

109016-109021

E9000-2
" -3
" -4
" -5

" -6
" -7

12619
MWO

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 Enerquip, LLC, 611 North Road, Medford, Wisconsin, 54451-0467, USA
(Name and address of Manufacturer)
- 2. Manufactured for DDCE, 500 Park Boulevard, Suite 545, Itasca, Illinois, 60143, USA
(Name and address of Purchaser)
- 3. Location of installation Niles Ferry Industrial Park, 200 Industrial Drive, Vonore, Tennessee, 37885, USA
(Name and address)
- 4. Type Horizontal BEMH Heat Exchanger 11391 to 11396
(Horizontal, vertical, or sphere) (Tank, separator, jkt. vessel, heat exh., etc.) (Manufacturer's serial number)
- N/A SA-3395-C 9080-9085 2009
(CRN) (Drawing number) (National Board number) (Year built)
- 5. ASME Code, Section VIII, Div. 1 2007/ 2008 N/A N/A
Edition and Addenda (date) Code Case number Special Service per UG-120(d)

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

- 6. Shell (a) Number of course(s): 1 (b) Overall length 0' 141.780"

No.	Course(s)		Material Spec./Grade or Type	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B, & C)			Heat Treatment	
	Diameter	Length		Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
1	4.500" OD	141.780"	SA-312 TP304L WLD	.120"	N/A	1	None	1	N/A	N/A	N/A	N/A	N/A

- 7. Heads: (a) N/A (b) N/A
(Material spec. number, grade or type) (H.T. - Time & Temp.)

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

If removable, bolts used (describe other fastening) N/A
(Material, spec. number, grade, size, number)

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

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

- 9. MAWP 150 psi N/A at max. temp. 375 °F N/A Min. design metal temp. -20 °F at 375 psi
(internal) (external) (internal) (external)

- 10. Impact test No, Impact Testing Not Required Per UHA-51(d), (d)(1)(a) & (g) at test temperature of N/A
(Indicate yes or no and the component(s) impact tested)

- 11. Hydro., pneu., or comb. test press. Hydro. at 225 psi Proof test N/A

Items 12 and 13 to be completed for tube sections.

- 12. Tubesheet: SA-240 304L - No H.T. (2) 4.998" .890" N/A Welded
(Stationary (material spec. no.)) (Diameter, (subject to press.)) (Nominal thickness) (Corr. allow.) Attachment (welded or bolted)
- N/A N/A N/A N/A N/A
(Floating (material spec. no.)) (Diameter) (Nominal thickness) (Corr. allow.) (Attachment)

- 13. Tubes: SA-249 TP304L .750" .049" 7 Straight
(Material spec. no., grade or type) (O. D.) (Nominal thickness) (Number) (Type (Straight or U))

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

- 14. Shell (a) No. of course(s): 1 (b) Overall length 5.220"

No.	Course(s)		Material Spec./Grade or Type	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B, & C)			Heat Treatment	
	Diameter	Length		Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
1	4.500" OD	5.220"	SA-312 TP304L WLD	.120"	N/A	N/A	N/A	N/A	1	None	.85	N/A	N/A

- 15. Heads: (a) SA-403 304L WPW (b) N/A
(Material spec. number, grade or type) (H.T. - Time & Temp.)

Location (Top, Bottom, Ends)	Thickness		Radius		Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure		Category A		
	Min.	Corr.	Crown	Knuckle					Convex	Concave	Type	Full, Spot, None	Eff.
(a) ENDS	.120"	N/A	N/A	N/A	2	N/A	N/A	N/A		X	1	None	.85

If removable, bolts used (describe other fastening) Stud SA-193 B8 Class 2, 1/2-13 UNC x 3.00" Long - Qty (8); Nut SA-194 Grade 8, 1/2-13 UNC Hex - Qty (16)
(Material, spec. number, grade, size, number)

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16. MAWP 150 psi N/A at max. temp. 375 °F N/A Min. design metal temp. -20 °F at 150 psi
(internal) (external) (internal) (external)

17. Impact test No, Impact Test Not Required Per UHA-51(d), (d)(1)(a) & (g) at test temperature of N/A
(Indicate yes or no and the component(s) impact tested)

