

EXCHANGER INDUSTRIES

MECHANICAL DESIGN CALCULATION COVER SHEET

205 V2.05

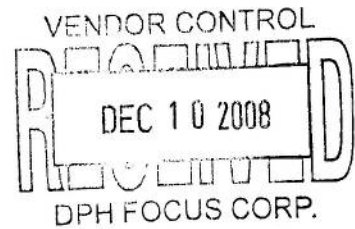
Design Code: ASME Section VIII Div 1
2007 Edition and Addenda

Date December 3, 2008

Customer DPH Focus Corp.
Owner EnCana FCCL Oil Sands Ltd.
Location Foster Creek
Customer Reference FCSR-DPH-4001C
E.I. Job No. 08-5060
Item E-5862
Prepared by AS
Description Amine Regen O/H Condenser

File 5060

Checked by BG



Design Conditions	Tube	
Pressure	50	psi
Temperature	300	°F
Vacuum	15@300	°F
MDMT	-49	°F
Corrosion	0.25	inch
Radiography	None	
PWHT	Yes	

UG-22 Checked?
Yes

DWG Changed?
N/A

Calculation Set
Revision Number 0
Description and Page Number
Initial Issue -- All Pages

Date 3-Dec-08
Approved BG

VENDOR DRAWING REVIEW

- A. Reviewed without comment. Proceed. Provide As-Built drawing.
- B. Reviewed with comments. Reissue For Construction. Proceed with fabrication.
- C. Reviewed with comments. Reissue For Review. Proceed with material order only.
- D. Reviewed with comments. Reissue For Review. DO NOT proceed with mfg. or fab.
- E.

DATE Feb 2/09 BG

Press Sort

EXCHANGER INDUSTRIES

Customer DPH Focus Corp.
 Job 08-5060
 Item E-5862

61 V2.03

Date December 3, 2008
 Dsgn AS
 Chkd *AS*
 File 5060

Page	Table of Contents	Rev	Date
1	Cover Sheet (1.1)	0	0-Jan-00
2.1	Table of Contents (2.1)	0	0-Jan-00
3	UG-22 Check list	0	0-Jan-00
4	Tube Internal Pressure	0	2-Dec-08
5	Tube External Pressure	0	2-Dec-08
6	Nozzle Internal Pressure	0	2-Dec-08
7	Nozzle External Pressure	0	2-Dec-08
8	Nozzle Neck Stress	0	3-Dec-08
9	Front Fixed Header Box Internal Pressure	0	3-Dec-08
10	Rear Floating Header Box Internal Pressure	0	3-Dec-08
11	Front Fixed Header Box External Pressure	0	3-Dec-08
12	Section Loads	0	3-Dec-08
13	Column Loads	0	7-Oct-08

EXCHANGER INDUSTRIES

206-V1.08

Page 3

ASME Section VIII Div 1 2007 Edition and Addenda Calculation Checklist

Customer DPH Focus Corp.
E.I. Job No. 08-5060
Item E-5862

Date December 3, 2008
Dsgn AS
Chkd **BY**
File (.CAL) 5060
Rev 0

		Tubeside
UG-22	Are the Primary Membrane Stress Calculations Included ?	Yes
	Are the Support Calculations Included ?	Standard
	Are the Nozzle Loadings Included ?	Yes
	Are the Attachment / Lifting Loadings Included ?	Standard
	Are the Thermal Loadings Included ?	Yes
	Are the Dynamic, Cyclic, or Shock Loadings Included ?	No
	Are the Weather and Seismic Loadings Included ?	Yes

Supplemental		
Is the Unit In Lethal Service ?		No
Is the Unit In Sour or Hydrogen Service ?		Yes
Is the Unit Generating Steam Over 50 psi ?		No

	Tubeside	Tubesheet	Flat Cover
<u>Impact Testing</u>	Required Per UCS-66	Required Per UCS-66	

		Tubeside
UG-20 f 1	Is the Material P-No 1, Gr-1 or 2 ?	Yes
	Listed on UCS-66 Curve A and below 1/2 inch thick ?	No
	Listed on UCS-66 Curve B, C or D and below 1 inch thick or less ?	Yes
	Vessel is exempt per this Paragraph	Yes

