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ONE AND TWO PIPE SYSTEMS - MAINS AND RISERS

The steam system piping recommendations that follow are designed to help guide an individual working on existing systems; systems that may require alterations or additions for a variety of reasons. These recommendations are conservative but in light of many unknown variables, they will serve one well.

TWO PIPE STEAM

1. STEAM MAIN Capacity in Sq. Ft. E.D.R.

Size of Pipe in In.	Distance of Main		
	100'	200'	300'
2	650	461	375
2-1/2	1,030	731	595
3	1,860	1,320	1,075
4	3,800	2,698	2,196
6	11,250	7,987	6,502
8	22,250	15,797	12,860
10	40,800	28,968	23,582
12	66,000	46,860	38,148

Note: Mains must be pitched for steam & condensate to flow in same direction.

2. STEAM RISERS

Maximum Capacity (Sq. Ft. E.D.R.) at Various Riser Pitch With Steam and Condensate Flowing in Opposite Direction.

Pipe Size in In.	Pitch of Pipe per 10' Length				
	1"	2"	3"	4"	5"
3/4	22.8	28.4	33.2	38.6	42.0
1	46.8	59.2	69.2	76.8	82.0
1-1/4	79.6	108.0	125.2	133.6	152.4
1-1/2	132.0	168.0	187.2	203.2	236.8
2	275.2	371.6	398.4	409.6	460.0

Note: Above E.D.R. is maximum. Greater load will cause problems with increased steam velocities.

3. CONDENSATE RETURN MAINS (Horizontal, Pitched)

Capacity based on sq. ft. E.D.R. (2 oz PD per 100')		
Pipe Size in In.	Dry Return	Wet Return
1	370	900
1-1/4	780	1,530
1-1/2	1,220	2,430
2	2,660	5,040
2-1/2	4,420	8,460
3	8,100	13,500
4	17,380	27,900

4. CONDENSATE RETURN RISERS (Vertical, Horizontal Pitch)

Capacity Based on Sq. Ft. (E.D.R.) (2 oz. PD per 100')	
Pipe Size	Dry Return
3/4"	170
1"	410
1¼”	890
1½”	1,350

ONE PIPE STEAM

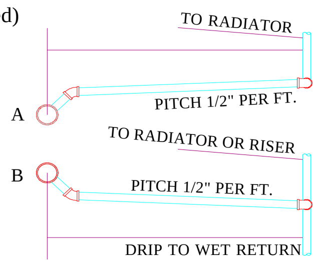
1. STEAM MAIN

Capacity in Sq. Ft. (E.D.R.) (Based on 2 oz. PD)		
Pipe Size Inches	T.E.L. 100'	T.E.L. 200'
2"	350	235
2½”	580	385
3"	1,050	700
4"	2,210	1,480
6"	6,880	4,480

Notes: Mains must be pitched for steam & condensate to flow in same direction. If steam and condensate counterflows, increase piping one size.

2. STEAM RISER - Capacity in Sq. Ft. (E.D.R.)
(Up-feed Riser - Horizontal Travel
8' Max. - Riser Not Dripped)

Pipe Size Inches	Sq. Ft. E.D.R.
1"	25
1¼”	55
1½”	85
2"	150



Notes:
(A) Horizontal travel beyond 10' increase one size
(B) Horizontal travel sloped down and dripped decrease one size

3. DRY RETURN - Capacity in Sq. Ft. (E.D.R.)

Pipe Size	Sq. Ft. (E.D.R.)
1-1/4”	640
1-1/2”	1,000
2"	2,180

4. WET RETURN - Capacity in Sq. Ft. (E.D.R.)

Pipe Size	Sq. Ft. (E.D.R.)
1-1/4”	1,100
1-1/2”	1,700
2"	3,600

NUMBER OF SMALLER PIPES EQUIVALENT TO ONE LARGER PIPE												
PIPE SIZE	**PIPE SIZE**											
	1/2"	**3/4"**	**1"**	**1-1/4"**	**1-1/2"**	**2"**	**2-1/2"**	**3"**	**3-1/2"**	**4"**	**5"**	**6"**
1/2"	1	2.27	4.88	10	15.8	31.7	52.9	96.9	140	205	377	620
3/4"		1	2.05	4.3	6.97	14	23.2	42.5	65	90	166	273
1"			1	2.25	3.45	6.82	11.4	20.9	30	44	81	133
1-1/4"				1	1.5	3.1	5.25	9.1	12	19	37	68
1-1/2"					1	2	3.34	6.13	9	13	23	39
2"						1	1.67	3.06	4.5	6.5	11.9	19.6
2-1/2"							1	1.82	2.7	3.87	7.12	11.7
3"								1	1.5	2.12	3.89	6.39
3-1/2"									1	1.25	2.5	4.25
4"										1	1.84	3.02
5"											1	1.65
6"												1

STEAM VELOCITIES IN STEAM PIPING

To obtain steam velocity in feet per second, multiply load by proper factor shown below.

Initial Pressure of Dry Steam		**PIPE SIZE - INCHES**											
		1"	**1-1/4"**	**1-1/2"**	**2"**	**2-1/2"**	**3"**	**4"**	**5"**	**6"**	**8"**	**10"**	**12"**
Sq. Ft. EDR Factor	5 PSI Gauge			.1000	.0610	.0425	.0276	.0160	.0101	.0071	.0041	.0026	.00182
	2 PSI Gauge	.2750	.1580	.1170	.0700	.0490	.0320	.0186	.0118	.0082	.0047	.0030	.0021
	0 PSI Gauge	.3094	.1778	.1316	.0788	.0551	.0360	.0209	.0133	.0093	.0054	.0034	.0024

FRICTION LOSSES - FLOW OF STEAM THROUGH PIPES

Based On: Dry Steam at 2PSI Gauge Initial Pressure. Schedule 40 Steel Pipe.
Loads: Are in Sq. Ft. EDR.

Friction Losses: Are in ounces per 100 linear feet of pipe, or the equivalent.
For Capacities In Pounds Per Hour: Divide Sq. Ft. EDR by 4.

LOAD SQ. FT. EDR	PRESSURE LOSS OUNCES - PER 100 FEET OF STEEL PIPE							
	PIPE SIZE - INCHES							
	3/4"	**1"**	**1¼"**	**1½"**	**2"**	**2½"**	**3"**	**4"**
30	0.80							
35	1.05							
40	1.31							
45	1.62							
50	1.95	.60						
75	4.01	1.21						
100	6.7	2.05	.54					
125	10.2	3.07	.80					
150	14.3	4.27	1.12	.54				
175	18.9	5.7	1.48	.70				
200	24.3	7.2	1.88	.89				
225		9.0	2.33	1.11				
250		10.9	2.83	1.33				
275		13.2	3.35	1.59				
300		15.4	3.92	1.86				
350		20.6	5.2	2.47				
400		26.5	6.7	3.15	.92			
450			8.3	3.90	1.14			
500			10.0	4.75	1.38			
550			12.0	5.6	1.64			
600			14.1	6.6	1.91			
650			16.4	7.7	2.22			
700			19.0	8.8	2.55	1.06		
800			24.4	11.4	3.27	1.35		
900				14.1	4.05	1.68		
1000				17.2	4.93	2.04		
1100				20.6	5.9	2.43		
1200				24.3	6.9	2.85		
1300				28.3	8.1	3.32	1.14	
1400					9.3	3.81	1.30	
1500					10.6	4.31	1.48	
1600					11.9	4.89	1.66	
1700					13.4	5.5	1.86	
1800					14.9	6.1	2.07	
1900					16.6	6.8	2.28	
2000					18.2	7.5	2.51	
2200					21.8	8.9	3.00	
2400					25.8	10.6	3.53	
2600						12.3	4.08	1.08
2800						14.1	4.73	1.24
3000						16.1	5.4	1.40
3200						18.2	6.1	1.58
3500						21.6	7.2	1.86
4000						27.9	9.2	2.41
4500							11.5	2.98
5000							14.1	3.62
5500							16.9	4.34
6000							[illegible]	5.1

PROPERTIES OF SATURATED STEAM

Pressure psig	Temp °F	Heat in BTU/lb. Sensible	Latent	Total	Specific Volume Cu. ft. per lb.
Inches Vac 25	134	102	1017	1119	142
20	162	129	1001	1130	73.9
15	179	147	990	1137	51.3
10	192	160	982	1142	39.4
5	203	171	976	1147	31.8
0	212	180	970	1150	26.8
1	215	183	968	1151	25.2
2	219	187	966	1153	23.5
3	222	190	964	1154	22.3
4	224	192	962	1154	21.4
5	227	195	960	1155	20.1
6	230	198	959	1157	19.4
7	232	200	957	1157	18.7
8	233	201	956	1157	18.4
9	237	205	954	1159	17.1
10	239	207	953	1160	16.5
12	244	212	949	1161	15.3
14	248	216	947	1163	14.3
16	252	220	944	1164	13.4
18	256	224	941	1165	12.6
20	259	227	939	1166	11.9
22	262	230	937	1167	11.3
24	265	233	934	1167	10.8
26	268	236	933	1169	10.3
28	271	239	930	1169	9.85
30	274	243	929	1172	9.46
32	277	246	927	1173	9.10
34	279	248	925	1173	8.75
36	282	251	923	1174	8.42
38	284	253	922	1175	8.08
40	286	256	920	1176	7.82
42	289	258	918	1176	7.57
44	291	260	917	1177	7.31
46	293	262	915	1177	7.14
48	295	264	914	1178	6.94
50	298	267	912	1179	6.68
55	300	271	909	1180	6.27
60	307	277	906	1183	5.84
65	312	282	901	1183	5.49
70	316	286	898	1184	5.18
75	320	290	895	1185	4.91
80	324	294	891	1185	4.67
85	328	298	889	1187	4.44
90	331	302	886	1188	4.24
95	335	305	883	1188	4.05
100	338	309	880	1189	3.89
105	341	312	878	1190	3.74
110	344	316	875	1191	3.59

RELATIONS OF ALTITUDE, PRESSURE & BOILING POINT

Altitude Feet	Atmospheric Pressure Absolute		Boiling Point of Water °F (Gage Pressure PSI)				
	Inches of Mercury (Barometer)	Lbs. per Sq. In.	0	1	5	10	15
-500	30.46	14.96	212.8	216.1	227.7	239.9	250.2
-100	30.01	14.74	212.3	215.5	227.2	239.4	249.9
Sea Level	29.90	14.69	212.0	215.3	227.0	239.3	249.7
500	29.35	14.42	211.0	214.4	226.3	238.7	249.2
1000	28.82	14.16	210.1	213.5	225.5	238.1	248.6
1500	28.30	13.90	209.4	212.7	225.0	237.6	248.2
2000	27.78	13.65	208.2	211.7	224.1	236.8	247.7
2500	27.27	13.40	207.3	210.9	223.4	236.3	247.2
3000	26.77	13.15	206.4	210.1	222.7	235.7	246.7
3500	26.29	12.91	205.5	209.2	222.1	235.1	246.2
4000	25.81	12.68	204.7	208.4	221.4	234.6	245.7
4500	25.34	12.45	203.7	207.5	220.7	234.0	245.2
5000	24.88	12.22	202.7	206.8	220.1	233.4	244.7
6000	23.98	11.78	200.9	205.0	218.7	232.4	243.8
7000	23.11	11.35	199.1	203.3	217.3	231.3	242.9
8000	22.28	10.94	197.4	201.6	216.1	230.3	242.0
9000	21.47	10.55	195.7	200.0	214.8	229.3	241.3
10000	20.70	10.17	194.0	198.4	213.5	228.3	240.4
11000	19.95	9.80	192.2	196.8	212.3	227.3	239.6
12000	19.23	9.45	190.6	195.2	211.1	226.3	238.7
13000	18.53	9.10	188.7	193.6	209.9	225.4	237.9
14000	17.86	8.77	187.2	192.3	208.8	224.5	237.2
15000	17.22	8.46	185.4	190.6	207.6	223.6	236.4

EXPANSION OF PIPES IN INCHES PER 100 FT

Temp. Degrees F.	Cast Iron	Wrought Iron	Steel	Brass or Copper
0	0.00	0.00	0.00	0.00
50	0.36	0.40	0.38	0.57
100	0.72	0.79	0.76	1.14
125	0.88	0.97	0.92	1.40
150	1.10	1.21	1.15	1.75
175	1.28	1.41	1.34	2.04
200	1.50	1.65	1.57	2.38
225	1.70	1.87	1.78	2.70
250	1.90	2.09	1.99	3.02
275	2.15	2.36	2.26	3.42
300	2.35	2.58	2.47	3.74
325	2.60	2.86	2.73	4.13
350	2.80	3.08	2.94	4.45

STEAM SUSPENDED UNIT HEATERS/UNIT VENTILATORS

Output is normally based on 2PSI steam/60° entering air. Output will increase or decrease with changes in steam pressure and/or entering air.

FACTORS			FOR CONVERSION OF BASIC STEAM RATINGS @ 2 lbs. ga./60 deg. entering air to various conditions of steam pressure and air temperature											
STEAM			ENTERING AIR TEMP. DEG. F.											
lbs. per sq. in	Temp ºF	l. heat Btu/lb.	-10	0	10	20	30	40	50	60	70	80	90	100
0	212.0	970.2					1.19	1.11	1.03	.96	.88	.81	.74	.67
2	218.5	966.2				1.32	1.24	1.16	1.08	1.00	.93	.85	.78	.71
5	227.2	960.5	1.64	1.55	1.46	1.37	1.29	1.21	1.13	1.05	.97	.90	.83	.76
10	239.4	952.5	1.73	1.64	1.55	1.46	1.38	1.29	1.21	1.13	1.06	.98	.91	.84
15	249.7	945.5	1.80	1.71	1.61	1.53	1.44	1.34	1.28	1.19	1.12	1.04	.97	.90

Note: If it is found that operting conditions create a final air temperature below 90°, the output air stream may be uncomfortable and steam pressure should be increased.

Problem: Condensate will increase. How much?

Example: A unit heater rated at 100,000 btuh (2 psi/60° e.a.) is installed with 50° entering air but final air temperature is below 90°.

Factory Rating: 100,000 btuh ÷ 966.2 (latent heat at 2 psi) = 103.5 lbs. per hr.

Operating Conditions: 100,000 x 1.08 (50° e.a.) ÷ 966.2 = 111.8 lbs. per hr.

Increasing pressure to 5 psi: 100,000 x 1.13 ÷ 960.5 = 117.7 lbs. per hr.

STEAM CONVERSION FACTORS

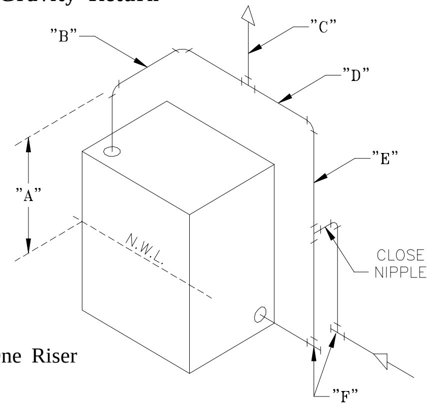
MULTIPLY	BY	TO GET
• Boiler Horsepower (BHP)	34.5	Lb. of Steam Water per hour (lb/hr)
• Boiler Horsepower (BHP)	0.069	Gallons of Water Per Minute (GPM)
• Sq. Feet of Equivalent Direct Radiation (EDR)	0.000637	Gallons of Water per Minute(GPM)
• Boiler Horsepower (BHP)	33,479	B.T.U.
• Boiler Horsepower (BHP)	108	Sq. Feet of Equivalent Direct Radiation (EDR)
• Lbs. of Steam Water per Hour (lb/hr)	0.002	Gallons of Water per Minute(GPM)
• Lbs. per square inch	2.307	Feet of Water
• Lbs. per square inch	2.036	Inch of Mercury
• Feet of Water (head)	0.4335	Lbs. per square inch
• Inch of Mercury	13.6	Inch of Water Column
• Gallons of Water	8.34	Lbs. of Water
• Cubic Feet of Water	7.48	Gallons of Water
• Cubic Feet per Minute	62.43	Lbs. of Water per Minute
• Cubic Feet per Minute	448.8	Gallons per hour
• Cubic Centimeters per ltr. of Oxygen	1,400	Parts per billion of Oxygen
• Lbs. of Condensate	4	Sq. ft. E.D.R.

Note: Use above factors to match condensate return and boiler feed equipment with boiler size.

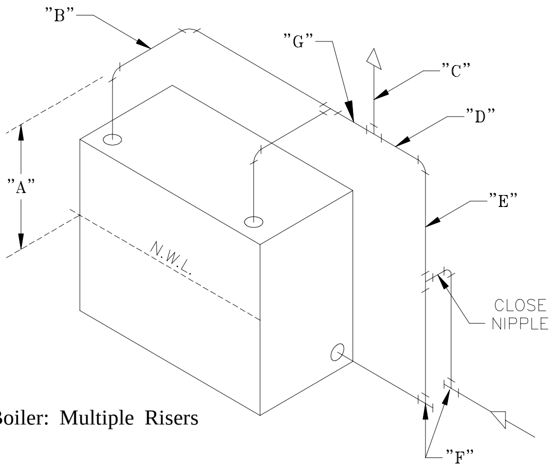
- Size Condensate Receivers for 1 min. net storage capacity based on return rate.
- Size Boiler Feed Receivers for system capacity (normally estimated at 10 min.)
- Size Condensate Pumps at 2 to 3 times condensate return rate.
- Size Boiler Feed Pumps at 2 times boiler evaporation rate or .14 GPM/boiler HP (continuous running boiler pumps may be sized at 1-1/2 times boiler evaporation rate or .104 GPM/boiler HP)

STEAM PIPING BOILER DETAIL

A. Steam: Gravity Return



Boiler: One Riser



Boiler: Multiple Risers

A. 24" vertical rise.

B. Horizontal traverse to line up header with rear return tapping.

C. Vertical rise to existing main. Same size as header.

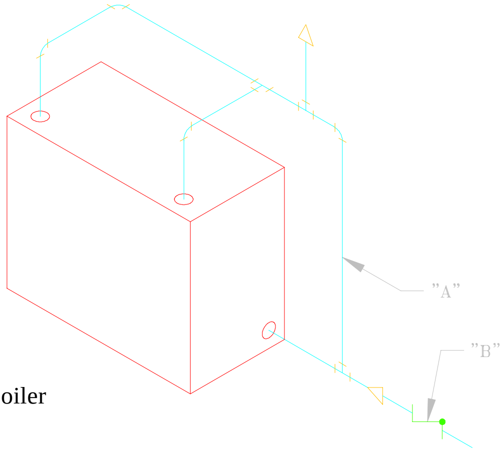
D. Nipple: 6" residential; 12" commercial.

E. Hartford Loop. Height/size, consult manufacturer.

F. Preferable use plugged tees in lieu of 90° elbow in wet returns.

G. Header all steam risers before moving steam to system.

B. Steam: Pump Return



Single Boiler

Notes refer to Single & Multiple Boilers

A. Header drip. Use in lieu of Hartford Loop when pump returns condensate. Size same as equalizer. May reduce below W.L.

B. Install check valve. Preferably lift check in lieu of swing.

C. Install F & T trap in header drip at N.W.L. Will maintain proper water level in unfired boilers. Return overflow to condensate receiver.

D. Multiple boilers with common boiler feed system must have each boiler return isolated with motorized valves.

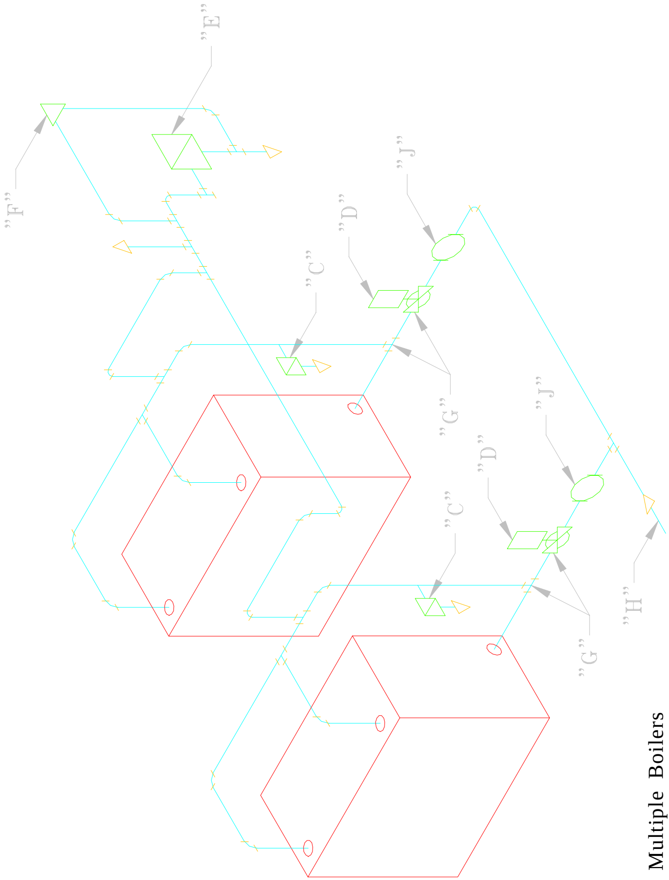
E. Initial call for steam may create excess condensate in common drop header. F & T trap will safely guide condensate to condensate receiver.

F. Thermostatic trap piped from header to F & T will help remove air from header.

G. Size motorized valve by GPM flow. Increase pipe size between solenoid and boiler to reduce water velocity into boiler. See recommendations for water flow on condensate pump piping detail.