18. Hydro., pneu., or comb. test press. Hydro. at 225 psi Proof test N/A

19. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	No.	Diam. or Size	Flange Type	Material		Nozzle Thickness		Reinforcement Material	How Attached		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
Inlet/Outlet	2	1" NPS	150# ANSI LJ	SA-312 TP304L WLD	SA-403 304L	.109"			(c)	bw	
Shell Inlet/Outlet	2	2" NPS	150# ANSI LJ	SA-312 TP304L WLD	SA-403 304L	.109"			(c)	bw	
Shell Vent/Drain	2	3/4" NPT	Coupling	SA-312 TP 304L WLD	SA-182 F304L	.113"			(c)	sw	

20. Supports: Skirt No Lugs N/A Legs 3 Others Belly Band Attached Shell, Welded
(Yes or no) (Number) (Number) (Describe) (Where and how)

21. Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report:

N/A
(List the name of part, item number, Manufacturer's name and identifying number)

22. Remarks:

Length of tubes: 143.88"
(19.) Nozzle Attachments Described Above Are Per Those Described In UW-16.1; bw = butt weld sw = socket weld
Pressure And/Or Temperature Devices Are Not By Enerquip, LLC
Inspection Openings are omitted In Fixed Tubesheet Heat Exchangers Per UG 46(a)

Shell Side Body Flange (Qty 2)
.890" Thick x 7.000" Outside Diameter 6.060" Diameter Bolt Circle;
SA-240 304L Quantity (4) .562 Holes Equally Spaced Straddling Horizontal And Vertical Centerlines.
Additional Remarks - See Attached U-4...

CERTIFICATE OF SHOP COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. U Certificate of Authorization Number 38115 Expires 12/15/2011

Date 08/26/2009 Name Enerquip, LLC Signed [Signature]
(Manufacturer) (Representative)

CERTIFICATE OF SHOP INSPECTION

I, the undersigned, holding a valid commission issued by The National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of WI and employed by HSB CT of Hartford, CT have inspected the pressure vessel described in this Manufacturer's Data Report on August 26, 2009, 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 08/26/2009 Signed [Signature] Commissions 11875A, WI100115
(Authorized Inspector) (National Board incl. endorsements, State, Province and number)

CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE

We certify that the statements made in this report are correct and that the field assembly construction of all parts of this vessel conforms with the requirements of ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. U Certificate of Authorization No. _____ Expires _____

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

CERTIFICATE OF FIELD ASSEMBLY INSPECTION

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

Date _____ Signed _____ Commissions _____
(Authorized Inspector) (National Board incl. endorsements, State, Province and number)



Enerquip, LLC
 611 North Road • PO. Box 467 • Medford • Wisconsin • 54451
 Tel: 715.748.5888 • Fax: 715.748.6484 • Website: www.enerquip.com