		Tubeside
UG-20 f 2	Will the Vessel be hydro tested per UG-99b, UG-99c or 27-3 ?	Yes
	Vessel is exempt per this Paragraph	Yes

		Tubeside
UG-20 f 3	Is the Design Temperature above 650°F (343°C) or Below -20°F (-29°C)	Yes
	Vessel is exempt per this Paragraph	No

		Tubeside
UG-20 f 4	Are Thermal or Mechanical Shock Loads Controlling ?	No
	Vessel is exempt per this Paragraph	Yes

		Tubeside
UG-20 f 5	Are Cyclic Loads Controlling ?	No
	Vessel is exempt per this Paragraph	Yes

		Tubesheet
Tubesheet / Flat Cover Listed on UCS-66 Curve A and below 2 inch thick ?		
Tubesheet / Flat Cover Listed on UCS-66 Curve B, C or D and 4 inch thick or less ?		Yes

EXCHANGER INDUSTRIES

66-V3.04

Page 4

Thickness of shells of revolution (internal pressure)
Per ASME Section VIII Div 1, 2001, UG-27, UG-32, App 1

For DPH Focus Corp.
Job 08-5060
Item E-5862

Date December 2, 2008
Dsgn AS
Chkd BU
File (.CYL) 5862
Rev 0

Design Pressure 50 psi
Design Temperature 300 °F
Corrosion 0 inch

Description	Tube	Material SA-179		$T = \left(\frac{P R}{S E + F P} \right) + C_a$
Shell Type	Tube	Stress Hot	13,400 psi	
Finished Thickness	0.083 inch	Stress Cold	13,400 psi	
Diameter	1.25 inch OD	Efficiency E	1	MAWP New & Cold 1,879.3 psi
		Type factor F	0.4	MAWP Corr & Hot 1,879.3 psi
				Required Thickness 0.002 inch

EXCHANGER INDUSTRIES

Thickness of Shells, Tubes and Heads Under External Pressure
Per ASME Section VIII Div 1, 2001, UG-28 & UG-33

92-V3.03

For DPH Focus Corp.
Job 08-5060
Item E-5862

Date December 2, 2008
Dsgn AS
Chkd BA
File (.CYL) 5862
Rev 0

Shell Type Tube
Corrosion Allowance 0 inch
Wall Thickness 0.083 inch
Unreinforced Length 384 inch
Outside Diameter 1.25 inch
Material SA-179
External Pressure Chart CS-1
Allowable Stress 13,400 psi

t 0.0830 inch
Do/t 15.06
L/Do 50.0000
External Pressure 15 psi
Design Temperature 300 °F

	Do/t = 15		Do/t = 20		Do/t = 15.06	
	L/Do	A	L/Do	A	L/Do	A
Data from	50	0.00490	50	0.00275		
ASME Tables	50	0.00490	50	0.00275		
Interpolation	50	0.00490	50	0.00275	50	0.00487

A 0.00487

	CS-1 @ 300°F		CS-1 @ 500°F		CS-1 @ 300 °F	
	Factor A	Factor B (psi)	Factor A	Factor B (psi)	Factor A	Factor B (psi)
Data from	0.00200	12,300	0.00250	9,950		
ASME Tables	0.00950	13,800	0.01950	13,100		
Interpolation	0.00487	12,874.8	0.00487	10,389.9	0.00487	12,874.8

B 12,875 psi

$$P_a = \left(\frac{4B}{3 \left(\frac{D_o}{t} \right)} \right)$$

Pa (Max External Pressure) 1,139.9 psi

tr req'd thck. @ 15.0 psi = 0.0110" (Exclusive of corrosion)

EXCHANGER INDUSTRIES

66-V3.04

Page 6

Thickness of shells of revolution (internal pressure)
Per ASME Section VIII Div 1, 2007, UG-27, UG-32, App 1

