mounting system
(Single or multiple BAHX assemblies)
Warm end up (typical)



D. MOUNTING, BRACING, AND SHIPPING SUPPORT

II. D. 1. f.

To avoid excessive bending moments on the support angle itself, the edge of the support surface must be no more than 1.0 inches (25.4 mm) from the BAHX side bar face. A distance of 0.5 inches (13 mm) is recommended (see Figure IX).

II. D. 1. g.

The support system should be safeguarded by the provision of a sway brace, located at the opposite end of the BAHX away from the main support angles or pedestal base, whenever the total external loads (pipe, wind, and earthquake) are sufficient to cause lateral movement of the BAHX.

A close fit between the BAHX wear plate and the sway brace is required since changing from ambient to operating at cryogenic temperatures at this position can produce 0.12 inches (3 mm) of movement from thermal contraction. If requested, wear plates can be furnished on the BAHX by Chart.

Do not fasten any sway brace directly to the BAHX. The BAHX must be free to move in the vertical direction.

II. D. 1. h.

For reversing (air separation service) BAHX, supporting directly from the bottom (warm end) manifolds is acceptable if provided for on the Chart assembly drawing. Warm end manifolds for reversing BAHX should always be provided with sumps and drains of adequate size to return any condensed water from the manifold piping so that water will not be entrained in the fluid stream or slugged into the BAHX during pressure reversals.

II. D. 2. Pedestal Base Mounting System (Single or Multiple BAHX Assemblies)

An alternative method to the support angle mounting system is an aluminum pedestal base mounting system provided with the BAHX (see Figure X). The pedestal base mounting system is generally employed when cold box installation is not required and the BAHX can be mounted at ground level as this is usually a less costly method for mounting.

The same recommendations regarding shimming, insulation, bolt hole size, bolt tightness, and bracing for support angle mounting systems in Section II. D. 1. should be followed for pedestal base mount systems.

II. D. 3. Core-in-Kettle® Assemblies

The holes for the anchor bolts are slotted in the sliding saddle to allow for thermal contraction and expansion. When installing a Core-in-Kettle® assembly it is critical to align the anchor bolts in the center of the slots. In rare cases the saddle geometry may require the anchor bolts be installed offset in the slots. In these cases the required positioning is specified on the Core-in-Kettle® assembly drawing.

E. PIPE CONNECTIONS

II. E. Pipe Connections

II. E. 1. Pipe Loads

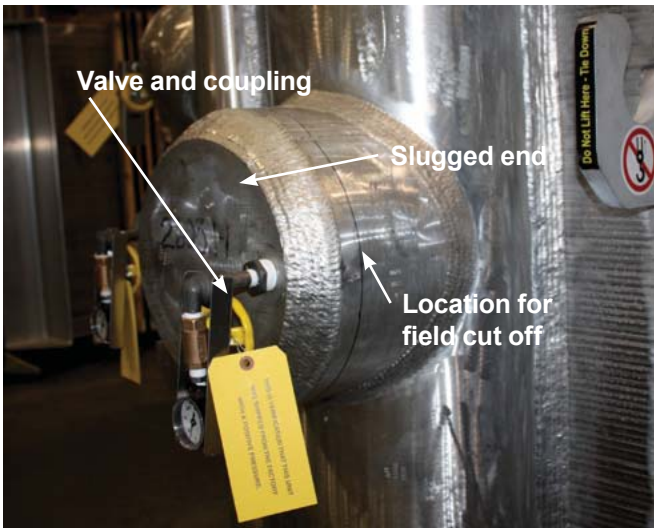
A table indicating maximum allowable pipe loads for the BAHX or assembly is provided with the Chart drawing. This table indicates the maximum allowable bending moment and the axial load that can be applied at each header location on the BAHX. These maximum loads are not to be applied simultaneously. Instructions for summing applied moments and forces are supplied with this table.

It is the customer's responsibility to provide sufficient piping flexibility or anchor points in the customer piping to ensure that the combined loads on each nozzle and on the BAHX are within the allowable limits specified by Chart.

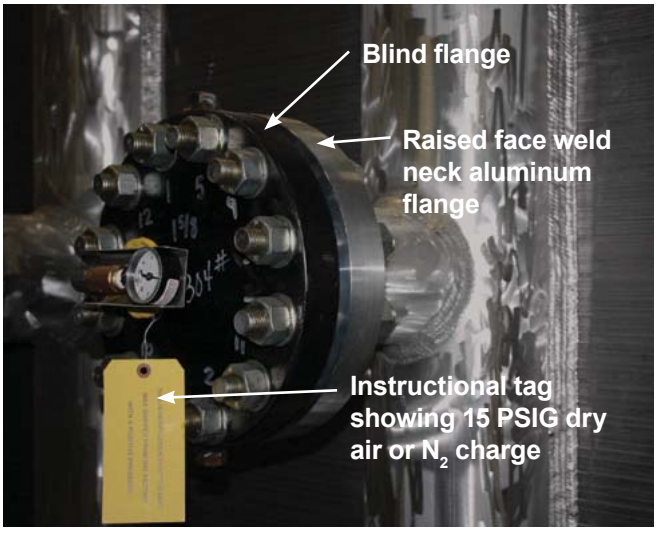
FAILURE TO PROVIDE SUFFICIENT PIPE FLEXIBILITY OR ANCHOR POINTS COULD RESULT IN COMBINED PRESSURE AND EXTERNAL PIPE LOADS BEING APPLIED WHICH EXCEED THE ALLOWABLE LOADS OF THE BAHX AND MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

FIGURE XI

Typical connections for BAHX and assemblies shipped with pressure



Typical slugged connection



Typical flanged connection

E. PIPE CONNECTIONS

II. E. 2. Connection Configurations

II. E. 2. a. Slugged Connections

Do not pressurize connections above 25 psig without contacting Chart for confirmation of slug design pressure.

