ENGINEERING DATA - HOT WATER CAPACITIES, CALCULATIONS AND CORRECTION FACTORS

Use the following two tables to determine

1. Heating Capacity (MBH)
2. Leaving Air Temperature (LAT)
3. Water Flow in Gallons per Minute (GPM)
4. Water Pressure Drop (WPD) in feet of water

The performances reflected in these tables are based on the following:

Entering Water Temperature (EWT): 200°F (93°C)
Water Temperature Drop (WTD): 20° (11°C)
Entering Air Temperature (EAT): 60° (16°C)

TABLE A - Low Speed Fan Setting

Size	Approx. Fan rpm	MBH Output	Leaving Air Temp. (LAT)		Water Flow		WPD feet of water	Air Volume	
			°F	°C	Gal. per Minute	Liters per Minute		cfm	(m^3/hr)
18/24	1,100	13	104°	40°	1.31	4.96	0.06	270	459
23/33	1,100	17	107°	42°	1.72	6.49	0.01	330	561
44/62	1,100	32	113°	45°	3.23	12.22	0.08	560	952
60/85	1,100	45	112°	44°	4.54	17.18	0.23	800	1,359
78/110	1,100	58	109°	43°	5.85	22.15	0.48	1,100	1,869
96/120	850	72	115°	46°	7.26	27.49	0.95	1,200	2,039
140/175	850	105	115°	46°	10.59	40.09	1.90	1,750	2,973
190/238	850	141	119°	48°	14.22	53.84	4.50	2,200	3,738
300/350	850	230	116°	47°	23.20	87.82	3.30	3,800	6,457

TABLE B - High Speed Fan Setting

Size	Approx. Fan rpm	MBH Output	Leaving Air Temp. (LAT)		Water Flow		WPD feet of water	Air Volume	
			°F	°C	Gal. per Minute	Liters per Minute		cfm	(m^3/hr)
18/24	1,550	19	104°	40°	1.92	7.27	0.11	400	680
23/33	1,600	24	104°	40°	2.42	9.16	0.04	500	850
44/62	1,600	45	108°	42°	4.54	17.18	0.15	860	1,461
60/85	1,600	64	107°	42°	6.46	24.45	0.45	1,250	2,124
78/110	1,600	82	106°	41°	8.27	31.30	0.95	1,650	2,804
96/120	1,080	89	113°	45°	8.98	33.99	1.30	1,550	2,634
140/175	1,080	131	112°	45°	13.22	50.04	2.80	2,300	3,908
190/238	1,080	177	117°	47°	17.86	67.60	7.00	2,850	4,842
300/350	1,080	276	114°	45°	27.84	105.37	4.80	4,750	8,071

TABLE C - Hot Water Correction Factors for EAT and EWT different from cataloged information

Entering Air Temperature (EAT)		Entering Water temperature with 20° Temperature Drop										
		100	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**
30°F	**-1°C**	0.462	0.615	0.769	0.923	1.077	1.231	1.385	1.538	1.692	1.846	2.000
40°F	**4°C**	0.385	0.538	0.692	0.846	1.000	1.154	1.308	1.462	1.615	1.769	1.923
50°F	**10°C**	0.308	0.462	0.615	0.769	0.923	1.077	1.231	1.385	1.538	1.692	1.846
60°F	**16°C**	0.231	0.385	0.538	0.692	0.846	1.000	1.154	1.308	1.462	1.615	1.769
70°F	**21°C**	0.154	0.308	0.462	0.615	0.769	0.923	1.077	1.231	1.385	1.538	1.692
80°F	**27°C**	0.077	0.231	0.385	0.538	0.692	0.846	1.000	1.154	1.308	1.462	1.615
90°F	**32°C**	0.000	0.154	0.308	0.462	0.615	0.769	0.923	1.077	1.231	1.385	1.538
100°F	**38°C**	0.000	0.077	0.231	0.385	0.538	0.692	0.846	1.000	1.154	1.308	1.462

TABLE D - Hot Water Correction Factors for WTD different from cataloged information

Water Temp. Drop	5°F	10°F	15°F	20°F	25°F	30°F	35°F	40°F	45°F	50°F	55°F	60°F
MBH Correction Factor	1.25	1.15	1.08	1.00	0.95	0.89	0.87	0.84	0.80	0.78	0.74	0.73
GPM Correction Factor	5.00	2.30	1.44	1.00	0.74	0.59	0.49	0.40	0.35	0.30	0.27	0.24

TABLE E - Hot Water Conversion Factors for Water Flow different from cataloged information

% Water Flow*	25%	50%	75%	100%	125%	150%	175%
MBH Correction Factor	0.80	0.89	0.96	1.00	1.04	1.07	1.10

*Calculate % of Water Flow by dividing actual water flow in GPM by the “cataloged” water flow.

