CHAPTER 55

RADIATORS, CONVECTORS, BASEBOARD AND FINNED-TUBE UNITS

Definitions, Heat Emission, Radiators, Convectors, Baseboard, Finned-Tube, Ratings, Corrections for Non-Standard Conditions, Enclosed Radiators

RADIATORS, convectors, baseboard, and finned-tube units are types of heat-distributing units commonly used in steam and low temperature water heating systems. They supply heat through a combination of radiation and convection, and their function is to maintain the desired air temperature in the space. In general, these types of heat-distributing units should be placed at the points of greatest heat loss of the space, so as to offset or counteract these losses. For example, such units are commonly located under windows, along exposed walls, and at door openings.

The term *radiator* is generally confined to sectional cast-iron radiation of column, large tube, or small tube type.

The term *convector* refers to a heat-distributing unit that operates with gravity circulated air, has a heating element with a large amount of secondary surface, and is surrounded on all sides by an enclosure having an air inlet opening below, and an air outlet opening above, the heating element.

The terms *baseboard* or *baseboard radiation* refer to heat-distributing units designed for installation along the bottom of walls, in place of the conventional baseboard. They may be made of cast-iron, with a substantial portion of the front face directly exposed to the room, or with a finned-tube element in a sheet metal enclosure. They operate with gravity-circulated room air.

The term *finned tube* refers to heat-distributing units fabricated from metallic tubing with metallic fins bonded to the tube. They operate with gravity-circulated room air, and may be installed without an enclosure, with an open type grille, a cover, or an enclosure having top, front, or inclined outlets.

HEAT EMISSION

These types of heat-distributing units emit heat by a combination of radiation to the space and convection to the air within the space. These heat transfer processes and the factors which influence them are discussed in detail in Chapter 4. In general, those units which have a large portion of their heated surface exposed to the space, i.e., radiators and cast-iron baseboard, emit a larger portion of heat by radiation than do units having completely or partially concealed heating surface, i.e., convectors, finned tube, and finned tube type baseboard.

The output ratings of these types of heat-distributing units are expressed in units of Btu per hour (Btuh), 1000 Btu per hour (MBh), or in square feet equivalent direct radiation (EDR) (e.g., 240 Btuh = 1 sq ft EDR with 1 psig steam). Ratings in EDR are largely being abandoned by many manufacturers in the industry.

The general responsibility for this chapter is assigned to TC 3.1, Hot Water and Steam Heating.

RADIATORS

Column and *large-tube radiators* are no longer manufactured, but, since many of these units are still in use, Tables 1 and 2 are included to provide principal dimensions and average ratings.

The *small-tube* type radiators, with a length of only $1\frac{3}{4}$ in. per section, occupy less space than the older column and large-tube units, and are particularly suited to installation in recesses.

After a study of the demand for various sizes of radiators, the Institute of Boiler and Radiator Manufacturers, in co-operation with the Division of Simplified Practice of the National Bureau of Standards, established the *Simplified Practice Recommendation R174-47, Cast Iron Radiators*, for small-tube radiators. Table 3 shows the dimensions and ratings of the units now being manufactured under R174-47.

Wall radiators are well adapted to use in factory buildings, storage areas, etc. Tests have shown that the heat emitted from a wall type radiator may be reduced 5 to 15 percent, if the radiator is located at the ceiling with the tubes horizontal. Such ceiling installations are not recommended because the resulting temperature gradients between floor and ceiling are excessive and make it difficult to heat the living zone satisfactorily. Dimensions and output ratings of wall type radiators in normal wall installation are given in Table 4.

PIPE COILS

Pipe coils were once a popular type of heat-distributing unit in factory buildings, but they have now largely been replaced by finned-tube radiation. The heat emission of such pipe coils is shown in Table 5, for purposes of estimating replacement requirements and boiler loads.