IF A FIELD PRESSURE TEST IS TO BE CONDUCTED WITH PRESSURE ABOVE 25 PSIG BEFORE THE SHIPPING SLUG IS REMOVED, CONTACT CHART TO CONFIRM THE MAXIMUM WORKING PRESSURE RATING OF THE SLUG.

OVERPRESSURIZATION OF A BAHX OR ASSEMBLY WITH SLUGGED ENDS NOT DESIGNED FOR PRESSURE TEST PURPOSES COULD RESULT IN A RUPTURE OF THE SLUGGED ENDS WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

Prior to removing the plug or pressure gauge from the shipping valve, be sure the valve is in the closed position. Exercise caution and accepted safety procedures for removal of a plug from a pressure vessel.

FAILURE TO CONFIRM THE SHIPPING VALVE IS IN THE CLOSED POSITION PRIOR TO REMOVAL OF THE PLUG OR PRESSURE GAUGE CAN RESULT IN THE PLUG OR GAUGE BECOMING A PROJECTILE WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

The proper cut off location of the nozzle or pipe can be found on the Chart assembly drawing (see Figure XI). Beveling and welding procedures should be followed per the applicable code requirements. Before making final connections to the BAHX, care should be exercised to remove any saw chips, torch slag, or other foreign material from the pipe, nozzle, and header area. These items can plug the BAHX.

E. PIPE CONNECTIONS

II. E. 2. b. Flanged Connections

Do not pressurize blind flanges above 25 psig without contacting Chart for confirmation of blind flange design pressure.

IF A FIELD PRESSURE TEST IS TO BE CONDUCTED WITH PRESSURE ABOVE 25 PSIG BEFORE THE BLIND FLANGE IS REMOVED, CONTACT CHART TO CONFIRM THE MAXIMUM WORKING PRESSURE RATING OF THE BLIND FLANGE.

OVERPRESSURIZATION OF A BAHX OR ASSEMBLY WITH BLIND FLANGES NOT DESIGNED FOR PRESSURE TEST PURPOSES COULD RESULT IN A RUPTURE OF THE FLANGED ENDS WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

Prior to removing the plug or pressure gauge from the shipping valve, be sure the valve is in the closed position. Exercise caution and accepted safety procedures for removal of a plug from a pressure vessel.

FAILURE TO CONFIRM THE SHIPPING VALVE IS IN THE CLOSED POSITION PRIOR TO REMOVAL OF THE PLUG OR PRESSURE GAUGE CAN RESULT IN THE PLUG OR GAUGE BECOMING A PROJECTILE WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

Aluminum or steel (stainless for cryogenic service) mating flanges are typically used with the Chart flanged connection.

E. PIPE CONNECTIONS

Care should be exercised to protect the machined face of the flange against scratches, dents, and other damage that will reduce the effectiveness of the gasket in making a proper seal.

The two mating surfaces of the flanges should be parallel with each other prior to connecting. Flange faces should be aligned to the design plane to within 0.06 inches/foot (0.5%) maximum, measured across the diameter of the flange mating face, and flange bolt holes should be aligned to within 0.12 inches (3 mm) maximum offset.

Connections should be made by gradually tightening diametrically opposite bolt pairs and tightening the pairs in a sequence that uniformly loads the gasket. Installed bolts and gaskets shipped with the blind flange must not be used for making final connections as they are not designed for cryogenic service. Stainless steel bolts and nuts must be used for the final field connection for cryogenic service. Stainless steel washers must be used under the bolt heads or nuts on the aluminum flange, and threads should be lubricated for proper torque wrench applications.

Gasket Recommendations For Use With Aluminum Flanges:

Chart recommends Flexitallic Flexpro gaskets or equivalent (m=2.0, y=2500 psi [17.2 MPa]). If stainless steel spiral wound gaskets are used, Chart recommends they be low seating stress such as Flexitallic LS (m=3.0, y=5000 psi [34.5 MPa]). If higher seating stress gaskets are selected consult Chart to determine if Chart's standard recommended bolt torques are adequate.

Bolting recommendations:

	Down to -50 °F (-45 °C)	Below -50 °F (-45 °C) Stud Diameters thru 1.5 inches (38 mm)	Below -50 °F (-45 °C) Stud Diameters above 1.5 inches (38 mm)
Studs	SA193 B7	SA320 B8 CL2	SA193 B8M2
Nuts	A194 GR 2H	SA194 GR 8	SA194 GR 8

Recommended Bolt Torques:

All bolting must be given a final tightening by torque wrench. Bolts are to be torqued to the full value shown in the table below and then re-torqued after 15 minutes. Torque values are based on a resultant bolt stress of 30,000 psi assuming well lubricated studs, nuts, and washers.

Bolt torques for use with flanges:

Bolt Size (in)	TPI	Torque (ft-lbs)	Torque Increments
1/2	13	30	Snug, then full torque
5/8	11	60	
3/4	10	100	
7/8	9	160	Snug, 1/2 torque,
1	8	245	then full torque
1-1/8	8	355	
1-1/4	8	500	
1-3/8	8	680	
1-1/2	8	800	Snug, 1/3 torque, 2/3
1-5/8	8	1100	torque, then full torque
1-3/4	8	1500	
1-7/8	8	2000	
2	8	2200	Snug, 1/4 torque,
2-1/4	8	3180	1/2 torque, 3/4 torque,
2-1/2	8	4400	then full torque
2-3/4	8	5920	
3	8	7720	

E. PIPE CONNECTIONS

II. E. 2. c. Weld Prepared Connections
Weld prepared connections are properly trimmed to length and beveled for welding. The trim length and beveling detail is provided on the Chart drawing. Connections prepared for welding are covered during shipments. The BAHX or assembly does not ship with pressure.