H. See pump piping detail for condensate return to boiler.

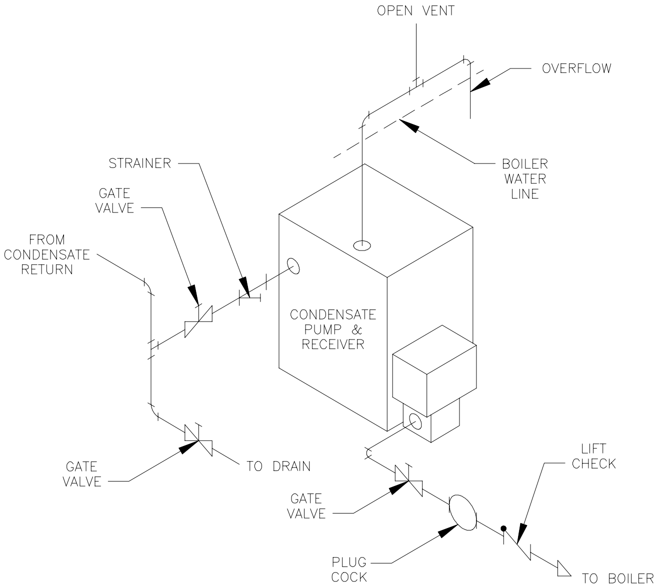
J. Plug valves must be installed next to each motorized valve to regulate GPM flow to each boiler from common pumping.



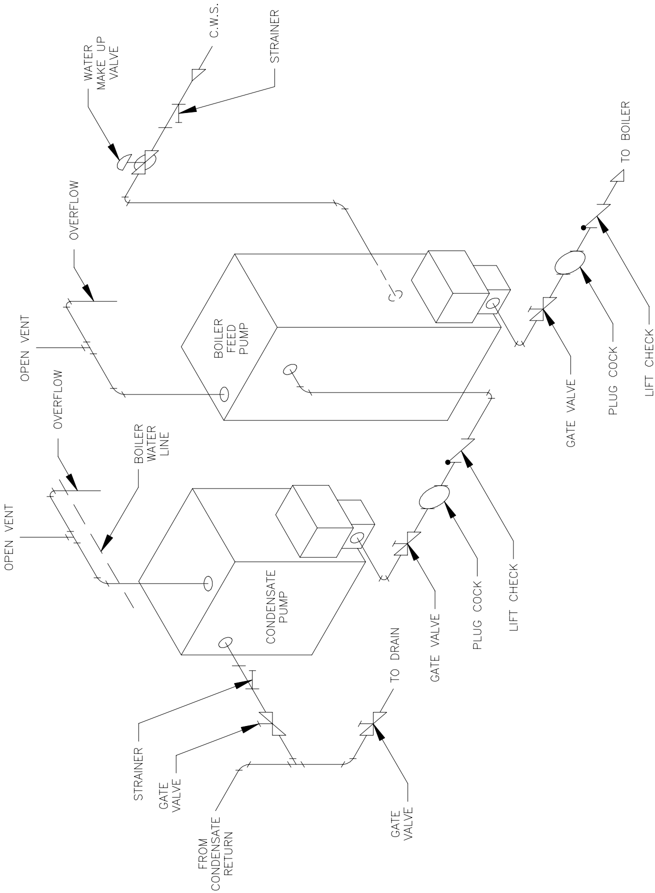
Multiple Boilers

STEAM PIPING - PUMP DETAIL

A. Condensate Pump



B. Boiler Feed Pump and Condensate Pump

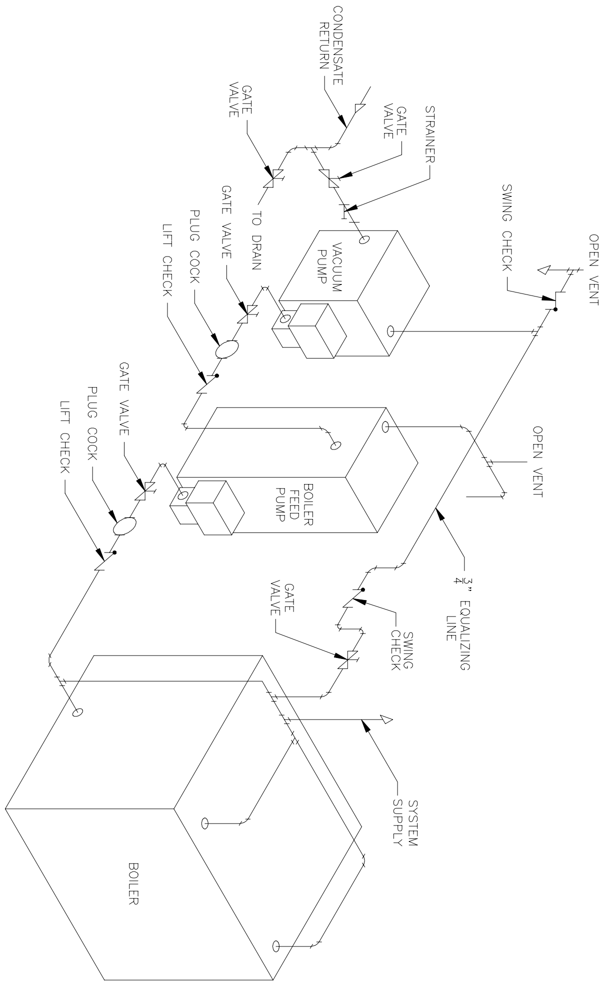


Control of Combination Units

- Condensate Unit. Float mechanism in receiver operates pump. It will move water to the boiler feed receiver.
- Boiler Feed Unit. Pump Controller (#150/42A McDonnell-Miller are typical) will control the movement of water directly to the boiler. Should the water in the boiler feed receiver drop too low, an installed water make-up valve will raise the receiver to a safe level.

C. Boiler Feed and Vacuum Pumps

Control & Pipe (same as Boiler Feed & Condensate Pump)
Additional Piping: Equalizing line between boiler steam header and vacuum pump. Equalizing line will prevent a possible vacuum developing in steam supply that could be greater than vacuum in the return.



SIZING OF VACUUM PUMP

Vacuum condensate pumps are normally sized at 2 or 3 times the system condensing rate. This is the same procedure for sizing standard condensing rate. The vacuum pump must also remove air from the return system. The system size, the inches of vacuum desired, and tightness of the system piping must be considered. The following chart will help.

Air Removal Requirements

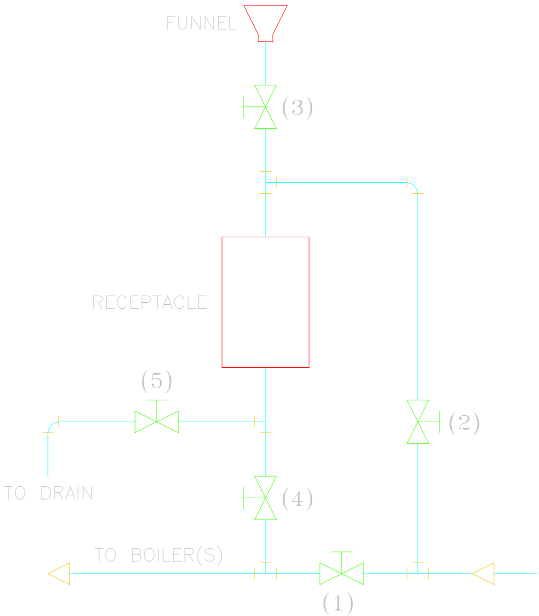
System	Vac/In. Hg.	CFM/1,000 EDR
• up to 10,000 EDR (tight)	0-10	.5
• over 10,000 EDR (tight)	0-10	.3
• all systems, some air in-leakage	0-10	1.0

HIGHEST TEMPERATURE °F OF CONDENSATE PERMISSIBLE WITH VACUUM PUMPS

Vacuum Inches of Mercury in Pump Receiver	Highest Permissible Temperature of Condensate °F
15	179
12	187
10	192
8	196
6	201
4	205
2	209
1	210

STEAM PIPING CHEMICAL FEED TO BOILER

Placement of Chemical Feed to Boiler



• Between boiler and boiler feed pump.
• Chemical treatment added ahead of the pump suction will increase the friction and shorten the life of the mechanical pump seals.

Procedure
• Open valve (3).
• Pour chemicals into funnel to rest in receptacle.
• Close valves (1) - (3) - (5); open valves (2) - (4). Condensate will move from the pump through the receptacle and take the chemicals to the boiler.
• When feeding is complete, close valves (2) and (4), thenopen valve (1).
• Residue in receptacle may be drained by opening valve (5).

CONVERTING A STEAM SYSTEM TO HOT WATER

GUIDELINES

1. If the heat emitters are cast iron radiators make certain that the sections are nippled (connected) at both the top and bottom.

2. Size boiler based on a calculated heat loss not installed radiation.

3. Measure the installed radiation. Divide total E.D.R. (sq. ft.) into the calculated heat loss. The answer will indicate the number of BTU's each sq. ft. of radiation must develop at outdoor design temperature.

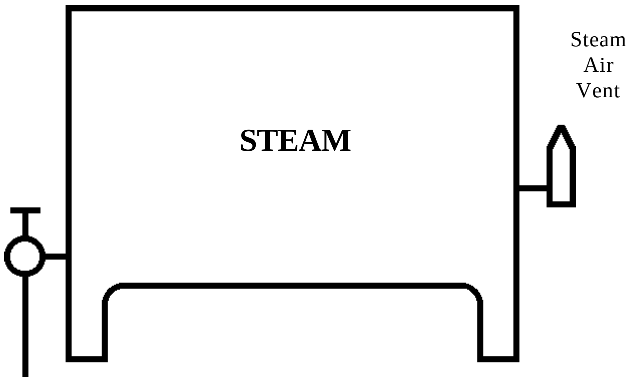
Refer to the chart on page 22. In the BTU column move horizontally to the number nearest your calculation. Above that number will be the maximum system temperature you need. Vertically below will be the amount of radiation (sq. ft.) that the various pipe sizes will handle.

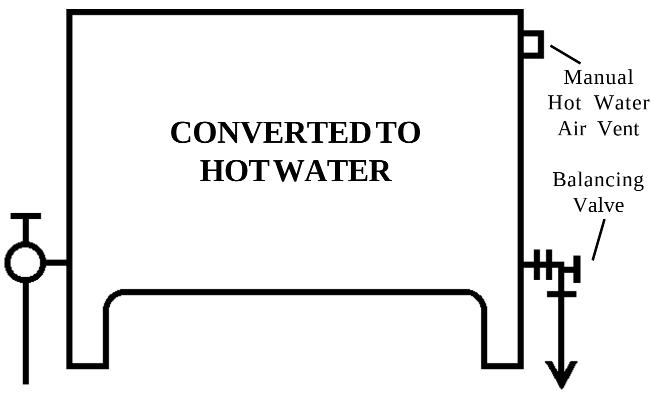
4. **One-Pipe Steam System:** Existing steam mains and risers may be reused. However, new return risers and return main must be installed. Use the chart on page 13 to determine their size.

5. **Two-Pipe Steam System:** With the exception of the near boiler piping, all the system piping (steam mains, risers, and condensate returns) may be reused. Typically, a residential steam system that has 2" steam mains will have a minimum 1 1/4" dry return. If the heat loss is less than the 160 MBH that 1 1/4" dry return would be of sufficient size. The chart on page 13 gives the MBH capacity of pipe sizes from 1/2" to 2".

6. Regardless of the system, never reuse existing wet return piping.

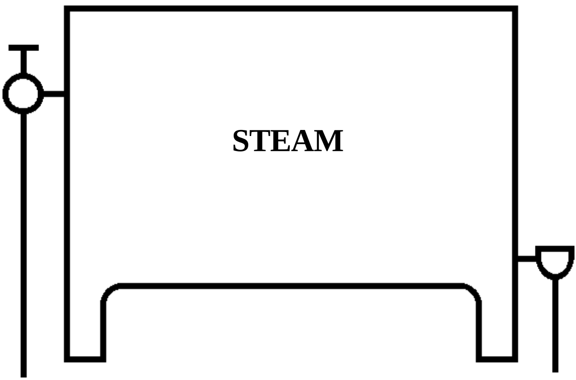
ONE PIPE STEAM (Figure 1)

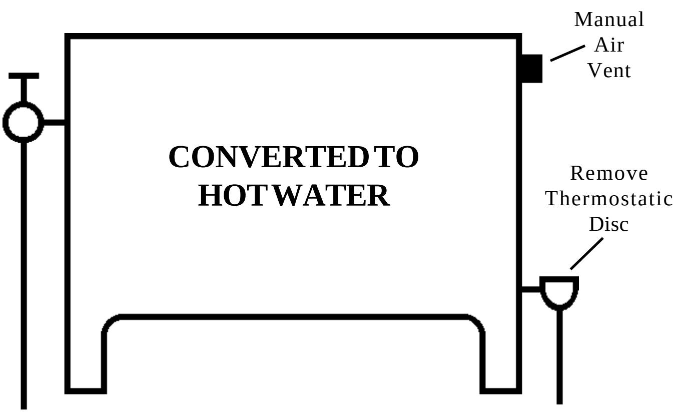




NOTE: Radiator must be nippled top & bottom.

TWO PIPE STEAM (Figure 2)





Capacity Basis: 70°F Room Temperature 20°F Temperature Drop												
Sq. Ft. Radiation												
Temp.		215°	200°	190°	180°	170°	160°	150°	140°	130°	120°	110°
BTU		240	210	190	170	150	130	110	90	70	50	30
Pipe Size	MBH											
1/2"	17	71	81	90	100	113	131	155	189	243	340	567
3/4"	39	163	186	205	229	260	300	355	433	557	780	1300
1"	71	296	338	374	418	473	546	646	789	1014	1420	2367
1 1/4"	160	667	762	842	914	1067	1231	1455	1778	2286	3200	5333
1 1/2"	240	1000	1143	1263	1412	1600	1846	2182	2667	3429	4800	8000
2"	450	1875	2143	2368	2647	3000	3462	4091	5000	6429	9000	15000

Use chart to determine BTU load on radiation converted from steam to H.W.
Note: Heat loss of building will determine BTU load on system piping.
Divide sq. ft. of installed radiation into heat loss = BTU load per sq. ft.

Pipe Capacity in MBH
at 500 Milinches Restriction Per Foot of Pipe

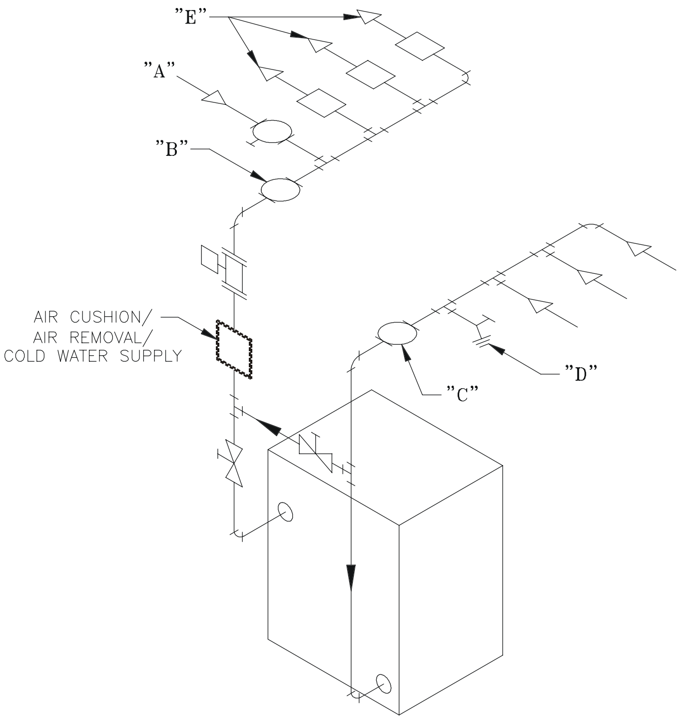
Pipe Size	MBH	+Friction Head Feet Per 100'	G.P.M. at 20° T.D.	Velocity Flow of Water	
				Inches Per Sec.	Ft. Per Min.
1/2"	17	4.2'	1.7	23	115
3/4"	39	4.2'	3.9	27	135
1"	71	4.2'	7.1	34	170
1-1/4"	160	4.2'	16.0	40	200
1-1/2"	240	4.2'	24.0	*45	225
2"	450	4.2'	45.0	*54	270
2-1/2"	750	4.2'	75.0	*62	310
3"	1400	4.2'	140.0	*72	360
4"	2900	4.2'	290.0	*80	400

* - Maximum velocity flow

+ - In order for a pump to move the G.P.M. listed, the pump must overcome a friction head of 4.2 feet per 100' of pipe travers. (Total Equivalent Length)

Example: If one wants to carry 16 gpm in a 1-¼" pipe through a pipe circuit of 300' (T.E.L.), the pump must overcome a friction head of 4.2' x 3 or 12.6 ft. In other words, the pump specification would be to pump 16 gpm against a 12.6 friction head.

SYSTEM PURGE IN LIEU OF AIR VENTS



(A) Separate ½" C.W.S. with Globe valve or by-pass P.R.V.
(B) Ball valve: optional but preferred
(C) Ball valve
(D) Hose bib (for purging)
(E) Zone valves or ball valves

SYSTEM PURGE IN LIEU OF AIR VENTS

APPLICATION

Any series loop piping, especially where system high points may be con- cealed or venting is impractical. "System purge" is designed to remove air initially from the piping system, especially the high points.

GUIDELINES

After the initial removal of air it is important for the system to be able to handle air that will develop when the system water is heated. Installation of an air scoop or an in-line airtrol at the boiler supply will be necessary to either vent the air from the system or direct the air to a standard expansion tank.

A system purge is recommended only on Series Loop Installations. If other than non-ferrous baseboard is used, such as Base-Ray, the interconnecting pipe will purge but vents must be placed on each free standing assembly of Base-Ray.

PROCEDURE

1. Fill system with water. Isolate boiler by closing valves (B) and (C).

2. Begin purge by opening first zone or loop. Next, open valve (A) (cold water supply). Finally and immediately, open hose bib (D). Once water flows freely, close the first zone or loop and then do the same for the remaining zones or loops.

INDIRECT DOMESTIC HOT WATER PIPING

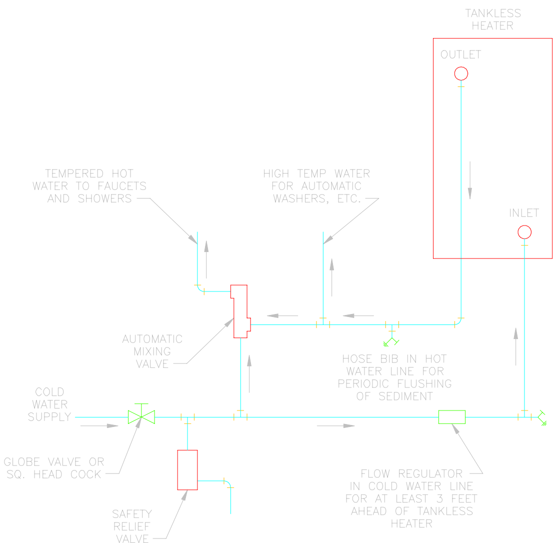
1. APPLICATION

A. Tankless Heater: Piping below is essential for safe and reliable operation.

B. Storage Heater: If the storage water temperature is maintained at or below 120°F, piping below is unnecessary.

If there is need to increase the storage, this can be accomplished by storing hotter water then tempering it. This will necessitate the piping below.

2. PIPING SCHEMATIC



(1) Preferably the mixing valve should be set no higher than 120°F. Install mixing valve 15" below H.W. outlet. This will create a beneficial cooling leg.

(2) Automatic Flow Regulator (tankless only) must match GPM rating of the tankless. If piped downstream of mixing valve, GPM flow will increase if heater water is hotter than 120°F.

(3) Placement of hose bibs will permit periodic back flushing of heater (coil).

3. INDIRECT DOMESTIC HOT WATER CONCERN

Scalding: Temperature - Minimum Time - Degree of Burn

Temp (°F)	1st Degree	2nd & 3rd Degree
111.2°	5 hrs.	7 hrs.
116.6°	35 min.	45 min.
118.4°	10 min.	14 min.
122.0°	1 min.	5 min.
131.0°	5 sec.	22 sec.
140.0°	2 sec.	5 sec.
149.0°	1 sec.	2 sec.
158.0°	1 sec.	1 sec.

INDIRECT SWIMMING POOL HEATING

APPLICATION

The use of a house heating boiler to indirectly heat a swimming pool is possible and even desirable. A factor of major significance would be comparable heat loads.

SIZING CONSIDERATIONS

Gallons of water to heat, temperature rise, and time allotted for temperature rise.

1. SIZING FORMULA (INITIAL RAISING OF WATER TEMPERATURE)

Gallons of Water = Pool (width x length x avg. depth) x 7.48 (gal. per cu. ft.)

Gallons of water x 8.34 x temp. rise ÷ hours to heat pool = BTUH

Example: Pool (40' x 20' x 5' avg.)
with initial pool water of 55°F to be raised to 75°F
allowing 48 hours to raise temperature

40' x 20' x 5' x 7.48 = 29,920 gallons of water

29,920 x 8.34 x 20 ÷ 48 = 103,972 BTUH (I=B=R Net Ratings).

