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Advanced Heat Transfer Topics

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Outline

- Selection of Heat Exchanger Technology
- Estimating Heat Exchanger Sizing
- Evaluating Heat Exchangers

Types of Heat Exchangers

- Shell & Tube
- Double Pipe / Multi-Tube Hairpin
- Plate & Frame
- Spiral
- Direct Steam Injection
- Air Coolers / Coils
- Waste Heat Recovery Units
- Wet Surface Air Coolers
- Electric Heaters
- Fired Heaters
- Tank / Reactor Coolers and Heaters

Heat Exchanger Type Selection

- Factors which influence Decision
  - Temperature Cross
  - Approach Temperature
  - Design Pressure / Temperature
  - Cleanability
  - Size
  - Utility Availability

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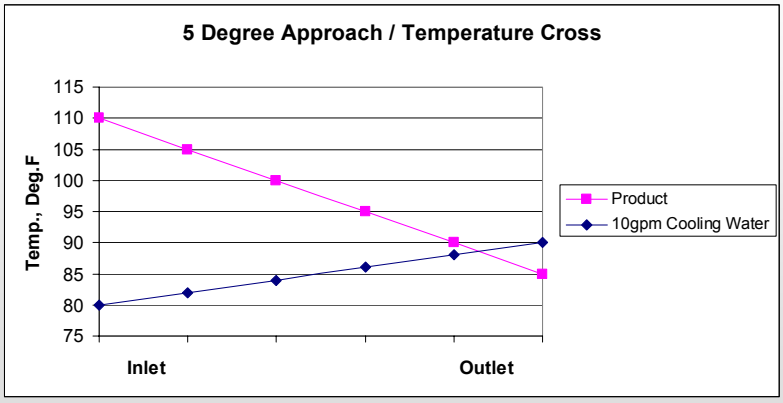
Temperature Cross / Approach



Temperature Cross / Approach

Exchanger Type	Cross?	Approach?
Shell & Tube	Single Pass or Multiple Units	5-10˚F
Hairpin	Yes	5-10˚F
Plate & Frame	Yes	3-10˚F
Spiral	Yes	5-10˚F

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Design Temperature / Pressure

Exchanger Type	Temperature	Pressure
Shell & Tube	1,200˚F	5-10,000 psi
Hairpin	1,200˚F	5-10,000 psi
Plate & Frame	250-350˚F	250 psi
Spiral	400˚F	400 psi

Cleanability

Exchanger Type	Cleanable?
Shell & Tube	Tubeside: Straight Tubes Shellside: Removable Bundles
Hairpin	Tubeside: Rod-Through Tubes Shellside: Removable Bundles
Plate & Frame	Gasketed Units Only
Spiral	With Removable Covers

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Size

Exchanger Type	Size
Shell & Tube	Large
Hairpin	Large
Plate & Frame	Small
Spiral	Medium

Utility Availability

- Heating / Cooling Media Available?
  - Use One Of The Exchangers Shown Above
- Heating / Cooling Media NOT Available?
  - Cooling
    - Air Cooler, WSAC
    - Cooling Tower or Chiller with Exchanger
  - Heating
    - Fired Heater, Waste Heat Recovery, or Electric Heater

Single Fluid Exchangers Temperature Approach

Exchanger Type	Approach / Max Temp?
Air Cooler	20˚F to Dry Bulb
WSAC	10˚F to Wet Bulb
Electric Heat	1,200˚F Max Temp
Fired Heat	1,600˚F Max Temp
Waste Heat	

Single Fluid Exchangers Cleanability

Exchanger Type	Cleanable?
Air Cooler	Yes, with straight tubes
WSAC	Yes, with straight tubes
Electric Heat	Depends on Element Layout
Fired Heat	By pigging in some units
Waste Heat	No

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Single Fluid Exchangers Size

Exchanger Type	Size
Air Cooler	Very Large
WSAC	Very Large
Electric Heat	Small
Fired Heat	Very Large
Waste Heat	Medium

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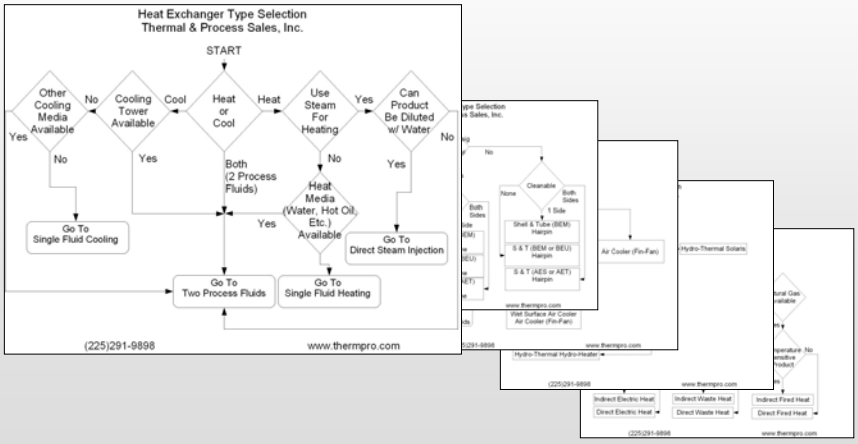
Heat Exchanger Type Selection Tool



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Steps for Estimating the Size of a Heat Exchanger:

- Determine Heat Duty
- Determine Type of Exchanger
- Estimate Heat Transfer Coefficient
- Calculate LMTD
- Calculate Surface Area Required
- Determine Approximate Size of Exchanger

Determine Heat Duty

- $Q = \dot{m} c_p \Delta T$ (No phase change)
  - Q is the heat transferred (BTU/lb)
  - $\dot{m}$ is the mass flowrate (lb/hr)
  - c_p is the specific heat (BTU/lb°F)
  - ΔT is the temperature change (°F)
- $Q = \dot{m} h_{fg}$ (phase change only)
  - Q is the heat transferred (BTU/lb)
  - h_{fg} is the latent heat (BTU/lb)

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Heat & Mass Balance

- One of the most common errors on information submitted for us to design is incorrect heat balance.
- Heat transferred from the hot body must equal that transferred to the cold body!

$$\dot{m}_{hot} c_{p_{hot}} \Delta T_{hot} + \dot{m}_{hot} h_{fg_{hot}} = \dot{m}_{cold} c_{p_{cold}} \Delta T_{cold} + \dot{m}_{cold} h_{fg_{cold}}$$

Determine Type of Exchanger to Use

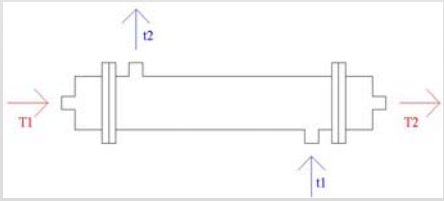
- Recall from earlier in this presentation
- Assume Shell & Tube
- No Extended Surface
- No Internal Enhancements

Heat Transfer in Exchangers

- $Q = UA\Delta T_{LM}$
  - Q is the heat transferred (BTU/hr)
  - U is the Heat Transfer Coefficient (BTU/hr ft °F)
  - A is the surface area (ft^2)
  - ΔT_{LM} is the log mean temperature difference (°F)