For DPH Focus Corp.
Job 08-5060
Item E-5862

Date December 2, 2008
Dsgn AS
Chkd *BS*
File (.CYL) 5862
Rev 0

Design Pressure 50 psi
Design Temperature 300 °F
Corrosion 0.25 inch

Description	Inlet & Outlet Nozzles	Material SA-333-6		$T = \left(\frac{P R}{A (SE + FP)} \right) + \left(\frac{C_a}{A} \right)$
Shell Type	Pipe	Stress Hot	17,100 psi	
Finished Thickness	0.718 inch	Stress Cold	17,100 psi	
Diameter	8.625 inch OD (8"NPS)	Efficiency E	1	MAWP New & Cold 2,645.2 psi
		Type factor F	0.4	MAWP Corr & Hot 1,554.3 psi
		Factor A [Mill Tolerance]	0.875	Required Thickness 0.300 inch

UG 45 8" SCH STD 0.322" + 0.25" = 0.572" < 0.718"
o/c

EXCHANGER INDUSTRIES

Thickness of Shells, Tubes and Heads Under External Pressure
Per ASME Section VIII Div 1, 2007, UG-28 & UG-33

92-V3.03

For DPH Focus Corp.
Job 08-5060
Item E-5862

Date December 2, 2008
Dsgn AS
Chkd *AS*
File (.CYL) 5862
Rev 0

Shell Type Pipe
Corrosion Allowance 0.25 inch Material SA-333-6
Wall Thickness 0.718 inch
Unreinforced Length 10 inch External Pressure Chart CS-2
Outside Diameter 8.625 inch (8"NPS) Allowable Stress 17,100 psi

t 0.3783 inch External Pressure 15 psi
Do/t 22.80 Design Temperature 300 °F
L/Do 1.1594

	Do/t = 20		Do/t = 25		Do/t = 22.80	
	L/Do	A	L/Do	A	L/Do	A
Data from	1	0.01560	1	0.01110		
ASME Tables	1.2	0.01270	1.2	0.00902		
Interpolation	1.15942029	0.01329	1.15942029	0.00944	1.15942029	0.01113

A 0.01113

	CS-2 @ 300°F		CS-2 @ 500°F		CS-2 @ 300 °F	
	Factor A	Factor B (psi)	Factor A	Factor B (psi)	Factor A	Factor B (psi)
Data from	0.00500	17,200	0.01000	14,600		
ASME Tables	0.02500	17,600	0.01500	15,500		
Interpolation	0.01113	17,322.7	0.01113	14,803.9	0.01113	17,322.7

B 17,323 psi

Pa (Max External Pressure) 1,012.9 psi

$$P_a = \left(\frac{4B}{3 \left(\frac{D_o}{t} \right)} \right)$$

tr req'd thck. @ 15.0 psi = 0.0288" (Exclusive of corrosion)

Nozzle reinforcement not required per UG-37(d)1.

EXCHANGER INDUSTRIES

Nozzle Neck Stresses Due to External Loads
 Local Stresses in Pressure Vessels 2nd Ed
 Fred Foreman, P.V. Handbook

65-V3.03a

For DPH Focus Corp.
 Job 08-5060
 Item E-5862

Date December 3, 2008
 Design AS
 Chkd [Signature]
 File (.MAC) 5862
 Rev 0

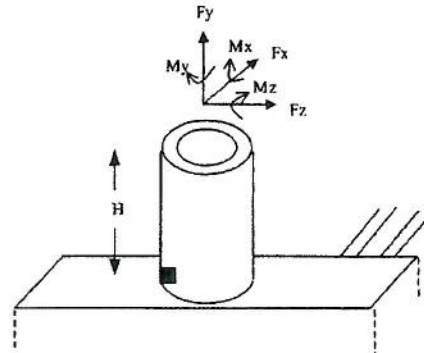
Design Temperature 300 °F
 Design Pressure 50 psi
 Corrosion Allowance 0.25 in

Nozzle OD 8.625 in
 Nozzle Wall T 0.718 in
 Nozzle Stand-Out H 10 in
 Wrapper T 0.625 in

Nozzle Identifier Inlet & Outlet Nozzles
 Neck Material SA-333-6
 Allowable Stress Sa 17,100 psi
 Wrapper Material SA-516-70N
 Allowable Stress Sa 20,000 psi

