PLATE & FRAME HEAT EXCHANGER SIZING

FORMULAS

CFM (ft3/min) x 7.48052 = GPM (gals/min)

GPM / 7.48052 (ft3/lb) x D (lbs/ft3) x 60 (min/hr) = M (lbs/hr)

or GPM x 8.021 x D = M

Q (mbh) = M x SH x (Ti - To) / 1000 =

(GPM x 8.021 x D) x SH x (Ti - To) /1000 =

GPM x 0.008021 x D x SH x (Ti - To)

Ti1 = Fluid-1 - In
To1 = Fluid-1 - Out
Ti2 = Fluid-2 - In
To2 = Fluid-2 - Out

LMTD (Log Mean Temp Diff) =

[(To2-Ti1) - (Ti2-To1)] / [LN{(To2-Ti1) / (Ti2-To1)}]

where (To2-Ti1) > (Ti2-To1)

LMTD = (DT1- DT2) / (LN (DT1/DT2))

where DT1 > Dt2

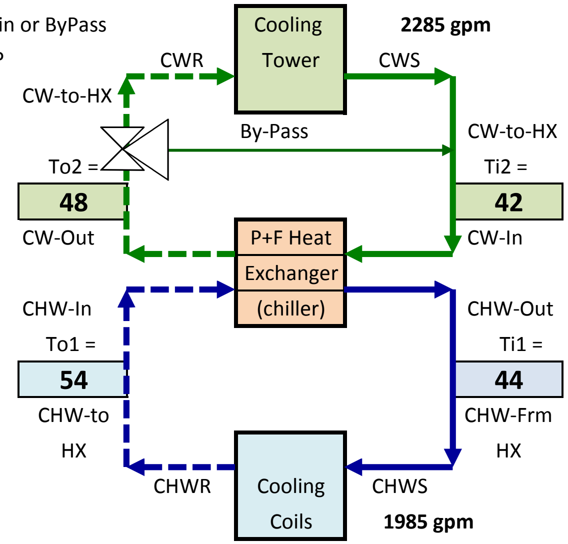
DT1 = ABS (Ti1 - To2)
DT2 = ABS (Ti2 - To1)

Q = A x U x LMTD   Surface Area (**A**) = Q / (U x LMTD)

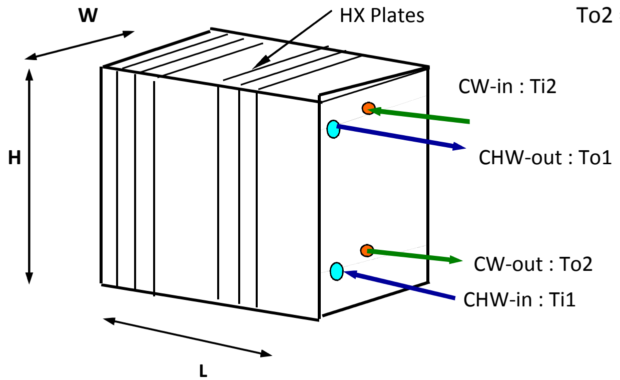
To1 =	CHW-In	**54**
Ti1=	CHW-Out	**44**
Ti2 =	CW-In	**42**
To2 =	CW-Out	**48**

WATERSIDE ECONOMIZER (WSE)

Operates from Nov-Mar when WB <= 40 F
Heater in Clg Twr Basin or ByPass
to prevent freezing ??



Log Mean Temperature Difference (LMTD)



WSE - COUNTER FLOW

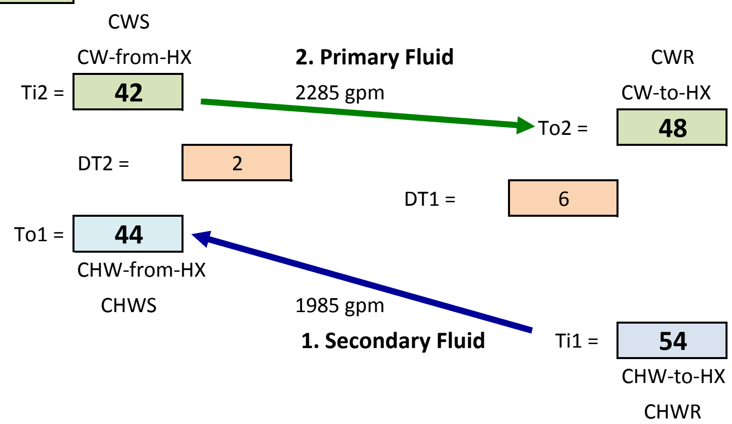


Plate & Frame Heat Exchanger

Notes:

(1) See manufacturer's catalogs to get standard heights (H) and widths (W)

(2) Length (L) varies with heat transfer surface area required and number of plates

(3) Obtain U-value of heat transfer material from HX manufacturer (catalog)

http://www.taco-hvac.com/products.html?current_category=73

http://www.tranter.com/pd

CHW and CW Loop Flow (GPM) with NO Waterside Economizer)

CHW-Loop = 1985
2 pumps 1000 gpm each

CW-Loop = 2285
2 pumps 1150 gpm each

Heat Exchanger Calculations

Two basic formulas are used in all heat exchanger calculations. These are:

Heat transfer Btu/hr = lbs/hr x sp ht x temp. change °F

In the case of water, the specific heat can usually be considered as 1.0 and the formula expressed as:

Btu/hr = flow rate in GPM x 500 x temp. change °F (1)

where: **500 = 8.33 lbs/gal x 60 min/hr** conversion to lbs/hr

Heat transfer in Btu/hr = (U)(A)(LMTD) (2)

where: **U = overall heat transfer coefficient A = heat transfer area in sq. ft.**

U = overall heat transfer coefficient A = heat transfer area in sq. ft.