Heat Exchanger Specification Sheet

1	Customer Name:	Genera Energy, LLC				Proposal No.:	28220K							
2	Location:	Knoxville, TN				Your Reference:	7001-W07, W08, W09, W10							
3	Service of Unit:	Stillage Exit Cooler												
4	Item No.:													
5	Date:	6/17/09 11:00 AM												
6	Shell OD (in.)	4.500	Length (in.)	144.00	Type	BEMH	hor/vert	Hor	Connected in	1	parallel	4	series	
7	Surf/unit(eff.)	16.40	ft ²	Shells/unit	4	Surf/shell (eff.)	65.6	ft ²						
PERFORMANCE OF ONE UNIT														
8	Fluid allocation					Shell Side				Tube Side				
9	Fluid name													
10	Fluid quantity, Total					lb/h								
11	Vapor (In/Out)					lb/h								
12	Liquid					lb/h								
13	Noncondensable					lb/h								
14														
15	Temperature (In/Out)					F								
16	Dew / Bubble point					F								
17	Density (Vap / Liq)					lb/ft ³								
18	Viscosity					cp								
19	Molecular wt, Vap													
20	Molecular wt, NC													
21	Specific heat					BTU/(lb*F)								
22	Thermal conductivity					BTU/(ft*h*F)								
23	Latent heat					BTU/lb								
24	Pressure					psi								
25	Velocity					ft/s								
26	Pressure drop, allow./calc.					psi								
27	Fouling resist. (min)					ft ² *h*F/BTU								
28	Heat exchanged					BTU/h				MTD corrected	F			
29	Transfer rate, Service					Calculated				Clean	BTU/(h*ft ² *F)			
CONSTRUCTION OF ONE SHELL														
30						Shell Side				Tube Side				
31	Design/Test pressure	psig				150	Code		150	Code				
32	Design temperature	F				375			375					
33	Number passes per shell					1			1					
34	Corrosion allowance	in				0.0			0.0					
35	Connections	In				2 " NPS 150# ANSI			1 " NPS 150# ANSI					
36	Size/rating	Out				2 " NPS 150# ANSI			1 " NPS 150# ANSI					
37		in												
38	Tube No.	7	OD	0.750	Tkns - Avg	0.049 in	Length	12.0 ft	Pitch	0.93750 in				
39	Tube type	Plain Welded			Material	SS 304L			Tube pattern	30				
40	Shell	SS 304L		ID (in.)	4.260	OD (in.)	4.500	Shell cover						
41	Channel or bonnet	SS 304L		Fabricated				Channel cover						
42	Tubesheet-stationary	SS 304L						Tubesheet-floating						
43	Floating head cover							Impingement protection	None					
44	Baffle-crossing	22	SS 304	Type	Single Segmental	Cut(%d)	40 H	Spacing: c/c	6 in					
45	Baffle-long					Seal type					Inlet	in		
46	Supports-tube					U-bend	Type							
47	Bypass seal					Tube-tubesheet joint	Grooved & Expanded							
48	Expansion joint					Type								
49	RhoV2-Inlet nozzle					Bundle entrance					Bundle exit			
50	Gaskets - Shell side					Tube Side	EPDM O-Ring							
51	Floating head													
52	Code requirements	ASME Section VIII Div. 1				TEMA class	C - General Service							
53	Weight/Shell	360.73	Filled with water		443.88	Bundle	39.23	lb						
54	Remarks	Unit designed by: Jon Clark - 715-748-5888 (ext. 230) - jonclark@enerquip.com Non-Sanitary Design. No performance evaluation done for this unit. No thermal process guarantees by Enerquip. All nozzles to project 8" from unit and include insulation rings for insulation by others. Unit to be supplied with mounting supports, lifting lugs, and an electrical grounding pad. NOTE: This design incorporated four (4) units in series per customer request.												
Mean metal temperatures (NOTE: Customer provided values.)														
	Shell side	94.00 °F	Tube side	108.00 °F									1	
													2	
													3	
													4	
													5	
													6	
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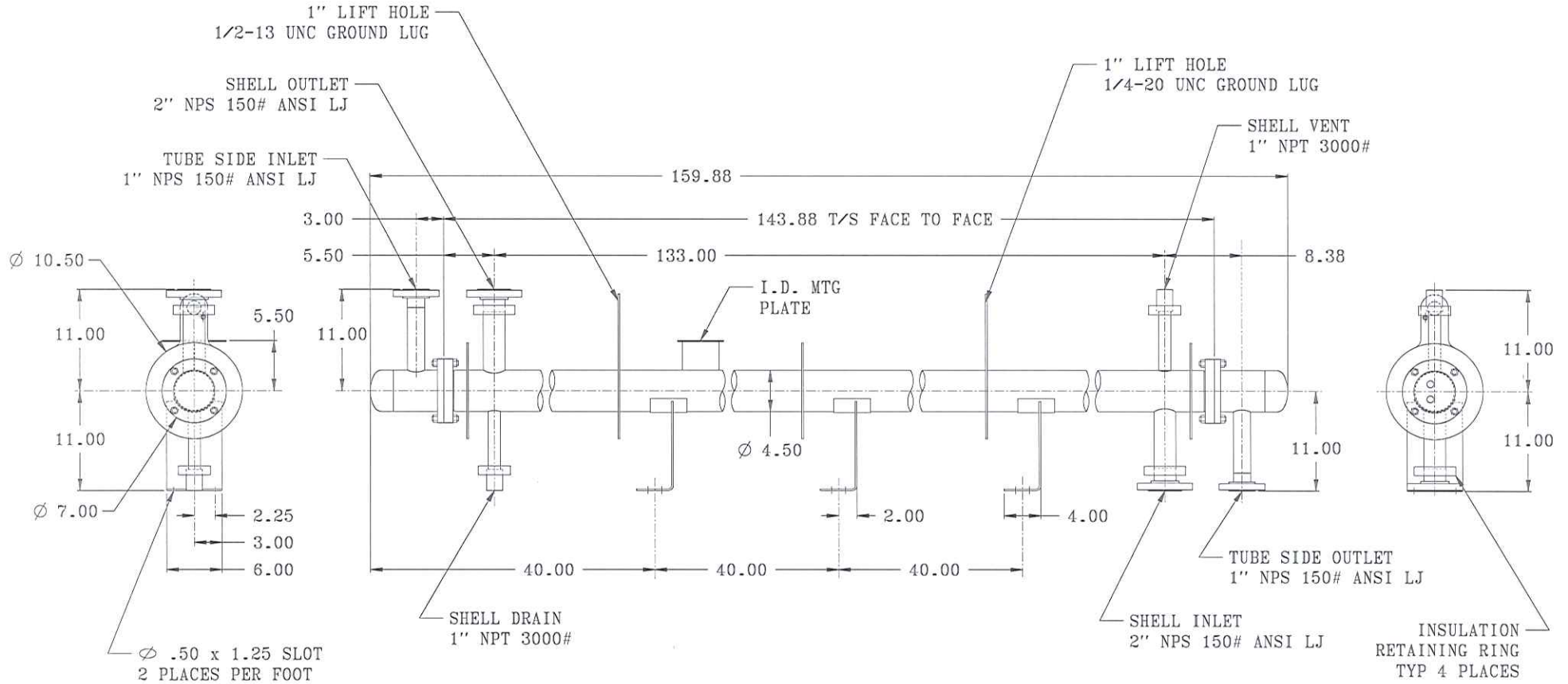
FOR ENERQUIP USE ONLY