Beveling of the mating pipe and welding procedures should be per the applicable code requirements. Before making final connections to the BAHX, remove any saw chips, torch slag, or other foreign material from the pipe, nozzle, and header area. These items can plug the BAHX.

II. E. 3 Transition Joints (see Figure XII)
Unless authorized by the joint manufacturer, transition joints are to be attached only to piping components.

To prevent failure of the bond during welding, precautions must be taken to avoid overstressing the bond due to differential expansion between the aluminum and stainless steel joint components. These stresses can be maintained within allowable limits by taking the following precautions:

- Place a chill block or damp rags on the aluminum/steel overlapping bond area. If damp rags are used, care should be taken to keep the rags or cloths damp. A dry cloth will allow the joint to become excessively hot. Temperature in the aluminum/steel overlapping area must be held to a maximum of 300 °F (149 °C), unless higher temperatures are permitted by the joint manufacturer.

FIGURE XII

Typical transition joints for piping connections

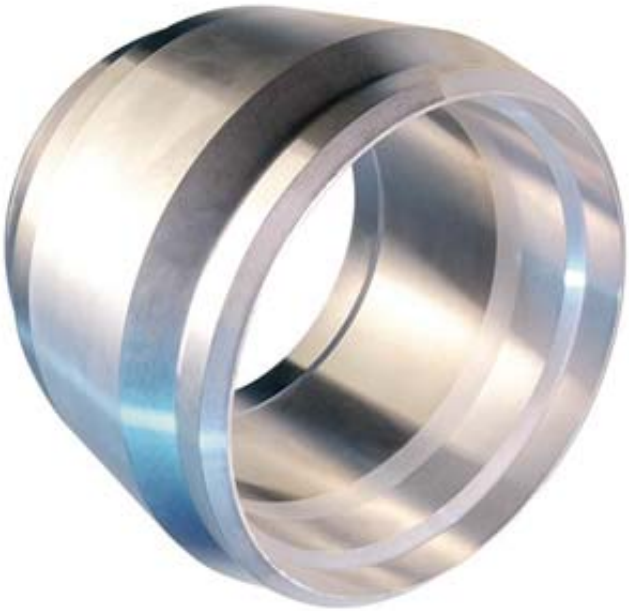


Photo courtesy of Groupe RBDH

Photo courtesy of Asahi Kasei Corporation

E. PIPE CONNECTIONS

- When installing a loose transition joint, weld the stainless steel end first whenever possible. This will provide a larger sink for the heat generated by the aluminum welding.

- Use weld techniques and sequences to minimize the heat input.

- Care should be taken to avoid non-uniform heating, weld sequences, or weld techniques that would cause isolated high stress areas, i.e. “Block Welding,” local repair welds, or other similar types of localized welding.

F. VENTING

II. F. Venting

External venting of inactive or non-operational internal zones of some BAHX is required when specified on the Chart drawing. Examples of inactive zones that require venting are:

- the modular space formed by welding together two BAHX blocks.
- the dead corner of a reversing stream warm end distributor employing the slant bar drainability feature.
- the space formed between two tandem streams having adjacent side headers at mid BAHX.
- other special cases.

Chart BAHX that have an inactive zone are normally designed to be self venting and simply require that the plastic shipping plugs be removed just prior to insulating and pressurizing any stream. This requirement is stated on the Chart drawing and on a tag attached to BAHX.

If you wish to monitor an inactive zone by attaching a vent line, be sure to extend the vent line outside the cold box or insulation and provide a relief valve on the vent line to protect the inactive zone of the BAHX against pressurization over 15 psig (1 barg). Maintain the vent line in an internally frost free condition to eliminate the possibility of line blockage from freezing liquids. A 3/4” NPS (20DN) or larger line is recommended to avoid potential flow restriction.

FIGURE XIII

Vent plug tag

FAILURE TO LIMIT THE PRESSURIZATION OF INACTIVE ZONES IN THE BAHX TO A MAXIMUM OF 15 PSIG COULD RESULT IN A RUPTURE OF THE BAHX WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

G. INSULATION

II. G. Insulation

Since BAHX usually operate at cryogenic temperatures, highly efficient insulation should be applied by the customer to minimize heat leak. Insulation material is normally applied after the unit is installed at the job site. Flammable materials should be avoided for insulation. Insulation materials are not normally applied to the BAHX prior to installation because insulation materials are easily damaged in transit, they restrict the use of shipping tie downs and supports, and they would impair accessibility to the unit for lifting, mounting, leak testing, and other installation preparations.

When the BAHX is not mounted inside a cold box, the BAHX's exterior is normally insulated with rigid polyurethane foam, or other alternatives such as Foamglass® insulation, according to the thickness and requirements specified by the engineering contractor. These insulations are positioned and fastened around the BAHX and covered with a vapor barrier. Protective metal coverings or flashing can be used for this purpose.

In all installations, some form of insulation such as a Micarta® spacer should be used between the BAHX support member and the supporting beam or platform (see Section II. D. 1. c.).

Caution should always be exercised whenever welding or flame cutting near insulation materials.

Refer to the Cold Box Installation, Operation, and Maintenance Manual for instructions on insulating BAHX installed in cold box assemblies.

III. TESTING AND OPERATION

A. Field Proof Testing

B. Fouling and Corrosion Protection

1. Filtering
2. Hydrate Suppression (Methanol Injection)
3. Corrosion Protection

C. Start Up, Operation, and Shut Down

A. FIELD PROOF TESTING

III. A. Field Proof Testing

Most codes require a pressure test of the piping system after the BAHX or assembly is installed. A pneumatic test is most often performed.