Log Mean Temperature Difference

- Duty weighted average temperature difference in the heat exchanger.
- This is the thermal determination of how well heat will transfer between two bodies.



$$LMTD = \frac{\Delta t_2 - \Delta t_1}{\ln\left(\Delta t_2 / \Delta t_1\right)}$$

$$\Delta t_1 = T_1 - t_2$$

$$\Delta t_2 = T_2 - t_1$$

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Corrected LMTD

- LMTD calculation assumes counter-current flow profile in the heat exchanger.
- Other (non counter-current) configurations have specific LMTD correction factors (F), which are published in TEMA and GPH.
- $Corrected\ LMTD = MTD = LMTD \times F$

Overall Heat Transfer Coefficient, U

- This is a mechanical determination of how well heat will transfer between two bodies.

$$\frac{1}{U} = \frac{1}{h_i\left(D_i/D_o\right)} + \frac{1}{h_o} + \frac{2.3D_o}{2k}\log\left(D_o/D_i\right) + fouling \approx \frac{1}{h_i} + \frac{1}{h_o} + fouling$$

- h is the coefficient of heat transfer
- k is the thermal conductivity of the tubes
- $D_{i/o}$ is the tube ID / OD

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Fouling

- Factor which increases the required surface area to account for dirt, salt, scale and other contaminant buildup on the heat transfer surface area.
- Can have a significant effect on surface area:
  - Original U (without fouling)=150, U (with 0.005 fouling)=85. This case requires a unit which is 76% over-surfaced based on clean unit.

Select Heat Transfer Coefficient

Approximate Overall Heat Transfer Coefficient U (Btu/hr-Ft^2-deg. F)

Hot Fluid	Cold Fluid	Overall U - S&T	Overall U Plate	Hot Fluid	Cold Fluid	Overall U - S&T	Overall U Plate
Water	Water	100-200	1200	Naptha	Water	30-60	
Light H.C.	Water	50-100	200	Steam	#2 Fuel Oil	40-70	100
Medium H.C.	Water	30-70	140	Steam	Butane (L)	50-150	
Heavy H.C.	Water	5-60	80	Steam	Crude	10-25	50
Nat. Gas	Water	5-35		Steam	Sulfur Slurry	50-100	
Methanol	Water	100-200		Steam	Methanol	100-400	
Ammonia	Water	100-200	500	Steam	Ammonia	100-400	
Hydrogen	Water	10-60		Steam	Light Organic	100-200	300
Oxygen	Water	10-60		Steam	Aqueous Soln.		
Air	Water	10-60			Less than 2 Cp	100-400	900
Glycol	Water	30-150	1100		More than 2 Cp	75-250	500
Toluene	Water	20-70		Steam	Medium Organic	50-100	
Sulfuric Acid	Water	20-55	1000	Steam	Gas	5-40	
Nitrogen	Water	10-60		Glycol	H.C. Vapor	5-15	80
Diesel Fuel	Water	50-110	800	Glycol	Glycol	6-40	400
Sour Nat. Gas	Water	25-60		Benzene	Benzene	50-100	
Lube Oil	Water	10-25	600	Toluene	Benzene	20-100	
Carbon Dioxide	Water	15-40		Brine	Gas	20-75	
Terpenes	Water	10-25		Diesel	Crude	20-60	100
Geraniol	Water	10-25		Oil	Fuel Gas	20-60	100
Steam	#6 Fuel Oil	5-25	100	H.C. Vapor	Crude	5-20	
Steam	Light H.C.	15-50	100	Ethanol	Butane	50-100	
Steam	Gas	50-120		Sour Nat. Gas	Sour Nat. Gas	25-100	
Steam	Nitrogen	50-120		Amine	Amine	20-60	500
Steam	50% Caustic	7-20	90	15% DEA	Crude	5-15	80
Fuel Oil	Water	10-20	120	Butane	Butane	30-60	
Fuel Oil	Oil	6-15	80	Aqueous Soln.	Aqueous Soln.	200-450	1100
Gasoline	Water	30-75	200	Heavy Organic	Heavy Organic	10-35	100
Asphalt	Water	10-20		Light Organic	Light Organic	30-65	100
Kerosene	Water	15-40	100	Slurry	Slurry	5-30	80

Estimated Values are based on 4 ft/sec shellside and 6 ft/sec tubeside velocity
Light H.C. refers to fluids with 0.5 Cp viscosity or lower
Medium H.C. refers to fluids with 0.5 to 1.0 Cp viscosity
Heavy H.C. refers to fluids with above 1.0 Cp viscosity

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Solve for Area Required

- Add additional area as required
  - Fouling
  - Process Variations
  - “Safety” Factor

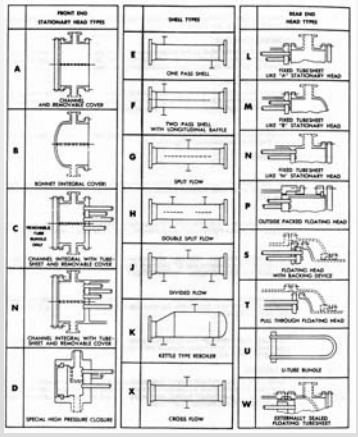
Heat Exchanger Surface Area

- Generally, the heat exchanger surface area is calculated based on the outside diameter of the tubes.

$$A = \frac{OD}{12} * \pi * L * n$$

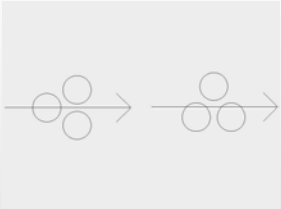
- A is measured in ft^2
- OD is measured in inches
- L is measured in ft
- n is the number of tubes

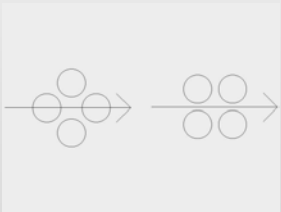
Shell & Tube Configurations



- Design Options
  - Straight Tube
  - U-Tube
  - Removable Bundle
  - Floating Tubesheet
- Code Options
  - ASME Section VIII
  - TEMA B, C, or R

Shell & Tube Configurations





- Tube Layout
  - Triangular
    - More tubes
    - Not cleanable on shellside
  - Square
    - Less tubes
    - Cleanable on shellside

Given Area, Estimate Size:

Shell & Tube Surface Area, Sq. Ft.						
		Lengths (ft.)				
Size (in.)	# Tubes	6	10	16	20	24
8	34	40	67	107	134	160
10	64	75	126	201	251	302
12	102	120	200	320	401	481
14	126	148	247	396	495	594
16	178	210	350	559	699	839
18	236	278	463	741	927	1112
20	306	360	601	961	1202	1442
24	486	573	954	1527	1909	2290
30	794	935	1559	2494	3118	3742
36	1172	1381	2301	3682	4602	5523
48	2144	2526	4210	6736	8419	10103
Tube OD = 3/4"						
Assumes Triangular Pitch - 15/16"						
Assumes 4 Pass						

Plate & Frame?