APPROVED FOR MANUFACTURE

MWO	DATE	BY
PRODUCTION <input type="checkbox"/>	INSPECTION <input type="checkbox"/>	SHOP <input type="checkbox"/>


REVISIONS

NO	DESCRIPTION	DATE	BY	APVD
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PLANE: DUPONT DANISCO CELLULOSIC ETHANOL, LLC
 PROJECT: MARATHON
 DDCE ORDER NO.: DDCE11-0083
 EQUIPMENT NUMBER: E9000-2, E9000-3, E9000-4,
 E9000-5, E9000-6, E9000-7

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PREPARED BY	DATE	 TITLE HEAT EXCHANGER			
CHECKED	DATE				
ENGINEER	DATE				
4 NPS x 144 BEMH		SIZE A	TEMA CLASS C	DRAWING NO. 266552	REVISION
MWO 12619	18220K/L	SCALE .06 = 1		SHEET 1 OF 1	

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,

1. Manufactured and certified by Enerquip, LLC, 611 North Road, Medford, Wisconsin, 54451-0467, USA
(Name and address of Manufacturer)

2. Manufactured for DDCE, 500 Park Boulevard, Suite 545, Itasca, Illinois, 60143, USA
(Name and address of Purchaser)

3. Location of Installation Niles Ferry Industrial Park, 200 Industrial Drive, Vonore, Tennessee, 37885, USA
(Name and address)

4. Type Horizontal BEMH Heat Exchanger 11391 to 11396
(Horizontal, vertical, or sphere) (Tank, separator, heat exh., etc.) (Manufacturer's serial number)

N/A SA-3395-C 9080-9085 2009
(CRN) (drawing no.) (National Board number) (Year built)

Additional nozzles, inspection and safety valve openings:

Additional Remarks:

Tube Side Body Flange (Qty 2)
.690" Thick x 4.530" Inside Diameter x 7.000" Outside Diameter 6.060" Diameter Bolt Circle;
SA-240 304L Quantity (4) .562" Holes Equally Spaced Straddling Horizontal And Vertical Centerlines

Tube Side Nozzles Include 1" NPS 150# SA-182 F304L Lap Joint Flange

Shell Side Nozzles Include 2" NPS 150# SA-182 F304L Lap Joint Flange

Certificate of Authorization: Type "U" No. 38115 Expires 12/15/2011

Date 08/26/2009 Name Enerquip, LLC Signed [Signature]
(Manufacturer) (Representative)

