

separate system of distribution piping is generally not required.

The heating capacity of finned tube varies over a wide range depending on tube size, fin size and thickness, spacing of fins, and the materials used. A major portion of the heat transferred to the room to be heated is by convection.

The heating capacity of finned-tube heat-distributing units is determined by test. The Institute of Boiler and Radiator Manufacturers has developed a testing and rating code for finned-tube type of radiation.*

Heat loss calculations for finned-tube heating systems are the same as those used for other types of radiation. Ratings are expressed in Btuh per linear foot or square feet Equivalent Direct Radiation per linear foot for steam, and Btuh per linear foot for water.

RATINGS OF HEAT-DISTRIBUTING UNITS

Radiators

A standard method of testing radiators was adopted by the ASHRAE in 1927.⁴ This Code was withdrawn but the method is still used in industry. It provides for a standard test room, the temperature of which is to be maintained at 70 F, measured in the center of the room at an elevation of 5 ft above the floor. The steam temperature in the radiator is to be 215 F, which corresponds to 15.6 psia. The weight of condensate per hour, under these standard conditions, multiplied by the difference in the enthalpy of the steam entering the radiator and that of the condensate leaving the radiator, gives the radiator output in Btu per hour (Btuh).

If the rating in square feet Equivalent Direct Radiation is to be 215 F, which corresponds to 15.6 psia. The weight of condensate per hour, under these standard conditions, multiplied by the difference in the enthalpy of the steam entering the radiator and that of the condensate leaving the radiator, gives the radiator output in Btu per hour (Btuh).

Correction of output from non-standard test conditions to output at 70 F room and 215 F steam may be made by multiplying the output under test by the ratio

$$\frac{(\text{Standard temperature difference, steam} - \text{air})^{1.25}}{(\text{Test temperature difference, steam} - \text{air})^{1.25}}$$

Convectors

The generally accepted method of testing and rating both ferrous and non-ferrous convectors, is given in *Commercial Standard CS140-47, Testing and Rating Convectors*,⁵ which has been developed cooperatively by the Convector Manufacturers Association, the Institute of Boiler and Radiator Manufacturers, other members of the trade, and the National Bureau of Standards. This *Commercial Standard* contains details covering construction and instrumentation of the test booth or room and procedures for determining both steam and water ratings.

Steam ratings are expressed in square feet EDR and Btu per hour (Btuh). Water ratings are expressed in Btuh at specified water temperature drops and average water temperatures.

Under the provisions of *Commercial Standard CS140-47* the rating of a top outlet convector is established at a value not in excess of the test capacity (which is the heat extracted from the steam or water in the convector under standard test conditions). For convectors with other types of enclosures or cabinets a percentage that varies up to a maximum of 15 percent depending on the height and type of enclosure or cabinet is added for heating effect.^{6,7} The additions made for heating effect must be shown in the manufacturer's literature.

Table 6.... Factors to Convert $I = B = R$ Finned-Tube Steam Ratings to Hot Water Ratings at Temperatures Indicated

Average Radiator Temperature	Factor	Average Radiator Temperature	Factor
150	0.45	190	0.78
155	0.49	195	0.82
160	0.53	200	0.86
165	0.57	205	0.91
170	0.61	210	0.95
175	0.65	215	1.00
180	0.69	220	1.05
185	0.73		

Baseboard

The generally accepted method of testing and rating baseboards is covered in the *I = B = R Testing and Rating Code for Baseboard Type of Radiation*.⁸ This Code contains details covering construction and instrumentation of the test booth or room, procedures for determining steam ratings, and licensing provisions for the obtaining of approval of these ratings.

Baseboard ratings include an allowance for heating effect of 15 percent, added to the test capacity. The addition made for heating effect must be shown in the manufacturer's literature.

Steam ratings are expressed in Btuh per linear foot or square feet EDR per linear foot. Water ratings are determined from steam ratings and are expressed in Btuh per linear foot, at specified water flow rates and average water temperatures.

Finned-Tube

The generally accepted method of testing and rating finned-tube heat-distributing units is covered in the *I = B = R Testing and Rating Code for Finned-Tube Type of Radiation*.⁹ This Code contains details covering construction and instrumentation of the test booth or room, procedures for determining steam and water ratings, and licensing provisions for the obtaining of these ratings. Steam ratings are expressed in Btuh per linear foot or square feet EDR per linear foot. Water ratings are determined from steam ratings and are expressed in Btuh per linear foot at specified water flow rates and average water temperatures.