- Same Process
- Use Higher U value
- Must use common plate sizes
- On-Line sizing programs
  - www.phewizard.com

Plate & Frame Surface Areas

Model Type	Surface Area For Units With Specified Number of Plates (ft²)					
	50 Plates	100 Plates	150 Plates	200 Plates	250 Plates	300 Plates
APV - SR1	46	92				
APV - SR2	94	187	281	374	468	561
APV - N35	188	375				
APV - Q030	156	312	468	624	780	936
APV - R5*	280	560	840	1,120	1,400	1,680
APV - Q055	296	592	888	1,184	1,480	1,776
APV - Q080	442	883	1,325	1,766	2,208	2,649
APV - J060	282	564	846	1,128	1,410	1,692
APV - J092	450	900	1,350	1,800	2,250	2,700
APV - J107	534	1,067	1,601	2,134	2,668	3,201
APV - J185	996	1,991	2,987	3,982	4,978	5,973
APV - B063	339	678	1,017	1,356	1,695	2,034
APV - B110	592	1,184	1,776	2,368	2,960	3,552
APV - B134	721	1,442	2,163	2,884	3,605	4,326
APV - B158	850	1,700	2,550	3,400	4,250	5,100
APV - B205	1,103	2,206	3,309	4,412	5,515	6,618
APV - P190	1,025	2,050	3,075	4,100	5,125	6,150
APV - SR23PD	1,365	2,730	4,095	5,460	6,825	8,190

Plate & Frame Sizes

Model Type	Connection Dia. (in.)	Maximum US GPM	Active Area Per Plate ft²	Width	Height	Standard Frame Length (Inches)**	Maximum Plate Capacity***
APV - SR1	1.5	125	0.92	10-5/16"	26-3/4"	33-7/8"	128
APV - SR2	2	200	1.87	13-7/8"	41-7/16"	51-1/2"	335
APV - N35	3	460	3.75	18-1/16"	53-3/16"	24-5/16"	139
APV - Q030	4	800	3.12	24-3/8"	49-5/16"	112-3/8"	319
APV - R5	4	800	5.6	21-7/8"	73-3/8"	234-3/8"	700
APV - Q055	4	800	5.92	24-3/8"	68-1/2"	112-3/8"	442
APV - Q080	4	800	8.83	24-3/8"	90-1/2"	112-3/8"	440
APV - J060	8	3100	5.64	34-7/8"	61-7/8"	150-11/16"	692
APV - J092	8	3100	9	34-7/8"	76-11/16"	150-11/16"	692
APV - J185	8	3100	19.91	35-1/16"	121-7/8"	150-11/16"	692
APV - B063	12	7000	6.78	38-15/16"	80-13/16"	168-1/8"	899
APV - B110	12	7000	11.84	38-15/16"	99-3/4"	167-1/8"	903
APV - B134	12	7000	14.42	38-15/16"	109-3/16"	165-15/16"	896
APV - B158	12	7000	17	38-15/16"	118-5/8"	164-3/4"	890
APV - B205	12	7000	22.06	38-15/16"	137-1/2"	163-3/4"	885
APV - P190	14	9600	20.5			179"	541
APV - SR23PD	16	11000	27.3			244"	730

** 150# ASME Frame Design as Basis
*** Based on Standard Plate Thickness

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Example: Amine Cross Exchanger

- Given:
  - Amine Flow rate 21,000 lb/hr
  - Lean Amine in at 250°F out at 160°F
  - Rich Amine in at 86 °F
  - Lean Amine Cp = 0.93 (BTU/lb°F)
  - Rich Amine Cp = 0.83 (BTU/lb°F)

Step 1: Determine Heat Duty

- $Q = \dot{m} c_p \Delta T$ (No phase change)
  - Q is the heat transferred (BTU/lb)
    - Solve for Q
  - $\dot{m}$ is the mass flowrate (lb/hr)
    - 21,000 lb/hr
  - c_p is the specific heat (BTU/lb°F)
    - (Lean) 0.93
  - ΔT is the temperature change (°F)
    - 250°F -160°F = 90°F
- Q = 1,558,200 Btu/hr

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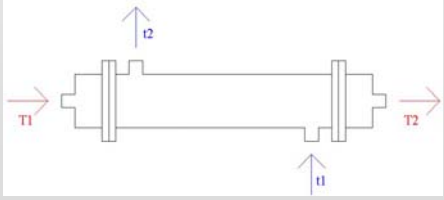
Step 2: Balance Heat & Mass

$$\dot{m}_{hot} c_{p_{hot}} \Delta T_{hot} + \dot{m}_{hot} h_{fg_{hot}} = \dot{m}_{cold} c_{p_{cold}} \Delta T_{cold} + \dot{m}_{cold} h_{fg_{cold}}$$

- No phase change
- Mass flow rate is the same on both sides
- Solve for Temp. Change to determine Rich Amine Outlet Temp.

Step 3: Calculate LMTD

- T1-t2 = 250 - 166.3
- T2-t1 = 160 – 86.0
- LMTD = 78.8



$$LMTD = \frac{\Delta t_2 - \Delta t_1}{\ln\left(\Delta t_2 / \Delta t_1\right)}$$

$$\Delta t_1 = T_1 - t_2$$

$$\Delta t_2 = T_2 - t_1$$

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Step 4: Select U

Approximate Overall Heat Transfer Coefficient U (Btu/hr-Ft^2-deg. F)

Hot Fluid	Cold Fluid	Overall U - S&T	Overall U Plate	Hot Fluid	Cold Fluid	Overall U - S&T	Overall U Plate
Water	Water	100-200	1200	Naptha	Water	30-60	
Light H.C.	Water	50-100	200	Steam	#2 Fuel Oil	40-70	100
Medium H.C.	Water	30-70	140	Steam	Butane (L)	50-150	
Heavy H.C.	Water	5-60	80	Steam	Crude	10-25	50
Nat. Gas	Water	5-35		Steam	Sulfur Slurry	50-100	
Methanol	Water	100-200		Steam	Methanol	100-400	
Ammonia	Water	100-200	500	Steam	Ammonia	100-400	
Hydrogen	Water	10-60		Steam	Light Organic	100-200	300
Oxygen	Water	10-60		Steam	Aqueous Soln.		
Air	Water	10-60			Less than 2 Cp	100-400	900
Glycol	Water	30-150	1100		More than 2 Cp	75-250	500
Toluene	Water	20-70		Steam	Medium Organic	50-100	
Sulfuric Acid	Water	20-55	1000	Steam	Gas	5-40	
Nitrogen	Water	10-60		Glycol	H.C. Vapor	5-15	80
Diesel Fuel	Water	50-110	800	Glycol	Glycol	6-40	400
Sour Nat. Gas	Water	25-60		Benzene	Benzene	50-100	
Lube Oil	Water	10-25	600	Toluene	Benzene	20-100	
Carbon Dioxide	Water	15-40		Brine	Gas	20-75	
Terpenes	Water	10-25		Diesel	Crude	20-60	100
Geraniol	Water	10-25		Oil	Fuel Gas	20-60	100
Steam	#6 Fuel Oil	5-25	100	H.C. Vapor	Crude	5-20	
Steam	Light H.C.	15-50	100	Ethanol	Butane	50-100	
Steam	Gas	50-120		Sour Nat. Gas	Sour Nat. Gas	25-100	
Steam	Nitrogen	50-120		Amine	Amine	20-60	500
Steam	50% Caustic	7-20	90	15% DEA	Crude	5-15	80
Fuel Oil	Water	10-20	120	Butane	Butane	30-60	
Fuel Oil	Oil	6-15	80	Aqueous Soln.	Aqueous Soln.	200-450	1100
Gasoline	Water	30-75	200	Heavy Organic	Heavy Organic	10-35	100
Asphalt	Water	10-20		Light Organic	Light Organic	30-65	100
Kerosene	Water	15-40	100	Slurry	Slurry	5-30	80