Only clean, dry gases should be used for pneumatic proof and subsequent leak testing. Water, or any fluid that may freeze, should not be used in any testing or cleaning of the Chart BAHX as it is extremely difficult to dry the BAHX in the field. Trapped water can freeze in the BAHX matrix and develop hydraulic pressures sufficient to rupture the internals of the BAHX without any external evidence. If water is accidentally introduced into the BAHX, see Section IV. C. 1. for drying procedures. In Section IV. B., several practical field tests are recommended for determining leaks.

The pneumatic proof test pressure must comply with National Board Inspection Code requirements or, if applicable, international pressure vessel code inspection requirements and must not exceed 1.1 times the maximum working pressure specified on the Chart nameplate.

OVERPRESSURIZATION OF THE BAHX COULD RESULT IN A RUPTURE OF THE BAHX WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

B. FOULING AND CORROSION PROTECTION

III. B. Fouling and Corrosion Protection

BAHX are capable of handling a wide variety of fluids. Fluids should be clean, dry, and non-corrosive to aluminum. Fluids containing particulate matter, waxy components, or corrosive elements should not be used in the BAHX.

III. B. 1. Filtering

The presence of particulates in the fluid may not only lead to BAHX fouling but may also cause erosion in the high velocity areas of the BAHX. If there is any potential for the presence of particulates in any fluid stream entering the BAHX, the fluid should be filtered with a 177 micron (80 Mesh Tyler Standard) screen or finer, directly upstream of the BAHX.

The user should consider a dual filter system with sufficient valving to allow a filter to be changed without shut down. A heavy duty, cleanable filter or strainer is recommended.

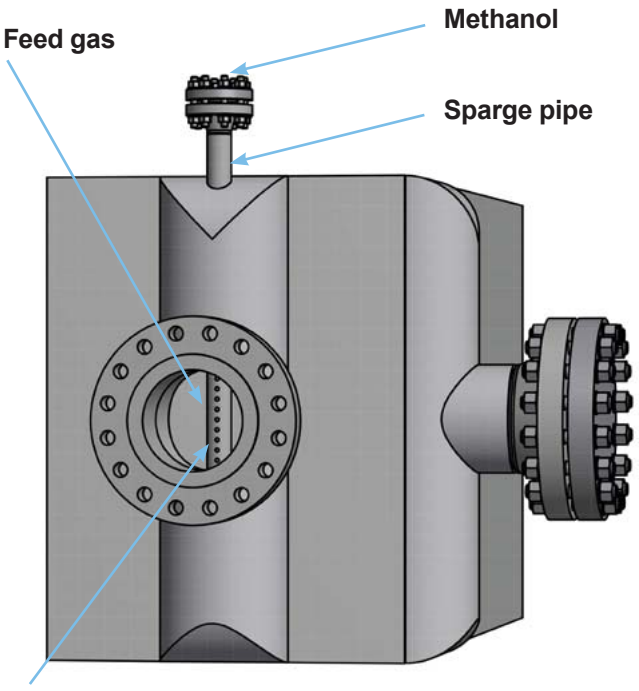
All connecting pipelines carrying BAHX fluids should be thoroughly cleaned of all pipe scale, dirt, sand, and other debris before placing the BAHX in service. Strainers may be needed for startup, particularly on liquid streams that wash particulates toward the BAHX. Once the system is flushed clean, these startup filters can normally be removed. Fouling of the BAHX can be detected by a gradual or sudden increase in pressure drop and a loss of heat transfer performance.

III. B. 2. Hydrate Suppression (Methanol Injection)

During start up, upset, or even normal operating conditions, the presence of hydrates or heavy hydrocarbons in the feed or other streams may freeze in the BAHX at operating temperatures. These hydrates or heavy hydrocarbons may eventually block some or all of the layers in the BAHX.

FIGURE XIV

Typical methanol sparge system top view (warm end)



0.125 inches (3 mm) diameter methanol injection holes spaced 0.5 inches (13 mm) apart (extra drain holes provided on opposite side of sparge pipe)

B. FOULING AND CORROSION PROTECTION

When complete shut down for deriming is undesirable (see Section IV. C. 1.) methanol injection can be used to remove hydrates during operation if the operating temperature is warmer than -170 °F (-112.2 °C) (methanol freezes at approximately -170 °F). This method of hydrate suppression involves injecting methanol into the process fluid upstream of the Chart BAHX. An aluminum sparge pipe injector can be provided for this purpose inside the header of the Chart BAHX (see Figure XIV). Methanol is injected into the incoming feed gas via this sparge pipe. The feed gas then carries the methanol into the BAHX.

If a methanol injection sparge system is not to be used for an extended period of time, the methanol should be purged from the piping to eliminate the potential for methanol corrosion. This can be accomplished by blowing dry air or nitrogen through the methanol piping. Drain holes on the underside of the sparge pipe are provided for draining purposes.

If hydrate contamination is an ongoing problem, any upstream equipment where water could enter the BAHX stream should be inspected for leaks.

III. B. 3. Corrosion Protection

Trace impurities of H_2S, NH_2, CO_2, SO_2, NO_2, CO, Cl and other acid-forming gases may cause corrosion when liquid water is present in the stream. Additionally, certain water acidity levels can cause corrosion of aluminum. To avoid corrosion, the pH level of the water condensate should be between 5 and 7.

Carefully guard against the ingress of water vapor or liquid, either during commissioning or similar plant events where the BAHX is vulnerable to water ingress (for example, during core repair involving removal of piping to the BAHX), or by process fluids containing water. If allowed to freeze, accumulated water in trapped areas of the BAHX can structurally damage the internals of the BAHX.

External surface corrosion can be avoided by keeping the externals of the BAHX under a dry environment during installation and operation. Such precautions will eliminate the potential for intergranular corrosion attack or stress corrosion cracking of the BAHX components.