CONVECTORS

Convectors are made in a wide variety of depths, sizes, lengths, and enclosure or cabinet types. The basic sizes and types are listed in *Simplified Practice Recommendation* 238-50, *Convectors*. The heating elements are available in fabricated ferrous and non-ferrous metals. The air enters the enclosure below the heating element, is heated in passing through the element, and leaves the enclosure through the outlet grille located above the heating element. Factory-assembled units comprised of a heating element and enclosure are widely used. These may be free standing, wall hung, or recessed (Fig. 1), and may have outlet grilles and arched inlets or inlet grilles, as desired.

In cases where cabinets or enclosures are to be used, but are not furnished by the manufacturer, it is important that the proportions of the cabinets or enclosures and the grilles

Table 1 . . . . Column-Type Cast-Iron Radiator

Height In.	Generally Accepted Rating per Section[a]					
	One Column		Two Column		Three Column	
	Sq Ft	Btuh	Sq Ft	Btuh	Sq Ft	Btuh
15			1½	360		
18					2¼	540
20	1½	360	2	480		
22			2¼	540	3	720
23	1⅔	400	2⅓	560		
26	2	480	2⅔	640	3¾	900
32	2½	600	3⅓	800	4½	1080
38	3	720	4	960	5	1200
45			5	1200	6	1440
	Four Column		Five Column		Six Column	
	Sq Ft	Btuh	Sq Ft	Btuh	Sq Ft	Btuh
13					3	720
16					3¾	900
18	3	720	4⅔	1120	4½	1080
20					5	1200
22	4	960				
26	5	1200	7	1680		
32	6½	1560				
38	8	1920	10	2400		
45	10	2400				

[a] These ratings are based on steam at 215 F and air at 70 F. They apply only to installed radiators exposed in a normal manner; not to radiators installed behind enclosures, grilles, or under shelves. For Btu per hour ratings at other temperatures, divide table values by factors found in Table 7.

be so designed that they will not impair the performance of the assembled convector. It is desirable that the cabinet or enclosure for the convector fit as snugly as possible, so that the air passing through cannot bypass the heating element.

BASEBOARD UNITS

Baseboard heat-distributing units are divided into three types: (1) radiant, (2) radiant-convector, and (3) finned-tube.[1]

Radiant-type baseboard is made of cast iron or steel. This type of unit emits a large portion of its heat output by radiation. Units are sometimes suspended from the ceiling in rooms having little or no available wall space for floor mounted units. As the convected heat obtained from these units when mounted at the ceiling is less than when they are mounted at floor level, additional length must be added as recommended by the manufacturer, to allow for the reduction.

Radiant-convector type baseboard is also made of cast iron or steel. The units are provided with air openings at the top and bottom to permit circulation of room air over the wall side of the unit. The wall side of the unit has extended surface to provide increased heat output. A large portion of the heat emitted is transferred by convection. This type of baseboard, having a greater output per linear foot than the radiant type, is particularly adaptable where wall space is at a premium or the heat loss of the room is high.

Finned-tube type baseboard has a finned-tube heating element that is concealed by a long, low sheet-metal enclosure or cover. A major portion of the heat is transferred to the room by convection. The output varies over a wide range, depending on the physical dimensions and the materials used. When selecting this type of baseboard, the designer should avoid using a unit with too high an output per linear foot. Baseboard performs best when units are so selected that they are installed along as much of the exposed wall as possible.

Table 2 . . . . Large-Tube Cast-Iron Radiators

Sectional, cast-iron, tubular-type radiators of the large-tube pattern, that is, having tubes approximately 1⅜ in. in diameter, 2½ in. on centers.

Number of Tubes per Section	Catalog Rating per Section[a]		Height	Width	Section Center Spacing[b]	Leg Height[c] to Tapping
	Sq Ft	Btuh	In.	In.	In.	In.
	1¾	420	20		2½	4½
	2	480	23		2½	4½
3	2⅓	560	26	4⅝	2½	4½
	3	720	32		2½	4½
	3½	840	38		2½	4½
	2¼	540	20			
	2½	600	23		2½	4½
4	2¾	660	26	6¼–6$^{13}/_{16}$	2½	4½
	3½	840	32		2½	4½
	4¼	1020	38		2½	4½
	2⅔	640	20		2½[d]	4½
	3	720	23		2½[d]	4½
5	3½	840	26	8–8$^{9}/_{16}$	2½[d]	4½
	4⅓	1040	32		2½[d]	4½
	5	1200	38		2½[d]	4½
	3	720	20		2½	4½
	3½	840	23		2½	4½
6	4	960	26	9–10⅜	2½	4½
	5	1200	32		2½	4½
	6	1440	38		2½	4½
	2½	600	14		2½	3
7	3	720	17	11⅜–12$^{13}/_{16}$	2½	3
	3⅔	880	20		2½	3 or 4½