LMTD = log mean temperature difference = (large temp. diff.) - (small temp. diff.) all divided by: the natural log of (large temp. diff - small temp. diff)

The range of the heat transfer coefficient "U" varies widely, depending upon the physical conditions such as the solution viscosities, surface fouling, fluid velocities and turbulence, involved, constant or change of state, and metal resistance.

For example, water-to-water heat exchangers typically have "U" value ranges like:

Plate-frame: 500 to 1,200 Btu/(hr x sq ft x°F)

Shell and tube: 150 to 350 Btu/(hr x sq ft x°F)

Plate-coil: 50 to 250 Btu/(hr x sq ft x°F)

These can be contrasted to "U" values of 4 to 8 for air-to-air or steam-to-air heat transfer, which is why these are usually plate-fin coils with very large surface areas

---

Q = U x A x LMTD x Cf where: Q = Heat load in Btu/hr

U = Overall heat transfer coefficient in Btu/hr·ft2 oF A = Area (ft2)

LMTD = Log mean temperature difference (oF)

Cf = LMTD correction factor (0.85 - 1.0 for most geothermal applications).

Example selection: Application - radiant floor heating in 350,000 ft2 factory

Resource temperature - 170 °F Available geothermal flow - 375 gpm

Load - 7,500,000 Btu/hr Building loop supply water temperature - 135 °F max.

Geothermal temperature drop: = 7,500,000 Btu/hr ÷ (500 · 375 gpm) = 40 °F.

Geothermal exit temperature: = 170 °F - 40 °F = 130 °F.

Geothermal side 170 °F to 130 °F Building side 135 °F to 120 °F

Dt1 = 170 °F - 135 °F = 35 °F **Dt2 = 130 °F - 120 °F = 10 °F**

$$LMTD = \frac{35 - 10}{\ln(\frac{35}{10})}$$

Q = U x A x LMTD x Cf

Using a LMTD convection factor of 0.90, required heat exchanger area is:

Area = 7,500,000 Btu/hr ÷ (19.9 °F · 0.90 · 950 Btu/hr·ft2 °F) = 441 ft2

T R A N T E R

http://www.tranter.com/pd

T A C O

http://www.taco-hvac.com/products.html?current_category=73

PROPERTIES OF LIQUIDS

Kinematic Viscosity (sq.ft./sec) in Liquid Tables are: (value shown)/1,000,000

Liquid	Properties	Temperature (F)						
		-30	0	30	60	100	150	210
Water	Density (lb/cu ft)			62.42	62.37	62.00	61.20	59.81
	Specific Gravity = Dens/62.4			1.00	1.00	0.99	0.98	0.96
	Kinematic Viscosity (sq ft/sec)			19.31	12.17	7.39	4.76	3.20
	Specific Heat (Btu/lb oF)			1.00	1.00	1.00	1.00	1.01
Glycol	Density (lb/cu ft)	67.98	67.55	67.11	66.55	65.74	64.68	63.12
	Specific Gravity = Dens/62.4	1.09	1.08	1.08	1.07	1.05	1.04	1.01
	Kinematic Viscosity (sq ft/sec)	595.00	190.00	85.40	48.60	22.60	12.50	6.40
	Specific Heat (Btu/lb oF)	0.70	0.73	0.76	0.78	0.81	0.85	0.88
Brine	Density (lb/cu ft)	78.59	78.21	77.71	77.21	76.09		
	Specific Gravity = Dens/62.4	1.26	1.25	1.25	1.24	1.22		
	Kinematic Viscosity (sq ft/sec)	171.70	77.50	34.70	21.80	8.90		
	Specific Heat (Btu/lb oF)	0.66	0.67	0.68	0.69	0.71		

PROPERTIES OF HIGH TEMPERATURE HOT WATER

Temp deg F T	Satr Pr psig P	Density lb/cu ft D	Specific Gravity D/62.4	Kin Visc sqft/sec V	Sp. Heat Btu/lb-F H
212	0.0	59.81	0.96	3.20	1.0055
220	2.5	59.63	0.96	3.00	1.0068
240	10.3	59.10	0.95	2.70	1.0104
260	20.7	58.51	0.94	2.50	1.0148
280	34.5	57.94	0.93	2.30	1.0200
300	52.3	57.31	0.92	2.10	1.2600
350	119.9	55.59	0.89	1.90	1.0440
400	232.6	53.65	0.86	1.70	1.0670
450	407.9	51.55	0.83	1.50	1.0950