Date 08/26/2009 Name [Signature] Commissions: 11875A, WI100115
(Authorized Inspector) (National Board (incl. endorsements), State, Province and number)

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Enerquip, LLC

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 Tel: 715.748.5888 • Fax: 715.748.6484 • Website: www.enerquip.com

Heat Exchanger Specification Sheet

1	Customer Name:	Genera Energy, LLC				Proposal No.:	28220L						
2	Location:	Knoxville, TN				Your Reference:	7001-W11, W12						
3	Service of Unit:	Stillage Exit Cooler											
4	Item No.:												
5	Date:	6/17/09 11:00 AM											
6	Shell OD (in.)	4.500	Length (in.)	144.00	Type	BEMH	hor/vert	Hor	Connected in	1	parallel	2	series
7	Surf/unit (eff.)	16.40	ft2	Shells/unit	4	Surf/shell (eff.)			32.8	ft2			

PERFORMANCE OF ONE UNIT

		Shell Side	Tube Side
8	Fluid allocation		
9	Fluid name		
10	Fluid quantity, Total	lb/h	
11	Vapor (In/Out)	lb/h	
12	Liquid	lb/h	
13	Noncondensable	lb/h	
14			
15	Temperature (In/Out)	F	
16	Dew / Bubble point	F	
17	Density (Vap / Liq)	lb/ft3	
18	Viscosity	cp	
19	Molecular wt, Vap		
20	Molecular wt, NC		
21	Specific heat	BTU/(lb*F)	
22	Thermal conductivity	BTU/(ft*h*F)	
23	Latent heat	BTU/lb	
24	Pressure	psi	
25	Velocity	ft/s	
26	Pressure drop, allow./calc.	psi	
27	Fouling resist. (min)	ft2*h*F/BTU	
28	Heat exchanged	BTU/h	MTD corrected F
29	Transfer rate, Service	Calculated	Clean BTU/(h*ft2*F)

CONSTRUCTION OF ONE SHELL

		Shell Side	Tube Side
31	Design/Test pressure	psig	Code
32	Design temperature	F	Code
33	Number passes per shell	1	1
34	Corrosion allowance	in	
35	Connections	In	1 " NPS 150# ANSI
36	Size/rating	Out	1 " NPS 150# ANSI
37		Intermediate	
38	Tube No.	7	OD 0.750
39	Tube type	Plain Welded	Tkns - Avg 0.049 in
40	Shell	SS 304L	Length 12.0 ft
41	Channel or bonnet	SS 304L	Pitch 0.93750 in
42	Tubesheet-stationary	SS 304L	Material SS 304L
43	Floating head cover		Shell cover
44	Baffle-crossing	22	ID (in.) 4.260
45	Baffle-long	SS 304	OD (in.) 4.500
46	Supports-tube	Type	Fabricated
47	Bypass seal		Shell cover
48	Expansion joint	Type	Channel cover
49	RhoV2-Inlet nozzle	Bundle entrance	Tubesheet-floating
50	Gaskets - Shell side	Tube Side	Impingement protection
51	Floating head		None
52	Code requirements	ASME Section VIII Div. 1	Cut(%d) 40 H
53	Weight/Shell	360.73	Spacing: c/c 6 in
54	Remarks	Unit designed by: Jon Clark - 715-748-5888 (ext. 230) - jonclark@enerquip.com	

Non-Sanitary Design.
 No performance evaluation done for this unit. No thermal process guarantees by Enerquip.
 All nozzles to project 8" from unit and include insulation rings for insulation by others.
 Unit to be supplied with mouting supports, lifting lugs, and an electrical grounding pad.
 NOTE: This design incorporated two (2) units in series per customer request.