2. HEAT LOSS FROM POOL SURFACE*
(MAINTAINING WATER TEMPERATURE)

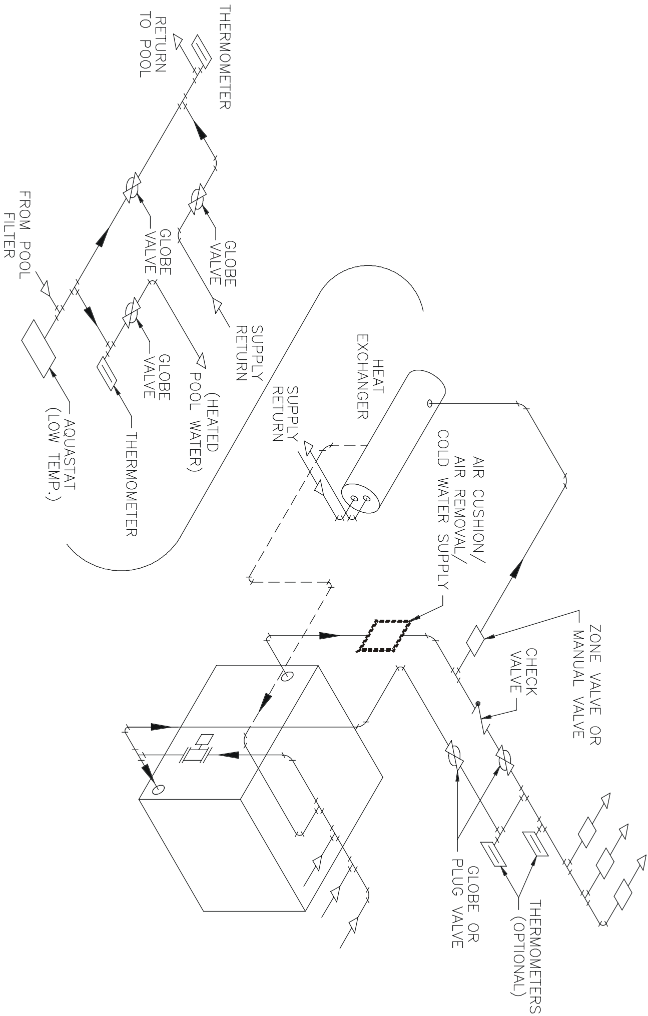
Temperature Difference °F	10°	15°	20°	25°	30°
BTUH/per Sq. Ft.	105	158	210	263	368

Notes: •Assumed wind velocity: 3.5 mph
Wind velocity of 5 mph multiply BTUH by 1.25
Wind velocity of 10 mph multiply BTUH by 2.00
•Temperature Difference: Ambient air and desired water temp.

* Maintaining pool temperature when outside air is 20° to 30°F lower than pool water may require a larger boiler.

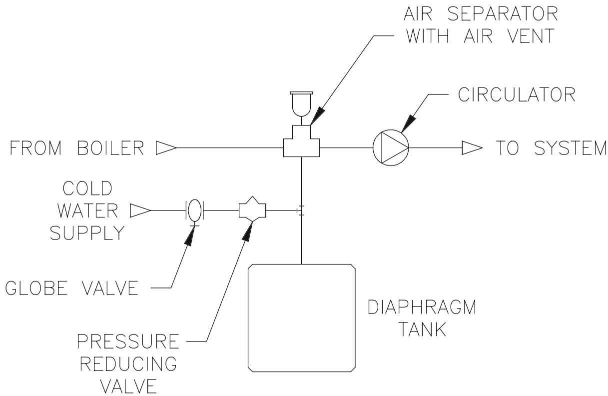
PIPING: INDIRECT SWIMMING POOL HEATING

Note: By-pass enables one to regulate flow through heat exchanger and also provide a manual disconnect from heating system.

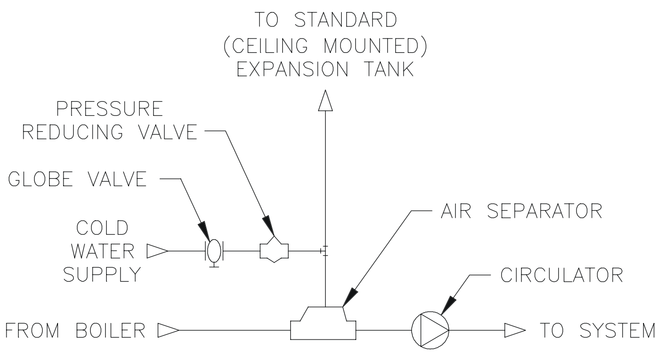


PIPING: HOT WATER SYSTEM AIR CUSHION AND AIR REMOVAL OPTIONS

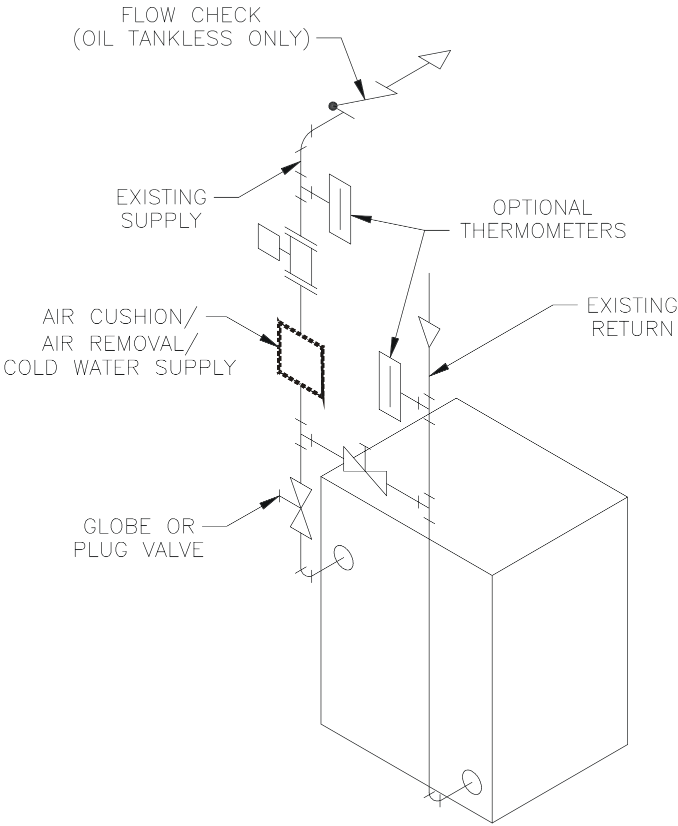
AIR REMOVAL SYSTEM



AIR CONTROL SYSTEM



1. BOILER BY-PASS - ONE ZONE



1. BOILER BY-PASS - ONE ZONE (CONT.)

PURPOSE FOR BY-PASS

GAS BOILER CONNECTED TO LARGE WATER CONTENT RADIATION

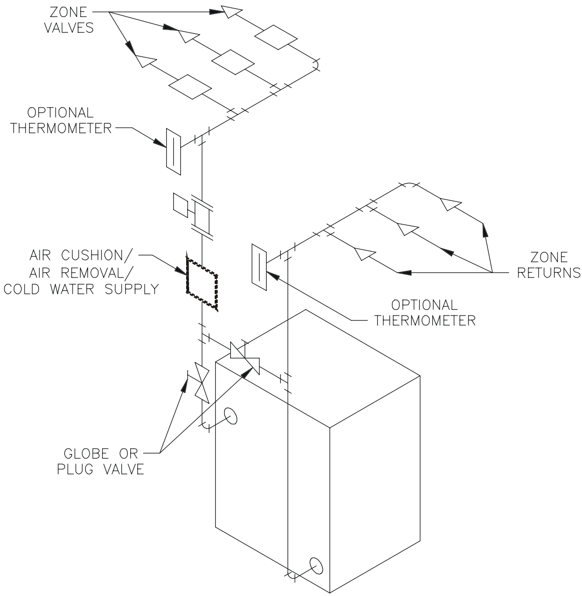
- Flue gas condensation will occur when the "burner" is on and the water in the boiler is less than 130°F. Over 50% of the heating season the radiators will satisfy the need for heat with less than 130°F. By-pass piping will permit the boiler to carry a higher temperature than the radiation. Regulation comes from the globe or plug valves. Thermometers, positioned above, will facilitate a proper by-pass. The supply water temperature need only overcome the temperature drop of the system. Even with water moving as slow as 2' to 1' per second in the oversized gravity piping, within a few minutes the thermometer mounted in the by-pass (return water) will begin to register temperature rise then serious balancing can start.

OIL BOILER WITH TANKLESS CONNECTED TO LARGE WATER CONTENT RADIATION

- Flue gas condensation can occur in oil boilers too. However, there is greater concern regarding system operation. Without a boiler by-pass, water returning from one radiator will drastically drop the boiler temperature and cause the circulator to stop. Heat leaves the boiler in "spurts" and all the "hot 'spurts'" end up in the same radiator and the heating system is quickly out of balance. By-pass piping properly set will dramatically minimize this problem.

2. BOILER BY-PASS - MULTI-ZONE HEATING

PURPOSE OF BY-PASS (GAS AND OIL)

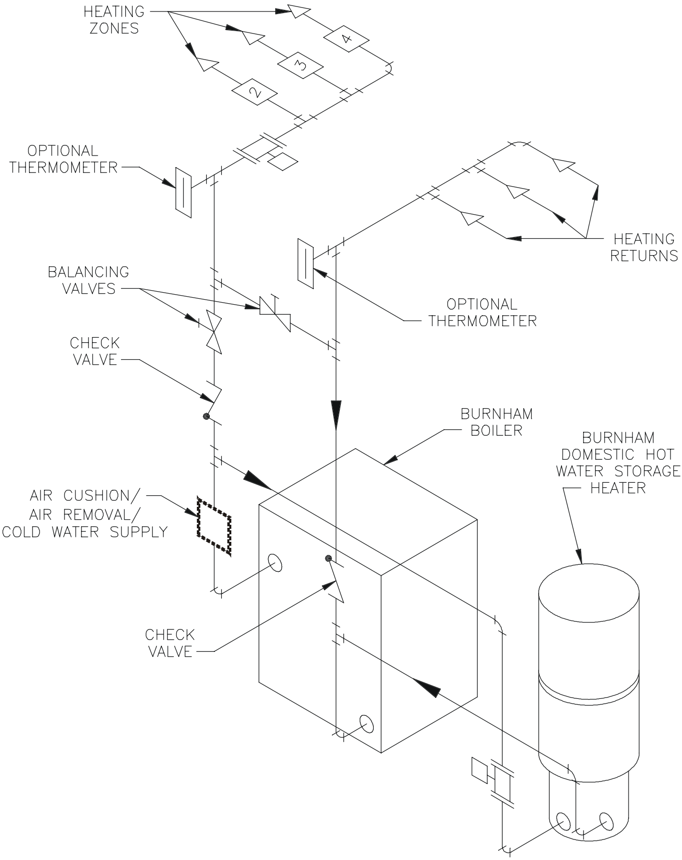


- In a multi-zone (cold start) system excess temperature develops. When one zone calls for heat it cannot dissipate the heat the boiler (sized for all zones) creates. When the zone is satisfied the hot water trapped in the boiler stays hot while the hot water trapped in the non-ferrous baseboard cools quickly. Before the next call for heat the temperature difference may be as high as 100°F. The system will be plagued with expansion noises unless boiler by-pass piping is installed. If, for example, the temperature drop in each of the zones is approximately 10°F then the balancing valves need only show on the thermometers a 15°F variance between supply and return piping, and expansion noises will be eliminated.

Beyond Boiler By-Pass

- Two-stage thermostats or an indoor-outdoor reset controller will minimize the temperature rise in the boiler but even with these controls, boiler by-pass piping will help.

3. BOILER BY-PASS - MULTI-ZONE HEATING AND INDIRECT D.H.W. ZONE



3. BOILER BY-PASS - MULTI-ZONE HEATING AND INDIRECT D.H.W. ZONE (CONT.)

PURPOSE OF BY-PASS (GAS AND OIL)

- Serves only the heating zones. Though, indirectly, the hotter boiler water it creates will help the indirect domestic hot water zone. Boiler by-pass piping, per se, is helpful to the heating zones yet detrimental to the DHW zone. However, with properly positioned check valve by-pass piping can serve both operations.

EXAMPLES

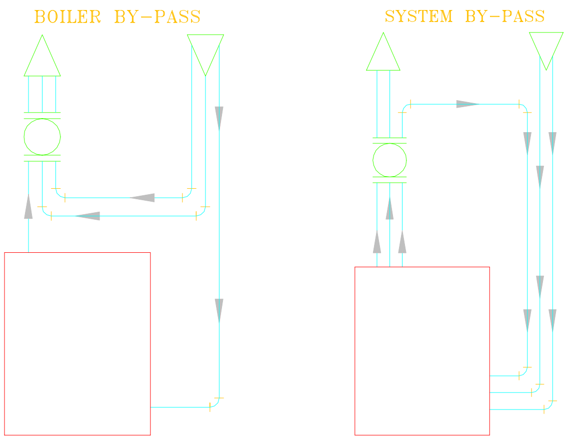
1. Heating zone (2, 3 or 4) calls for heat: Full flow of the circulator will move from the radiation to point (A). If the balancing valves (globe or plug) are adjusted to slightly overcome the temperature drop of the zone(s), typically 30% of the flow will move into the boiler at point (B) and 70% will by-pass the boiler at (C). At point (D) the full, but blended, flow will move to the radiation.

2. Indirect DHW zone (1) calls for heat: Full flow of the circulator will move through the boiler at (B). No water will move through the by-pass at (C) because of the check valve at point (E). In other words, all the heat in the boiler will be dedicated to satisfying the DHW needs.

3. Heating zone and indirect DHW zone call for heat simultaneously. Through the use of a special relay the DHW zone could be given priority. This means the heating zone is put on hold until the DHW zone is satisfied. One option would be to let the piping handle the situation. Remember, water flow takes the course of least restriction and there is considerably less restriction in the DHW zone piping.

4. BOILER BY-PASS VS SYSTEM BY-PASS

Several variations of by-pass piping exist for different reasons. Because the piping is near the boiler it is commonly categorized as "boiler by-pass" even though some may be a "system by-pass". The difference is illustrated below.



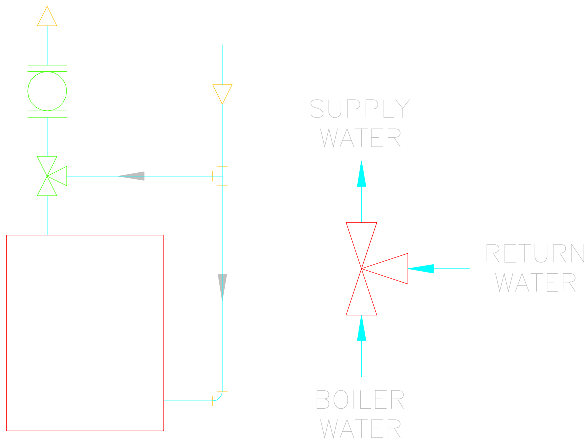
Boiler by-pass

1. Drawing illustrates how water by-passes the boiler.
2. Total circulator's capacity is dedicated to the system

System by-pass

1. Drawing illustrates how water by-passes the system.
2. Some of the circulator's capacity is used to recirculate boiler water.

5. BOILER BY-PASS - THREE-WAY MIXING VALVES



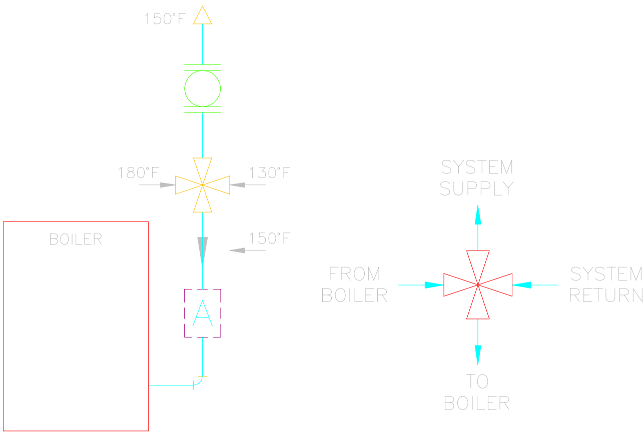
NOTES:

- Restricting boiler water flow will increase return water flow and vice versa. Supply water flow will always be boiler water plus return water.

- Mixing may be accomplished manually or with an actuating motor.

- Three-way valve application is a boiler by-pass.

6. SYSTEM BY-PASS - FOUR-WAY MIXING VALVE



1. With application of four-way valve the preferred location of the circulator is on the "system supply" side.

2. Mixing may be accomplished manually or with an actuating motor.

3. Four-way valve application is a system by-pass.

4. Four-way valve application may require a second circulator, one dedicated to system flow and the other to boiler flow. The second circulator should be installed at point (A) pumping into the boiler

5. **Concern:** Should four-way valve be fully opened to the system, both circulators will be pumping in series.

DOMESTIC HOT WATER SIZING REQUIREMENTS

A. RESIDENTIAL: Sizing residential water heaters vary with manufacturers. HUD and FHA have established minimum permissible water heater sizes as shown in the following table.

HUD--FHA Minimum Water Heater Capacities for One- and Two-Family Living Units

Number of Baths	**1 to 1.5**			**2 to 2.5**				**3 to 3.5**			
Number of Bedrooms	**1**	**2**	**3**	**2**	**3**	**4**	**5**	**3**	**4**	**5**	**6**
GAS (a)											
Storage, gal	20	30	30	30	40	40	50	40	50	50	50
1000 Btu/h input	27	36	36	36	36	38	47	38	38	47	50
1-h draw, gal	43	60	60	60	70	72	90	72	82	90	92
Recovery, gph	23	30	30	30	30	32	40	32	32	40	42
TANK TYPE INDIRECT (b,c)											
I-W-H rated draw, gal in 3-h, 100°F rise		40	40		66	66	66	66	66	66	66
Manufacturer-rated draw, gal in 3-h, 100°F (55.6°C) rise		49	49		75	75d	75	75	75	75	75
Tank capacity, gal		66	66		66	66d	82	66	82	82	82
TANKLESS TYPE INDIRECT (c,e)											
I-W-H rated, gpm 100°F rise		2.75	2.75		3.25	3.25d	3.75	3.25	3.75	3.75	3.75

a. Storage capacity, input, and recovery requirements indicated in the table are typical and may vary with each individual manufacturer. Any combination of these requirements to produce the stated 1-h draw will be satisfactory.
b. Boiler-connected water heater capacities [180°F boiler water, internal or external connection].
c. Heater capacities and inputs are minimum allowable. A.G.A. recovery ratings for gas heaters, and IBR ratings for steam and hot water heaters.
d. Also for 1 to 1.5 baths and 4 B.R. for indirect water heaters.
e. Boiler-connected heater capacities [200°F boiler water, internal or external connection].

Reference: ASHRAE/Systems Handbook (Service Water Heating)

B. COMMERCIAL: Commercial buildings have different domestic hot water needs. Building Type will be the major variable. The two charts that follow analyze the demand based either on Fixture or on Occupancy.

Note: Both charts presume the use of storage type heaters.

Chart #1

[Gallons of water per hour per fixture, calculated at a final temperature of 140°F]

	Apt. House	Club	Gym	Hospital	Hotel	Ind. Plant	Ofice Bldg.	Priv. Res.	School	YMC
1. Basins, private lavatory	2	2	2	2	2	2	2	2	2	2
2. Basins, public lavatory	4	6	8	6	8	12	6	--	15	8
3. Bathtubs	20	20	30	20	20	--	--	20	--	30
4. Dishwashers	15	50-10	--	50-150	50-20	20-10	--	15	20-100	20-100
5. Foot basins	3	3	12	3	3	12	--	3	3	12
6. Kitchen Sink	10	20	--	20	30	20	20	20	20	20
7. Laundry, stationary tubs	20	28	--	28	28	--	--	20	--	28
8. Pantry sink	5	10	--	10	10	--	10	5	10	10
9. Showers	30	150	225	75	75	225	30	30	225	225
10. Slop sink	20	20	--	20	30	20	20	15	20	20
11. Hydrotherapeutic showers				400						
12. Circular wash sinks				20	20	30	20		30	
13. Semicircular wash sinks				10	10	15	10	15		
14. DEMAND FACTOR	0.30	0.30	0.40	0.25	0.25	0.40	0.30	0.30	0.40	0.40
15. STORAGE CAPACITY FACTOR	1.25	0.90	1.00	0.60	0.80	1.00	2.00	0.70	1.00	1.00

Notes:
A. #1 through #13 - Possible Maximum Demand.
B. #14 (Demand Factor) - Probable Maximum Demand
C. #15 Ratio of Storage Tank Capacity to Probable Max. Demand Per Hr.

Example:

50 Unit Apartment Building

50 lavatories x 2	=	100 GPH
50 showers x 30	=	1500 GPH
50 kitchen sinks x 10	=	500 GPH
10 laundry tubs x 20	=	200 GPH
A) Possible Maximum Demand	=	2300 GPH
Demand Factor (#14)		x .30
B) Probable Maximum Demand	=	690 GPH
Storage Capacity Factor (#15)		1.25
C) Storage Tank Size	=	863 GAL.

CHART #2

This chart may be used as a cross check to Chart #1. The Hot Water Demand listed represents the actual metering of 129 buildings. The number of each building type sampled is listed at the extreme left side of chart.

Number	Type of Building	Maximum Hour	Maximum Day	Average Day
8	Men's dormitories	3.8 gal/student	22.0 gal/student	13.1 gal/student
8	Women's dormitories	5.0 gal/student	26.5 gal/student	12.3 gal/student
15	Motels: no. of units (a) 20 or less, 60 100 or more	6.0 gal/unit 5.0 gal/unit 4.0 gal/unit	35.0 gal/unit 25.0 gal/unit 15.0 gal/unit	20.0 gal/unit 14.0 gal/unit 10.0 gal/unit
13	Nursing homes	4.5 gal/bed	30.0 gal/bed	18.4 gal/bed
6	Office buildings	0.4 gal/person	2.0 gal/person	1.0 gal/person
25	Food establishments: Type A--full meal restaurants and cafeterias Type B--drive-ins, grilles, luncheonettes, sandwich and snack shops	1.5 gal/max meals/h 0.7 gal/max meals/h	11.0 gal/max meals/h 6.0 gal/max meals/h	2.4 gal/avg meals/day* 0.7 gal/avg meals/day*
26	Apartment houses: no. of apartments 20 or less 50 75 100 200 or more	12.0 gal/apt. 10.0 gal/apt. 8.5 gal/apt. 7.0 gal/apt. 5.0 gal/apt.	80.0 gal/apt. 73.0 gal/apt. 66.0 gal/apt. 60.0 gal/apt. 50.0 gal/apt	42.0 gal/apt. 40.0 gal/apt. 38.0 gal/apt. 37.0 gal/apt. 35.0 gal/apt.
14	Elementary schools	0.6 gal/student	1.5 gal/student	0.6 gal/student*
14	Junior and senior high schools	1.0 gal/student	3.6 gal/student	1.8 gal/student*

*Per day of operation.
(a) Interpolate for intermediate values.