PROPERTIES OF STEAM

Press psig	Temp deg F	Sp. Vol. cuft/lb	Density lbs/cuft	Sp. Gr D/62.4	Enthalpy btu/lb Liquid	Enthalpy btu/lb Latent	Enthalpy btu/lb Total	Sp. Ht. Btu/lb-F	Kin Visc sqft/sec
0	212.0	26.80	0.03731	0.00060	180.1	970.3	1150.4	0.45300	0.00023
5	227.3	20.34	0.04916	0.00079	195.5	960.5	1156.0	0.36601	0.00017
10	240	16.46	0.06075	0.00097	207.9	952.5	1160.4	0.34646	0.00014
15	250	13.86	0.07215	0.00116	218.3	945.6	1163.9	0.35000	0.00012
20	258.8	11.98	0.08347	0.00134	227.5	939.5	1167.0	0.35227	0.00010
25	266.9	10.56	0.09470	0.00152	235.6	934.0	1169.6	0.32099	0.00009
30	274.1	9.45	0.10582	0.00170	243.0	928.9	1171.9	0.31944	0.00008
35	280.7	8.56	0.11682	0.00187	249.8	924.2	1174.0	0.31818	0.00007
40	286.8	7.83	0.12771	0.00205	256.0	919.8	1175.8	0.29508	0.00007
45	292.4	7.20	0.13889	0.00223	261.8	915.7	1177.5	0.30357	0.00006
50	297.7	6.68	0.14970	0.00240	267.2	911.8	1179.0	0.28302	0.00006
60	307.3	5.83	0.17153	0.00275	277.2	904.6	1181.8	0.29167	0.00005
70	316.4	5.18	0.19305	0.00309	286.2	898.0	1184.2	0.26374	0.00004
80	323.9	4.66	0.21459	0.00344	294.4	891.9	1186.3	0.28000	0.00004
90	331.2	4.24	0.23585	0.00378	301.9	886.1	1188.0	0.23288	0.00004
100	337.9	3.89	0.25707	0.00412	308.9	880.7	1189.6	0.23881	0.00003
110	344.2	3.59	0.27855	0.00446	315.5	875.5	1191.0	0.22222	0.00003
120	350.1	3.34	0.29940	0.00480	321.7	870.7	1192.4	0.23729	0.00003
130	355.6	3.12	0.32051	0.00514	327.6	865.9	1193.5	0.20000	0.00003
140	360.9	2.93	0.34130	0.00547	333.1	861.5	1194.6	0.20755	0.00002
150	365.9	2.76	0.36232	0.00581	338.4	857.2	1195.6	0.20000	0.00002
170	375.2	2.47	0.40486	0.00649	348.3	848.9	1197.2	0.17204	0.00002
200	387.8	2.13	0.46948	0.00752	361.9	837.4	1199.3	0.16667	0.00002
220	395.5	1.95	0.51282	0.00822	370.1	830.3	1200.4	0.14286	0.00002
250	406.1	1.74	0.57471	0.00921	381.6	820.1	1201.7	0.12264	0.00001

Density = 1 / Specific Volume

Density of Water @ 40 F = 62.4

Specific Gravity = Density of Fluid / Density of Water @ 40 F

Specific Heat (btu/lb.F) @ 0 psig & 212 F = 0.453

Sp. Ht. @ 15 psig & 250 F = (TH @ 250F -TH @ 240F) / (250 - 240)

Viscosity (Centipoise) of Steam @ 0 psig & 212 F = 0.0125

Viscosity (Centipoise) of Steam @ ? psig & 932 F = 0.028

Kinematic Viscosity (Centistokes) = Viscosity (Centipoise) / Specific Gravity

Centistokes = 1.0 sq mm / sec = 0.00001076 sq ft / sec

Kin Visc (sqft/sec) = Viscosity (Centipoise) x 0.0000108 / Specific Gravity

PROPERTIES OF HEAT TRANSFER MATERIALS & SURFACES

U : btu/hr.ft2.F K : btu/hr.ft2.F/in Film Coeff Ho,Hi : btu/hr.ft2.F

U = 1 / (1/Ho + t/K + 1/Hi) t = Thickness of Material (inches)

Applic	Ht Trans Materl	t	Ho	Hi	K-value	U-value
Heatg	Copper	0.0747	300	1000	2680	229
Water	Aluminum	0.0747	300	1000	1570	228
with	Carbon Steel	0.0747	300	1000	312	219
Steam	Stainless Steel	0.0747	300	1000	113	200
Heatg	Copper	0.0747	300	300	2680	149
Water	Aluminum	0.0747	300	300	1570	149
with	Carbon Steel	0.0747	300	300	312	145
HW	Stainless Steel	0.0747	300	300	113	136
Heatg	Copper	0.0747	5	1000	2680	4.97
Air	Aluminum	0.0747	5	1000	1570	4.97
with	Carbon Steel	0.0747	5	1000	312	4.97
Steam	Stainless Steel	0.0747	5	1000	113	4.96