Under certain conditions, mercury can corrode aluminum and therefore caution must be used when handling process fluids containing mercury. However, Chart BAHX have been successfully used with fluids containing mercury provided the proper equipment design and operating procedures are implemented.

If mercury is suspected or anticipated:

- BAHX should not be exposed to process fluids containing mercury concentrations greater than 0.1 µg/Nm^3. Above this limit, mercury guard beds should be installed and mercury tolerant features should be considered in the design of the exchanger.

- Below 0.1 µg/Nm^3, purchasers should consider using exchangers with mercury tolerant features and mercury guard beds because the same gas field can sometimes contain large variations in mercury levels over time.

C. START UP, OPERATION, AND SHUT DOWN

III. C. Start up, Operation, and Shut Down

Chart BAHX can be expected to provide many years of useful life when operated in strict accordance with the instructions, practices, and procedures outlined in this manual. The range of life can vary depending on the process design, how demanding the operating conditions are, and other factors. A typical useful life is 20 years or more.

FAILURE TO OPERATE WITHIN THE GUIDELINES MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

III. C. 1.

Prior to start up, purge and dryout procedures should be completed to remove moisture and heavy hydrocarbons which may freeze at cryogenic operating temperatures. A thorough dryout must be carried out at the commissioning and after every subsequent shutdown where moisture may reach the cryogenic equipment. A warm (70 to 100 °F) (21 to 38 °C) dry gas must be used to achieve adequate dryness. All dead legs in the piping must be drained and purged.

ALL OPERATING CONDITIONS MUST BE WITHIN THE SPECIFIED CHART NAMEPLATE LIMITS AND THE CHART SPECIFICATIONS FOR THE BAHX BEING OPERATED. THE MAXIMUM WORKING PRESSURE AND TEMPERATURES ARE SHOWN ON THE CHART NAMEPLATE AND THE CHART DRAWING (SEE FIGURE II).

THE BAHX MUST BE OPERATED AT PRESSURES THAT DO NOT EXCEED THE MAXIMUM WORKING PRESSURE FOR EACH STREAM ON THE CHART NAMEPLATE. THE BAHX MUST BE OPERATED AT TEMPERATURES WITHIN THE LIMITS OF THE CHART NAMEPLATE WORKING TEMPERATURES.

C. START UP, OPERATION, AND SHUT DOWN

EXCEEDING ANY OF THE MAXIMUM WORKING PRESSURES OR TEMPERATURES SPECIFIED ON THE CHART NAMEPLATE COULD RESULT IN A RUPTURE OF THE BAHX WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

III. C. 2.

Appropriate pressure relief valves with settings below the Chart nameplate maximum working pressures must be provided by the user.

III. C. 3.

As with any pressure containing equipment, stresses in each component of a BAHX must be maintained within allowable limits during operation. Pressure loads, externally applied loads (e.g. piping forces and moments), and thermally induced loads each produce stress in the components. The resultant stress from these loadings must be controlled within allowable limits to prevent component damage or failure.

The conditions that produce thermal stress must be controlled to maintain the thermal stresses within the designed margin. Thermal stress arises from local metal temperature differences in BAHX components that are close and rigidly attached in all directions.

The high thermal conductivity of aluminum helps to minimize temperature differences in BAHX, but large local metal temperature differences can arise from operational instabilities, changes in operating conditions, or transient events associated with start-up, shutdown, or upset conditions. Operational instabilities can result from unstable boiling within the BAHX or from externally produced hydraulic fluctuations caused by poorly designed piping systems or inadequate control systems. Detrimental transient events associated with start-up, shutdown, or upset conditions can result from improper procedures or inadequate control systems.

If the local metal temperature differences are large, the margin for thermal stress can be exceeded and the combined thermal and mechanical stress can exceed the yield strength and possibly the ultimate strength of the material. Stresses at or above the ultimate strength subject the BAHX to failure after only one event. Stresses below ultimate strength can result in failure if applied repeatedly. The number of cycles an exchanger can withstand before failure depends on the stress amplitude and history.

As with any piece of thermal equipment, the BAHX should be brought to or from operating or derime conditions slowly.

C. START UP, OPERATION, AND SHUT DOWN

FAILURE TO CONTROL METAL TEMPERATURE CHANGES AND GRADIENTS CAN INDUCE EXCESSIVE THERMAL STRESS WHICH CAN RESULT IN FAILURE OR RUPTURE OF THE BAHX BELOW THE STREAM DESIGN PRESSURE AND MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

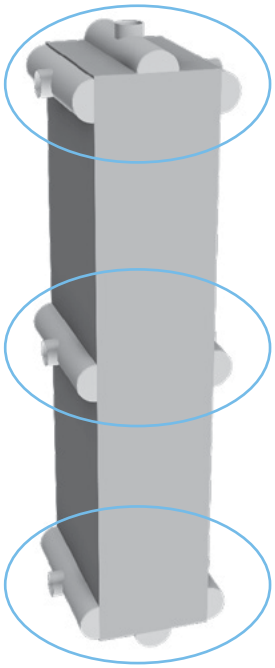
Damaging thermal stress can occur if the local metal temperatures are allowed to change faster than 3.6 °F (2 °C) per minute, or if adjacent parting sheet temperatures exceed 50 °F (28 °C), or if severely non-linear temperature profiles are induced. Additionally, failure from thermal fatigue can occur if local metal temperatures are allowed to change faster than 1.8 °F (1 °C) per minute repeatedly.