The rating of a finned-tube unit in an enclosure having a top outlet is established at a value not in excess of the test capacity (which is the heat extracted from the steam or water in the unit under standard test conditions). For finned-tube with other types of enclosures or covers a percentage is added for heating effect which varies up to a maximum of 15 percent depending on the height and type of enclosure or cover. The additions made for heating effect must be shown in the manufacturer's literature.

Corrections for Non-Standard Conditions

The heat output of a radiator, convector, baseboard or finned-tube heat-distributing unit is an exponential function of the temperature difference between the air in the room

Radiators, Convectors, Baseboard and Finned-Tube Units

Table 7.... Correction Factors for Direct Cast-Iron Radiators and Convectors*

Steam Press. (Approx.)	Gage Vacuum In. Hg	Abs Lb per Sq In.	Heating Medium Temp. F Steam or Water	Factors for Direct Cast-Iron Radiators							
				Room Temperature F							
				80	75	70	65	60	55	50	
22.4	3.7	150	2.58	2.36	2.17	2.00	1.86	1.73	1.62		
20.3	4.7	160	2.17	2.00	1.86	1.73	1.62	1.52	1.44		
17.7	6.0	170	1.86	1.73	1.62	1.52	1.44	1.35	1.28		
14.6	7.5	180	1.62	1.52	1.44	1.35	1.28	1.21	1.15		
10.9	9.3	190	1.44	1.35	1.28	1.21	1.15	1.10	1.05		
6.5	11.5	200	1.28	1.21	1.15	1.10	1.05	1.00	0.96		
Lb per Sq In.											
1	15.6	215	1.10	1.05	1.00	0.96	0.92	0.88	0.85		
6	21	230	0.96	0.92	0.88	0.85	0.81	0.78	0.76		
15	30	250	0.81	0.78	0.76	0.73	0.70	0.68	0.66		
27	42	270	0.70	0.68	0.66	0.64	0.62	0.60	0.58		
52	67	300	0.58	0.57	0.55	0.53	0.52	0.51	0.49		

Steam Press. (Approx.)	Gage Vacuum In. Hg	Abs Lb per Sq In.	Heating Medium Temp. F Steam or Water	Factors for Convectors							
				Inlet Air Temperature F							
				80	75	70	65	60	55	50	
22.4	3.7	150	3.14	2.83	2.57	2.35	2.15	1.98	1.84		
20.3	4.7	160	2.57	2.35	2.15	1.98	1.84	1.71	1.59		
17.7	6.0	170	2.15	1.98	1.84	1.71	1.59	1.49	1.40		
14.6	7.5	180	1.84	1.71	1.59	1.49	1.40	1.32	1.24		
10.9	9.3	190	1.59	1.49	1.40	1.32	1.24	1.17	1.11		
6.5	11.5	200	1.40	1.32	1.24	1.17	1.11	1.05	1.00		
Lb per Sq In.											
1	15.6	215	1.17	1.11	1.05	1.00	0.95	0.91	0.87		
6	21	230	1.00	0.95	0.91	0.87	0.83	0.79	0.76		
15	30	250	0.83	0.79	0.76	0.73	0.70	0.68	0.65		
27	42	270	0.70	0.68	0.65	0.63	0.60	0.58	0.56		
52	67	300	0.56	0.54	0.53	0.51	0.49	0.48	0.47		

* To determine the size of a radiator or a convector for a given space, multiply the heat loss of the space in Btu per hour by the proper factor from the above table and select radiator or convector having an equivalent Btu per hour rating.

An alternate method is to divide the heat loss in Btu per hour by 340 and multiply the result by the proper factor from the above table and select radiator or convector having an equivalent square foot rating.