Estimated Values are based on 4 ft/sec shellside and 6 ft/sec tubeside velocity
Light H.C. refers to fluids with 0.5 Cp viscosity or lower
Medium H.C. refers to fluids with 0.5 to 1.0 Cp viscosity
Heavy H.C. refers to fluids with above 1.0 Cp viscosity

Step 5: Calculate Area Required

- $Q = UA\Delta T_{LM}$
  - Q is the heat transferred (BTU/hr)
    - 1,568,700 Btu/hr
  - U is Heat Trans Coef. (BTU/hr ft °F)
    - 30 (BTU/hr ft °F)
  - A is the surface area (ft^2)
    - Solve for area!
  - ΔT_{LM} is the LMTD (°F)
    - 78.8 °F
- Area Required is 1000 ft^2

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Step 6: Estimate Size

Surface Area, Sq. Ft.						
		Lengths (ft.)				
Size (in.)	# Tubes	6	10	16	20	24
8	34	40	67	107	134	160
10	64	75	126	201	251	302
12	102	120	200	320	401	481
14	126	148	247	396	495	594
16	178	210	350	559	699	839
18	236	278	463	741	927	1112
20	306	360	601	961	1202	1442
24	486	573	954	1527	1909	2290
30	794	935	1559	2494	3118	3742
36	1172	1381	2301	3682	4602	5523
48	2144	2526	4210	6736	8419	10103
Tube OD = 3/4"						
Assumes Triangular Pitch - 15/16"						
Assumes 4 Pass						

Verify Size

- Selected size for this example is 20-240
- Could also use 24-192 or 30-120
- These are intended to be estimates only!
- Many factors may alter size or improve design
- Heat exchanger rating engineers should be consulted

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Plate & Frame Surface Areas

Model Type	Surface Area For Units With Specified Number of Plates (ft²)					
	50 Plates	100 Plates	150 Plates	200 Plates	250 Plates	300 Plates
APV - SR1	46	92				
APV - SR2	94	187	281	374	468	561
APV - N35	188	375				
APV - Q030	156	312	468	624	780	936
APV - R5*	280	560	840	1,120	1,400	1,680
APV - Q055	296	592	888	1,184	1,480	1,776
APV - Q080	442	883	1,325	1,766	2,208	2,649
APV - J060	282	564	846	1,128	1,410	1,692
APV - J092	450	900	1,350	1,800	2,250	2,700
APV - J107	534	1,067	1,601	2,134	2,668	3,201
APV - J185	996	1,991	2,987	3,982	4,978	5,973
APV - B063	339	678	1,017	1,356	1,695	2,034
APV - B110	592	1,184	1,776	2,368	2,960	3,552
APV - B134	721	1,442	2,163	2,884	3,605	4,326
APV - B158	850	1,700	2,550	3,400	4,250	5,100
APV - B205	1,103	2,206	3,309	4,412	5,515	6,618
APV - P190	1,025	2,050	3,075	4,100	5,125	6,150
APV - SR23PD	1,365	2,730	4,095	5,460	6,825	8,190

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Verify Size - PHE

- Selected model for this example is Q055 w/200 plates
- Could also use J107 w/100+ plates
- These are intended to be estimates only!
- Design is flexible w/ number of plates
- Heat exchanger rating engineers should be consulted

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Consider Pressure Drop

- Beyond the scope of this presentation
- Is the process or equipment particularly sensitive to pressure drop?
  - What type of pump is used?
  - What is the downstream pressure?
- Is the viscosity in range? Does it change?

"Black Magic"

- Some heat exchanger designs make several common mistakes:
  - High "U" values
  - Low fouling factors
  - Incorrect viscosities
  - Incorrect MTD

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Heat Exchanger Comparison

- Typical Differences in Heat Exchanger Design
  - Surface Area
  - Heat Exchanged / Duty
  - Mean Temperature Difference (MTD)
  - Heat Transfer Coefficient (U)

Thermal & Process Sales, Inc.

Surface Area

- Heat Exchanged (Q)
- Heat Transfer Rate (U)
- Mean Temperature Difference (MTD)