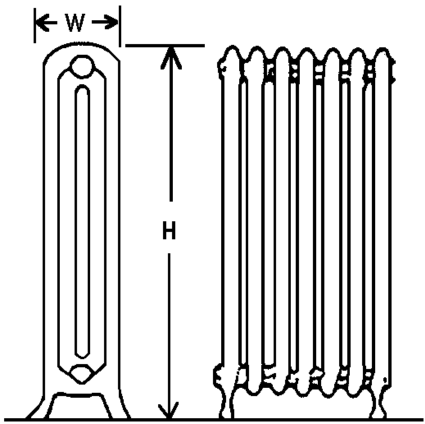
Reference: ASHRAE/Systems Handbook (Service Water Heating)

SIZING OBSOLETE RADIATION - CAST IRON RADIATORS

The output of a radiator is measured in square feet of radiation. To determine the number of square feet of radiation in a radiator:

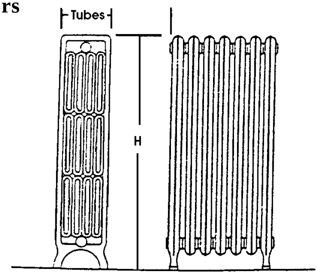
1. Measure the height of the radiator.
2. Count the number of columns in a section.
3. Count the number of sections.
4. Multiply the total number of sections by the number of square feet per section as shown in the following tables:

Column Type Radiators



Sq. Ft. Radiation Per Section					
Height Inches	4-1/2" W One Column	7-1/2" W Two Column	9" W Three Column	11-1/2" W Four Column	13"W Window
13	—	—	—	—	3
16	—	—	—	—	3-3/4
18	—	—	2-1/4	3	4-1/4
20	1-1/2	2	—	—	5
22	—	—	3	4	—
23	1-2/3	2-1/3	—	—	—
26	2	2-2/3	3-3/4	5	—
32	2-1/2	3-1/3	4-1/2	6-1/2	—
38	3	4	5	8	—
45	—	5	6	10	—

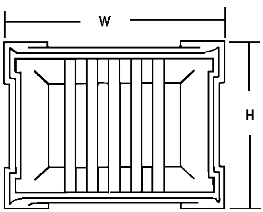
Tube Type Radiators



Sq. Ft. Radiation Per Section					
Height Inches	5" Three Tube	7" Four Tube	8-3/4" Five Tube	9-3/4" Window Six Tube	12-1/2" Seven Tube
14	—	—	—	—	2-1/2
17	—	—	—	—	3
20	1-3/4	2-1/4	2-2/3	3	3-2/3
23	2	2-1/2	3	3-1/2	—
26	2-1/3	2-3/4	3-1/2	4	4-3/4
32	3	3-1/2	4-1/3	5	—
38	3-1/2	4-1/4	5	6	—

Wall Type Radiators

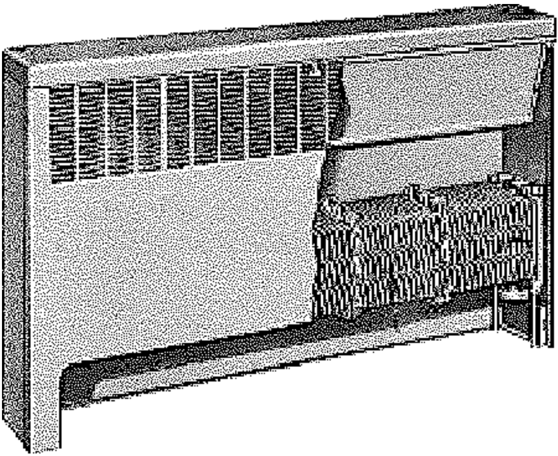
Wall radiators are measured by their height, length and thickness. The following table shows the number of square feet of heating surface per section.



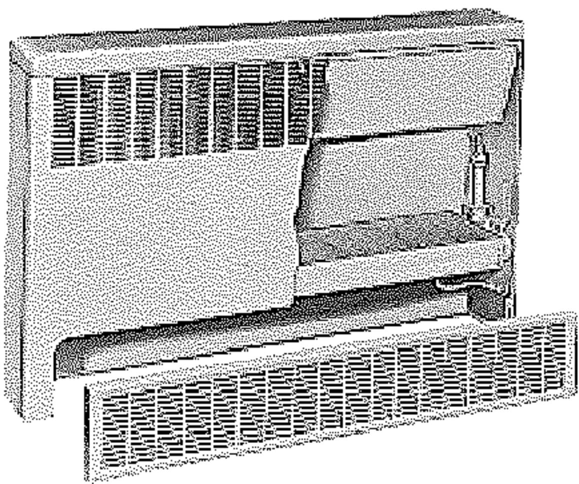
Sq. Ft. Radiation Per Wall Radiator Section Heating				
Type of Section	Height In.	Length or Width In.	Thickness In.	Sq. Ft. Radiation
5-A	13-5/16	16-5/8	2-7/8	5
7-A	13-5/16	21-7/8	2-7/8	7
7-B	21-7/8	13-3/16	3-1/16	7
9-A	18-5/16	29-1/16	2-7/8	9
9-B	29-1/16	18-5/16	3-11/16	9

CONVECTORS

Cast Iron - Ratings: Page 43



Copper - Ratings: Page 44



SIZING: CONVECTORS - *CAST IRON*
RATINGS - SQUARE FEET OF RADIATION

FRONT OUTLET AND SLOPING OUTLET TYPE UNITS Cabinet Height - Floor Types		18	20	24	26	32	38
Cabinet Depth Inches	**Cabinet Length Inches**						
4½"	18½	8.4	9.1	10.5	11.0	11.8	12.3
	23½	10.9	11.8	13.5	14.2	15.2	15.9
	28½	13.3	14.4	16.5	17.4	18.6	19.4
	33½	15.8	17.1	19.7	20.6	22.1	23.0
	38½	18.2	19.7	22.7	23.8	25.5	26.5
	43½	20.6	22.3	25.7	26.9	28.9	30.1
	48½	23.1	25.0	28.7	30.1	32.3	33.6
	53½	25.5	27.6	31.8	33.3	35.7	37.2
	58½	28.0	30.3	34.8	36.5	39.1	40.7
	63½	30.5	33.0	37.9	39.7	42.5	44.3
6½"	18½	12.3	13.5	15.4	16.2	17.5	18.2
	23½	15.9	17.4	19.9	20.9	22.6	23.5
	28½	19.5	21.3	24.4	25.6	27.7	28.8
	33½	23.1	25.2	28.9	30.4	32.9	34.1
	38½	26.7	29.2	33.4	35.1	38.0	39.4
	43½	30.3	33.1	37.9	39.8	43.1	44.7
	48½	33.9	37.0	42.4	44.5	48.1	50.0
	53½	37.5	40.9	46.8	49.2	53.3	55.3
	58½	41.1	44.8	51.3	53.9	58.4	60.6
	63½	44.7	48.7	55.8	58.7	63.5	65.9
8½"	18½	-----	17.1	19.4	20.4	22.5	23.7
	23½	-----	22.2	25.0	26.4	29.1	30.6
	28½	-----	27.2	30.7	32.4	35.7	37.5
	33½	-----	32.2	36.4	38.4	42.3	44.5
	38½	-----	37.2	42.1	44.3	48.9	51.4
	43½	-----	42.3	47.8	50.3	55.5	58.4
	48½	-----	47.3	53.5	56.3	62.0	65.3
	53½	-----	52.3	59.2	62.3	68.6	72.3
	58½	-----	57.3	64.9	68.3	75.2	79.2
	63½	-----	62.3	70.6	74.3	81.8	86.1
10½"	18½	-----	20.6	23.4	24.6	27.3	28.8
	23½	-----	26.7	30.3	31.8	35.3	37.2
	28½	-----	32.8	37.2	39.1	43.3	45.7
	33½	-----	38.9	44.2	46.3	51.4	54.2
	38½	-----	45.0	51.1	53.6	59.5	62.7
	43½	-----	51.1	58.0	60.8	67.5	71.2
	48½	-----	57.2	64.9	68.1	75.6	79.6
	53½	-----	63.3	71.8	75.4	83.6	88.1
	58½	-----	69.4	78.7	82.6	91.6	96.6
	63½	-----	75.5	85.6	89.8	99.7	105.1

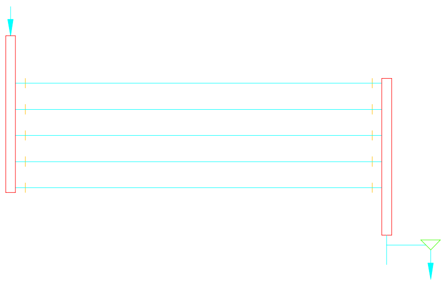
SIZING: CONVECTORS - *COPPER*
FRONT OUTLET TYPE UNITS
RATINGS - SQUARE FEET OF RADIATION

FRONT OUTLET AND SLOPING OUTLET TYPE UNITS Cabinet Height - Floor Types		18	20	24	26	32	38
Cabinet Depth Inches	**Cabinet Length Inches**						
4-1/4"	20½	10.4	11.3	13.1	13.4	14.0	14.6
	24½	12.8	13.9	16.1	16.4	17.2	18.0
	28½	15.2	16.5	19.2	19.5	20.4	21.3
	32½	17.6	19.1	22.2	22.5	23.6	24.6
	36½	19.7	21.7	25.2	25.6	26.8	28.0
	40½	22.3	24.3	28.2	28.6	30.0	31.3
	44½	24.7	26.9	31.2	31.7	33.2	34.7
	48½	27.1	29.5	34.2	34.7	36.4	38.0
	56½	31.9	34.7	40.2	40.8	42.8	44.7
	64½	36.6	39.9	46.2	46.9	49.2	51.7
6-1/4"	20½	15.3	16.3	18.4	18.8	19.6	20.6
	24½	18.8	20.1	22.6	23.1	24.1	25.3
	28½	22.3	23.8	26.9	27.4	28.6	30.1
	32½	25.8	27.6	31.1	31.7	33.2	34.8
	36½	29.3	31.3	35.4	36.0	37.7	39.6
	40½	32.8	35.1	39.6	40.3	42.2	44.3
	44½	36.3	38.9	43.8	44.6	46.7	49.0
	48½	39.8	42.6	48.1	48.9	51.2	53.8
	56½	46.8	50.1	56.6	57.5	60.3	63.3
	64½	53.9	57.7	65.0	66.2	69.3	72.7
8-1/4"	20½	18.7	20.0	22.5	23.0	24.4	25.8
	24½	22.9	24.5	27.7	28.2	30.0	31.7
	28½	27.2	29.1	32.8	33.5	35.6	37.7
	32½	31.5	33.7	38.0	38.8	41.2	43.6
	36½	35.8	38.3	43.2	44.1	46.8	49.5
	40½	40.1	42.9	48.3	49.4	52.4	55.5
	44½	44.3	47.4	53.5	54.6	58.0	61.4
	48½	48.6	52.0	58.7	59.9	63.6	67.3
	56½	57.2	61.2	69.0	70.5	74.8	79.2
	64½	65.7	70.3	79.4	81.0	86.0	91.0
10-1/4"	20½	20.4	22.0	25.0	25.7	27.4	29.3
	24½	25.2	27.1	30.9	31.7	33.8	36.2
	28½	30.0	32.3	36.8	37.7	40.2	43.1
	32½	34.8	37.4	42.6	43.7	46.6	50.0
	36½	39.6	42.6	48.5	49.8	53.1	56.9
	40½	44.4	47.7	54.4	55.8	59.5	63.7
	44½	49.2	52.9	60.3	61.8	65.9	70.6
	48½	53.9	58.0	66.1	67.8	72.3	77.5
	56½	63.5	68.3	77.9	79.9	85.2	91.2
	64½	73.1	78.6	89.6	91.9	98.0	105.0

STEEL PIPE COILS - Sq Ft of Radiating Surface Per Linear Ft of Coil

Nominal Pipe Size (Inches)	Number of Rows of Pipe In Coil							
	1	2	3	4	5	6	8	10
1	.57	1.09	1.53	1.90	2.20	2.44	2.83	3.14
1-1/4	.71	1.36	1.91	2.37	2.74	3.04	3.52	3.90
1-1/2	.81	1.55	2.18	2.70	3.12	3.46	4.02	4.45
2	.95	1.81	2.55	3.17	3.66	4.05	4.71	5.22

Notes: 1. Based on 70°F room temperature.
2. Pipes are positioned level, on vertical wall.
3. For coils positioned along floor or ceiling. Multiply chart value for 1 row of pipe x no. of rows of pipe.



CORRECTION FACTORS IF ROOM TEMPERATURE IS OTHER THAN 70° DIVIDE SQ. FT. OF RADIATION BY

Rm. Temp	80°	75°	70°	65°	60°	55°	50°
Divisor	1.10	1.05	1.00	0.96	0.92	0.88	0.85

Heat Emissions for Cast Iron Radiators			
Design or Average Water Temperature	**Heat Emissions Rates Btuh per sq. ft.**	**Design or Average Water Temperature**	**Heat Emission Rates Btuh per sq. ft.**
110°	30	180°	170
120°	50	185°	180
130°	70	190°	190
140°	90	195°	200
150°	110	200°	210
160°	130	205°	220
170°	150	210°	230
175°	160	215°	240

HEAT LOSSES FROM BARE STEEL PIPE

Based On 70° Surrounding Air

Diameter of Pipe, Inches	Temperature of Pipe, Deg. F					
	100	120	150	180	210	240
	Heat Loss per Lineal Foot of Pipe, BTU per Hour					
1/2	13	22	40	60	82	106
3/4	15	27	50	74	100	131
1	19	34	61	90	123	160
1-1/4	23	42	75	111	152	198
1-1/2	27	48	85	126	173	224
2	33	59	104	154	212	275
2-1/2	39	70	123	184	252	327
3	46	84	148	221	303	393
3-1/2	52	95	168	250	342	444
4	59	106	187	278	381	496
5	71	129	227	339	464	603
6	84	151	267	398	546	709
8	107	194	341	509	697	906
10	132	238	420	626	857	1114
12	154	279	491	732	1003	1305
14	181	326	575	856	1173	1527
16	203	366	644	960	1314	1711
18	214	385	678	1011	1385	1802
20	236	426	748	1115	1529	1990

HEAT LOSSES FROM BARE TARNISHED COPPER TUBE

Based On 70° Surrounding Air

Diameter of Pipe, Inches	Temperature of Pipe, Deg. F					
	100	120	150	180	210	240
	Heat Loss per Lineal Foot of Pipe, BTU per Hour					
1/4	4	8	14	21	29	37
3/8	6	10	18	28	37	48
1/2	7	13	22	33	45	59
5/8	8	15	26	39	53	68
3/4	9	17	30	45	61	79
1	11	21	37	55	75	97
1-1/4	14	25	45	66	90	117
1-1/2	16	29	52	77	105	135
2	20	37	66	97	132	171
2-1/2	24	44	78	117	160	206
3	28	51	92	136	186	240
3-1/2	32	59	104	156	212	274
4	36	66	118	174	238	307
5	43	80	142	212	288	373
6	51	93	166	246	336	432
8	66	120	215	317	435	562
10	80	146	260	387	527	681
12	94	172	304	447	621	802

HEAT LOSSES FROM COVERED PIPE 85 PERCENT MAGNESIA TYPE BTU PER LINEAR FOOT PER HOUR PER °F TEMPERATURE DIFFERENCE (SURROUNDING AIR ASSUMED 75 °F)					
Pipe Size	Insulation, Thickness, Inches	Max. Temp. of Pipe Surface °F.			
		125	**175**	**225**	**275**
½	1	.145	.150	.157	.160
¾	1	.165	.172	.177	.180
1	1	.190	.195	.200	.203
	1½	.160	.165	.167	.170
1¼	1	.220	.225	.232	.237
	1½	.182	.187	.193	.197
1½	1	.240	.247	.255	.260
	1½	.200	.205	.210	.215
2	1	.282	.290	.297	.303
	1½	.230	.235	.240	.243
	2	.197	.200	.205	.210
2½	1	.322	.330	.340	.345
	1½	.260	.265	.270	.275
	2	.220	.225	.230	.237
3	1	.375	.385	.395	.405
	1½	.300	.305	.312	.320
	2	.253	.257	.263	.270
3½	1	.419	.430	.440	.450
	1½	.332	.339	.345	.352
	2	.280	.285	.290	.295
4	1	.460	.470	.480	.492
	1½	.362	.370	.379	.385
	2	.303	.308	.315	.320
5	1	.545	.560	.572	.585
	1½	.423	.435	.442	.450
	2	.355	.360	.367	.375
6	1	.630	.645	.662	.680
	1½	.487	.500	.510	.520
	2	.405	.415	.420	.430

EXISTING RADIATION/PIPING

A. RADIATION

Based on Sq. Ft. Rating	Water Content/Gal.	Weight/Lbs.
Slenderized Radiators	0.066	4.5
Large Tube Radiators	0.103	5.25
Column Radiators	0.188	7.0
Convectors (Non-Ferrous)	0.004	1.5
Convectors (Cast Iron)	0.040	3.4
Radiant Radiators	0.066	5.0
Base-Ray (Cast Iron Baseboard)	0.066	4.4

B. STEEL AND WROUGHT IRON PIPE (STD. WGT.)

Nominal Size: Inches	Based On Lineal Foot	
	Water Content/Gal.	Weight/Lbs.
1/2"	.016	.132
3/4"	.028	.231
1"	.045	.375
1-1/4"	.078	.648
1-1/2"	.106	.883
2"	.174	1.455
2-1/2"	.249	2.076
3"	.384	3.205
4"	.661	5.519
5"	1.039	8.662
6"	1.501	12.510

C. COPPER TUBING (TYPE L)

Nominal Size: Inches	Based on Lineal Foot	
	Water Content/Gal.	Weight/Lbs.
3/8"	.007	.063
1/2"	.012	.101
5/8"	.018	.151
3/4"	.025	.210
1"	.043	.357
1-1/4"	.065	.544
1-1/2"	.092	.770
2"	.161	1.340

D. WATER CONVERSION FACTORS

Lbs. of Water x 0.12 = Gallons
Gallons of Water x 8.34 = Lbs.

SHORT FORM HEAT LOSS SURVEY

Application: Excellent when determining heat loss of a building as a whole.Precise method of sizing replacement hot water boilers.

*Heating Multipliers (H.M.) BTU/Hr. Based on 60°F Temperature Difference (T.D.)

WALL	*H.M.	CEILING	*H.M.	FLOOR	*H.M.
No Insulation	15	3 Inches	5	No Insulation	4
2 Inches	6	6 Inches	4	Overhang — 3"	5
3 Inches	4	10 Inches	2	Overhang — 6"	3

WINDOWS/DOOR	*H.M.	INFILTRATION	*H.M.
Storm	34	1-1/2 Air Change	1.61
Insulated	41	1 Air Change	1.07
Single	67	3/4 Air Change	.81

PROCEDURE:

1. Measure the length (L) and width (W) of the outside walls of the house and record. Calculate gross wall area by multiplying height of the walls by total length of outside walls. (2L + 2W).
2. Measure the window and door area and record.
3. Record Net Wall Area = (gross wall area minus door and window area) select proper H.M.
4. Measure and record the ceiling area and select H.M.
5. Measure and record floor area and select H.M. (H.M. of 4 used unheated basement).
6. Multiply Floor area by ceiling height to obtain volume of home and select proper air change factor: 1.61 for Loose House - 1.07 for Average House - .81 for Tight House.

H.M. Floor over Basement T.D. 20°

WORKSHEET:

LENGTH ________ WIDTH _________ HEIGHT _______

	AREA (ft²)	H.M. (BTU/Hr.)	BTU/Hr. LOSS
GROSS	____________	X ________	= ____________
WINDOWS & DOORS	____________	X ________	= ____________
NET WALL	____________	X ________	= ____________
CEILING	____________	X ________	= ____________
FLOOR	____________	X ________	= ____________
INFILTRATION (CU. FT.) (HEIGHT) X (FLOOR AREA)	____________	X ________	= ____________

TOTAL HEAT LOSS = __________

TEMP. DIFFERENCE CORRECTION = __________

*To Increase Temp. Difference to70°F, Multiply Total Heat Loss 1.18
80°F, Multiply Total Heat Loss 1.34
90°F, Multiply Total Heat Loss 1.50
100°F, Multiply Total Heat Loss 1.66

GREENHOUSE HEAT LOSS CALCULATION

The method described in this manual based on the method prepared and adopted by N.G.M.A. (National Greenhouse Manufacturer's Association).

The recommended equation for calculating heat loss is:

[A1 + (A2 x R)] x TD x G x W x C = BTU/Hr. Heat Loss, where:

- A1 - Square feet of exposed glass area;
- A2 - Square feet to exposed wall area (other than glass);
- R - Resistance of greenhouse wall base transposed into a "glass" factor;
- T - Highest temperature to be maintained is greenhouse minus outside design temperature;
- G - Coefficient of transmission of glass is BTU/Hr./Ft.2/°F. **(Table 2)**.
- W - Wind factor **(Table 3)**;
- C - Construction factor **(Table 4)**.