Mean metal temperatures (NOTE: Customer provided values.)			
Shell side	49.00 °F	Tube side	64.00 °F
			1
			2
			3
			4
			5
			6

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CALCULATIONS

DDCE ORDER NO.: DDCE11-0083
EQUIP NO.: E9000-2, E9000-3, E9000-4
E9000-5, E9000-6, E9000-7 **STILLAGE EXIT COOLER**

Master Work Order #: 12619

Issued By: **J. Dumholt**

Date: **July 30, 2009**

Customer: **DDCE**

Reviewed By: *A. Olejniczak*

Final Assembly Drawing #: **SA-3395-C**

Date: *31 July 09*

The following calculations submitted are in compliance with:
 ASME Boiler and Pressure Vessel Code Section VIII, Division 1, 2007 Edition, A08

Calculations Submitted:

AT J. Dumholt
Reviewed
08/10/09

TUBING	X	OUTLET WATERBOX SHELL	X
TUBESHEET	X	OUTLET WATERBOX FLANGE	X
TUBESHEET		WATERBOX HEAD #2	X
SHELL	X	OUTLET	X
INLET NOZZLE (2" NPS)	X	DRAIN	
OUTLET NOZZLE (2" NPS)	X	LIFT RING	X
VENT (3/4" NPS)	X	NOZZLE (1" NPS)	X
DRAIN (3/4" NPS)	X	STUB END (1" NPS)	X
SHELL FLANGE		TUBESHEET TO SHELL WELD SHEET	X
SHELL FLATHEAD		NOZZLE (2" NPS)	X
WATERBOX SHELL	X	NOZZLE (3/4" NPS)	X
WATERBOX FLANGE	X	STUB END (2" NPS)	X
WATERBOX HEAD	X	SUPPORT FOOT	X
INLET (1" NPS)	X	NOZZLE FLATHEAD TO NOZZLE WELD SHEET	
DRAIN		SLIP-ON FLANGE DIMENSION SHEET	
FERRULE		SLIP-ON FLANGE TO NOZZLE PIPE WELD SHEET	
NOZZLE -		UG-22 LOADINGS SPECIFICATION SHEET	X
TOP HEAD		UG-38 FLUED OPENINGS IN SHELLS & HEADS	
BOTTOM HEAD		HYDRO-STATIC TEST PRESSURE VERIFICATION	X

UG-22 LOADINGS CHECKLIST SHEET

MWO: 12619

APPLICABLE LOADINGS PER UG-22 HAVE BEEN CONSIDERED WITH SUPPORTING CALCULATIONS ENCLOSED.

UG-22(a): INTERNAL OR EXTERNAL DESIGN PRESSURE (AS DEFINED IN UG-21.)

UG-22(b): WEIGHT OF THE VESSEL AND NORMAL CONTENTS UNDER OPERATING OR TEST CONDITIONS (THIS INCLUDES ADDITIONAL PRESSURE DUE TO STATIC HEADS OF LIQUIDS.)

UG-22(c): SUPERIMPOSED STATIC REACTIONS.

UG-22(d): THE ATTACHMENT OF:
1. INTERNALS (SEE APPENDIX D)
2. VESSEL SUPPORTS, SUCH AS LUGS, RINGS, SKIRTS, SADDLES, AND LEGS (SEE APPENDIX G)

UG-22(e): CYCLIC AND DYNAMIC REACTIONS DUE TO PRESSURE OR THERMAL VARIATIONS, MECHANICAL LOADINGS.

UG-22(f): WIND, SNOW, AND SEISMIC REACTIONS.

UG-22(g): IMPACT REACTIONS SUCH AS THOSE DUE TO FLUID SHOCK.

UG-22(h): TEMPERATURE GRADIENTS AND DIFFERENTIAL THERMAL EXPANSION.

UG-22(i): ABNORMAL PRESSURES, SUCH AS THOSE CAUSED BY DEFLAGRATION.