$$A = \frac{Q}{U * MTD}$$

THERMAL & PROCESS SALES, INC. WWW.THERMPRO.COM — **HEAT EXCHANGER SPECIFICATION SHEET**

CUSTOMER	Thermal & Process Sales				JOB / REFERENCE NO.					
					PROPOSAL NO.				REV	
PLANT LOCATION					ITEM NO.					
SERVICE OF UNIT	BFW Preheater				DATE				1/20/2006	
SIZE 31-288	TYPE	CEU	ORIENTATION	horizontal	CONNECTED IN	series				
SQ. FT. SURF. / UNIT	3384		SHELLS / UNIT	1	SQ. FT. SURF. / SHELL	3384				
PERFORMANCE OF ONE UNIT										
FLUID ALLOCATION			IN	SHELL SIDE	OUT	IN	TUBE SIDE	OUT		
FLUID NAME				Boiler Feedwater			Condensate Blowdown			
FLUID QUANTITY, TOTAL		lb/hr		928,000			224,700			
VAPOR (IN / OUT)		lb/hr								
LIQUID		lb/hr								
STEAM		lb/hr								
WATER		lb/hr	928,000	928,000		224,700	224,700			
NONCONDENSABLE		lb/hr								
TEMPERATURE (IN / OUT)		F	178.3	259		589.1	243.9			
SPECIFIC GRAVITY / DENSITY		lb/ft^3	60.71	58.66		43.23	59.29			
VISCOSITY		cP	0.3497	0.2208		0.08246	0.2395			
MOLECULAR WEIGHT, VAPOR										
MOLECULAR WEIGHT, CONDENSABLE										
SPECIFIC HEAT		BTU/lb*F	1	1.016		1.446	1.008			
THERMAL CONDUCTIVITY		BTU/ft*hr*F	0.3885	0.3961		0.3064	0.3979			
LATENT HEAT		BTU/lb								
INLET PRESSURE		psi	490			1,415				
VELOCITY		ft/sec				5				
PRESSURE DROP, ALLOW / CALC.		psi	10	/	10	10	/	8.5		
FOULING RESISTANCE (MIN)		hr*ft^2*f/BTU	0.001			0.002				
HEAT EXCHANGED		75,400,000	BTU/hr	MTD CORRECTED	122.2	F				
TRANSFER RATE, SERVICE		182.4	BTU/ft^2*f*hr	CLEAN						
CONSTRUCTION OF ONE SHELL							SKETCH			
			SHELL SIDE	TUBE SIDE						
DESIGN / TEST PRESSURE	psig	500	/	1,540	/					
DESIGN TEMPERATURE / MDMT	F	300	/ 32	650	/ 32					
NO. PASSES PER SHELL		1		6						
CORROSION ALLOWANCE	in	1/16		1/16						
CONNECTIONS	IN	14" - 300 # RF		8" - 900 # RTJ						
SIZE & RATING	OUT	14" - 300 # RF		8" - 900 # RTJ						
	INTERMEDIATE									
TUBE NO.	350	U OD	3/4	in	THK	16	BWG	LENGTH	24	ft	PITCH	15/16	in
TUBE TYPE	Bare				MATERIAL	ASTM A789 Gr S32205					LAYOUT		
SHELL	SA-516-70	ID	30.75	in	OD	32	in	SHELL COVER	SA-516-70			(INTEG / REMOV)	
BONNET / CHANNEL	SA-516-70							CHANNEL COVER	SA-516-70				
TUBESHEET - STATIONARY	SA-516-70 w/ 2205 weld overlay							TUBESHEET - FLOATING					
FLOATING HEAD COVER								IMPINGEMENT PROTECTION					
BAFFLES - CROSS	CS	TYPE	horiz - seg	% CUT				SPACING C/C			INLET		in
BAFFLES - LONG								SEAL TYPE					
BYPASS SEAL ARRANGEMENT								TUBE - TUBESHEET JOINT					
EXPANSION JOINT								TYPE					
GASKET	SHELL			TUBE				FLOATING HEAD					
CODE REQUIREMENTS	ASME SECTION	VIII, Div 1						TEMA CLASS	R				
REMARK													

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Thermal & Process Sales, Inc.

Heat Exchanged

- Flowrate ($\dot{m}$)
- Specific Heat (c_p)
- Temperature Difference (ΔT)
- Latent Heat (h_{fg})

$$Q = \dot{m} * c_p * \Delta T + \dot{m} * h_{fg}$$

THERMAL & PROCESS SALES, INC. WWW.THERMPRO.COM — **HEAT EXCHANGER SPECIFICATION SHEET**

CUSTOMER	Thermal & Process Sales				JOB / REFERENCE NO.					
					PROPOSAL NO.				REV	
PLANT LOCATION					ITEM NO.					
SERVICE OF UNIT	BFW Preheater				DATE				1/20/2006	
SIZE 31-288	TYPE	CEU	ORIENTATION	horizontal	CONNECTED IN	series				
SQ. FT. SURF. / UNIT	3384		SHELLS / UNIT	1	SQ. FT. SURF. / SHELL	3384				
PERFORMANCE OF ONE UNIT										
FLUID ALLOCATION			IN	SHELL SIDE	OUT	IN	TUBE SIDE	OUT		
FLUID NAME				Boiler Feedwater			Condensate Blowdown			
FLUID QUANTITY, TOTAL		lb/hr		928,000			224,700			
VAPOR (IN / OUT)		lb/hr								
LIQUID		lb/hr								
STEAM		lb/hr								
WATER		lb/hr	928,000	928,000		224,700	224,700			
NONCONDENSABLE		lb/hr								
TEMPERATURE (IN / OUT)		F	178.3	259		589.1	243.9			
SPECIFIC GRAVITY / DENSITY		lb/ft^3	60.71	58.66		43.23	59.29			
VISCOSITY		cP	0.3497	0.2208		0.08246	0.2395			
MOLECULAR WEIGHT, VAPOR										
MOLECULAR WEIGHT, CONDENSABLE										
SPECIFIC HEAT		BTU/lb*F	1	1.016		1.446	1.008			
THERMAL CONDUCTIVITY		BTU/ft*hr*F	0.3885	0.3961		0.3064	0.3979			
LATENT HEAT		BTU/lb								
INLET PRESSURE		psi	490			1,415				
VELOCITY		ft/sec				5				
PRESSURE DROP, ALLOW / CALC.		psi	10	/	10	10	/	8.5		
FOULING RESISTANCE (MIN)		hr*ft^2*f/BTU	0.001			0.002				
HEAT EXCHANGED		75,400,000	BTU/hr	MTD CORRECTED	122.2	F				
TRANSFER RATE, SERVICE		182.4	BTU/ft^2*f*hr	CLEAN						
CONSTRUCTION OF ONE SHELL							SKETCH			
			SHELL SIDE	TUBE SIDE						
DESIGN / TEST PRESSURE	psig	500	/	1,540	/					
DESIGN TEMPERATURE / MDMT	F	300	/ 32	650	/ 32					
NO. PASSES PER SHELL		1		6						
CORROSION ALLOWANCE	in	1/16		1/16						
CONNECTIONS	IN	14" - 300 # RF		8" - 900 # RTJ						
SIZE & RATING	OUT	14" - 300 # RF		8" - 900 # RTJ						
	INTERMEDIATE									
TUBE NO.	350	U OD	3/4	in	THK	16	BWG	LENGTH	24	ft	PITCH	15/16	in
TUBE TYPE	Bare				MATERIAL	ASTM A789 Gr S32205					LAYOUT		
SHELL	SA-516-70	ID	30.75	in	OD	32	in	SHELL COVER	SA-516-70			(INTEG / REMOV)	
BONNET / CHANNEL	SA-516-70							CHANNEL COVER	SA-516-70				
TUBESHEET - STATIONARY	SA-516-70 w/ 2205 weld overlay							TUBESHEET - FLOATING					
FLOATING HEAD COVER								IMPINGEMENT PROTECTION					
BAFFLES - CROSS	CS	TYPE	horiz - seg	% CUT				SPACING C/C			INLET		in
BAFFLES - LONG								SEAL TYPE					
BYPASS SEAL ARRANGEMENT								TUBE - TUBESHEET JOINT					
EXPANSION JOINT								TYPE					
GASKET	SHELL			TUBE				FLOATING HEAD					
CODE REQUIREMENTS	ASME SECTION	VIII, Div 1						TEMA CLASS	R				
REMARK													

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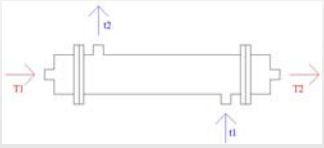
Thermal & Process Sales, Inc.