ENGINEERING DATA - HOT WATER CALCULATIONS AND CORRECTION FACTORS (cont'd)

The heating output of any particular installation is a function of many different factors. It is very seldom that any installation will exactly match the conditions described in the tables on the previous page. For those installations, correction factors must be used to determine heating output and other values.

Below is an example of conditions different from those given in TABLE A and B on the previous page. Following are procedures for determining heating output and other values at conditions other than "cataloged" conditions.

Example:

Unit	Reznor Model 23/33
Entering Water Temperature (EWT)	160°F
Entering Air Temperature (EAT)	40°F
Water Temperature Drop (WTD)	10°F

I.	In TABLE B find the Heating Capacity for "catalog" conditions with High Speed Fan Setting	24,000 BTUH
II.	Determine Heating Capacity for EWT at 160°F and EAT of 40°F	
	Find the correction factor in TABLE C that satisfies the conditions listed. In this instance, it is 0.846. Multiply original BTUH output by the correction factor.	24,000 BUTH x 0.846 = 20,304 BTUH
III.	Determine Heating Capacity for WTD of 10°F	
	Find the correction factor in TABLE D that satisfies the conditions listed. In this instance it is 1.15. Multiply BTUH output by the correction factor.	20,304 BTUH x 1.15 = 23,350 BTUH
IV.	Determine Gallons per Minute (GPM) at 200°F EWT, 60°EAT, but with WTD of 10°F	
	Find the GPM from TABLE B for "catalog" conditions with High speed Fan Setting	2.42 GPM
	In TABLE D find the GPM Correction Factor for WTD of 10°F. In this case it is 2.30. Multiply original GPM by the correction factor.	2.42 GPM x 2.30 = 5.57 GPM
	Note: This formula applies only to units with 200°F EWT and 60°F EAT. For all other applications, use the formula shown (right):	GPM = BTUH ÷ (500 x WTD)
	Determine GPM for installation described in step III above at 10°F	23350 ÷ (500 x 10°F WTD) = 4.67 GPM
V.	Determine Water Pressure Drop (WPD) in Feet of Water at 10°F WTD	
	Find the GPM from step IV above	4.67 GPM
	On the Heat Exchanger Resistance Chart on page 6, find the WPD at 4.67 GPM on the left side axis. Follow it until it meets the line for Model WS23/33. From that point, follow the line down to the bottom axis to determine the WPD at 176°F mean water temperature.	0.14 FT H_2O (as marked)
	Determine the Correction Factor (K). The above example started with an EWT of 160°F and WTD of 10°F. That would result in water temperature at 150°F as it leaves the heater. Find the mean (average water temperature).	(160°F + 150°F) ÷ 2 = 155°F
	Find the Correction Factor (K) for the value nearest 155°F. At 158°F the Correction Factor (K) is 1.05. Multiply 1.05 by the WPD found on the chart 0.14 FT H_2O.	0.14 FT H_2O x 1.05 = 0.147 FT H_2O
VI.	Determine Heating Capacity for water flow rate of 3.03 GPM	
	Determine the Heating Capacity from TABLE B for "catalog" conditions with High Speed Fan Setting	24,000 BUTH
	Divide actual flow rate in GPM by cataloged flow rate found in TABLE B.	3.03 GPM ÷ 2.42 GPM = 125%
	In TABLE E find the MBH Correction Factor for a flow rate of 125%. In this case it is 1.04. Multiply original MBH by the correction factor.	24,000 BTUH x 1.04 = 24,960 BTUH
VII.	Determine Leaving Air Temperature (LAT) using the formula shown (right):	LAT = EAT+ BTUH ÷ (CFM x 1.085)
	In TABLE B find the Air Volume (cfm) for "cataloged" model and apply it conditions described in Step III above.	40°F + (23,350 BTUH ÷ (500 cfm x 1.085)) = 83°F