HYDRO-STATIC TEST PRESSURE VERIFICATION

MASTER WORK ORDER NO: 12619

BEM HEAT EXCHANGER BEUB HEAT EXCHANGER

TANK 4 NPS x 144 BEMH

FINAL ASS'Y PART NO: SA-3395-C

TUBE SIDE DESIGN PRESSURE: 150 PSI @ 375 °F

SHELL SIDE DESIGN PRESSURE: 150 PSI @ 375 °F

CALCULATION	ALLOWABLE STRESS @ 70° F	ALLOWABLE STRESS @ DESIGN TEMPERATURE	STRESS @ 70°F / STRESS @ DESN TEMP	DESIGN PRESSURE X 1.30	ALLOWABLE HYDRO-STATIC PRESSURE
TUBING	14,200	13,600	1.0441	195	203
TUBESHEET	16,700	12,000	1.3916	195	271
SHELL W/	14,200	13,600	1.0441	195	203
INLET NOZZLE (2 NPS)	14,200	13,600	1.0441	195	203
OUTLET NOZZLE (2 NPS)	14,200	13,600	1.0441	195	203
VENT/DRAIN (3/4 NPS)	14,200	13,600	1.0441	195	203
STUB END (2 NPS)	16,700	16,000	1.0437	195	203
WATERBOX SHELL	16,700	16,000	1.0437	195	203
WATERBOX FLANGE	16,700	12,000	1.3916	195	271
WATERBOX HEAD	16,700	16,000	1.0437	195	203
IN/OUT NOZZLE (1 NPS)	14,200	13,600	1.0441	195	203
STUB END (1 NPS)	16,700	16,000	1.0437	195	203

HYDROSTATIC TEST PROCEDURE:

HYDRO SHELL SIDE @ 203 PSIG
CHECK TUBE/TUBESHEET JOINTS FOR LEAKS

HYDRO TUBE SIDE @ 203 PSIG
(SHELL SIDE PRESSURE TO BE 0 PSIG)

Tubes

ASME Section VIII Division 1, 2007 Edition, A08 Addenda

Component:	Tubes
Material specification:	SA-249 TP304L Wld tube (II-D p. 82, ln. 41)
Impact test exempt per UHA-51(d)	

Internal design pressure: $P = 150$ psi @ 375 °F
 External design pressure: $P_e = 150$ psi @ 375 °F

Static liquid head:

 $P_{th} = 0.13$ psi (SG = 1, $H_s = 3.5775'$, Horizontal test head)

Corrosion allowance	Inner C = 0"	Outer C = 0"
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Design MDMT = 0 °F	No impact test performed
Rated MDMT = -320 °F	Material is not normalized
	Material is not produced to Fine Grain Practice
	PWHT is not performed

Estimated weight	New = 4.5 lb	corr = 4.5 lb
Capacity	New = 0.21 US gal	corr = 0.21 US gal

OD = 0.75"
 Length $L_c = 144'$
 t = 0.049"

Design thickness, (at 375 °F) Appendix 1-1

$$\begin{aligned} t &= P R_o / (S E + 0.40 P) + \text{Corrosion} \\ &= 150 * 0.375 / (13,600 * 1.00 + 0.40 * 150) + 0 \\ &= 0.0042" \end{aligned}$$

Maximum allowable working pressure, (at 375 °F) Appendix 1-1

$$\begin{aligned} P &= S E t / (R_o - 0.40 t) - P_s \\ &= 13,600 * 1.00 * 0.0429 / (0.375 - 0.40 * 0.0429) - 0 \\ &= 1,629.45 \text{ psi} \end{aligned}$$

Maximum allowable pressure, (at 70 °F) Appendix 1-1

$$\begin{aligned} P &= S E t / (R_o - 0.40 t) \\ &= 14,200 * 1.00 * 0.0429 / (0.375 - 0.40 * 0.0429) \\ &= 1,701.34 \text{ psi} \end{aligned}$$

External Pressure, (Corroded & at 375 °F) UG-28(c)

$$\begin{aligned} L / D_o &= 144 / 0.75 = 50.0000 \\ D_o / t &= 0.75 / 0.0164 = 45.7237 \\ \text{From table G: } A &= 0.000546 \\ \text{From table HA-3: } B &= 5,144 \text{ psi} \end{aligned}$$

$$\begin{aligned}P_a &= 4*B / (3*(D_o / t)) \\ &= 4*5143.8037 / (3*(0.75 / 0.0164)) \\ &= 150 \text{ psi}\end{aligned}$$

Design thickness for external pressure $P_a = 150$ psi

$$t_a = t + \text{Corrosion} = 0.0164 + 0 = 0.0164''$$

Maximum Allowable External Pressure, (Corroded & at 375 °F) UG-28(c)

$$L / D_o = 144 / 0.75 = 50.0000$$

$$D_o / t = 0.75 / 0.0429 = 17.4927$$

From table G: $A = 0.003828$

From table HA-3: $B = 7,211$ psi

$$\begin{aligned}P_a &= 4*B / (3*(D_o / t)) \\ &= 4*7211.4199 / (3*(0.75 / 0.0429)) \\ &= 549.67 \text{ psi}\end{aligned}$$