Mean Temperature Difference

- Temperatures In / Out



$$LMTD = \frac{\Delta t_2 - \Delta t_1}{\ln\left(\Delta t_2 / \Delta t_1\right)}$$

$$\Delta t_1 = T_1 - t_2$$

$$\Delta t_2 = T_2 - t_1$$

THERMAL & PROCESS SALES, INC. WWW.THERMPRO.COM — **HEAT EXCHANGER SPECIFICATION SHEET**

CUSTOMER	Thermal & Process Sales				JOB / REFERENCE NO.						
					PROPOSAL NO.				REV		
PLANT LOCATION					ITEM NO.						
SERVICE OF UNIT	BFW Preheater				DATE				1/20/2006		
SIZE	31-288	TYPE	CEU	ORIENTATION	horizontal		CONNECTED IN	series			
SQ. FT. SURF. / UNIT	3384			SHELLS / UNIT	1		SQ. FT. SURF. / SHELL	3384			
PERFORMANCE OF ONE UNIT											
FLUID ALLOCATION				IN	SHELL SIDE	OUT	IN	TUBE SIDE	OUT		
FLUID NAME					Boiler Feedwater			Condensate Blowdown			
FLUID QUANTITY, TOTAL			lb/hr		928,000			224,700			
	VAPOR (IN / OUT)		lb/hr								
	LIQUID		lb/hr								
	STEAM		lb/hr								
	WATER		lb/hr	928,000		928,000	224,700		224,700		
	NONCONDENSABLE		lb/hr								
TEMPERATURE (IN / OUT)			F	178.3		259	589.1		243.9		
SPECIFIC GRAVITY / DENSITY			lb/ft^3	60.71		58.66	43.23		59.29		
VISCOSITY			cP	0.3497		0.2208	0.08246		0.2395		
MOLECULAR WEIGHT, VAPOR											
MOLECULAR WEIGHT, CONDENSABLE											
SPECIFIC HEAT			BTU/lb*F	1		1.016	1.446		1.008		
THERMAL CONDUCTIVITY			BTU/ft*hr*F	0.3885		0.3961	0.3064		0.3979		
LATENT HEAT			BTU/lb								
INLET PRESSURE			psi		490			1,415			
VELOCITY			ft/sec					5			
PRESSURE DROP, ALLOW / CALC.			psi	10	/	10	10	/	8.5		
FOULING RESISTANCE (MIN)			hr*ft^2*f/BTU		0.001			0.002			
HEAT EXCHANGED				75,400,000 BTU/hr			MTD CORRECTED		122.2 F		
TRANSFER RATE, SERVICE				182.4 BTU/ft^2*ft*hr			CLEAN				
CONSTRUCTION OF ONE SHELL							SKETCH				
				SHELL SIDE		TUBE SIDE					
DESIGN / TEST PRESSURE			psig	500	/	1,540	/				
DESIGN TEMPERATURE / MDMT			F	300	/ 32	650	/ 32				
NO. PASSES PER SHELL				1		6					
CORROSION ALLOWANCE			in	1/16		1/16					
CONNECTIONS	IN			14" - 300 # RF		8" - 900 # RTJ					
SIZE & RATING	OUT			14" - 300 # RF		8" - 900 # RTJ					
	INTERMEDIATE										
TUBE NO.	350	U OD	3/4 in	THK	16 BWG	LENGTH	24 ft	PITCH	15/16 in		
TUBE TYPE	Bare			MATERIAL	ASTM A789 Gr S32205			LAYOUT			
SHELL	SA-516-70	ID	30.75 in	OD	32 in	SHELL COVER	SA-516-70	(INTEG / REMOV)			
BONNET / CHANNEL	SA-516-70			CHANNEL COVER	SA-516-70						
TUBESHEET - STATIONARY	SA-516-70 w/ 2205 weld overlay			TUBESHEET - FLOATING							
FLOATING HEAD COVER				IMPINGEMENT PROTECTION							
BAFFLES - CROSS	CS	TYPE	horiz - seg	% CUT		SPACING C/C		INLET	in		
BAFFLES - LONG				SEAL TYPE							
BYPASS SEAL ARRANGEMENT				TUBE - TUBESHEET JOINT							
EXPANSION JOINT				TYPE							
GASKET	SHELL			TUBE		FLOATING HEAD					
CODE REQUIREMENTS	ASME SECTION	VIII, Div 1				TEMA CLASS	R				
REMARK											

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Thermal & Process Sales, Inc.

Heat Transfer Coefficient

- Process Factors
  - Flowrate
  - Specific Heat
  - Viscosity
  - Thermal Conductivity

THERMAL & PROCESS SALES, INC. WWW.THERMPRO.COM — HEAT EXCHANGER SPECIFICATION SHEET

CUSTOMER	Thermal & Process Sales				JOB / REFERENCE NO.						
					PROPOSAL NO.				REV		
PLANT LOCATION					ITEM NO.						
SERVICE OF UNIT	BFW Preheater				DATE				1/20/2006		
SIZE	31-288	TYPE	CEU	ORIENTATION	horizontal		CONNECTED IN	series			
SQ. FT. SURF. / UNIT	3384			SHELLS / UNIT	1		SQ. FT. SURF. / SHELL	3384			
PERFORMANCE OF ONE UNIT											
FLUID ALLOCATION				IN	SHELL SIDE	OUT	IN	TUBE SIDE	OUT		
FLUID NAME					Boiler Feedwater			Condensate Blowdown			
FLUID QUANTITY, TOTAL			lb/hr		928,000			224,700			
	VAPOR (IN / OUT)		lb/hr								
	LIQUID		lb/hr								
	STEAM		lb/hr								
	WATER		lb/hr	928,000		928,000	224,700		224,700		
	NONCONDENSABLE		lb/hr								
TEMPERATURE (IN / OUT)			F	178.3		259	589.1		243.9		
SPECIFIC GRAVITY / DENSITY			lb/ft^3	60.71		58.66	43.23		59.29		
VISCOSITY			cP	0.3497		0.2208	0.08246		0.2395		
MOLECULAR WEIGHT, VAPOR											
MOLECULAR WEIGHT, CONDENSABLE											
SPECIFIC HEAT			BTU/lb*F	1		1.016	1.446		1.008		
THERMAL CONDUCTIVITY			BTU/ft*hr*F	0.3885		0.3961	0.3064		0.3979		
LATENT HEAT			BTU/lb								
INLET PRESSURE			psi		490			1,415			
VELOCITY			ft/sec					5			
PRESSURE DROP, ALLOW / CALC.			psi	10	/	10	10	/	8.5		
FOULING RESISTANCE (MIN)			hr*ft^2*f/BTU		0.001			0.002			
HEAT EXCHANGED				75,400,000 BTU/hr			MTD CORRECTED		122.2 F		
TRANSFER RATE, SERVICE				182.4 BTU/ft^2*ft*hr			CLEAN				
CONSTRUCTION OF ONE SHELL							SKETCH				
				SHELL SIDE		TUBE SIDE					
DESIGN / TEST PRESSURE			psig	500	/	1,540	/				
DESIGN TEMPERATURE / MDMT			F	300	/ 32	650	/ 32				
NO. PASSES PER SHELL				1		6					
CORROSION ALLOWANCE			in	1/16		1/16					
CONNECTIONS	IN			14" - 300 # RF		8" - 900 # RTJ					
SIZE & RATING	OUT			14" - 300 # RF		8" - 900 # RTJ					
	INTERMEDIATE										
TUBE NO.	350	U OD	3/4 in	THK	16 BWG	LENGTH	24 ft	PITCH	15/16 in		
TUBE TYPE	Bare			MATERIAL	ASTM A789 Gr S32205			LAYOUT			
SHELL	SA-516-70	ID	30.75 in	OD	32 in	SHELL COVER	SA-516-70	(INTEG / REMOV)			
BONNET / CHANNEL	SA-516-70			CHANNEL COVER	SA-516-70						
TUBESHEET - STATIONARY	SA-516-70 w/ 2205 weld overlay			TUBESHEET - FLOATING							
FLOATING HEAD COVER				IMPINGEMENT PROTECTION							
BAFFLES - CROSS	CS	TYPE	horiz - seg	% CUT		SPACING C/C		INLET	in		
BAFFLES - LONG				SEAL TYPE							
BYPASS SEAL ARRANGEMENT				TUBE - TUBESHEET JOINT							
EXPANSION JOINT				TYPE							
GASKET	SHELL			TUBE		FLOATING HEAD					
CODE REQUIREMENTS	ASME SECTION	VIII, Div 1				TEMA CLASS	R				
REMARK											