To prevent damage or failure from these conditions, the following guidelines are recommended (Note that all temperature rates of change should be calculated using the time interval specified in the rate of change time unit, i.e. use one minute intervals when calculating stream inlet temperatures to compare against the 3.6 °F per minute guideline, and one hour intervals when comparing against 108 °F per hour guideline):

- Limit pressure and external loads in the BAHX to those specified by Chart.
- Limit the cyclic temperature fluctuations of all streams to less than 1.8 °F (1 °C) per minute to prevent thermal fatigue.
- Limit stream inlet and outlet temperature rates of change to less than 108 °F (60 °C) per hour, not to exceed 3.6 °F (2° C) per minute, by controlling changes in stream flowrates and inlet temperatures. If the flow in one stream stops suddenly, often the recommended course of action is to immediately stop the flow of all other streams.
- Limit all stream-to-stream and stream-to-metal temperature differences at any axial cross-section to less than 50 °F (28 °C) (see Figure XV). If a stream introduction has potential to exceed this guideline, then increase the flow rate from zero to full flow slowly enough to adhere to the stream outlet temperature rate of change guideline.

FIGURE XV

Temperature Difference Recommendations



Warm end max stream-to-stream and stream-to-metal temperature difference < 50 °F (28 °C)

Max temperature difference < 50 °F (28 °C)

Cold end max temperature difference < 50 °F (28 °C)

C. START UP, OPERATION, AND SHUT DOWN

- Review plant operations to identify operating conditions that have the potential to create high thermal stress and develop procedures to minimize the impact of these events. Typical conditions causing high thermal stress include cold and warm restart. Cold restart is where the BAHX is shut down and the metal cools due to boil-off of residual liquid, and at restart incoming warm streams could flow into a cold BAHX. Warm restart is where the BAHX is shut down and the metal allowed to warm due to the continued flow of warm fluids, and at restart incoming cold streams could flow into a warm BAHX.

Flow control is particularly critical when introducing liquid or two-phase streams. Liquid and two-phase fluids have a large capacity to rapidly change metal temperature in the BAHX. Flow control is less critical when introducing and sensibly heating or cooling vapors due to the limited capacity of the vapor to rapidly change metal temperature in the BAHX. For this reason, cooling or warming of the BAHX to or from operating conditions with a vapor prior to introducing a liquid or two-phase stream is highly recommended.

- Exercise extreme care in applications where the fluid must be totally vaporized in the BAHX and there is potential for unstable boiling.

The relatively large temperature differences associated with unstable boiling along with surging of the vaporizing fluid within the BAHX can cause thermally induced fatigue failure. When unstable boiling is suspected, the 50 °F (28 °C) maximum stream-to-stream and stream-to-metal temperature difference must be strictly adhered to.

- Design and operate the plant equipment and piping connected to the BAHX to prevent flow instabilities (for example, intermittent slugging of liquid to the BAHX). This is extremely important with boiling streams.

In instances where it is not possible to adhere to these guidelines, contact Chart to discuss your specific application.

III. C. 4.

Operating flow rates should be within the Chart specification limits for design or over design flow conditions. If higher flow rates are being considered, contact Chart for recommendations regarding maximum velocities inside the BAHX.

III. C. 5.

Precautions should be taken to prevent the transmission of operating fluid pulsations or vibrations (emanating from pumps, compressors, etc.) to the BAHX.

III. C. 6.

During prolonged or indefinite shut downs (mothballing), see Section IV. D. for recommendations.

III. C. 7.

For air separation reversing BAHX, limit the number and duration of upsets and cold or emergency shut downs in order to prevent repeated freezing of moisture which may have accidentally accumulated in the BAHX.

C. START UP, OPERATION, AND SHUT DOWN

III. C. 8.

Recommendations for blowdown:

- Shut off flow from the top of the exchanger and vent through the bottom of the exchanger. This will establish parallel (cocurrent) flow and minimize heat transfer during blowdown

- Minimize the distance between the blowdown valves and the BAHX to minimize the stream volume transferred through the BAHX during blowdown.

IV. MAINTENANCE

A. Operating Records

B. Field Leak Testing

1. Pressure Decay Test
2. Air-Soap Test
3. Internal Leak Testing

C. Cleaning

1. Deriming, Back Flushing, and Drying
2. Back Puffing

D. Mothballing

E. Repair and Service

A. OPERATING RECORDS

IV. A. Operating Records

Operating outside the guidelines stated in Section III. C. may lead to excessive thermal stress which could result in failure of BAHX components or lead to rupture even when operating within the design limits on the nameplate. A maintenance log must be kept to record normal operating procedures, any plant upsets, shut downs, and any other operating conditions. It is critical the operating data be monitored to ensure operation is within the IOM stated guidelines.

Potential warning signs where equipment requires inspection or repair prior to continued operation:

- Operating data indicates equipment is being subjected to temperature swings exceeding guidelines in Section III. C.
- Measurement of stream compositions indicating cross contamination has developed
- Other BAHX at the facility have developed leaks or failures
- Frost spots on cold box wall or insulation sheeting
- Liquid drainage from BAHX or from under insulation
- Indications from gas detection sensors
- Venting from the BAHX
- Abnormal BAHX performance

If any of these warning signs are present contact Chart.

PRIOR TO THE INSPECTION, TESTING, OR REPAIRING OF ANY UNIT, EITHER IN SERVICE OR RECENTLY REMOVED FROM OPERATION, THE SYSTEM MUST BE SAFETY CHECKED AND CLEARED PRIOR TO THE ADMITTANCE OF PERSONNEL FOR ANY SERVICE FUNCTION.

GIVEN THEIR CRITICALITY IN DETERMINING CAUSE, RESOLUTION, AND RESPONSIBILITY FOR ANY ISSUES WITH THE BAHX, THE OWNER MUST MAINTAIN ADEQUATE INSTALLATION, OPERATION, AND MAINTENANCE RECORDS TO ENSURE COMPLIANCE WITH THE GUIDELINES.