To determine the heating capacity of a radiator or a convector under conditions other than the basic ones with the heating medium at a temperature of 215 F, and the room temperature at 70 F in the case of a radiator, and the inlet air temperature at 65 F in the case of a convector, divide the heating capacity at the basic rating conditions by the proper factor from the above table.

and the heating medium in the room-heating unit, or, expressed as an equation

$$H = c(t_r - t_a)^n \quad (1)$$

where

H = heat output, Btu per hour (Btuh).

c = a constant determined by test from Equation 1.

t_r = average temperature of heating medium, Fahrenheit. For hot water the arithmetical average of the entering and leaving water temperatures is used.

t_a = room air temperature, Fahrenheit. Air temperature 60 in. above the floor is generally used for radiators while the entering air temperature is used for all other types of heating units.

n = an exponent which equals 1.3 for cast-iron radiators, 1.4 for baseboard radiation, and 1.5 for convectors. For finned-tube units n varies with both air and heat-

Table 8.... Correction Factors for Finned-Tube and Baseboard Radiation*

Steam Pressure (Approx.)	Gage Vacuum In. Hg	Abs Lb per Sq In.	Heating Medium Temp. F Steam or Water	Factors for Finned-Tube							
				Inlet Air Temperature F							
				80	75	70	65	60	55	50	
22.4	3.7	150	2.80	2.50	2.20	1.95	1.81	1.67	1.54		
20.3	4.7	160	2.34	2.14	1.94	1.75	1.62	1.50	1.37		
17.7	6.0	170	2.01	1.86	1.70	1.56	1.46	1.36	1.26		
14.6	7.5	180	1.76	1.65	1.53	1.42	1.32	1.24	1.15		
10.9	9.3	190	1.53	1.45	1.36	1.28	1.20	1.12	1.03		
6.5	11.5	200	1.38	1.31	1.24	1.16	1.09	1.02	0.95		
Lb per Sq In.											
1	15.6	215	1.17	1.12	1.06	1.00	0.95	0.90	0.85		
6	21	230	1.00	0.97	0.93	0.90	0.86	0.82	0.78		
15	30	250	0.88	0.85	0.82	0.78	0.75	0.71	0.67		
27	42	270	0.75	0.73	0.70	0.68	0.65	0.62	0.59		
52	67	300	0.62	0.60	0.58	0.56	0.54	0.52	0.50		

Steam Pressure (Approx.)	Gage Vacuum In. Hg	Abs Lb per Sq In.	Heating Medium Temp. F Steam or Water	Factors for Baseboard							
				Inlet Air Temperature F							
				80	75	70	65	60	55	50	
22.4	3.7	150	2.86	2.61	2.38	2.20	2.03	1.89	1.76		
20.3	4.7	160	2.38	2.20	2.03	1.89	1.76	1.64	1.56		
17.7	6.0	170	2.03	1.89	1.76	1.64	1.54	1.44	1.38		
14.6	7.5	180	1.76	1.64	1.55	1.44	1.38	1.29	1.23		
10.9	9.3	190	1.54	1.44	1.37	1.29	1.22	1.16	1.09		
6.5	11.5	200	1.38	1.29	1.23	1.16	1.09	1.05	1.00		
Lb per Sq In.											
1	15.6	215	1.16	1.10	1.05	1.00	0.95	0.92	0.88		
6	21	230	1.00	0.96	0.92	0.88	0.84	0.81	0.77		
15	30	250	0.86	0.82	0.79	0.76	0.73	0.70	0.68		
27	42	270	0.73	0.70	0.68	0.66	0.63	0.61	0.59		
52	67	300	0.58	0.57	0.55	0.53	0.52	0.51	0.49		

* To determine the heating capacity under conditions other than the basic ones with the heating medium at a temperature of 215 F, and the inlet air temperature at 65 F, divide the heating capacity at the basic rating conditions by the proper factor from the above table.

ing medium temperatures. Correction factors to convert outputs at standard rating conditions to outputs at other conditions are given in Tables 6, 7, and 8.

Enclosure, Paint, Humidity Effect

The general effect of an enclosure placed about a direct radiator is to restrict the air flow, and diminish the proportion of output due to radiation. Enclosures of proper design may, however, improve the heat distribution within the room as compared to the heat distribution obtained with an unenclosed radiator.¹⁰

For a radiator or cast-iron baseboard the finish coat of paint affects the heat output. Oil paints of any color will give about the same results as unpainted black or rusty surfaces, but an aluminum or a bronze paint will reduce the heat emitted by radiation. The net effect may be a reduction of 10 percent or more in the total heat output of the radiator.^{11, 12}

Some commercial enclosures and shields for use on direct radiators are equipped with water pans for the purpose of