Example (See **Figure 1**):

Given: Glass area = 4040 ft.2
wall area = 810 ft.2
design temperature:
inside = 60°F
outside = .10°F
brick wall = 8" thick
wind = 15 mph or less

Find: "R" for 8" brick wall = 0.43;
TD x "G" (Table 5) = 79;
"W" for 15 mph wind = 1.00;
"C" for all metal, glass = 1.08

Calculate:

Heat Loss = [A1 + (A2 x R)] x TD x G x W x C
= [404 + (810 X 0.43)] x 79 x 1.00 x 1.08]
= 4388 x 85.3
= 374,000 BTU/Hr.

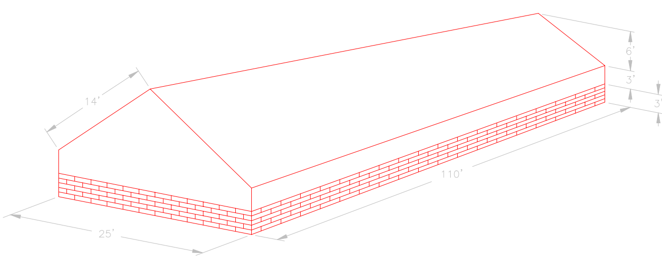


Figure 1
Typical Greenhouse

TABLE 1 - "R" FACTOR

These are factors for "curtain" wall materials normally used on greenhouses:

3/8 in. Courrugated asbestos cement board wall	0.94
4 in. Poured concrete wall	0.76
6 in. Poured concrete wall	0.67
8 in. Poured concrete wall	0.60
4 in. Concrete block wall	0.58
8 in. Concrete block wall	0.46
8 in. Brick Wall	0.43

TABLE 2
COEFFICIENT OF TRANSMISSION OF GLASS ("G" FACTOR)

Temp. Diff. Between Inside & Outside DesignTemp.	Coefficient of Transmission
50°	1.09
55°	1.10
60°	1.11
65°	1.12
70°	1.13
75°	1.14
80°	1.15
85°	1.16
90°	1.17
95°	1.18
100°	1.19
105°	1.20

TABLE 3
WIND "W" FACTOR (2)

If wind velocity exceeds 15 mi. per hr. average during the heating season, the heat loss calculation should be increased by 4% for each 5 mi. per hr. over 15 as below:

Wind Velocity In Miles Per Hour	"W" Factor	Alternate "W" Factor (3)
15 m.p.h. or less	1.00	1.10
20 m.p.h.	1.04	1.14
25 m.p.h.	1.08	1.18
30 m.p.h.	1.12	1.22
35 m.p.h.	1.16	1.26

TABLE 4 - CONSTRUCTION "C" FACTOR (4)

The condition and type of a greenhouse directly affect the heat loss. Consult this table for the factor which best describes the greenhouse on which you are calculating the heat loss.

All metal (good tight glass house - 20 or 24 in. glass spacing)	1.08
Wood & steel (good tight glass house - 16 or 20 in. glass spacing) (Metal gutters, vents, headers, etc.)	1.05
Wood houses (glass houses with wood bars, gutters, vents, etc.- up to and including 20 in. glass spacing)	
Good tight houses	1.00
Fairly tight houses	1.13
Loose houses	1.25
Fiberglass covered wood houses	0.95
Fiberglass covered metal houses	1.00
Plastic covered (5) metal houses (single thickness)	1.00
Plastic covered (6) metal houses (double thickness)	0.70

GREENHOUSE HEAT LOSS CALCULATION

TABLE 5 - HEAT REQUIREMENTS FOR GREENHOUSES

BTU/Hr. for each equivalent square foot of glass [C = 1.00 (7); W = 1.00 (8)]

Inside Temp °F	Outside design Temperature - °F						
	-30	-20	-10	0	10	20	30
40	79	67	54	43	33	22	11
45	86	73	61	49	38	27	16
50	92	79	67	54	43	33	22
55	99	86	73	61	49	38	27
60	105	92	79	67	54	43	33
65	112	99	86	73	61	49	38
70	119	105	92	79	67	54	43
75	126	112	99	86	73	61	49

TABLE 6 - CUSTOMARY GREENHOUSE TEMPERA-TURES

Type of Plant or Building Use	Temperature Range, °F
Carnation	45-55
Chrysanthemums, cut flowers and potted plants	60-65
Cool	45-50
Cucumber	65-60
Fern	60-65
Forcing	60-65
General purpose	55-60
Lettuce	40-45
Orchid, warm	65-70
Orchid, cool	50-55
Palm, warm	60-65
Palm, cool	50-55
Poinsettias	60-70
Propagating	55-60
Rose	55-60
Sweet pea	45-50
Tomato	65-70
Tropical	65-70
Violet	40-45

NOTES

2. The effect of wind on heat loss cannot be overemphasized. If increased wind velocity is not compensated for, there is likely to be a ½° temperature drop for every mile per hour over 15 mph. These figures are based on observations by greenhouse heating design engineers over many years of observation.
3. Lapped glass on greenhouses normally freezes shut when the outdoor temperature reaches 15° above zero. If high design temperatures are used (70° or over), if unit heaters or turbulators are located so that they blow air against the glass, if 40% or more of the greenhouse radiation will be overhead, or if the "green-house" will be used for other than "growing" purposes, use alternate "W" factors above.
4. These figures are based on observations by greenhouse heating design engineers.
5. With no air leaks (holes, tears, etc.)
6. ¼" minimum, 1½" maximum distance between layers with no air leaks (holes, tears, etc.)

There are several ways to calculate the operational cost of a specific boiler in a particular location. The accuracy of each will depend on the attention one gives the many variables.

Two popular methods are the "bin" and "degree-day". Though the "bin" method has the potential to be more accurate, it is more complicated when necessary weather data is not readily available. Discussion will be limited to the "Degree-Day" method.

The "Degree-Day" method is not without controversy. Historically, the reference temperature is 65°. This assumes that a building with average insulation and a thermostat set at 70° will cause a boiler to begin operation when outdoor temperature falls below 65°. Overlooked variables could be sunshine, wind, heavier insulation, different thermostat setting.

WHAT IS A DEGREE DAY?

When the outside temperature falls below 65°F, heat will be required to maintain the temperature within the building. The average outside temperature is estimated by adding the high and low temperature for a given day and dividing by two. (Example: A high of 40°F and a low of 20°F would be equivalent to a 30°F average temperature.) "Degree Days" are defined as the difference between the average temperature and the 65°F reference temperature. Therefore, 65°F minus 30°F equals 35 "Degree Days".

Degree Days = 65 - (high + low) ÷2

FUEL CONSUMPTION

In order to determine fuel usage the D.D. is used in the following equation:

$$F = \frac{HL \times 24 \times DD}{E \times P \times T.D.}$$

HL	=	Heating Load (Btuh)
DD	=	Degree Day
24	=	Hours in a day
E	=	*Boiler Efficiency (AFUE)
P	=	Heating value of fuel (Btu)
T.D.	=	Design temperature difference (inside-outside)
F	=	Annual fuel consumption

*Example: 80% = .8

HEATING DEGREE DAYS (SAMPLING) USA/CANADA

STATE/PROVINCE/CITY	D.D.
Alaska	
Anchorage	10860
Barrow	20265
Fairbanks	14290
Colorado	
Alamosa	8529
Colorado Springs	6410
Denver	6150
Connecticut	
Bridgeport	5617
Hartford	6170
Waterbury	6672
Delaware	
Wilmington	4930
District of Columbia	
Washington	4240
Georgia	
Atlanta	2990
Idaho	
Boise	5830
Pocatello	7030
Illinois	
Champaign/Urbana	5800
Chicago, O'Hare	6640
Rockford	6840
Springfield	5530
Indiana	
Fort Wayne	6220

STATE/PROVINCE/CITY	D.D.
Indianapolis	5630
South Bend	6460
Iowa	
Des Moines	6610
Dubuque	7380
Kansas	
Topeka	5210
Wichita	4640
Kentucky	
Lexington	4760
Louisville	4610
Maine	
Bangor	8220
Portland	7570
Maryland	
Baltimore	4680
Hagerstown	5130
Massachusetts	
Boston	5630
Lowell	6060
Pittsfield	7580
Worcester	6970
Michigan	
Battle Creek	6580
Detroit	6290
Flint	7200
Marquette	8390
Traverse City	7700

HEATING DEGREE DAYS (SAMPLING) USA/CANADA

STATE/PROVINCE/CITY	D.D.
Minnesota	
Duluth	9890
International Falls	10600
Minneapolis/St. Paul	8250
Missouri	
Kansas City	4750
St. Louis	4900
Montana	
Billings	7150
Butte	9730
Helena	8190
Nebraska	
Lincoln	6050
Omaha	6290
Nevada	
Reno	6150
New Hampshire	
Berlin	8270
Concord	7360
Manchester	7100
New Jersey	
Atlantic City	4810
Newark	4900
Trenton	4980
New Mexico	
Albuquerque	4250
Santa Fe	6120

STATE/PROVINCE/CITY	D.D.
New York	
Albany	6900
Binghamton	7340
Buffalo	6960
NYC-Central Park	4880
Poughkeepsie	5820
Syracuse	6720
North Carolina	
Ashville	4130
North Dakota	
Bismark	8960
Fargo	9250
Ohio	
Cleveland	6200
Columbus	5670
Pennsylvania	
Harrisburg	5280
Johnstown	7804
Philadelphia	5180
Pittsburgh	5950
Scranton/Wilkes-Barre	6160
Rhode Island	
Providence	5950
South Dakota	
Aberdeen	8620
Pierre	7550
Utah	
Logan	6750
Salt Lake City	5990

HEATING DEGREE DAYS (SAMPLING) USA/CANADA

STATE/PROVINCE/CITY	D.D.
Vermont	
Burlington	8030
Rutland	7440
Virginia	
Lynchburg	4166
Richmond	3910
Roanoke	4150
Winchester	4780
Washington	
Seattle-Tacoma	5190
Spokane	6770
West Virginia	
Charleston	4510
Morgantown	5100
Wheeling	5220
Wisconsin	
Green Bay	8100
Milwaukee	7470
Wausau	8490
Wyoming	
Casper	7510
Cheyene	7370
Alberta	
Calgary	9703
Edmonton	10268
British Columbia	
Kamloops	6799
Vancouver	5515
Victoria	5579

STATE/PROVINCE/CITY	D.D.
Manitoba	
Winnipeg	10679
New Brunswick	
Saint John	8453
Newfoundland	
Gander	9254
St. John's	8991
Northwest Terr.	
Resolute	22673
Yellowknife	15634
Nova Scotia	
Halifax	7361
Sydney	8049
Ontario	
London	7349
Thunder Bay	10405
Toronto	6827
Windsor	6579
Prince Edward Island	
Charlottetown	8486
Quebec	
Montreal	8213
Quebec	8937
Saskatchewan	
Regina	10806
Saskatoon	10856
Yukon Territory	
Whitehorse	12475

HOME HEATING COST
COMPARISON BETWEEN BOILER AND FURNACE

Fuel Consumption for Heating Systems Using Gas and Oil*

OIL HEAT-Gallons burned per year at the indicated heat-loss (approx.)

Heat Loss (Btuh)**	Hydronics (gallons)	Warm Air (gallons)	Hydronics Savings Per Year (gallons)
20,000	490	581	91
30,000	734	871	137
40,000	979	1,161	182
50,000	1,224	1,452	228
60,000	1,469	1,742	273
70,000	1,714	2,032	319
80,000	1,958	2,323	364
90,000	2,203	2,613	410
100,000	2,448	2,903	455
110,000	2,693	3,194	501
120,000	2,938	3,484	546

GAS HEAT-Therms burned per year at the indicated heat-loss (approx.)

Heat Loss (Btuh)**	Hydronic (therms)	Warm Air (therms)	Hydronic Savings Per Year (therms)
20,000	676	801	126
30,000	1,014	1,202	188
40,000	1,351	1,603	251
50,000	1,689	2,003	314
60,000	2,027	2,404	377
70,000	2,365	2,804	440
80,000	2,703	3,205	502
90,000	3,041	3,606	565
100,000	3,378	4,006	628
110,000	3,716	4,407	691
120,000	4,054	4,808	754

*Hydronics = Circulating hot water with boiler and baseboard.

Warm Air = Blower system with furnace, ducts and registers.

**Calculated heat loss per hour in BTU's.

NOTE: The average fuel saving is 18.6% for Hydronic systems over Warm air systems.

Hydronic system efficiency - DOE Minimum seasonal efficiency (AFUE) 80%[1] - Piping Losses 7½%[2] = 74% System Efficiency

Warm air system efficiency - DOE Minimum seasonal efficiency (AFUE)- 78%[3] - Duct losses 20%[4] = 62.4% System Efficiency

To determine the actual dollar savings, multiply the cost of a gallon of oil or a therm of gas, for your area, times gallons or therms saved.

1. Department of Energy Minimum Seasonal Efficiency (AFUE) for boilers as of January 1, 1992
2. "Summary Cooperative Research of Hydronic Heating and Cooling," University of Illinois, 1968
3. Department of Energy Minimum Seasonal Efficiency (AFUE) for furnaces, as of January 1, 1992
4. "Air Conditioning, Heating and Refrigeration News," February 19, 1973

Example #1: Using Oil

For a hydronically-heated oil-fueled home, with a heat loss of 40,000 Btuh: 40,000 heat loss house divided by 138,000 Btu/gallon for oil divided by .74 (system efficiency) x 2500 hours = 979 gallons used.

For a warm air-heated oil fueled home, with a heat loss of 40,000 Btuh: 40,000 heat loss house divided by 138,000 Btu/gallon for oil divided by .624 (system efficiency) x 2500 hours = 1,161 gallons used.

Example #2: Using Gas

For a hydronically-heated gas-fueled home, with a heat loss of 40,000 Btuh: 40,000 heat loss house divided by 100,000 Btu/therm for gas divided by .74 (system efficiency) x 2500 hours = 1,351 therms used.

For a warm air-heated gas-fueled home, with a heat loss of 40,000 Btut: 40,000 heat loss house divide by 100,000 Btu/therm for gas divided by .624 (system efficiency) x 2500 hours = 1,603 therms used.

NOTE: For the Northeast and Upper Midwest there are approximately 2,500 heat loss hours per year. (From GAMA "Consumers' Directory of Certified Efficiency Ratings," April, 1992)

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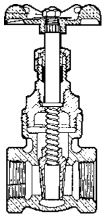
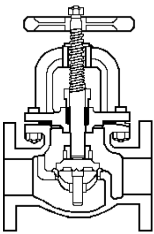
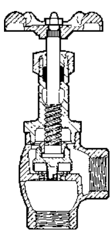


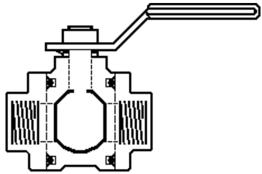
Gate Valve Has a wedge-shaped disc that is raised to open and lowered to close the valve. It is used either fully open or totally closed and is not designed for throttling.



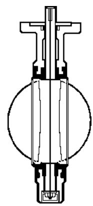
Globe Valve Uses a round disc or tapered plug-type disc that seats against a port to close the valve. Globe valves are used where throttling and/or when frequent operation is required.



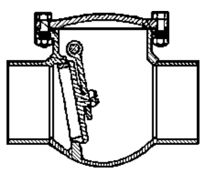
Angle Valve Operates the same as globe valve. Has less resistance to flow than its globe counterpart and by design acts as a 90° elbow, eliminationg the need for a fitting.



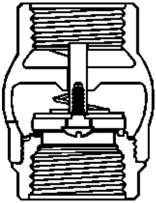
Ball Valve Its operating device consists of a ball with a hole through its center. The valve operator rotates 90 degrees from fully open to the fully closed position. Its major application is isolation but can be used to regulate flow.



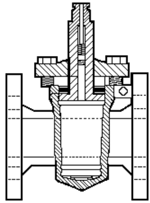
Butterfly Valve Has a wafer-shaped body with a thin, rotating disc closing device. Like the ball valve, the butterfly operates with a one-quarter turn to go full open to closed. The disc is always in the flow but the disc is thin and offers little flow restriction.



Swing Check Valve Has a hinged disc that swings on a hinge pin. When the flow reverses, the pressure pushes the disc against a seat preventing back flow.



Lift Check Valve Has a guided disc that rises from its seat by upward flow pressure. Flow reversal pushes the disc down against its seat, stopping back flow. Though the lift check has greater flow resistance than the swing check, it is more suitable for rapid operation cycles.



Plug Valve Uses a tapered cylindrical plug that fits a body seat of corresponding shape. A one-quarter turn (90°) operates the valve from open to close. Valve plugs may be lubricated or non-lubricated.

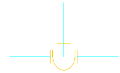
APPLICATION

Valve Type	Principle Service Function	Full Open-Flow Fesistance	Throttling Application	Closure Speed	Allowable Frequency of Operation	Positive Shut-off
Gate	Isolation	Low	Unacceptable	Slow	Low	Poor
Globe	Flow regulation	High	Good	Moderate	Moderate	Good
Angle	Flow regulation	Medium-high	Good	Moderate	Moderate	Good
Ball	Isolation	Low	Fair	Fast	High	Good
Butterfly	Isolation	Low	Fair to good	Fast	High	Good
Swing check	Flow-reversal control	Low	N/A	Fast	Low	Poor
Lift check	Flow-reversal control	High	N/A	Moderate	Moderate	Fair
Plug	Flow regulation/ isolation	Low	Good to excellent	Fast	Moderate	Good

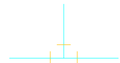
CONNECTIONS

Connections to Mains

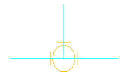
from top



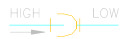
from side



from bottom



Drop in Main



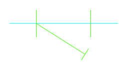
Rise in Main

FITTINGS

Pipe Flange

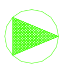
Union

Strainer

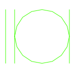


MISCELLANEOUS

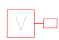
Pump



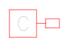
Hot Water



In-Line

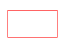


Vacuum



Condensation

Tank



Tank - Designate Type

Thermostat

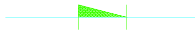
PIPING

Anchor

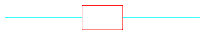
Condensate Discharge

Dry Return

Eccentric Reducer



Expansion Joint



First Floor Radiation

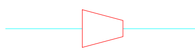
Hanger or Support

High Pressure Steam

Low Pressure Steam

Medium Pressure Steam

Reducer



Riser and Designation Number

Vacuum Vent Line

Wet Return

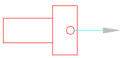
RADIATION

Fin Tube Radiation

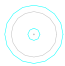
Heat Transfer Surface

Unit Heaters

Propeller Fan Type

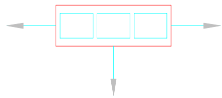


Horizontal

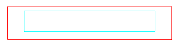


Vertical

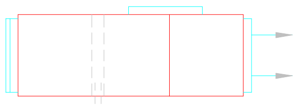
Centrifugal Fan Type



Unit Ventilator



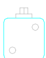
Unit Ventilator - Auditorium Type



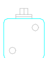
TRAPS

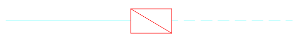
Alternates

Float Trap

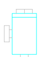


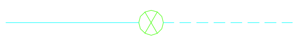
Float and Thermostatic Trap





Thermostatic Trap





VALVES — Alternates

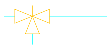
Angle

Ball

Butterfly Valve

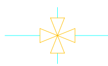
Check Valve

Three Way

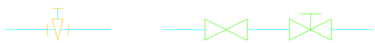


Diaphragm Valve

Four Way



Gate Valve

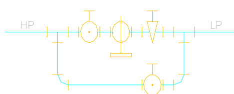


Globe Valve

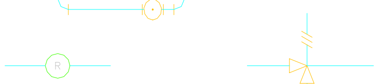
Plug Valve

Motor Operated Valve

Pressure Reducing Valve



Relief Valve



CHAPTER 10 - VENTING FLUE PRODUCTS

A. ACCEPTABLE VENTING MATERIAL

Type	Temperature	Application
AL29-4C® (Proprietary stainless steel pipe)	100°F to 480°F	Pressure vented gas equipment
Single-wall metal pipe	Refer to codes and to manufacturer's recommendations	Aluminum, galvanized steel or stainless steel; depending on the application (1)
B and BW vent	To 550°F	Gas equipment
L vent	To 1000°F	Oil equipment (1)
Factory-built chimney	500°F to 2,200°F	Oil or gas-fired equipment (1)
Masonry chimney (tile liner and air space)	360°F to 1,800°F	Gas or oil equipment (metal liner may be required.) (2)

(1) Stainless-steel vents can resist the heat that is associated with oil-fired vent gases, but when the inner wall temperature is below 250°F, it loses its ability to resist acidic damage.

(2) Masonry chimneys also are susceptible to acidic damage.