3 times API nozzle Load

Vertical Load (Fy) 9,000 Lb
 Cross Load (Fx) 3,840 Lb
 Cross Load (Fz) 5,400 Lb
 Torsion (My) 13,500 ft-Lb
 Bending (Mz) 4,950 ft-Lb
 Bending (Mx) 6,750 ft-Lb



$$ID = (OD - 2xT) = 7.689 \text{ in}$$

$$A = \left(\frac{\pi}{4}\right) (OD^2 - ID^2) = 11.99 \text{ in}^2$$

$$Z = \left(\frac{\pi}{32}\right) \left(\frac{OD^4 - ID^4}{OD}\right) = 23.21 \text{ in}^3$$

$$M_r = \sqrt{\left(M_x + \left(\frac{F_x H}{12}\right)\right)^2 + \left(M_z + \left(\frac{F_z H}{12}\right)\right)^2} = 13,892 \text{ ft-Lb}$$

$$\text{Shear Stress } S_v = V_m \times My + \sqrt{(F_x^2 + F_y^2)} / A$$

$$S_p = \frac{P \times ID}{2 \times T} = 411 \text{ psi}$$

Page 62 $V_m = 0.164$

$$\text{Shear Stress } S_v = 2771 \text{ psi}$$

$$S_m = \left(\frac{F_y}{A}\right) + \left(\frac{12 \times M_r}{Z}\right) + (S_p) + (S_v) = 11,116 \text{ psi}$$

S_m or $(S_m + S_v)$ May not exceed 1.5 x Lesser Allowable
 S_p May not exceed Lesser Allowable
 S_v May not exceed 70% of Lesser Allowable

Header Box With Two Compartments
 Per ASME VIII Div 1 App. 13-9(a) 2007 Edition, A07, Fig. 13-2(a) Sketch 7
 End plate Per App. 13-4(f), Fig. 13-2(a) Sketch 1

Date December 3, 2008
 Dsgn AS
 Chkd BA
 File 5060
 Rev 0

For DPH Focus Corp
 Job 08-5060
 Item E-5862
 Comment Front Fixed Header Box

Pressure P 50 psi
 Temperature T 300 °F

t1 = 0.625 in Wrapper
 t2 = 1 in Tubesheet
 t3 = 0.875 in Stay Plate
 t4 = 0.625 in End Plate

Material SA-516-70N
 Stress Hot Sh 20000 psi
 Stress Cold Sc 20000 psi
 Corrosion C 0.25 in

t4 = .446 min, C = .2, Z = 1.07

Box Height 18.625 in
 Width 10 in

I1 = 0.0044 in⁴ K= 7.7714
 I2 = 0.0352 in⁴ α = 0.9714

Tubesheet Span 8.25 in (h=8.7500)
 Wrapper Span 8 in (H=8.5000)

Membrane Stress:

Sm w 576 psi
 Sm t 486 psi
 Sm s 1182 psi

Tube Dia. Td 1.25 in
 Tube Pitch Tp 3 in
 Ligament Efficiency 0.5833 UG-53

Bending Stress:

(Sb)N w 6376 psi
 (Sb)Q w 12891 psi
 (Sb)M t 5988 psi
 (Sb)Q t 3223 psi

Stay Perforations No

Total Stress:

(ST)N w 6951 psi
 (ST)Q w 13466 psi
 (ST)M t 6473 psi
 (ST)Q t 3708 psi

Maximum Allowable Pressure:

Corroded & Hot = 111 psi
 New & Cold = 337 psi

Stresses may not exceed:

Total ST 30000 psi
 Bending Sb 30000 psi
 Membrane Sm 20000 psi

Single Chamber Header Box per ASME VIII Div. I App. 13-7(a) 2007 Edition, A07
End plate Per App. 13-4(f), Fig. 13-2(a) Sketch 1

Date December 3, 2008

For DPH Focus Corp
Job 08-5060
Item E-5862
Comment Rear Floating Header Box

Dsgn AS
Chkd BK
File 5060
Rev 0

Pressure P 50 psi
Temperature T 300 °F

t1 = 0.625 in Wrapper
t2 = 1 in Tubesheet
te = 0.625 in End Plates

Material SA-516-70N
Stress Hot Sh 20000 psi
Stress Cold Sc 20000 psi
Corrosion C 0.25 in

te = 0.404 in min, C = .2, Z = 2.33

Box Height 10.875 in (h = 10.125)
Width 6 in (H = 4.5)
Box Length 91.875 in

I1 = 0.0044 in⁴ K= 3.5556
I2 = 0.0352 in⁴ α= 0.4444

Tubesheet Span 9.625 in
Wrapper Span 4 in

Membrane stress:

Sm w 675 psi
Sm t 257 psi

Tube Dia. Td 1.25 in
Tube Pitch Tp 3 in
Ligament Efficiency 0.5833 UG-53

Bending Stress:

(Sb)M w 1410 psi
(Sb)Q w 6810 psi
(Sb)M t 8797 psi
(Sb)Q t 1703 psi

Stresses may not exceed:

Total ST 30000 psi
Bending Sb 30000 psi
Membrane Sm 20000 psi

Combined Stresses:

(ST)M w 2085 psi
(ST)Q w 7485 psi
(ST)M t 9054 psi
(ST)Q t 1960 psi

Maximum Allowable Pressure:

Corroded & Hot = 165 psi
New & Cold = 354 psi

External Pressure for Single Chamber Header Box
Per ASME VIII Div. I App. 13-14 2007 Edition, A07

Date December 3, 2008

Dsgn AS

Chkd *Bl*

File 5060

Rev 0

For DPH Focus Corp
Job 08-5060
Item E-5862
Comment Front Fixed Header Box

External Pressure 15 psi
Temperature 300 °F

Material SA-516-70N
Allowable Stress 20,000 psi
Yield Stress Sy 33600 psi
Modulus E 28 E6 psi
Corrosion 0.25 in

Tubesheet Span 17.375 in
Wrapper Span 8 in

Tube Diameter 1.25 in
Tube Pitch 3 in
Ligament Efficiency 0.5833 UG-53

Fig. 13-2(a) Sketch 1

t1 = 0.625 in Wrapper
t2 = 1 in Tubesheet
te = 0.625 in End Plate

Lv = 91.875 in Vessel Length
v = 0.3 Poisson Ratio

h = 17.8750 in Box Height
H = 8.5000 in Box Width

KA = 5.9375 Long / Short sides - Use 5.5 per Fi
KB = 11.25 Short/Long sides

Short Side Plates :

Sma = 103.52
Smb = 357.50

ScrA = 32635
ScrB = 4743

$\frac{2 \cdot Sma}{ScrA} + \frac{2 \cdot Smb}{ScrB} \leq 1.0$

0.1571 <= 1 SIDE PLATES ADEQUATE

Long Side Plates :

Sma = 103.52
Smb = 145.71

ScrA = 30464
ScrB = 6456

$\frac{2 \cdot Sma}{ScrA} + \frac{2 \cdot Smb}{ScrB} \leq 1.0$

0.0519 <= 1 SIDE PLATES ADEQUATE

End Plates :

Sma = 135.01
Smb = 299.27

ScrA = 32635
ScrB = 31348

$\frac{2 \cdot Sma}{ScrA} + \frac{2 \cdot Smb}{ScrB} \leq 1.0$

0.0274 <= 1 END PLATES ADEQUATE

Column Stability (tubesheet & plugsheet must be the same thickness i.e. y)

Sa = 117.40 Sb = 109.59
Fa = 17766 Fe = 79313

$\frac{Sa}{Fa} + \frac{Sb}{(1-Sa/Fe)S} \leq 1.0$

0.0121 < 1 HEADER IS STABLE

Note: this calculation covers Rear Floating Header Box external pressure calculation.