Tubesheet -- ASME

ASME Section VIII, Division 1, 2007 Edition, A08 Addenda

Tubesheet

Type of heat exchanger:	Fixed Both Ends
Type of construction:	Fixed\Stationary tubesheet per Fig. UHX-13.1 Configuration b: shell-side integral, tubesheet extended as a flange
Simply supported:	No
Tubesheet material specification:	SA-240 304L (II-D p. 82, ln. 39)
Tube layout:	Triangular
Tubesheet outer diameter, A:	7 in
Tubesheet thickness, h:	1.19 in ($t_{design} = 0.4226$ in)
Number of tubes, N_t :	7
Tube pitch, p:	0.9375 in
Radius to outer tube center, r_o :	0.9375 in
Total area of untubed lanes, A_L :	0 in ²
Pass partition groove depth, h_g :	0 in
Corrosion allowance shell side, c_s :	0 in
Corrosion allowance tube side, c_t :	0 in
Tubesheet poisson's ratio, ν :	0.3
Consider radial thermal expansion per UHX-13.8:	No
Gasket groove depth shell side:	0 in
Gasket groove depth tube side:	0 in

Shell

Shell material specification:	SA-312 TP304L Wld pipe (II-D p. 86, ln. 3)
Shell inner diameter, D_s :	4.26 in
Shell thickness, t_s :	0.12 in
Shell inner corrosion allowance:	0 in
Shell outer corrosion allowance:	0 in
Shell poisson's ratio, ν_s :	0.31

Channel

Channel material specification:	SA-312 TP304L Wld pipe (II-D p. 86, ln. 3)
Channel inner diameter, D_c :	4.26 in
Channel thickness, t_c :	0.12 in
Channel inner corrosion allowance:	0 in
Channel outer corrosion allowance:	0 in
Channel poisson's ratio, ν_c :	0.3

Tubes

Tube material specification:	SA-249 TP304L Wld tube (II-D p. 82, ln. 41)
Tube outer diameter, d_t :	0.75 in
Tube nominal thickness, t_t :	0.049 in
Tube minimum thickness, $t_{t,min}$:	0.0429 in
Tube tolerance:	12.5%
Tube length between outer tubesheet faces, L_t :	144 in
Tube inner corrosion allowance:	0 in
Tube outer corrosion allowance:	0 in
Tube expansion depth ratio, ρ :	0.85
Tube poisson's ratio, ν_t :	0.3

Flange

Bolt circle diameter, C: 6.06 in
 Channel side gasket load reaction diameter, G_C: 5.137 in

Tube Supports

Tube supports present: Yes
 Support all tubes: No
 Maximum distance from tubesheet to first support: 18.3075 in
 Maximum distance between tube supports: 11.25 in

Tube-To-Tubesheet Joints

Calculation method: Appendix A
 Joint type: Table A-2 Type i, Expanded, enhanced with two or more grooves

Tube-To-Tubesheet Joint Loads

Summary Tables

Tubesheet Design Thickness Summary	
Condition	t _{design} (in)
Operating	0.4225683
Tube side hydrotest	0.3672333
Shell side hydrotest	0.1714878

Bolt Load Summary		
Condition	Load Case	Design bolt load W (lb _f)
Operating	Load case 1	7,853.64
	Load case 2	6,300
	Load case 3	7,853.64
	Load case 4	6,300
	Load case 5	7,853.64
	Load case 6	6,300
	Load case 7	7,853.64
Tube side hydrotest	Load case 1	8,323.14
Shell side hydrotest	Load case 2	6,300

Pressures and Temperatures								
Condition	Shell side design pressure P _s (psi)	Tube side design pressure P _t (psi)	Tubesheet design temp T (°F)	Shell design temp T _s (°F)	Channel design temp T _c (°F)	Tube design temp T _t (°F)	Shell mean temp T _{s,m} (°F)	Tube mean temp T _{t,m} (°F)
Operating	150	150	375	375	375	375	94	108
Tube side hydrotest	0	195.33	70	70	70	70	70	70
Shell side hydrotest	203.93	0	70	70	70	70	70	70