B. METAL VENTS

Type	Description
"B"	Double-wall round gas vent pipe with a relatively low permissible temperature of vent gases.
"BW"	Double-wall oval gas vent pipe designed to fit within a conventional stud wall. Same application as Type "B".
"L"	Double-wall round stainless steel insulated. Type "L" is rated for higher temperature vent gas than the Type "B". Type "L" may be used in lieu of "B" but not vice versa.
"C"	Single-wall galvanized

IMPORTANT:

VENTING GUIDE FOR ALL BURNHAM RESIDENTIAL GAS BOILERS -- SEE PAGE 109

C. VENTING CATEGORIES: GAS-FIRED EQUIPMENT

Operating characteristics	Category I	Category II	Category III	Category IV
Pressure in the vent	Negative	Negative	Positive	Positive
Temperature of vent gas (4)	Above 275°F	Below 275°F	Above 275°F	Below 275°F
Annual efficiency	Below 84%	Above 84%	Below 84%	Above 84%
Condensation	Not acceptable (1)	Possible (in vent)	Possible (3)	In heat exchanger
Design requirements				
Gas (air) tight vent	No	No	Yes	Yes
Corrosion-resistant vent (water tight)	No (1)	Yes	Possible (3)	Yes
Vent into masonry chimney	Permitted (1) and (2)	No	No	No
Combined venting	Permitted	No	No	No
Condensate drain	No	Ask manufacturer	Possible (3)	Yes (At equipment)
Source of information	N.F.G.C. Fuel gas code, heating equipment and vent system manufacturers	Manufact. literature	Manufact. literature	Manufact. literature

NOTE 1 Usually, there is no problem when high vent gas temperature equipment is vented into double-wall vent or into a lined masonry chimney; but condensation could occur if mid-efficiency (80% to 84%) mechanical draft equipment is vented into a vent that has highly conductive walls, cold walls, or massive walls. In this case, design a vent system that minimizes the wall losses (use double-wall pipe for the whole run and avoid long runs through cold spaces).

NOTE 2 Install either a rigid or flexible metal liner inside of the masonry chimney and use a double-wall connector when venting mid-efficiency (80% to 84%), mechanical draft equipment.

NOTE 3 Condensation in the vent is possible with some types mid-efficiency (80% to 84%), direct-vent equipment, depending on the ambient temperature and the conductivity of the vent walls. In this case, design a vent system that minimizes the wall losses (use insulated pipe and avoid long runs through cold spaces). A corrosion-resistant flue and a drain may be required if condensation cannot be prevented — refer to the manufacturer's recommendations.

NOTE 4 The dewpoint of the vent gas depends on the fuel (natural or LP gas), the amount of excess air and the amount of dilution air. The limiting case occurs when the dewpoint of the vent gas is at a maximum, which is about 135°F. This maximum is produced when natural gas is burned with no excess air or dilution air. Therefore 275°F = 135°F dewpoint + 140°F rise.

A. UNITS OF ELECTRICAL MEASUREMENT

· VOLTAGE: In order for current to flow in any conductor there must be an excess of electrons at one point and a deficiency of electrons at another point. The amount of difference between the two points is called "potential" or "voltage".

· AMPERES: current flow

· OHMS: resistance or "voltage drop" through a conductor

· WATTS: amount of power (volts multiplied by amperes)

Watts = Amps x volts
Volts = watts ÷ amps
Amps = watts ÷ volts

Note: For convenience, **magnitude** of any of the above is expressed with the following prefixes:

KILO	=	1,000 (one kilowatt = 1,000 watts)
MEG(A)	=	1,000,000 (one megohm = 1,000,000 ohms)
MILLI	=	1,000 divisor (one millivolt = 1/1,000th of a volt)
MICRO	=	1,000,000 divisor (one microampere = 1/1,000,000th of an ampere)

B. DIRECT CURRENT AND ALTERNATING CURRENT

· Direct Current (D.C.) is a continuous current that always flows in the same direction.

· Alternating Current (A.C.) is a current that periodically "cycles", or reverses its direction of flow. The number of complete cycles that occur in one second is the frequency of the current.

· Commercially produced power, and the utilization equipment for use on commercial power, is almost universally A.C.

C. MOTORS (TYPES)

· Universal: Essentially a D.C. motor modified to run on A.C. Primarily used in small household appliances (mixers, shavers, small power tools). Single phase only.

· Capacitor Start/Induction Run: Has good torque characteristics and is used in heavy duty applications such as pumps, blowers, and large power burners.

· Shaded Pole: The simplest of all A.C. motors, it operates only on single phase current. Is available in sizes up to and including 1/3 H.P. It has no brushes or commutator. Has very low starting torque and therefore should not be used on equipment that is hard to start in motion. Some typical applications are small fans, heater blowers, etc.

· Split Phase: Has starting windings and a centrifugal switch. Its simplicity, good torque, and rugged construction give it a wide range of fractional horsepower applications.

D. TRANSFORMERS

· A transformer transfers power from one circuit to another circuit of different voltage, without an electrical connection between the two circuits.

· Input of a transformer must be A.C. current, and the output will also be A.C. current.

· A step-up transformer increases voltage but the available amperage decreases. A step-down transformer decreases voltage but the available amperage increases.

· The safe load rating of a transformer is expressed in VA. The actual power drawn depends on the connected load.

E. RELAYS

An electromagnetic switching device that can perform switching action in two or more circuits that have no electrical connection.

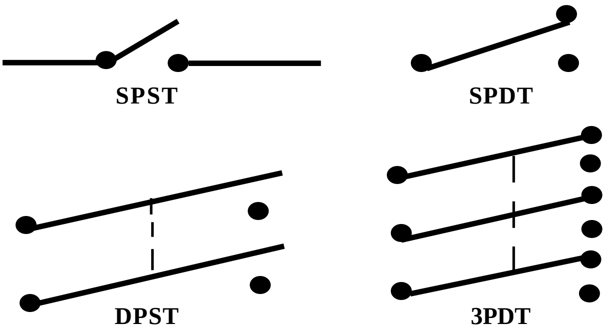
Relay Terminology

Relays are referred to as "single-pole-single throw", "single pole-double throw", "double pole-single throw", etc.

The poles are stationary and are usually used for power input. The arms extending from the poles of each switch or relay are mechanically linked together but are independent of each other electrically.

Relay Terminology (con't)

The arms extending from each pole include a moveable contact. the number of throws is the number of positions in which the moveable contact, connected to each pole, can complete a circuit. See examples below:



The dotted lines indicate that the arms are mechanically linked and will move together.

- Normally open, Normally closed: refers to the position of the switch contacts when the magnetic coil is not energized.

Relay Types

1. Time delay relay: incorporates a means for delaying the opening or closing of the load contacts for a specific period of time after the control circuit is energized or de-energized.
2. Transfer relay: incorporates overlapping load contacts that permit the load to be transferred from one circuit to another when the coil is energized.
3. Transformer relay: incorporates a step-down transformer to power the low voltage control circuit.
4. Alarm silencing relay: incorporates contacts arranged to silence an audible alarm when a push button is depressed, without re-establishing the main load circuit to the controlled device.
5. Contactor: a heavy duty relay for control of motors or high amperage loads. May incorporate auxiliary holding contacts for interlocking with safety limits or other devices.

6. Balancing relay: used in bridge circuits to equalize resistance values.

7. Overload relay: opens the load circuit if current drawn exceeds a selected value ("magnetic overload relay") or in response to heat generated by excessive current flow ("thermal overload relay").

F. SWITCHES

· Switches are used to open (break) or complete (make) a circuit.

· Switches may be actuated manually, by heat, mechanically, or electromagnetically.

· Switches are identified by the number of poles provided, and whether they are single throw or double throw.

G. OVERLOAD PROTECTION

· Fuses and circuit breakers are used in the power circuit to protect against damage from a short circuit (circuit failure that permits the current to take a shortcut between the terminals of a power source).

· Motors have their own overload protection in addition to power circuit overload protection.

H. ELECTRIC SERVICE

· Single Phase Two Wire: residential service to older buildings, seldom used in new construction. Provides power at 115 volts.

· Single Phase Three Line: residential and light commercial service universally used in new construction. Provides power at 115/230 volts.

· Three Phase Three Wire: commercial/industrial service. Provides power at a number of nominal supply voltages (240, 480 or 600 volts; sometimes 220, 440 or 550 are available).

· Three Phase Four Wire: commercial/industrial service. Provides power at nominal system voltages of 208, 416 or 480 volts.

CAUTION: The above description is oversimplified but electrical characteristics of heating equipment must be compatible with the available power supply.

BUILDING CODES & STANDARDS

ANSI American National Standards Institute
11 West 42nd St., New York, NY 10036

ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329

BOCA Building Officials & Code Administrators International, Inc.
4051 W. Flossmoor Rd., Country Club Hills, IL 60477

CABO Council of American Building Officials
5203 Leesburg Pike, Suite 708, Falls Church, VA 22041

IAPMO International Association of Plumbing & Mechanical Officials
20001 South Walnut Dr., Walnut, CA 91789

ICBO International Conference of Building Officials
5360 South Workman Mill Rd., Whittier, CA 90601

NBS National Bureau of Standards
Washington, DC 20234

NCSBCS National Conference of States on Building Codes and Standards, Inc.
481 Carlisle Drive, Herndon, VA 22070

NFPA National Fire Protection Association
Batterymarch Park, P.O. Box 9101, Quincy, MA 02269

SBCCI Southern Building Code Congress International, Inc.
900 Montclair Rd., Birmingham, AL 35213

PROFESSIONAL ASSOCIATIONS & SOCIETIES

ABMA American Boiler Manufacturers Association
950 N. Glebe Rd., Suite 160, Arlington, VA 22203

ACCA Air Conditioning Contractors of America
1513 16th Street NW, Washington, DC 20036
(formerly National Environmental Systems Contractors Association)

ARI Air-Conditioning and Refrigeration Institute
1501 Wilson Blvd., Suite 600, Arlington, VA 22209

ASGE American Society of Gas Engineers
P.O. Box 31756, Independence, OH 44131

BHC	Better Heating-Cooling Council P.O. Box 218, Berkeley Heights, NJ 07922
GAMA	Gas Appliance Manufacturers Association, Inc. 1901 N. Moore St., Suite 1100, Arlington, VA 22209
GRI	Gas Research Institute 8600 W Bryn Mawr Ave., Chicago, IL 60631
HYDI	Hydronics Institute 35 Russo Place, Berkeley Heights, NJ 07922
MCAA	Mechanical Contractors Association of America, Inc. 1385 Piccard Drive, Rockville, MD 20850
NAPHCC	National Association of Plumbing-Heating-Cooling Contractors 180 S Washington St., P.O. Box 6808, Falls Church, VA 22040
RSES	Refrigeration Service Engineeers Society 1666 Rand Rd., Des Plaines, IL 60016
SMACNA	Sheet Metal and Air Conditioning Contractors' National Assoc. 8224 Old Courthouse Rd., Vienna, VA 22180

APPROVAL AGENCIES

ETL/ETLc	Intertech Testing Services 18 Boulden Circle, Suite 34, New Castle, DE 19720
AGA	American Gas Association 1515 Wilson Blvd., Arlington, VA 22209
CGA	Canadian Gas Association 55 Scarsdale Rd., Toronto, Ontario M3B 2R3
IAS	International Approval Services Joint Venture of AGA and CGA (effective 1/1/96) Offices in Cleveland, OH, Los Angeles, CA, and Toronto, Ontario
ASME	American Society of Mechanical Engineers 345 East 47th St., New York, NY 10017
CSA	Canadian Standards Association 178 Rexdale Blvd., Rexdale, ONT M9W 1R3, Canada
IBR	Institute of Boiler and Radiator Manufacturers superseded by Hydronics Institute
UL	Underwriters' Laboratories, Inc. 333 Pfingsten Rd., Northbrook, IL 60062

CHAPTER 13 - THE METRIC SYSTEM

The metric system, a European system of measurement, was developed by the French during the latter part of the 18th century to standardize measurement units. By the end of the 19th century it was being used as a commercial unit of measure by most European nations as well as Central and South America.

The system is not new to the United States. As early as 1790 Thomas Jefferson had suggested its use. In 1866 an Act of Congress made the metric measure legal but not mandatory. Since World War II many other nations have changed to metric: Russia, The Peoples Republic of China, India, Japan, The United Kingdom, Germany, Mexico and Canada.

1. THE METRIC UNITS:

LENGTH:

The base unit of metric length is the meter -- this unit is 39.37 inches and is divided into one hundred centimeters. The meter is one thousandth part of the kilometer which is the unit that will replace the mile.

Symbols:

Millimeter	mm
Centimeter	cm
Decimeter	dm
meter	m
Kilometer	km = 1,000 m.

AREA:

The base unit of metric area is the square meter -- this unit is one ten thousandth part of a hectare. The hectare is approximately 2½ acres in area and will probably replace the acre as a basis for land surveys.

Symbols:

Square centimeter	cm^2
Square decimeter	dm^2
Square meter	m^2
are	a
hectare	ha
Square kilometer	km^2 = 100 ha.

VOLUME:

The base unit of metric volume is the liter -- this unit is 1.8 fl. ounces larger than the U.S. Quart. Drug dispensers prefer to work with cubic centimeters or milliliters as the unit is also known. One teaspoon is the equivalent of 5 milliliters. For measuring larger quantities, e.g. readymix concrete, cubic meters is the unit used.

Symbols:

Cubic centimeter	cm^3 or cc. as it is commonly referred to milliliter ml
cubic decimeter	dm^3
liter	l
cubic meter	m^3 = 1,000 l

WEIGHT/MASS:

The base unit of metric weight is the gram -- this unit is approximately one thirtieth of an avoirdupois ounce and is mostly used in pharmaceutical and scientific work. The more convenient unit is the kilogram, weighing approximately 2.2 pounds.

Symbols:

milligram	mg
gram	g
Kilogram	kg
Metric ton	t = 1,000 kg.

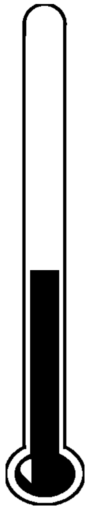
TEMPERATURE:

Most countries using the Metric System use the Celsius (formerly centigrade) thermometer where water freezes at 0°C and boils at 100°C. Comfortable room temperature would be about 22°C and body temperature 37°C.

Temperature conversion from Fahrenheit to Celsius (Centigrade):

The simple formula is: Fahrenheit to Celsius = (F° - 32°) ÷ 1.8
Celsius to Fahrenheit = C° x 1.8 + 32

	°Fahrenheit	°Celsius
Boiling Point of Water	212.0	100
	167.0	75
	122.0	50
	104.0	40
Body Temperature	98.6	37
	95.0	35
	85.0	30
	77.0	25
Comfortable Room Temp.	72.0	22.2
	68.0	20
	59.0	10
	50.0	10
	41.0	5
	39.2	4
	37.4	3
	35.6	2
	33.8	1
Freezing Point of Water	32 F	0 C



2. TABLES OF METRIC WEIGHTS AND MEASURES:

LINEAR MEASURE (LENGTH):

10 millimeters (mm)	= 1 Centimeter (cm)
10 centimeters	= 1 Decimeter (dm)
	= 100 millimeters
10 decimeters	= 1 Meter (m)
	= 1,000 millimeters
10 meters	= 1 Dekameter
10 dekameters	= 1 Hectometer (hm)
	= 100 meters
10 hectometers	= 1 Kilometer (km)
	= 1,000 meters

SQUARE MEASURE (AREA):

100 Square Millimeters	= 1 Sq. Centimeter (cm^2)
10,000 Square Centimeters	= 1 Square Meter (m^2)
100 Square meters	= 1 Are (a)
100 Ares	= 1 Hectare (ha)

100 Hectares	= 1 Square kilometer (km^2)
	= 1,000,000 square meters

VOLUME MEASURE:

1 milliliter	= 1 cubic centimeter (cm^3 or cc)
1 liter	= 0.001 cubic meter
10 milliliters (ml)	= 1 Centiliter (cl)
10 centiliters	= 1 Deciliter (dl)
	= 100 milliliters
10 deciliters	= 1 Liter (l)
	= 1,000 milliliters
10 liters	= 1 dekaliter
10 dekaliters	= 1 Hectoliter (hl)
	= 100 liters
10 hectoliters	= 1 kiloliter
	= 1,000 liters

CUBIC MEASURE (CAPACITY):

1,000 cubic millimeters	= 1 cubic centimeter (cm^3 or cc)
1,000 cubic centimeters	= 1 cubic decimeter
	= 1,000,00 cubic millimeters
	= 1 liter
1,000 cubic decimeters	= 1 cubic meter

WEIGHT MEASURE:

10 milligrams (mg)	= 1 centigram (cg)
10 centigrams	= 1 decigram (dg)
10 decigrams	= 1 gram (g)
10 grams	= 1 dekagram
10 dekagrams	= 1 hectogram (hg)
10 hectograms	= 1 kilogram (kg)
1,000 kilograms	= 1 Metric Ton

3. MULTIPLES AND SUBMULTIPLES:

Prefix	Symbol	Equivalent	Factor
atto-	a	quintillionth part	$x10^{-18}$
femto-	f	quadrillionth part	$x10^{-15}$
pico-	p	trillionth part	$x10^{-12}$
nano-	n	billionth part	$x10^{-9}$
micro-	µ	millionth part	$x10^{-6}$
milli-	m	thousandth part	$x10^{-3}$
centi-	c	hundredth part	$x10^{-2}$
deci-	d	tenth part	$x10^{-1}$
deka	da	tenfold	x10
hecto-	h	hundredfold	$x10^{2}$
kilo-	k	thousandfold	$x10^{3}$
mega-	M	millionfold	$x10^{6}$
giga-	G	billionfold	$x10^{9}$
tera-	T	trillionfold	$x10^{12}$

The small figure in the factor determines the position of the decimal point in multiplying out a conversion.

EXAMPLE:

3.0×10^2 = 3.00 x 10 x 10
move decimal point 2 places to the right
= 300.00

6.37×10^3 = 6.37 x 10 x 10 x 10
move decimal point 3 places to the right
= 6370.00

6.37×10^{-3} = .00637
move decimal point 3 places to the left

4. TABLE OF EQUIVALENTS:

LENGTH/DISTANCE:

1 chain (surveyors)	= 66 feet
	= 20.1168 meters
1 fathom	= 6 feet
	= 1.8288 meters
1 foot	= 0.3048 meter
1 inch	= 2.54 centimeters
	= 25.4 millimeters

1 mile (statute)	= 1.609 kilometers
1 mile (nautical)	= 1.151 statute miles
	= 1.852 kilometers
1 yard	= 0.9144 meter
1 centimeter	= 0.3937 inch
1 decimeter	= 3.937 inches
1 dekameter	= 32.808 feet
1 kilometer	= 0.621 mile
1 meter	= 1.094 yards
	= 39.37 inches
1 millimeter	= 0.03937 inch

AREA/SURFACE:

1 acre	= 4,840 square yards
	= 0.405 hectare
1 square foot	= 929.030 square centimeters
1 square inch	= 6.4516 square centimeters
1 square mile	= 258.999 hectares
1 square yard	= 0.836 square meter
1 are	= 119.599 square yards
	= 0.025 acre
1 hectare	= 2.471 acres
1 square centimeter	= 0.155 square inch
1 square decimeter	= 15.500 square inches
1 square kilometer	= 247.105 acres
	= 0.386 square mile
1 square meter	= 10.764 square feet
	= 1.196 square yards
1 square millimeter	= 0.002 square inch

CAPACITY/VOLUME:

1 cubic foot	= 28.316 cubic decimeters
1 cubic inch	= 16.387 cubic centimeters
1 cubic yard	= 0.765 cubic meter
1 U.S. gallon	= 128 fluid ounces
	= 231 cubic inches
	= 3.785 liters

1 gill	= 4 fluid ounces
	= 0.118 liter
1 U.S. fluid ounce	= 29.574 milliliters
1 U.S. fluid quart	= 57.75 cubic inches
	= 0.946 liter
1 cubic centimeter	= 0.061 cubic inch
1 cubic decimeter	= 61.024 cubic inches
1 cubic meter	= 1.308 cubic yards
1 cubic dekaliter	= 2.642 gallons
1 hectoliter	= 26.418 gallons
1 liter	= 61.024 cubic inches
1 milliliter	= 0.061 cubic inch

WEIGHT/MASS:

1 carat	= 200 milligrams
1 gram	= 0.035 ounce
1 kilogram	= 2.205 pounds
1 Metric Ton	= 2,204.623 pounds
1 ounce	= 28.35 grams
1 pound	= 0.453592 kg

5. UNIT CONVERSIONS

To Convert	Into	Multiply by
Acre	Hectare	0.4047
Astronomical Unit	Kilometers	1.495×10^{8}
Bolt (U.S. cloth measure)	Meters	36.576
B.T.U.	Kilowatt Hours	2.928×10^{-4}
B.T.U./Hr	Watts	0.2931
Centimeters	Kilometers	1×10^{-5}
Centimeters	Meters	1×10^{-2}
Centimeters	Millimeters	10.00
Centimeters	Feet	3.281×10^{-2}

Centimeters	Inches	0.3937
Cubic Centimeters	Cubic Inches	0.06102
Cubic Feet	Cubic Meters	0.02832
Feet	Centimeters	30.48
Feet	Meters	0.3048
Feet/Min	Centimeters/Sec	0.5080
Foot Pounds	Kilowatt Hours	3.766×10^{-7}
Gallons	Liters	3.785
Grams	Ounces	3.527×10^{-2}
Grams	Pounds	2.205×10^{-3}
Hectares	Acres	2.471
Hectares	Square Feet	1.076×10^{5}
Horsepower	Kilowatts	0.7457
Horsepower	Watts	745.7
Inches	Centimeters	2.54
Kilograms	Pounds	2.205
Kilometers	Feet	3,281.00
Kilometers	Miles	0.6214
Kilometers/hour	Knots	0.5396
Kilowatts	Horsepower	1.341
Kilowatt Hours	B.T.U.	3,413.00
Liters	Cubic Inches	61.02
Liters	U.S. Liquid Gallons	0.2642
Liters	U.S. Liquid Pints	2.113

Meters	Feet	3.281
Meters	Miles (Nautical)	5.396×10^{-4}
Meters	Miles (Statute)	6.214×10^{-4}
Miles (Nautical)	Kilometers	1.853
Miles (Statute)	Kilometers	1.609
Millimeters	Inches	3.937×10^{-2}
Ounces	Grams	28.349527
Pounds	Kilograms	0.4536
Pounds per Square Inch (PSI)	Grams per Square Centimeter	70.31
Quarts (Liquid)	Liters	0.9463
Tons (long)	Kilograms	1,016.00
Tons (short)	Kilograms	907.1848
Watts	B.T.U./hour	3.4129
Watts	Horsepower	1.341×10^{-3}
Yards	Meters	0.914

ENERGY TERMS - CONVERSIONS - HEAT VALUES

A. PREFIXES

Prefixes indicateorders of magnitude in steps. Prefixes provide a convenient way to express large and small numbers and to eliminate nonsignificant digits and leading zeros in decimal fractions. The following are the more commonly used prefixes:

English System

Symbol	Represents
C	100
M	1,000
MM	1,000,000

Metric System

K	1,000
M*	1,000,000

*Caution: make certain of the system.