B. FIELD LEAK TESTING

CAUTION MUST BE EXERCISED WITH REGARD TO THE FLAMMABILITY, TOXICITY, EXPLOSION POTENTIAL, OR PRESSURE POTENTIAL OF ANY FLUID OR STREAM WITHIN OR IN THE PROXIMITY OF THE BAHX. ALL PERSONNEL INVOLVED WITH INSTALLATION OR MAINTENANCE OF COLD BOX ASSEMBLIES SHOULD BE MADE AWARE OF THE DANGERS OF SUFFOCATION, ESPECIALLY IN NITROGEN FILLED CONTAINERS.

FAILURE TO OBSERVE PROPER SAFETY PRECAUTIONS IN THIS REGARD COULD RESULT IN EQUIPMENT RUPTURE, FIRES, TOXIC GAS OR FLUID ESCAPE, SUFFOCATING GAS ATMOSPHERES OR OTHER ACCIDENTS WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

IV. B. Field Leak Testing

Internal leaks in a BAHX are generally indicated by a change of purity in any of the fluid streams. External leaks can be determined by sight, smell, audible sounds of leaking fluid, external gas monitoring equipment, or localized cold spots appearing on the external insulation or cold box casing. External leaks in BAHX mounted in a cold box are also generally indicated by excessive venting through the breather valve or cold spots on the cold box casing. Breather valve gas detection methods are within the scope of operator.

DO NOT EXCEED THE MAXIMUM WORKING PRESSURE SPECIFIED FOR EACH STREAM ON THE CHART NAMEPLATE. OVER–PRESSURIZATION COULD RESULT IN A RUPTURE OF THE BAHX WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

B. FIELD LEAK TESTING

It is critical that any leaking BAHX be repaired immediately and that the cause of the leak be identified and corrected. Prolonged operation may lead to further damage of the unit when the cause is due to cyclical thermal or mechanical fatigue. Prolonged operation of an externally leaking BAHX installed in a perlite insulated cold box may lead to further damage and increased leakage due to perlite erosion of the BAHX metal.

Common field tests used for determining leaks are described below.

IV. B. 1. Pressure Decay Test

Pressurize a stream with dry air or nitrogen.

A stream is considered leak free if it maintains the original pressure for over eight hours with correction for temperature changes. Keep in mind that the pressure decay time test is a function not only of the leak size but the test pressure, temperature, and BAHX size, as well.

For large BAHX and assemblies with large internal volumes, and/or for leak tests at lower pressures (less than 50 psig [3.4 barg]), leaks may take longer than eight hours to detect, depending upon the size of the leak.

The BAHX temperature should be the same at the two pressure checks since any change in temperature will change the air pressure in the BAHX. If it is impractical to make the two pressure checks when the temperatures are the same, the following pressure correction can be used:

$$P_2 = \frac{P_1 T_2}{T_1}$$

Where

P = Absolute Pressure

T = Absolute Temperature (°R or K)

1 = Initial Reading

2 = Final Reading

For individual recommendations, contact Chart.

IV. B. 2. Air-Soap Test (External Leaks)

If the stream does not maintain the original pressure during the decay test, above, determine what kind of leak exists by repressurizing the stream and checking the exterior of the BAHX with a soap bubble test. If the BAHX passes this test, the leak is internal.

DO NOT EXCEED THE MAXIMUM WORKING PRESSURE SPECIFIED FOR EACH STREAM ON THE CHART NAMEPLATE. OVER–PRESSURIZATION COULD RESULT IN A RUPTURE OF THE BAHX WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

B. FIELD LEAK TESTING

IV. B. 3. Internal Leak Testing

The method used to locate the individual layer leak involves a soap test over each port of the stream in question while air or nitrogen pressure is applied to the other stream. This operation normally involves removal of the header and should only be performed by Chart authorized service personnel.

C. CLEANING

IV. C. Cleaning

If the BAHX is fouled or plugged, several options are available to the user for cleaning the BAHX. When the fouling is solid and coats the fins in the BAHX, the BAHX should be cleaned by chemical removal through a series of deriming, back flushing, and drying procedures (see Section IV. C. 1.).

If the BAHX is fouled or plugged by hydrates and/or ice, a warm derime is required and consideration given to other methods for hydrate suppression (see Section III. B. 2.).

If the BAHX is fouled or plugged by particulate matter, back puffing procedures are usually successful in cleaning the BAHX (see Section IV. C. 2.).

The piping and instrumentation diagrams should be carefully reviewed at the plant design phase to ensure adequate nozzles and valves on the piping are available to carry out any of the above cleaning procedures that are anticipated.

IV. C. 1. Deriming, Back Flushing, and Drying

Deriming and back flushing involves the use of heat and/or solvents to remove hydrates, heavy hydrocarbons, waxy materials, compressor oils, or other soluble matter which freeze or collect in the BAHX. The presence of these materials is detected by an increase in the stream pressure drop and/or loss of heat transfer performance.

When systems for injecting methanol during operation have not been provided (see Section III. B. 2.), shut down and purge the BAHX and allow it to warm and defrost itself by natural heat leak or by an approved derime procedure. Normally, the combination of warming and back flushing with a solvent rinse such as trichloroethane, toluene, propylene, or methanol is successful for this purpose.

Prior to startup, purge and dryout the BAHX in accordance with III. C. 1.

If a water based solvent is used to derime or back flush, or if water accidentally gets introduced into the BAHX, the BAHX must be completely dried before returning to service in order to prevent plugging or rupture caused by freezing. Use dry air or nitrogen or other dry gas as the drying medium.

IV. C. 1. a.

The derime, back flushing, or drying temperature should not exceed 150 °F (65 °C), unless the maximum working temperature on the Chart nameplate is higher. Do not exceed the maximum working temperature specified on the Chart nameplate.

IV. C. 1. b.

The derime, back flushing or drying media must be non-corrosive to aluminum. Always use clean fluids. If any vessels, piping, or temporary pipe sections are used during the cleaning, it is important to clean them of pipe scale, dirt, weld slag, or any other foreign material which could enter and plug the BAHX.