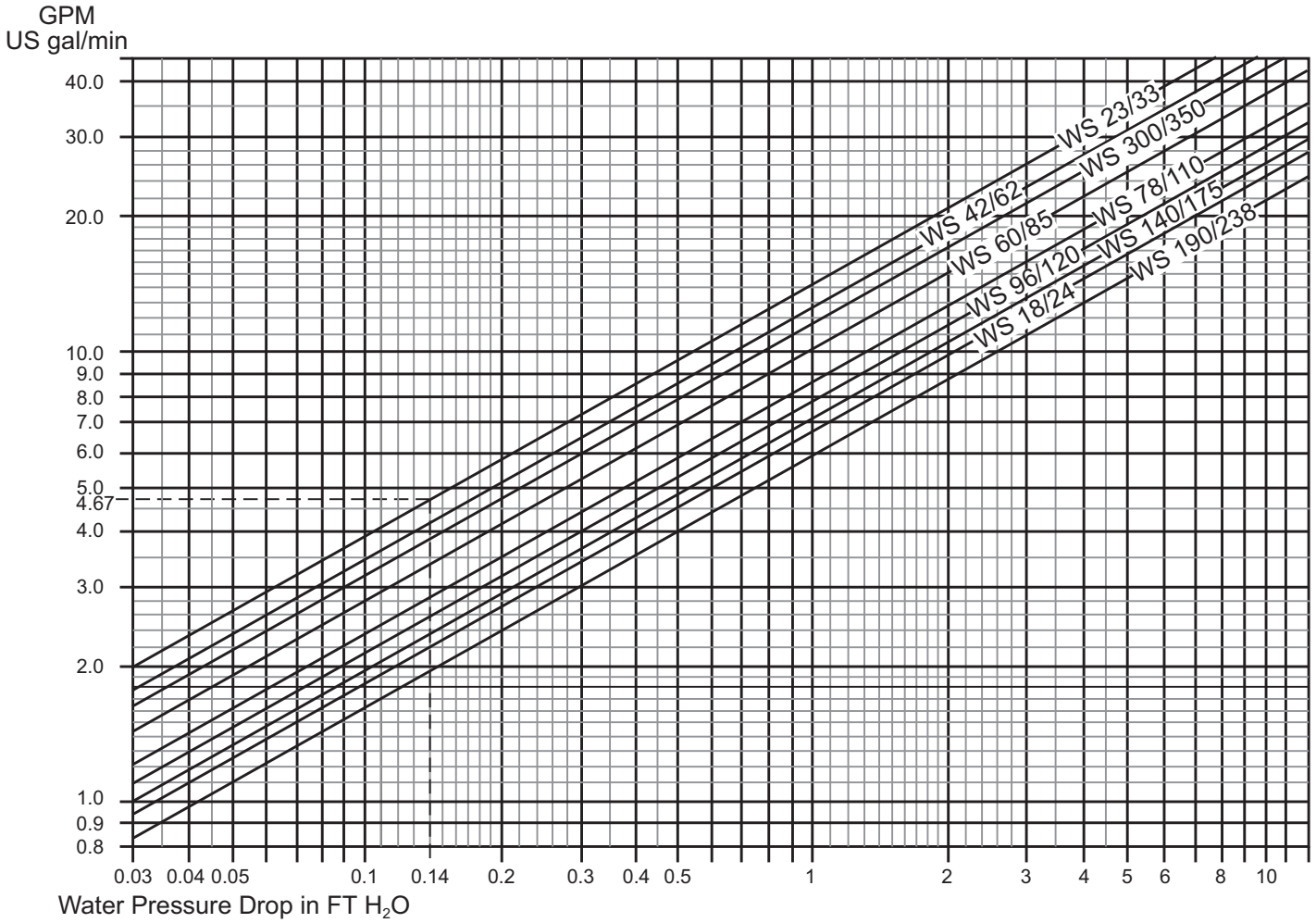
To obtain Pressure Loss Feet of water for other GPM see the graphic data on page 6.

HEAT EXCHANGER RESISTANCE CHART

The following table indicates the Water Pressure Drop (WPD) in FT H_2O for each model for a mean water temperature of 176°F (80°C)

Mean water temperature - °F, °C
Correction Factor - K

°C	°F	K
50	122	1.15
60	140	1.10
70	158	1.05
80	176	1.00
90	194	0.95
100	212	0.89
110	230	0.83
120	248	0.78
130	266	0.72
140	284	0.67
150	302	0.61



ENGINEERING DATA - TERMS, ABBREVIATIONS AND FORMULAS

Following is a list of terms, abbreviations and formulas to assist in specifying the correct size hydronic heating equipment for a specific application. All terms and abbreviations apply to both steam and hot water heating unless otherwise noted.