B. NATURAL GAS ENERGY MEASUREMENTS IN BTU

1,000	=	1 Cubic Foot
100,000	=	1 therm or 1 CCF or 100 MBTU
1,000,000	=	1 MMBTU or 1,000 CF or 1 MCF
1,000,000,000	=	1 billion BTU or 1 MMCF
1,000,000,000,000	=	1 trillion BTu or 1 BCF
1,000,000,000,000,000	=	1 quadrillion BTU or 1 TCF

C. ENERGY MEASUREMENTS OF OTHER FUELS IN BTU

Propane	2,550 btu	=	1 CF
	21,650 btu	=	1 Lb.
	91,800 btu	=	1 Gal.
Butane	3,200 btu	=	1 CF
	21,500 btu	=	1 Lb.
	102,400 btu	=	1 Gal.
Oil	5,825,000 btus	=	1 barrel crude
	6,200,000 btus	=	1 barrel #5 (Residual)
	6,400,000 btus	=	1 barrel #6 (heating)
	134,000 btus	=	1 Gal. #1 oil (kerosene)
	139,000 btus	=	1 Gal. #2 oil
	146,800 btus	=	1 Gal. #4 oil
	150,000 btus	=	1 Gal. #6 oil
	(1 U.S. Barrel	=	42 U.S. Gallons)

Electric	3,412 btus	=	1 Kilowatt
Coal	21,700,000 btus	=	1 Ton Bituminous (soft)
	22,800,000 btus	=	1 Ton Anthracite (hard)
Wood	3,500 btus	=	1 Lb. (mixed average)
	14,000,000 btus	=	1 Cord (mixed average)

D. QUICK FUEL COMPARISONS BASED ON 1,000,000 BTUS

Natural Gas	=	10 Therms
Propane Gas	=	10.89 Gal.
Butane Gas	=	9.77 Gal.
#1 Oil	=	7.46 Gal.
#2 Oil	=	7.19 Gal.
#4 Oil	=	6.81 Gal.
#6 Oil	=	6.67 Gal.
Bituminous Coal	=	.046 Ton (92 Lbs.)
Anthracite Coal	=	.044 Ton (88 Lbs.)
Wood (mixed avg)	=	286 Lbs.

E. SPECIFIC HEATING VALUE OF WOODS
(Based on U.S. Dept. of Agriculture Bulletin No. 753)

	Weight per cord. lb.		Heating Value BTU per lb.		Equivalent lb. of Coal of 13,500 BTU per lb.	
	Green	Air-dry	Green	Air-dry	Green	Air-Dry
Ash-white	4300	3800	4628	5395	0.343	0.400
Beech	5000	3900	3940	5359	0.292	0.397
Birch, yellow	5100	4000	3804	5225	0.282	0.387
Chestnut	4900	2700	2633	5778	0.195	0.428
Cottonwood	4200	2500	3024	6000	0.224	0.444
Elm, white	4400	3100	3591	5710	0.266	0.423
Hickory	5700	4600	4053	5391	0.300	0.399
Maple, sugar	5000	3900	4080	5590	0.302	0.414
Maple, red	4700	3200	3745	5969	0.277	0.442
Oak, red	5800	3900	3379	5564	0.250	0.412
Oak, white	5600	4300	3972	5558	0.294	0.412
Pine, yellow	3100	2300	7079	9174	0.526	0.680
Pine, white	3300	2200	4226	5864	0.313	0.434
Walnut, black	5100	4000	4078	4650	0302	0.344
Willow	4600	2300	2370	5870	0.176	0.435

A cord of Wood is a pile 4' x 4' x 8' = 128 cu. ft. comprising approximately 56% Solid wood and 44% Interstitial spaces.

MEASURING GAS & OIL INPUT

Gas on pages 85 and 86 - Oil on page 87

1. GAS RATE - CUBIC FEET PER HOUR

Seconds for One Revolution	Size of Test Dial		Seconds for One Revolution	Size of Test Dial	
	2 cu. ft.	5 cu. ft.		2 cu. ft.	5 cu. ft.
10	720	1800	55	131	327
11	655	1636	56	129	321
12	600	1500	57	126	316
13	555	1385	58	124	310
14	514	1286	59	122	305
15	480	1200	60	120	300
16	450	1125	62	116	290
17	424	1059	64	112	281
18	400	1000	66	109	273
19	379	947	68	106	265
20	360	900	70	103	257
21	343	857	72	100	250
22	327	818	74	97	243
23	313	783	76	95	237
24	300	750	78	92	231
25	288	720	80	90	225
26	277	692	82	88	220
27	267	667	84	86	214
28	257	643	86	84	209
29	248	621	88	82	205
30	240	600	90	80	200
31	232	581	92	78	196
32	225	563	94		192
33	218	545	96	75	188
34	212	529	98		184
35	206	514	100	72	180
36	200	500	102		176
37	195	486	104	69	173
38	189	474	106		170
39	185	462	108	67	167
40	180	450	110		164
41	176	439	112	64	161
42	172	429	116	62	155
43	167	419	120	60	150
44	164	409	125		144
45	160	400	130		138
46	157	391	135		132
47	153	383	140		129
48	150	375	145		124
49	147	367	150		120
50	144	360	155		116
51	141	353	160		113
52	138	346	165		109
53	136	340	170		106
54	133	333	175		103
55	131	327	180		100

Seconds for One Revolution	Size of Test Dial		Seconds for One Revolution	Size of Test Dial	
	1/2 cu. ft.	1 cu. ft.		1/2 cu. ft.	1 cu. ft.
10	180	360	35	103	
11	164	327	36	50	100
12	150	300	37	97	
13	138	277	38	47	95
14	129	257	39	92	
15	120	240	40	45	90
16	113	225	41		
17	106	212	42	43	86
18	100	200	43		
19	95	189	44	41	82
20	90	180	45	40	80
21	86	171	46	78	
22	82	164	47	38	
23	78	157	48	75	
24	75	150	49		
25	72	144	50	36	72
26	69	138	51		
27	67	133	52		69
28	64	129	53	34	
29	62	124	54		67
30	60	120	55		
31		116	56	32	64
32	56	113	57		
33		109	58	31	62
34	53	106	59		
35		103	60	30	60

2. OIL RATE -- GALLON PER HOUR

Nozzle Delivery Rates at Various Pressures for No. 2 Fuel Oil

Pump Pressure (PSI)

	80	90	100	125	150	175	200	225	250	275	300
1.0	0.9	.95	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.75
1.5	1.3	1.4	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.5	2.6
2.0	1.8	1.9	2.0	2.2	2.5	2.6	2.9	3.0	3.2	3.3	3.5
2.5	2.2	2.4	2.5	2.8	3.1	3.3	3.5	3.8	4.0	4.1	4.3
3.0	2.7	2.8	3.0	3.3	3.7	3.9	4.2	4.5	4.7	5.0	5.2
3.5	3.1	3.3	3.5	3.9	4.3	4.6	5.0	5.3	5.5	5.8	6.0
4.0	3.6	3.8	4.0	4.5	4.9	5.3	5.6	6.0	6.3	6.6	6.9
4.5	4.0	4.2	4.5	5.0	5.5	5.9	6.3	6.8	7.1	7.4	7.8
5.0	4.5	4.7	5.0	5.6	6.1	6.6	7.1	7.5	7.9	8.3	8.7
5.5	4.9	5.2	5.5	6.2	6.7	7.3	7.8	8.3	8.7	9.1	9.5
6.0	5.3	5.6	6.0	6.7	7.3	7.9	8.5	9.0	9.5	9.9	10.4
7.0	6.2	6.6	7.0	7.8	8.5	9.2	9.9	10.5	11.0	11.6	12.0
8.0	7.2	7.5	8.0	8.9	9.8	10.5	11.3	12.0	12.6	13.2	13.8
9.0	8.0	8.5	9.0	10.0	11.0	11.8	12.6	13.5	14.2	14.8	15.6
10.0	8.4	9.4	10.0	11.2	12.2	13.2	14.1	15.0	15.8	16.6	17.3
11.0	9.8	10.3	11.0	12.3	13.4	14.5	15.6	16.5	17.4	18.2	19.0
12.0	10.7	11.2	12.0	13.4	14.6	15.8	16.9	18.0	18.9	19.8	20.7
13.0	11.6	12.2	13.0	14.5	16.0	17.2	18.4	19.5	20.6	21.5	22.5
14.0	12.4	13.1	14.0	15.6	17.0	18.4	19.8	21.0	22.0	23.1	24.0
15.0	13.3	14.0	15.0	16.8	18.4	19.8	21.3	22.5	23.6	24.8	25.9
16.0	14.3	15.0	16.0	17.8	19.5	21.0	22.6	24.0	25.3	26.4	27.7
17.0	15.1	15.9	17.0	19.0	20.7	22.5	24.1	25.5	26.9	28.0	29.3
18.0	16.1	17.0	18.0	20.1	22.0	23.7	25.3	27.0	28.4	29.7	31.2
20.0	17.8	18.8	20.0	22.3	24.4	26.4	28.2	30.0	31.7	33.1	34.6
22.0	19.6	20.6	22.0	24.6	26.9	29.0	31.2	33.0	34.8	36.4	38.0

Notes: These delivery rates are approximate values.

Actual rates will vary slightly between different nozzles of the same nominal rating.

Delivery tends to increase with higher viscosity, or lower oil temperature, or lower specific gravity.

ACIDITY AND ALKALINITY - (pH)

pH is the logarithm of the reciprocal of the Hydrogen concentration.

$$pH = \log_{10} \frac{1}{H+} \quad \text{(gram/liter equiv.)}$$

Since 1 hydroxyl ion is formed whenever a hydrogen ion develops, the pH scale also is used to measure the formation of hydroxyl ions.

Typical pH values, relative strength:

1	1,000,000	1/10 normal HCl sol
2	100,000	Gastric Fluid
3	10,000	Vinegar (4% acetic acid)
4	1,000	Orange or grape juice
5	100	Molasses
6	10	Milk (6.8 pH)
7	1	Pure Water, saliva
8	10	Baking Soda, sea water
9	100	Borax solutioin
10	1,000	Soap - Milk of magnesia
11	10,000	Tri-sodium phosphate
12	100,000	Household ammonia (10%)
13	1,000,000	Lye - Na O H

Manufacturers of hydronic and air conditioning equipment recommend a pH value of 7.5 to 8.5 in the circulating water.

The pH levels in all industrial cooling and heating systems are closely supervised. Excessive acidity (pH 5-6) causes corrosion and high alkalinity (pH 8-10) results in heavy scale deposits on hot heat transfer surfaces.

SOUND LEVELS

The human ear can accept an enormous range of sound levels. From a whisper (20 dB) to a police siren at 50 ft. (120dB) represents a sound pressure level ratio of 1 to 1 million. The ear can take it for short periods, but prolonged exposure to high noise levels will cause permanent hearing impairment.

Because of the very large audio level ratios and resulting cumbersome numbers, the decibel system was devised.

Honoring Alexander Graham Bell, the telephone industry named the unit of sound the Bel. This unit was found to be too large for convenience, so 1/10 Bel or the decibel (dB) was adopted internationally.

TYPICAL SOUND PRESSURE LEVELS

Db	Noise Source and Distance
130	Jet plane take-off at 200 ft.
120	Police siren at 50 ft.
110	Pneumatic hammer at 50 ft.
100	Millworking machines at 50 ft.
90	Manufacturing plants, average
80	Symphony orchestra, fortissimo
70	Vacuum cleaner at 10 ft.
60	Business machine areas
50	Normal business offices
40	Quiet residential areas at night
30	Normal speech at 3 ft.
20	Soft whisper at 3 ft.

Doubling of sound pressure from a single source results in a 3 dB rise in sound pressure level.

Doubling of the distance from the source of a sound to the receiver will reduce its level 6 dB.

A 10 dB rise in sound level indicates that the sound perceived by the ear will be twice as loud as the original sound.

A police siren developing 100 dB at 100 ft. will produce 94 dB at 200 ft.; 88 dB at 400 ft., etc.

GAS PIPE SIZING - RESIDENTIAL

Interior gas piping must be examined before installing a new gas boiler. A typical winter load and even a summer load (indirect hot water supply) must be considered. Listed below are average inputs of various gas appliances that may be on-line. Also listed is a chart to determine whether the existing piping can carry the seasonal load.

For specific appliances or appliances not shown below, the input should be determined from the manufacturer’s rating.

Approximate Gas Input for Some Common Appliances

Appliance	Input BTU Per Hr. (Approx.)
Range, Free Standing, Domestic	65,000
Built-In Oven or Broiler Unit, Domestic	25,000
Built-In Top Unit, Domestic	40,000
Water Heater, Automatic Storage - 30 to 40 Gal. Tank	45,000
Water Heater, Automatic Storage - 50 Gal. Tank	55,000
Fireplace/Gas Log	21,000 - 55,000
Grille	30,000 - 40,000
Boiler	----
Clothes Dryer, Type 1 (Domestic)	20,000 - 35,000
Gas Light	2,500
Incinerator, Domestic	35,000

Maximum Capacity of Pipe in Cubic Feet of Gas Per Hour

(Based on a pressure drop of 0.3 Inch Water Column and 0.6 Specific Gravity Gas)

Length In Feet	Nominal Iron Pipe Size, Inches								
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
10	132	278	520	1,050	1,600	3,050	4,800	8,500	17,500
20	92	190	350	730	1,100	2,100	3,300	5,900	12,000
30	73	152	285	590	890	1,650	2,700	4,700	9,700
40	63	130	245	500	760	1,450	2,300	4,100	8,300
50	56	115	215	440	670	1,270	2,000	3,600	7,400
60	50	105	195	400	610	1,150	1,850	3,250	6,800
70	46	96	180	370	560	1,050	1,700	3,000	6,200
80	43	90	170	350	530	990	1,600	2,800	5,800
30	40	84	160	320	490	930	1,500	2,600	5,400
100	38	79	150	305	460	870	1,400	2,500	5,100
125	34	72	130	275	410	780	1,250	2,200	4,500
150	31	64	120	250	380	710	1,130	2,000	4,100
175	28	59	110	225	350	650	1,050	1,850	3,800
200	26	55	100	210	320	610	980	1,700	3,500

Correction Factors for Specific Gravity Other Than 0.60

ABBREVIATIONS USED IN HEATING

Absolute .... abs
Alternating-Current .... a-c
Ampere .... amp
Atmosphere .... atm
Average .... avg
Avoirdupois .... avdp
Barometer .... bar
Boiling Point .... bp
Brake Horsepower .... bhp
Brake Horsepower, Hour ...... bhp-hr
British Thermal Unit .... Btu
per hour .... Btuh
Calorie .... cal
Centigram .... cg
Centimeter .... cm
Cubic .... cu
Cubic Centimeter cc
Cubic Foot .... cu ft
Cubic Feet per Minute .... cfm
Cubic Feet per Second .... cfs
Degree .... deg or °
Degree, Centigrade C
Degree, Fahrenheit .... F
Diameter .... diam
Direct-Current .... d - c
Feet per Minute .... fpm
Feet per Second .... fps
Foot .... ft
Foot-Pound .... ft lb
Freezing Point .... fp
Gallon .... gal
Gallons per Minute .... gpm
Gallons per Second .... gps
Gram .... g
Horsepower .... hp
Horsepower-Hour .... hp-hr
Hour .... hr
Inch .... in
Inch-Pound .... in-lb
Kilogram .... kg
Kilowatt .... kw
Melting Point .... mp
Meter .... m
Miles per Hour .... mph
Millimeter .... mm
Minute .... min
Ounce .... oz
Pound .... lb
Pounds per Square Inch .... psi
Pounds per Square Inch, Gage .... psig
Pounds per Square Inch, Absolute ..... psia
Revolutions per Minute .... rpm
Revolutions per Second. .... rps
Second .... sec
Specific Gravity .... sp gr
Specific Heat .... sp ht
Square Foot .... sq ft
Square Inch .... sq in
Volt v
Watt .... w
Watt Hour .... whr

CAPACITY OF ROUND STORAGE TANKS

Number of Gallons

Depth or Length in Ft.	Inside Diameter in Inches									
	18	24	30	36	42	48	54	60	66	72
1	1.10	1.96	3.06	4.41	5.99	7.83	9.91	12.24	14.81	17.62
2	26	47	73	105	144	188	238	294	356	423
2-1/2	33	59	91	131	180	235	298	367	445	530
3	40	71	100	158	216	282	357	440	534	635
3-1/2	46	83	129	184	252	329	416	513	623	740
4	53	95	147	210	288	376	475	586	712	846
4-1/2	59	107	165	238	324	423	534	660	800	952
5	66	119	181	264	360	470	596	734	899	1057
5-1/2	73	130	201	290	396	517	655	808	978	1163
6	79	141	219	315	432	564	714	880	1066	1268
6-1/2	88	155	236	340	468	611	770	954	1156	1374
7	92	165	255	368	504	658	832	1028	1244	1480
7-1/2	99	179	278	396	540	705	889	1101	1335	1586
8	106	190	291	423	576	752	949	1175	1424	1691
9	119	212	330	476	648	846	1071	1322	1599	1903
10	132	236	366	529	720	940	1189	1463	1780	2114
12	157	282	440	634	864	1128	1428	1762	2133	2537
14	185	329	514	740	1008	1316	1666	2056	2490	2960
16	211	376	587	846	1152	1504	1904	2350	2844	3383
18	238	423	660	952	1296	1692	2140	2640	3200	3806
20	264	470	734	1057	1440	1880	2380	2932	3556	4230

CAPACITY OF RECTANGULAR TANKS

To find the capacity in U.S. gallons of rectangular tanks, reduce all dimensions to inches, then multiply the length by the width by the height and divide the product by 231.

Example: Tank 56” long x 32” wide x 20” deep

Then 56” x 32” x 20” = 35,840 cu. in.

35,840 ÷ 231 = 155 gallon capacity

GRAINS OF MOISTURE PER CUBIC FOOT OF AIR AT VARIOUS TEMPERATURES AND HUMIDITIES

Temp. °F.	Relative Humidity, Percent									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
75	9.35	8.42	7.49	6.55	5.61	4.68	3.74	2.81	1.87	0.94
72	8.51	7.66	6.81	5.96	5.11	4.25	3.40	2.55	1.70	0.85
70	7.98	7.18	6.38	5.59	4.79	3.99	3.19	2.39	1.60	0.80
67	7.24	6.52	5.79	5.07	4.35	3.62	2.90	2.17	1.45	0.72
65	6.78	6.10	5.43	4.75	4.07	3.39	2.71	2.04	1.36	0.68
60	5.74	5.17	4.60	4.02	3.45	2.87	2.30	1.72	1.15	0.57
50	4.08	3.67	3.26	2.85	2.45	2.04	1.63	1.22	0.82	0.41
40	2.85	2.56	2.28	1.99	1.71	1.42	1.14	0.86	0.57	0.29
30	1.94	1.74	1.55	1.35	1.16	0.97	0.78	0.58	0.39	0.19
20	1.23	1.11	0.99	0.86	0.74	0.62	0.49	0.37	0.25	0.12
10	0.78	0.70	0.62	0.54	0.47	0.39	0.31	0.23	0.16	0.08
0	0.48	0.43	0.39	0.34	0.29	0.24	0.19	0.14	0.10	0.05

7000 Grains of moisture = 1 pound of water

HEATING CONVERSION FACTORS

BTUs	X	1054.8	=	Joules
BTUs	X	0.2520	=	Kg. Cal.
Calories	X	4.186	=	Joules
Joules	X	0.23889	=	Calories
Joules	X	.0002389	=	Kg. Cal.
Kg. Cal.	X	3.9685	=	BTUs
KW-hr	X	860.01	=	Kg. Cal.
KW-hr	X	3413.0	=	BTUs
Watt-hr	X	3.413	=	BTUs

QUANTITY OF HEAT IN BTU REQUIRED TO RAISE 1 CU. FT. OF AIR THROUGH A GIVEN TEMPERATURE INTERVAL

External Temp. Degrees F	Temperature of Air in Room							
	40	50	60	70	80	90	100	110
-40	1.802	2.027	2.252	2.479	2.703	2.928	3.154	3.379
-30	1.540	1.760	1.980	2.200	2.420	2.640	2.860	3.080
-20	1.290	1.505	1.720	1.935	2.150	2.365	2.580	2.795
-10	1.051	1.262	1.473	1.684	1.892	2.102	2.311	2.522
0	0.822	1.028	1.234	1.439	1.645	1.851	2.056	2.262
10	0.604	0.805	1.007	1.208	1.409	1.611	1.812	2.013
20	0.393	0.590	0.787	0.984	1.181	1.378	1.575	1.771
30	0.192	0.385	0.578	0.770	0.963	1.155	1.345	1.540
40	—	0.188	0.376	0.564	0.752	0.940	1.128	1.316
50	—	—	0.184	0.367	0.551	0.735	0.918	1.102
60	—	—	—	0.179	0.359	0.538	0.718	0.897
70	—	—	—	—	0.175	0.350	0.525	0.700

MELTING POINTS OF METALS

	Degrees F.		Degrees F.
Aluminum	1220	Iron (Cast) Gray	2460-2550
Antimony	1167	Iron (Cast) White	1920-2010
Bismuth	520	Iron, Wrought	2460-2640
Brass (Red)	1870	Lead	622
Bronze	1900	Silver (Pure)	1761
Copper	1981	Steel	2370-2550
Glass	2377	Tin	449
Gold (Pure)	1945	Zinc	787
Solder (Lead-Tin)	250-570		

CONVERSION FACTORS

WATER

U.S. Gallons	x	8.34	=	Pounds
U.S. Gallons	x	0.13368	=	Cubic Feet
U.S. Gallons	x	231.00	=	Cubic Inches
U.S. Gallons	x	3.78	=	Liters
Imperial Gallons	x	277.3 Cubic Inches		
Imperial Gallons at 62°F	=	10.0 Pounds		
Cubic In. of Water (39.2°)	x	0.036130	=	Pounds
Cubic In. of Water (39.2°)	x	0.004329	=	U.S. Gallons
Cubic In. of Water (39.2°)	x	0.576384	=	Ounces
Cubic Feet of Water (39.2°)	x	62.427	=	Pounds
Cubic Feet of Water (39.2°)	x	7.48	=	U.S. Gallons
Cubic Feet of Water (39.2°)	x	0.028	=	Tons
Pounds of Water	x	27.72	=	Cubic Inches
Pounds of Water	x	0.01602	=	Cubic Feet
Pounds of Water	x	0.12	=	U.S. Gallons

PRESSURE

1 Pound Per Square Inch	=	144 Pounds Per Square Foot 2.0355 Inches of Mercury at 32°F. 2.0416 Inches of Mercury at 62°F. 2.309 Feet of Water at 62°F. 27.71 Inches of Water at 62°F 6.895 kPA (kilopascal)
1 Ounce Per Square Inch	=	0.1276 Inches of Mercury at 62°F. 1.732 Inches of Water at 62°F.
1 Atmosphere (14.7 Lbs. Per Sq. In.)	=	2116.3 Pounds Per Square Foot 33.947 Feet of Water at 62°F. 30 Inches of Mercury at 62°F. 29.922 Inches of Mercury at 32°F. 760 Millimeters of Mercury at 32°F. 101.3 kilopascal
1 Inch Water (at 62°F.)	=	0.03609 Lbs. or 0.5774 oz Per Sq. In. 5.196 Pounds Per Square Foot 0.248 kilopascal
1 Foot Water (at 62°F.)	=	0.433 Pounds Per Square Inch 62.355 Pounds Per Square Foot
1 Inch Mercury (at 62°F.)	=	0.491 Lbs. or 7.86 oz. Per Sq. In 1.132 Feet Water at 62°F. 13.58 Inches Water at 62°F.