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Thermal & Process Sales, Inc.

Heat Transfer Coefficient

- Mechanical Factors (Tubeside)
  - Tube Count
  - Number of Passes (tube)
  - Tube Diameter
  - Internal Enhancements

THERMAL & PROCESS SALES, INC. WWW.THERMPRO.COM								HEAT EXCHANGER SPECIFICATION SHEET			
CUSTOMER	Thermal & Process Sales							JOB / REFERENCE NO.			
								PROPOSAL NO.		REV	
PLANT LOCATION								ITEM NO.			
SERVICE OF UNIT	BFW Preheater							DATE			1/20/2006
SIZE	31-288	TYPE	CEU	ORIENTATION	horizontal	CONNECTED IN	series				
SQ. FT. SURF. / UNIT	3384			SHELLS / UNIT	1	SQ. FT. SURF. / SHELL	3384				
PERFORMANCE OF ONE UNIT											
FLUID ALLOCATION				IN	SHELL SIDE	OUT	IN	TUBE SIDE	OUT		
FLUID NAME					Boiler Feedwater			Condensate Blowdown			
FLUID QUANTITY, TOTAL			lb/hr		928,000			224,700			
VAPOR (IN / OUT)			lb/hr								
LIQUID			lb/hr								
STEAM			lb/hr								
WATER			lb/hr	928,000		928,000	224,700		224,700		
NONCONDENSABLE			lb/hr								
TEMPERATURE (IN / OUT)			F	178.3		259	589.1		243.9		
SPECIFIC GRAVITY / DENSITY			lb/ft^3	60.71		58.66	43.23		59.29		
VISCOSITY			cP	0.3497		0.2208	0.08246		0.2395		
MOLECULAR WEIGHT, VAPOR											
MOLECULAR WEIGHT, CONDENSABLE											
SPECIFIC HEAT			BTU/lb*F	1		1.016	1.446		1.008		
THERMAL CONDUCTIVITY			BTU/ft*hr*F	0.3885		0.3961	0.3064		0.3979		
LATENT HEAT			BTU/lb								
INLET PRESSURE			psi		490			1,415			
VELOCITY			ft/sec					5			
PRESSURE DROP, ALLOW / CALC.			psi	10	/	10	10	/	8.5		
FOULING RESISTANCE (MIN)			hr*ft^2*/BTU		0.001			0.002			
HEAT EXCHANGED			75,400,000 BTU/hr				MTD CORRECTED		122.2 F		
TRANSFER RATE, SERVICE			182.4 BTU/ft^2*ft*hr			CLEAN					
CONSTRUCTION OF ONE SHELL							SKETCH				
			SHELL SIDE	TUBE SIDE							
DESIGN / TEST PRESSURE		psig	500 /	1,540 /							
DESIGN TEMPERATURE / MDMT		F	300 / 32	650 / 32							
NO. PASSES PER SHELL			1	6							
CORROSION ALLOWANCE		in	1/16	1/16							
CONNECTIONS SIZE & RATING	IN		14" - 300 # RF	8" - 900 # RTJ							
	OUT		14" - 300 # RF	8" - 900 # RTJ							
	INTERMEDIATE										
TUBE NO.	350	OD	3/4 in	THK	16	BWG	LENGTH	24	ft	PITCH	15/16 in
TUBE TYPE	Bare			MATERIAL	ASTM A789 Gr S32205					LAYOUT	
SHELL	SA-516-70	ID	30.75 in	OD	32 in	SHELL COVER	SA-516-70			(INTEG / REMOV)	
BONNET / CHANNEL	SA-516-70					CHANNEL COVER	SA-516-70				
TUBESHEET - STATIONARY	SA-516-70 w/ 2205 weld overlay					TUBESHEET - FLOATING					
FLOATING HEAD COVER						IMPINGEMENT PROTECTION					
BAFFLES - CROSS	CS	TYPE	horiz - seg	% CUT		SPACING C/C		INLET		in	
BAFFLES - LONG						SEAL TYPE					
BYPASS SEAL ARRANGEMENT						TUBE - TUBESHEET JOINT					
EXPANSION JOINT						TYPE					
GASKET	SHELL			TUBE		FLOATING HEAD					
CODE REQUIREMENTS	ASME SECTION	VIII, Div 1				TEMA CLASS	R				
REMARK											

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Thermal & Process Sales, Inc.

Heat Transfer Coefficient

- Mechanical Factors (Shellside)
  - Tube Count
  - Tube Diameter
  - Tube Pitch / Layout
  - External Enhancements
  - Shell Diameter
  - Number of Passes (shell)
  - Baffle Type
  - Baffle Cut
  - Baffle Spacing