C. CLEANING

IV. C. 1. c.

When liquid solvents are used for purposes of deriming or back flushing the BAHX, the nozzle fluid velocity should not exceed 10 feet (3 meters) per second to prevent erosion inside the BAHX. Liquid solvents or any cleaning fluids should always be circulated through the BAHX in the reverse direction of normal operating flow.

IV. C. 1. d.

Cleaning solvents should always be chosen with regard to the suspected fouling agent. If the fouling agent is unknown, a sample of it should be chemically analyzed to determine its composition.

ONLY CLEANING SOLVENTS THAT ARE NON-CORROSIVE TO ALUMINUM MUST BE USED. CORROSIVE CLEANING SOLVENTS CAN WEAKEN PRESSURE RETAINING STRUCTURES WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT

If any special procedures are required to meet uncommon derime, back flushing, or drying conditions, contact Chart for further evaluation.

IV. C. 2. Back Puffing

When proper precautions are taken regarding filtering, many years of clean service can be expected. However, when foreign material (pipe scale, perlite, desiccant, mole sieve, etc.) is introduced into the BAHX itself, by accident or misoperation, back puffing can be an effective method for removing entrained particulates.

Since particulates normally cause blockages in the BAHX at the inlet ports and distributors, puffing in the reverse direction of normal operating flow is required to prevent pushing the particulates farther into the BAHX. The back puffing procedure involves attaching a rupture disk to the inlet nozzle or flange of the BAHX stream to be backpuffed.

C. CLEANING

IT IS THE USER'S RESPONSIBILITY TO TAKE THE APPROPRIATE SAFETY PRECAUTIONS REGARDING PERSONNEL, CLEARING THE TEST AREA, AND THE SUITABILITY OF THE SUPPORTS AND BRACING TO WITHSTAND THE REACTION FORCES DEVELOPED WHEN THE RUPTURE DISK BURSTS.

EXTREME CAUTION SHOULD BE EXERCISED AS THE RUPTURE OF THE DISK AND THE RELEASE OF GAS CAN RESULT IN A RAPID DISCHARGE OF GAS AND FLYING DEBRIS WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

The plugged stream is slowly filled with dry air or nitrogen until the rupture disk bursts. The sudden release of gas out of the BAHX will help dislodge particulate matter. This back puffing procedure should be repeated five to ten times, or until the amount of particulate removed becomes minimal and the discharge cloud is clear.

EXTREME CAUTION MUST BE EXERCISED SO AS NOT TO EXCEED THE MAXIMUM WORKING PRESSURE OF THE STREAM ON THE CHART NAMEPLATE, OR 100 PSIG, WHICHEVER IS LESS.

FAILURE TO LIMIT PRESSURIZATION TO THESE LIMITS COULD RESULT IN A RUPTURE OF THE BAHX WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

Contact Chart for guidance on the maximum allowed backpuffing pressure. If the maximum allowable pressure is reached and the rupture disk has not burst, the stream should be depressurized and a new rupture disk installed.

A back puffing event does not reduce the life of the equipment. However, remaining residue in the equipment has the potential to distort the thermal profile and induce thermal stress, which may reduce the life of the equipment.

D. MOTHBALLING

IV. D. Mothballing

BAHX which have seen prior service should be dried and pressurized prior to storage. An eight hour or longer purge with dry air or nitrogen having a dew point less than 32 °F (0 °C) is recommended to dry the BAHX.

Following the drying operation, each stream should be pressurized with dry air or nitrogen with a dew point of less than -40 °F (-40 °C). This low dew point is recommended to prevent galvanic corrosion in the BAHX which could result if traces of rust or other foreign materials have gained access to the BAHX during operation. The dry air or nitrogen pressure should be 15 psig (1 barg) or one third the stream design pressure, whichever is less.

The 15 psig (1 barg) pressure level should be checked periodically to assure that there are no leaks in the BAHX. In addition, the storage recommendations in Section II. B. should also be followed.

E. REPAIR AND SERVICE

IV. E. Repair and Service

If a leak is detected, Chart should be notified for repair recommendations. Chart is well qualified and staffed to perform field or factory service and repair on this type of BAHX equipment.

Refer to the National Board Number and the Chart serial number shown on the ASME U-1 data report form or unit nameplate when contacting Chart.

All ASME repairs must be certified by an “R” stamp and must be in accordance with the Chart Quality Assurance Policy, the National Board Inspection Code, and the ASME Code, and any local jurisdictional requirements.

Repair to the BAHX should be made only by Chart authorized personnel. The Chart warranty will be voided if repairs made to the Chart BAHX during the warranty period are made by unauthorized service personnel.

Improper welding on the BAHX block can damage the braze joints. Repairs not made in accordance with ASME procedure, and identified by the “R” stamp on the Chart nameplate, will invalidate the National Board registration of the BAHX.

IMPROPERLY REPAIRED BAHX MAY NOT BE SUITABLE TO WITHSTAND THE NAMEPLATE MAXIMUM WORKING PRESSURE RATINGS.

PRESSURIZATION OF AN IMPROPERLY REPAIRED BAHX COULD RESULT IN A RUPTURE OF THE BAHX WHICH MAY RESULT IN SERIOUS BODILY INJURY OR DEATH AND PROPERTY DAMAGE AS WELL AS IRREPARABLE DAMAGE TO THE CHART EQUIPMENT AND THE VOIDING OF ANY WARRANTIES APPLICABLE TO THE EQUIPMENT.

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Chart Energy & Chemicals, Inc. is an ISO:9001 and
ISO:14001 registered company

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INSTALLATION, OPERATION, AND MAINTENANCE MANUAL

for Chart Brazed Aluminum Heat Exchangers (BAHX) and Core-in-Kettle® Assemblies.

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