EQUIVALENT VALUE IN DIFFERENT UNITS

1 H.P.	=	746 watts
		.746 K.W.
		33,000 ft.-lbs. per minute
		550 ft.-lbs. per second
		2.64 lbs water evaporated per hour from and at 212°F.
1 H.P. Hour	=	746 K.W. hours
		2.64 lbs water evaporated per hour from and at 212°F.
		17.0 lbs. water raised from 62° to 212°F.
1 Kilowatt	=	1,000 watts
		1.34 H.P.
		3.53 lbs. water evaporated per hour from and at 212°F.
1 Watt	=	.00134 H.P.
		.0035 lb. water evaporated per hour
1 K.W. Hour	=	1,000 watt hours
		1.34 H.P. Hours
		3,600,000 joules
		3.53 lbs. water evaporated from and at 212°F.
		22.75 lbs. of water raised from 62°F to 212°F
1 Joule	=	1 watt second
		.000000278 K.W. hour
MJ = Megajoule	=	1,000,000 Joule = 948 BTU
		239 Kcal

EQUIVALENTS OF ELECTRICAL UNITS

1 Kilowatt	=	1.34 H.P.
		0.955 BTU per second
		57.3 BTU per minute
		3438 BTU per hour
1 Horse Power	=	746 watts
		42.746 BTU per minute
		2564.76 BTU per hour
1 BTU	=	17.452 watt minutes
		0.2909 watt hour

STANDARD SYMBOLS IN HEATING SPECIFICATIONS

D(delta) = differential, difference in, change in, increment

DP = pressure drop, differential, or loss usually in psi

DT = difference, change or drop in temperature

p (pi) = 3.141592654 = ratio of circumference of a circle to the diameter of that circle

S (sigma) = sum, summation, total of

W(omega) = ohm, unit of electric resistance = 1 V/A

± = plus or minus, tolerance

¹ = not equal to

< = (is) less than

£ = smaller than or equal to

> = (is) greater than

³ = greater than or equal to

<< = much smaller than

>> = much larger than

T = proportional to, similar to

» = approximately equal to

@ = congruent to

\ = therefore

∠ = angle

|| = parrallel to

^ = perpendicular to, at right angles to

¥ = infinity, infinite

Series 2 Gas Boiler

- **Cast Iron Package**
- **Hot Water**
- **DOE Capacities 31 to 244 MBH**

The Series 2 hot water boiler combines the dependability of the a conventional proven atmospheric draft design with the economy of gas heat. It is completely factory assembled and fire tested and requires only minimal hookup to put into operation. At the heart of every Series 2 is a durable cast iron heat exchanger that enhances energy efficiency and improves boiler performance and has an added bonus in the Lifetime True Blue Limited Warranty. Also, the sections are joined by push nipples that can expand and contract with the sections they join. The Series 2 is equipped with a fuel saving vent damper and achieves annual fuel utilization efficiencies up to 84% (Model 2h). Combined, the Series 2 is your long term investment in quality, dependable home heating. Certified for installation on combustible flooring. Do not install on carpeting.

Series 2PV Gas Boiler

- **Induced Draft**
- **Cast Iron Package**
- **Hot Water**
- **DOE Capacities 51 to 135 MBH**

The Series 2PV induced draft boiler is designed for new or replacement installations and electric heat conversions where a chimney is deteriorated or not available. It can be installed almost anywhere, such as a closet, utility room or garage. Available power vented directly through the wall. A cast iron heat exchanger, together with a draft inducing fan, provide for more heat with less fuel and eliminate heat loss through the vent. No vent damper is required. Burnham also backs the heat exchanger on the Series 2PV with their Lifetime True-Blue Limted Warranty.

Spirit® Gas Boiler

- **Direct Vent**
- **Cast Iron Package**
- **Hot Water**
- **DOE Capacities 62 to 164 MBH**

The Spirit direct vent gas boiler is designed for new or replacement installations and electric heat conversions where a chimney is not available. It can be installed almost anwhere, such as in a closet, utility room or garage. Its sealed combustion, direct vent design helps regulate combustion air to help avoid operational and safety problems. A cast iron heat exchanger, together with a draft inducing fan, provide for more heat with less fuel and eliminate heat loss through the vent. No vent damper is required. Certified for installation on combustible flooring. Do not install on carpeting.

Independence®/Independence PV Gas Boiler

- **Cast Iron Package, Semi-Pak or Knockdown**
- **Steam or Hot Water**
- **DOE Capacities:**
  Independence 51 to 317 MBH
  Independence PV 52 to 145 MBH
- **Natural Draft or Power Vent Models Available**

The Independence and Independence PV gas-fired steam or hot water boilers offer the dependability and quality of cast iron construction. The Independence can be used for natural gas or LP gas (IN3-IN9). Burnham also offers the Independence as a power vented boiler for situations where a chimney doesn't exist or or if an old chimney is deteriorated.

The Independence PV (steam only) induced draft boiler installs almost anywhere because no chimney is required for installation. Certified for installation on combustible flooring. Do not install on carpeting.

Revolution™ Gas Boiler

- **Direct Vent**
- **Cast Iron Package**
- **Hot Water**
- **87% AFUE**
- **DOE Capacities 55 to 160 MBH**

As Burnham's most efficient gas-fired boiler, the Revolution is unmatched in versatility. Available in five sizes, the Revolution is easily combined with an indirect water heater and zoning controls for total home comfort. And because of the variety of venting options, the Revolution is adaptable to the floorplan of virtually any home. Consider these features:

- Familiar and proven gas train and controls.
- No additional piping or accessories to run directly on radiant systems.
- Supply temperatures anywhere from 60 to 200 without worry of damage from condensation.
- A built-in injection pump to provide precise temperature control.
- A built-in primary/secondary loop to save time and simplify installation.
- All connections from top to allow for minimal clearances.

Minuteman® II Combination Boiler/Water Heater

- **Cast Iron Construction**
- **Natural or LP Gas**
- **AFUE up to 83%**
- **Sealed Combustion**
- **4 Sizes up to 140 MBH Input**
- **DOE Capacities 58-112 MBH**

The Burnham Minuteman II provides heat and hot water "all in one." Because of its small footprint, it can be easily installed in confined areas or closets. The Minuteman II is ideal for all heating applications ranging from single homes, multi-family units, to industrial or commercial applications. No chimney is necessary, which makes it the most versatile heating appliance for home comfort today.

Series 5B Gas Boiler

- **Cast Iron Knockdown Unit**
- **Steam or Hot Water**
- **Capacities 320 to 1,560 MBH**

The Series 5B boiler offers the capacities and features that make it ideal for commercial, institutional and high rise residential heating applications. The rear outlet drafthood is specifically suited to installations involving low ceiling heights. The Burnham 5B is rated at 50 psi water or 15 psi steam. It has an 80% combustion efficiency. Plus, only Burnham boilers come with the exclusive Iron Nipple Seal of Dependability certifying the use of cast iron nipples which expand and contract with the sections to insure superior quality and reliable performance. Do not install on combustible flooring.

Series 8B Gas Boiler

- **Cast Iron Packaged or Knockdown Unit**
- **Hot Water**
- **Capacities 212 to 475 MBH**

The Burnham Series 8B gas boiler has a vertical flue design which provides for maximum heat transfer. Cast iron push nipples assure the integrity of the cast iron section assembly by expanding & contracting at the same rate and providing a water tight seal. The Series 8B boilers can be installed 1" apart (subject to local codes) making them ideally suited for multiple boiler applications. Do not install on combustible flooring. A heat shield is required and available for combustible floor installations. Do not install on carpeting, even with a heat shield.

Series 8B Modular/Multiple System

- **Primary-Secondary Piping**
- **Capacities starting at 424 MBH**

The Burnham modular/multiple boiler system puts the efficiency, cost, and service advantages of compact gas boilers to work in space heating applications where a single commercial boiler would not be practical for reasons of budget or accessibility. The Series 8B boilers can be installed 1" apart (subject to local codes), making them ideally suited for modular applications. And the modular/multiple system utilizes primary-secondary piping to maximize energy efficiency.

Modular/Multiple Control Packages

- **Microprocessor-based**
- **User-programmable, User-friendly**

Burnham offers ten control packages for operating modular/multiple boiler systems. Control Package A and Penn Johnson A350 maintain a constant supply water temperature. Control Package B and Penn Johnson A350RN are the simplest system for step firing modules according to outdoor air temperature. Control packages D and E monitor supply water temperature and outdoor air temperature to step fire boiler modules for maximum fuel economy. Each has different levels of sophistication and added features. The Burnham microprocessor-based TMC panel senses supply water, return water, and outdoor air temperatures to automatically monitor and control the operation of up to eight boiler modules. The TMC Panel provides boiler status lights and digitally displays supply water, return water and outdoor air temperatures along with accumulated operating hours of each boiler. There are a number of programmable variables to allow accurate set-up for each installation, making the TMC Panel one of the most sophisticated controllers available. The tekmar 251, 252, 254 and 258 control offerings are also available.

V7 Series Oil Boiler

- **Cast Iron Package or Knockdown**
- **Hot Water or Steam**
- **DOE Capacities 68 to 299 MBH**

The fully factory-packaged Burnham V7 is available for steam or hot water with heating capacities ranging from 73 to 275 MBH. A knockdown model is available, as a water or steam unit, when access to the basement is confined.

The pinned heating surfaces of the V7's cast iron section assembly, together with a vertical flue design, extract maximum heat while maintaining low draft losses. This results in higher energy efficiencies and lower fuel costs. Cleaning can be easily accomplished from the top or side.

LE Series Oil Boiler/Natural Draft or Direct Vent

- **Oil Fired**
- **Steel Package**
- **Hot Water**
- **DOE Capacities 74 to 143 MBH**
- **AFUEs up to 86.7%**
- **LE Home Comfort System includes Energy Control 5000 Microprocessor and Alliance indirect water heater**

The Burnham LE boiler is the heart of the LE Home Comfort System, which includes the Energy Control 5000 and Alliance indirect water heater. The LE boiler allows quick, low energy start ups because it holds less water in the boiler vessel. A reversible cast iron swing door gives easy access to the combustion chamber for easy cleaning.

RSA Series Oil Boiler

- **Steel Package**
- **Hot Water**
- **Capacities: 100 to 318 MBH**

The RSA Series comes completely packaged, wired, and assembled for quick connection to water, fuel, and electrical service. The RSA comes equipped with split controls — a light sensing primary control and an operating/high limit control.

The high efficiency RSA has a large combustion area which promotes heating efficiency while maintaining low base temperatures. The RSA also features a new shell design for maximum heat transfer, and spiral turbulators which reduce stack temperatures while providing further heat transfer. A heat sheild is required and available for combustible floor installations. Do not install on carpeting even with a heat shield.

Woodlander Solid Fuel Boiler

- **Steel Knockdown Unit**
- **Two Models Available**

The Burnham Woodlander line of solid fuel units gives you a variety of heating options. The Woodlander add-on boiler is furnished complete with all controls necessary for integration with your present boiler. It fires either seasoned hardwood, anthracite or bituminous coal.

If you are replacing your entire heating unit, Burnham has the Woodlander-3, named for its three fuel flexibility. It has a high efficiency oil burning section in addition to the wood or coal burning unit. Do not install on combustible flooring.

FD Series Oil, Gas, or Combination Fuel Boiler

- **Steel Package**
- **Hot Water**
- **Vertical or Optional Horizontal Design**
- **Capacities 250 to 1,600 MBH**

The FD Series boiler is designed for forced draft firing. The rectangular shape of the FD provides a smaller footprint which can fit in areas where a sectional boiler will not.

The FD Series is ideal as an indirect hot water supply boiler for spas, car washes, laundries, commercial swimming pools and restaurants. It can also supply domestic hot water requirements for hotels, motels or apartments along with meeting their heating needs. Do not install on combustible flooring.

V9 Series Oil, Gas,or Combination Fuel Boiler

- **Cast Iron Packaged or Knockdown Unit**
- **Hot Water or Steam**
- **Capacities 346 to 1,899 MBH**

Versatile enough to meet plan and spec job requirements, the new Burnham V9 boiler is ideal for use in light commercial installations. Applicable to both new construction and replacement jobs, the V9 provides the longevity of a cast iron boiler assembled with the time-proven integrity of cast iron nipples. The sectional design of the V9 makes for easy maneuvering and installation in existing boiler rooms. The sections and individual components fit through standard doorways and are assembled on-site with a simple ratchet, wrench, and short draw rods. Packaged and fire-tested units are also available. And the V9 can be installed in a confined area, requiring only nine inches from a right side wall and 6 1/2 feet of vertical clearance.

V11 Series Oil, Gas, Combination Fuel Boiler

- **Cast Iron Packaged or Knockdown Unit**
- **Steam or Hot Water**
- **Capacities 667 to 4,551 MBH**

Cast iron construction, sectional design, top or rear flue outlets, and a variety of options make the V11 commercial boiler the complete heating package for engineers and contractors. Applicable to both new construction and replacement jobs, the V11 provides the longevity of a cast iron boiler assembled with the time-proven integrity of cast iron nipples. The sections and individual components fit through a standard doorway and are assembled on-site with a simple ratchet, wrench, and short draw rods. Packaged and fire-tested units are also available. Apartment buildings, schools, hospitals, and churches to name a few, can all benefit from the V11.

Baseray®

- **The Original Cast Iron Baseboard**

Baseray is the original cast iron radiant baseboard. It is designed to be inconspicuous but effective. In fact, Baseray's design enables heat to be disbursed in both horizontal and vertical directions. And its cast iron construction provides radiant heat, lifetime durability, and dependability.

Baseray assembles up to and including 6 lineal feet are shipped in one piece. Longer assemblies are shipped in two or more pieces or sub-assemblies of 6 feet or less for assembly on the job.

Radiators

- **Cast Iron**
- **Slenderized in 4 thru 48 sections**
- **Radiant in 4 thru 44 sections**

Burnham's line of cast iron radiators is suitable for both residential and commercial applications. Both the slenderized and the radiant models supply a continuous flow of radiant heat combined with convection heat.

Duo-Rad®

- **Fan Coil Units**
- **Heating and Cooling**
- **10,000 to 22,000 BTU/HR**

The Duo-Rad fan coil unit combines luxurious hydronic heating with cooling in one smartly styled heat distributor. Duo-Rads are ideal for both residential and commercial applications. They are constructed of rigid welded steel.

Alliance Indirect-Fired Water Heater

- **4 Sizes - 26, 40, 53, and 79 Gal.**
- **Commercial Capabilities**
- **Rapid Recovery**
- **Stainless Steel Tank and Coil**
- **Minimal Standby Losses**

The Alliance indirect-fired water heater provides more hot water than tankless coils and low BTU capacity direct-fired water heaters can supply. Available in 4 sizes, it provides abundant hot water at a minimal cost.

Energy Control 5000

- **Multiple Zone Heating Control**
- **Water Heater Control**

The Energy Control 5000 microprocessor continually monitors outdoor air temperature, indoor supply water temperature, and indoor room air temperature, maintaing the lowest water temperature necessary for comfort and boiler efficiency. The EC5000 provides control for four zones, with add-on modules available for additonal requirements.

The EC5000 also utilizes post purge, night setback, and warm weather shut down. Finally, the EC5000 helps protect your heating system by blending hot boiler water with cooler water to avoid thermal shock, and by periodically exercising pumps during the off season to keep them lubricated.

VENTING GUIDE FOR BURNHAM GAS BOILERS

®

- Vent system sizing and installation must be in accordance with National Fuel Gas Code (ANSI Z223.1-NFPA 54), Part 7, Venting of Equipment, or applicable provisions of local building codes.
  a. Masonry chimney construction must be in accordance with Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances (ANSI/ NFPA 211), which includes fire clay flue lining (ASTM C 315, Specifications for Clay Flue Linings) or listed chimney liner system.
  b. An indoor chimney has no outdoor exposure below the roof line. An outdoor chimney has one or more surfaces exposed to the outdoors below the roof line. A Type B vent or listed chimney lining system passing through an unused masonry chimney is considered to be an indoor chimney.
- Burnham will not authorize removal of the automatic vent damper on a boiler certified. "For use only with automatic vent damper device..." as stated on or near rating plate.
- Statements apply to Burnham boilers installed in the United States. A revised or separate Canadian Policy Statement will be issued at a later date.

BENEFITS OF BURNHAM'S HOME HEATING TEAM MEMBERSHIP

Burnham's Home Heating Team is a unique contractor program featuring unequalled benefits to members in promoting, selling, installing and servicing Burnham products.

As a member of the Home Heating Team Burnham will:

SUPPORT YOUR BUSINESS

1) Safest, most efficient, and most dependable products in the industry.

2) Toll-free telephone number for technical as well as sales and marketing assistance.

3) Team marketing manual to help you identify more prospects and to help increase your closure rate.

4) Experienced and competent sales force to give personal assistance in service and marketing.

5) Home Comfort Financing supports you with the easiest to offer and most effective consumer financing programs in the industry.

HELP YOU PROMOTE YOUR BUSINESS

1) Co-op advertising - provides personal funding as well as distributor assisted funding to support your promotional efforts.

2) Advertising assistance - ad samples for newspapers, radio, yellow pages, billboards and direct mail programs as well as prepared copy for local public relations submissions.

3) Tie-ins to regional ad campaigns. Team members will have the opportunity to join with Burnham in regional and local advertising campaigns.

PROVIDE EDUCATION TO YOUR EMPLOYEES

1) Burnham Reporter magazine - periodic magazine provides valuable information concerning new products, programs and membership activities.

2) Burnham Trade Talk videos - designed to assist team members in selling, applying and servicing Burnham products.

3) Training seminars - features two formats: a classic, full-day seminar that effectively educates your staff on steam, hot water, and modular boiler applications. Or participate in "mini" seminars, covering specialized topics like proper boiler venting, radiant panel systems, upgrading older systems, electric heat conversions, as well as selling Burnham products to consumers.

REWARD YOUR COMPANY

Burnham will provide substantial financial rewards to the team members such as:

1) Winter Warmth Assurance - lets you offer the most flexible 5 or 10-year extended parts and labor warranty in the industry. Burnham's WWA can be used as an add-on sale or can be included in the contractor's proposal to help close the sale.

2) Periodic promotions - designed to increase your profitability and make selling Burnham easier and more interesting.

3) Burnham Trade Council - (12) tradesmen are selected to represent each region of the country and Canada on the Trade Council. Burnham is committed to listen to and react to the needs and opportunities put forth at periodic meetings. Each region has a representative that is representing the trade in that area and the member is available to listen to your needs and desires.

To join the HHT, contact your local Burnham sales office and ask to have a Burnham representative contact you about membership. The offices are listed in the front of this book.

BURNHAM REGIONAL OFFICES

Northeast Region
(CT, ME, MA, NH, RI and VT)
Burnham Sales Corporation
19-27 Mystic Avenue
Somerville, MA 02145
617-625-9735

Metropolitan New York Region
(NY, NJ)
Middle Atlantic
(PA, DC, DE, MD, WV and Eastern OH)
Central and Western Regions
Burnham Corporation
Regional Sales Offices
PO Box 3079
Lancaster, PA 17604
717-481-8400

HOME HEATING TEAM MEMBERS:
Call your special 1-800#

Originally Published 6/93 - Fifth Edition 2/99