EXCHANGER INDUSTRIES

Aircooler Nozzle / Section Loads
 API Standard 661 6th Edition Feb 2006

252-V2.05

For DPH Focus Corp.
 Job 08-5060
 Item E-5862
 Front Fixed Header Box

Date December 3, 2008
 Design AS
 Chkd *DL*
 File (.MAC) 5862
 Rev 0

	1	2	3	4	5	6
<u>Nozzle Name:</u>						
Vertical Load Lb (Positive Upward) (Fy)	13,500					
Horizontal Load (Positive Along Tubes) (Fx)	6,750					
Load along header (Positive Right) (Fz)	11,250					
Nozzle Twist ft-Lb (My)	18,000					
Section Twist ft-Lb (Mx)	13,500					
Header Twist ft-Lb (Mz)	9,000					
Nozzle Elevation From Centerline (+Up) (in)						
Nozzle Offset (Positive to the Right) (in)						
Nominal Nozzle Size						

Maximum times API Figure 6 Load Moment

Total Header Combined Load	Fx = 6,750.0 Lb	Mx = 13,500.0 ft-Lb
Load Fraction Per API-661 7.1.10.2	Fy = 13,500.0 Lb	My = 18,000.0 ft-Lb
(API Orientation, Figure 6)	Fz = 11,250.0 Lb	Mz = 9,000.0 ft-Lb

Header Type	Fixed	No Slide Pads
Distance Between Header Clips (C-C)	91 in	50 Design pressure (psi)
Longest distance Between Clip and Column	95.75 in	2 Number of Fans
Tube Diameter	1.25 in	1,500 Header Weight (Lb)
Wall Thickness	0.083 in	15,773 Section Weight (Lb)
Tube Cross Sectional Metal Area	0.3043 in ²	118 Total Number of Tubes
Moment of Inertia per Tube	0.0521 in ⁴	18.625 Height of Tubesheet (in)
		10 Header Depth - back to front (in)
		A-A Type Clip
		15.375 Vertical Distance C-C between Clips

Compression Load on Local Corner Column	4,146 Lb
Compression Load on Middle Column	4,732 Lb each side
Minimum Longitudinal Sliding Load (Fx)	909 Lb
Minimum Lateral Sliding Load (Fz)	-2,245 Lb

Check Panel Rail Strength (vert load is 4732 lb)
 Section Slides on Panel in x direction.
 Section Slides on Panel in z direction.

NOTE:

Ensure bolts are tightened properly

EXCHANGER INDUSTRIES

Air Cooler Column Loads: Snow, Wind & Earthquake
per National Building Code of Canada 2005

83-V5.04

For DPH Focus Inc. Encana FCCL Oil Sands Ltd.
Job 08-5060
Item E-5862

Date October 7, 2008
Design WZ
Chkd *BL*
File 5060
Rev 0

Hydro Weight	66,072 lb/Bay
Walkway Load	4,040 lb/Bay
Piping Load	12,000 lb/Column *
Wind Load q	0.40 kPa
Exposure Ce	0.91
Gust Factor Cg* Cp	0.83 Windward -0.62 Leeward -1.00 Top
Snow Load Ss	1.70 kPa
Sr	0.10 kPa
Net Snow Load Sn	30.48 Lb/sqft
Seismic Load Factors	Sa(0.2) 0.120
Cold Lake, AB	Sa(0.5) 0.056
Per National Building Code	Sa(1.0) 0.023
of Canada 2005	Sa(2.0) 0.006
	PGA 0.059

Bay Width	16.7 ft
Unit Length	31.5 ft
Structure Height	20.6 ft
At Grade	
Sheltered Sides	0
Columns Wide	2
Columns Long	3
Snow Factors Ca	1.00
Cw	1.00
Cs	1.00
Cb	0.80
Ca*Cw*Cs*Cb	0.80

Mode Factor Mv = 1
Importance I = 1
Sa(0.2) = .12
No further analysis required per NBC 4.1.8.1.1

Site class E - Soft Soil
Acceleration Coefficient Fa = 2.1
Velocity Coefficient Fv = 2.1
Period T 0.34 sec

Rd = 3.0 Ro = 1.3
Moderately Ductile Braced Steel Frame
Concentrically braced in tension

Corner Columns	8,259 lb Dead 14,020 lb Live 2,005 lb Snow 500 lb Lift
Wind Vertical	414 lb Over T.
Horizontal	633 lb

Side Columns	16,518 lb Dead 4,009 lb Snow 1,001 lb Lift
Wind Vertical	761 lb Over T.
Horizontal	1,234 lb

Vertical Max	24,697 lb
Min	7,345 lb

Vertical Max	21,289 lb
Min	14,756 lb

* Maximum. Will be included on all front and rear columns.