THERMAL & PROCESS SALES, INC. WWW.THERMPRO.COM								HEAT EXCHANGER SPECIFICATION SHEET			
CUSTOMER	Thermal & Process Sales							JOB / REFERENCE NO.			
								PROPOSAL NO.		REV	
PLANT LOCATION								ITEM NO.			
SERVICE OF UNIT	BFW Preheater							DATE			1/20/2006
SIZE	31-288	TYPE	CEU	ORIENTATION	horizontal	CONNECTED IN	series				
SQ. FT. SURF. / UNIT	3384			SHELLS / UNIT	1	SQ. FT. SURF. / SHELL	3384				
PERFORMANCE OF ONE UNIT											
FLUID ALLOCATION				IN	SHELL SIDE	OUT	IN	TUBE SIDE	OUT		
FLUID NAME					Boiler Feedwater			Condensate Blowdown			
FLUID QUANTITY, TOTAL			lb/hr		928,000			224,700			
VAPOR (IN / OUT)			lb/hr								
LIQUID			lb/hr								
STEAM			lb/hr								
WATER			lb/hr	928,000		928,000	224,700		224,700		
NONCONDENSABLE			lb/hr								
TEMPERATURE (IN / OUT)			F	178.3		259	589.1		243.9		
SPECIFIC GRAVITY / DENSITY			lb/ft^3	60.71		58.66	43.23		59.29		
VISCOSITY			cP	0.3497		0.2208	0.08246		0.2395		
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MOLECULAR WEIGHT, CONDENSABLE											
SPECIFIC HEAT			BTU/lb*F	1		1.016	1.446		1.008		
THERMAL CONDUCTIVITY			BTU/ft*hr*F	0.3885		0.3961	0.3064		0.3979		
LATENT HEAT			BTU/lb								
INLET PRESSURE			psi		490			1,415			
VELOCITY			ft/sec					5			
PRESSURE DROP, ALLOW / CALC.			psi	10	/	10	10	/	8.5		
FOULING RESISTANCE (MIN)			hr*ft^2*/BTU		0.001			0.002			
HEAT EXCHANGED			75,400,000 BTU/hr				MTD CORRECTED		122.2 F		
TRANSFER RATE, SERVICE			182.4 BTU/ft^2*ft*hr			CLEAN					
CONSTRUCTION OF ONE SHELL							SKETCH				
			SHELL SIDE	TUBE SIDE							
DESIGN / TEST PRESSURE		psig	500 /	1,540 /							
DESIGN TEMPERATURE / MDMT		F	300 / 32	650 / 32							
NO. PASSES PER SHELL			1	6							
CORROSION ALLOWANCE		in	1/16	1/16							
CONNECTIONS SIZE & RATING	IN		14" - 300 # RF	8" - 900 # RTJ							
	OUT		14" - 300 # RF	8" - 900 # RTJ							
	INTERMEDIATE										
TUBE NO.	350	OD	3/4 in	THK	16	BWG	LENGTH	24	ft	PITCH	15/16 in
TUBE TYPE	Bare			MATERIAL	ASTM A789 Gr S32205					LAYOUT	
SHELL	SA-516-70	ID	30.75 in	OD	32 in	SHELL COVER	SA-516-70			(INTEG / REMOV)	
BONNET / CHANNEL	SA-516-70					CHANNEL COVER	SA-516-70				
TUBESHEET - STATIONARY	SA-516-70 w/ 2205 weld overlay					TUBESHEET - FLOATING					
FLOATING HEAD COVER						IMPINGEMENT PROTECTION					
BAFFLES - CROSS	CS	TYPE	horiz - seg	% CUT		SPACING C/C		INLET		in	
BAFFLES - LONG						SEAL TYPE					
BYPASS SEAL ARRANGEMENT						TUBE - TUBESHEET JOINT					
EXPANSION JOINT						TYPE					
GASKET	SHELL			TUBE		FLOATING HEAD					
CODE REQUIREMENTS	ASME SECTION	VIII, Div 1				TEMA CLASS	R				
REMARK											

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Thermal & Process Sales, Inc.

Heat Transfer Coefficient

- Other Factors
  - Shell and Tube sides switched?
  - Fluid Velocities
  - Pressure Drop
  - Fouling Factors
  - Materials of Construction (tubes)

THERMAL & PROCESS SALES, INC. WWW.THERMPRO.COM								HEAT EXCHANGER SPECIFICATION SHEET			
CUSTOMER	Thermal & Process Sales							JOB / REFERENCE NO.			
								PROPOSAL NO.			REV
PLANT LOCATION								ITEM NO.			
SERVICE OF UNIT	BFW Preheater							DATE			1/20/2006
SIZE	31-288	TYPE	CEU	ORIENTATION	horizontal		CONNECTED IN	series			
SQ. FT. SURF. / UNIT	3384			SHELLS / UNIT	1		SQ. FT. SURF. / SHELL	3384			
PERFORMANCE OF ONE UNIT											
FLUID ALLOCATION					IN	SHELL SIDE	OUT	IN	TUBE SIDE	OUT	
FLUID NAME					Boiler Feedwater			Condensate Blowdown			
FLUID QUANTITY, TOTAL			lb/hr		928,000			224,700			
VAPOR (IN / OUT)			lb/hr								
LIQUID			lb/hr								
STEAM			lb/hr								
WATER			lb/hr		928,000	928,000		224,700	224,700		
NONCONDENSABLE			lb/hr								
TEMPERATURE (IN / OUT)			F		178.3	259		589.1	243.9		
SPECIFIC GRAVITY / DENSITY			lb/ft^3		60.71	58.66		43.23	59.29		
VISCOSITY			cP		0.3497	0.2208		0.08246	0.2395		
MOLECULAR WEIGHT, VAPOR											
MOLECULAR WEIGHT, CONDENSABLE											
SPECIFIC HEAT			BTU/lb*F		1	1.016		1.446	1.008		
THERMAL CONDUCTIVITY			BTU/ft*hr*F		0.3885	0.3961		0.3064	0.3979		
LATENT HEAT			BTU/lb								
INLET PRESSURE			psi		490			1.415			
VELOCITY			ft/sec					5			
PRESSURE DROP, ALLOW / CALC.			psi		10	/ 10		10	/ 8.5		
FOULING RESISTANCE (MIN)			hr*ft^2*f/BTU		0.001			0.002			
HEAT EXCHANGED			75,400,000 BTU/hr					MTD CORRECTED	122.2 F		
TRANSFER RATE, SERVICE			162.4 BTU/ft^2*f/hr					CLEAN			
CONSTRUCTION OF ONE SHELL								SKETCH			
					SHELL SIDE		TUBE SIDE				
DESIGN / TEST PRESSURE			psig		500 /		1,540 /				
DESIGN TEMPERATURE / MDMT			F		300 / 32		650 / 32				
NO. PASSES PER SHELL					1		6				
CORROSION ALLOWANCE			in		1/16		1/16				
CONNECTIONS	IN				14" - 300 # RF		8" - 900 # RTJ				
SIZE &	OUT				14" - 300 # RF		8" - 900 # RTJ				
RATING	INTERMEDIATE										
TUBE NO.	350	O.D.	3/4	in	THK	16	BWG	LENGTH	24	ft	PITCH 15/16 in
TUBE TYPE	Bare				MATERIAL	ASTM A789 Gr S32205		LAYOUT			
SHELL	SA-516-70	I.D.	30.75	in	O.D.	32	in	SHELL COVER	SA-516-70		(INTEG / REMOV)
BONNET / CHANNEL	SA-516-70							CHANNEL COVER	SA-516-70		
TUBESHEET - STATIONARY	SA-516-70 w/ 2205 weld overlay							TUBESHEET - FLOATING			
FLOATING HEAD COVER								IMPINGEMENT PROTECTION			
BAFFLES - CROSS	CS	TYPE	horiz - seg	% CUT				SPACING C/C		INLET	in
BAFFLES - LONG								SEAL TYPE			
BYPASS SEAL ARRANGEMENT								TUBE - TUBESHEET JOINT			
EXPANSION JOINT								TYPE			
GASKET	SHELL			TUBE				FLOATING HEAD			
CODE REQUIREMENTS	ASME SECTION	VIII, Div 1						TEMA CLASS	R		
REMARK											

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Credits

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