ATR Air Temperature Rise - The difference between the Entering Air Temperature (EAT) and the Leaving Air Temperature (LAT) due to the amount of heat added.
BTUH British Thermal Units per Hour - The common measure of heating output or capacity.
CFM Cubic Feet per Minute - The volume of air moved through the heater.
COND Condensate - The amount of water that results from removing heat from steam, measured in Pounds per Hour (lb/hr) - steam heat only.
EAT Entering Air Temperature - The temperature of the air just before it passes through the heat exchanger.
EDR Equivalent Direct Radiation - A measure of heat output measured in square feet - steam heat only.
EWT Entering Water Temperature - The temperature of the water as it enters the heat exchanger - hot water heat only.
FPM Feet Per Minute - The measure of the velocity of air as it leaves the heater.
GPM Gallons Per Minute - The measure of the flow of water that passes through the heat exchanger - hot water heat only.
L Latent heat of steam - steam heat only.
LAT Leaving Air Temperature - The temperature of the heated air just after it passes through the heat exchanger.
LWT Leaving Water Temperature - The temperature of the water as it leaves the heat exchanger - hot water heat only.
MBH One thousand BTUH
PSI Pounds per Square Inch - The measure of the pressure of steam in pipes - steam heat only.
RPM Rotations Per Minute - The number of rotations the fan will make in one minute.
WPD Water Pressure Drop - The resistance to the flow of water through a system created by friction between the water and piping - hot water heat only.
WTD Water Temperature Drop - The difference between the Entering Water Temperature (EWT) and the Leaving Water Temperature (LWT) due to the amount of heat removed - hot water heat only.

ATR = BTUH ÷ (CFM x 1.08)
LAT = EAT + BTUH ÷ (CFM x 1.08)
GPM = BTUH ÷ (WTD x 500)
WTD = BTUH ÷ (GPM x 500)

COND = BTUH ÷ L
COND = EDR ÷ 4
EDR = BTUH ÷ 240 (at 2 psi only)

ENGINEERING DATA - STEAM CAPACITIES, CALCULATIONS AND CORRECTION FACTORS

Use the following two tables to determine

1. Heating Capacity (MBH)
2. Leaving Air Temperature (LAT)
3. Condensate of water in lbs./hr.
4. Heat output measured in square feet of Equivalent Direct Radiation:

   1 ft^2 EDR = 240 BTUH at 2 psi steam

The performances reflected in these tables are based on the following:

Steam pressure: 2 Pounds per Square Inch (psi)
Entering Air Temperature (EAT): 60° (16°C)

TABLE A - Low Speed Fan Setting

Size	Approx. Fan rpm	MBH Output	Leaving Air Temp. (LAT) °F	Leaving Air Temp. (LAT) °C	Cond. lbs./hr	Sq.Ft. EDR
18/24	1,100	18	121°	50°	19	75
23/33	1,100	23	124°	51°	24	96
44/62	1,100	44	132°	56°	46	183
60/85	1,100	60	129°	54°	62	250
78/110	1,100	78	125°	52°	81	325
96/120	850	96	134°	57°	99	400
140/175	850	140	134°	57°	145	583
190/238	850	190	140°	60°	197	792
300/350	850	300	133°	56°	310	1,250

TABLE B - High Speed Fan Setting

Size	Approx. Fan rpm	MBH Output	Leaving Air Temp. (LAT) °F	Leaving Air Temp. (LAT) °C	Cond. lbs./hr	Sq.Ft. EDR
18/24	1,550	24	115°	46°	25	100
23/33	1,600	33	121°	49°	34	138
44/62	1,600	62	126°	52°	64	258
60/85	1,600	85	123°	50°	88	354
78/110	1,600	110	121°	50°	114	458
96/120	1,080	120	131°	55°	124	500
140/175	1,080	175	130°	55°	181	729
190/238	1,080	238	137°	58°	246	992
300/350	1,080	350	128°	53°	362	1,458

TABLE C - Steam Correction Factors for Steam Pressure and EAT different from cataloged information

Entering Air Temperature (EAT)		Steam Pressure - psi (saturated) 0	2	5	10	15	20	30	40	50	75	100	125	150
30°F	**-1°C**	1.19	1.24	1.29	1.38	1.44	1.50	1.60	1.68	1.70	1.90	2.02	2.11	2.20
40°F	**4°C**	1.11	1.16	1.21	1.29	1.34	1.42	1.51	1.60	1.60	1.81	1.93	2.02	2.11
50°F	**10°C**	1.03	1.08	1.13	1.21	1.28	1.33	1.43	1.51	1.58	1.72	1.84	1.93	2.02
60°F	**16°C**	0.96	1.00	1.05	1.13	1.19	1.25	1.35	1.43	1.50	1.64	1.75	1.84	1.93
70°F	**21°C**	0.88	0.93	0.97	1.06	1.12	1.17	1.27	1.35	1.42	1.55	1.66	1.76	1.84
80°F	**27°C**	0.81	0.85	0.90	0.98	1.04	1.10	1.19	1.27	1.34	1.47	1.58	1.68	1.76
90°F	**32°C**	0.74	0.78	0.83	0.91	0.97	1.02	1.12	1.19	1.26	1.39	1.50	1.59	1.67
100°F	**38°C**	0.67	0.71	0.76	0.84	0.89	0.95	1.04	1.12	1.19	1.32	1.42	1.51	1.59

TABLE D - Properties of Saturated Steam

	STEAM PRESSURE (PSIG) 1	1	2	4	6	8	10	15	25	50	75	100	125
STEAM PRESSURE (PSIA)	14.7	15.7	16.7	18.7	20.7	22.7	24.7	29.7	39.7	64.7	89.7	114.7	139.7
BOILING POINT OF STEAM °F	212	215.3	218.5	224.4	229.8	234.8	239.4	249.8	266.8	297.7	320.1	337.9	352.9
VOLUME OF 1 LB. OF STEAM CU. FT.	26.79	25.2	23.78	21.4	19.45	17.85	16.49	13.87	10.57	6.68	4.91	3.891	3.225
HEAT OF THE LIQUID BTUH	180	183.3	186.6	192.5	198	203	207.7	218.2	235.6	267.2	290.3	308.8	324.4
L - LATENT HEAT OF STEAM BTUH	970.4	968.2	966.2	962.4	958.8	955.5	952.5	945.5	933.6	911.2	894.2	880	867.8
TOTAL HEAT OF STEAM BTUH	1150.4	1151.6	1152.8	1154.9	1156.3	1158.6	1160.2	1163.7	1169.2	1178.4	1184.4	1188.8	1192.2

ENGINEERING DATA - STEAM CAPACITIES, CALCULATIONS AND CORRECTION FACTORS (cont'd)

The heating output of any particular installation is a function of many different factors. It is very seldom that any installation will exactly match the conditions described in the tables on the previous page. For those installations, correction factors must be used to determine heating output and other values.

Below is an example of conditions different from those given in TABLE A and B on the previous page. Following are procedures for determining heating output and other values at conditions other than "cataloged" conditions.

Example:	Unit	Reznor Model 23/33
	Steam Pressure	10 psi
	Entering Air Temperature (EAT)	40°F

I.	In TABLE B find the Heating Capacity for "catalog" conditions with High Speed Fan Setting	33,000 BTUH
II.	Determine Heating Capacity for steam pressure of 10 psi and EAT of 40°F	33,000 BUTH x 1.290 = 42,570 BTUH
	Find the conversion factor in TABLE C that satisfies the conditions listed. In this instance, it is 1.290. Multiply original BTUH output by the conversion factor.	
III.	Determine Leaving Air Temperature (LAT) using the formula shown (right):	LAT = EAT+ BTUH ÷ (CFM x 1.085)
	In TABLE B find the Air Volume (cfm) for "cataloged" model and apply it conditions described in Step II above.	40°F + (42,570 BTUH ÷ (500 cfm x 1.085)) = 118°F
IV.	Determine the condensate in pounds per hour (lbs/hr).	42,570 BTUH ÷ 952.5 = 44.7 lbs/hr of condensate
	Divide the heating output by the Latent Heat of steam found in TABLE D at 10psi. In this case it is 952.5.	
V.	Determine the Equivalent Direct Radiation (EDR) in square feet based on conditions in step IV using the formula shown (right):	EDR = 4 x condensate (lbs/hr)
		4 x 44.7 lbs/hr = 179 sq. ft. EDR