[a] These ratings are based on steam at 215 F and air at 70 F. They apply only to installed radiators exposed in a normal manner; not to radiators installed behind enclosures, grilles, or under shelves. For Btu per hour ratings at other temperatures, divide table values by factors found in Table 7.

[b] Maximum assembly 60 sections. Length equals number of sections times 2½ in.

[c] Where greater than standard leg heights are required, this dimension shall be 6 in., except for 7-tube sections, in heights from 13 to 20 in., inclusive, for which this dimension shall be 4½ in. Radiators may be furnished without legs.

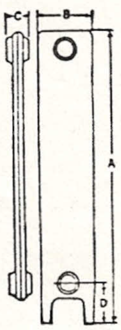
[d] For 5-tube hospital-type radiation, this dimension is 3 in.

The basic advantage of the baseboard heat-distributing unit is that its normal placement is along the cold walls and under areas where the greatest heat loss occurs. Other advantages claimed for the baseboard heat-distributing unit are: it is inconspicuous; it offers a minimum of interference with furniture placement, and it distributes the heat near the floor. This last characteristic reduces the floor-to-ceiling temperature gradient to about 2 to 4 F deg, and tends to produce uniform temperatures throughout the room. It also makes baseboard heat-distributing units adaptable to basementless homes, where cold floors are prevalent.[1]

Heat loss calculations for baseboard heating systems are the same as those used for other types of heat-distributing

Table 3 . . . . Small-Tube Cast-Iron Radiators

Number of Tubes per Section	Catalog Rating per Section[a]		Section Dimensions				
			A Height[c]	B Width		C Spacing[b]	D Leg Height[c]
				Min	Max		
	Sq Ft	Btuh	In.	In.	In.	In.	In.
3[d]	1.6	384	25	3¼	3½	1¾	2½
4[d]	1.6	384	19	4 7/16	4 13/16	1¾	2½
	1.8	432	22	4 7/16	4 13/16	1¾	2½
	2.0	480	25	4 7/16	4 13/16	1¾	2½
5[d]	2.1	504	22	5⅝	6 5/16	1¾	2½
	2.4	576	25	5⅝	6 5/16	1¾	2½
6[d]	2.3	552	19	6 13/16	8	1¾	2½
	3.0	720	25	6 13/16	8	1¾	2½
	3.7	888	32	6 13/16	8	1¾	2½



[a] These ratings are based on steam at 215 F and air at 70 F. They apply only to installed radiators exposed in a normal manner, not to radiators installed behind enclosures, grilles, or under shelves. For Btu per hour ratings at other temperatures, divide table values by factors found in Table 7.

[b] Length equals number of sections times 1¾ in.

[c] Overall height and leg height, as produced by some manufacturers, are one inch greater than shown in Columns *A* and *D*. Radiators may be furnished without legs. Where greater than standard leg heights are required this dimension shall be 4½ in.

[d] Or equal.

units. The procedure for designing baseboard heating systems is given in *I = B = R Installation Guide* No. 800.[2] Ratings for baseboard heat-distributing units are expressed in Btuh per linear foot.

FINNED-TUBE UNITS

A finned-tube heat-distributing unit is a room-air heater composed of a finned-tube element fabricated from metallic tube to which metallic fins have been bonded. It does not include a fin-tube type baseboard element provided with an enclosure for replacement of the conventional baseboard.

Finned-tube units are available in several tube sizes, either steel or copper (1 to 2 in. IPS or $\frac{3}{4}$ to $1\frac{1}{4}$ nominal copper) with various fin sizes, spacings, and materials. The resistance to the flow of steam or water in finned-tube elements is the same as that through standard distribution piping of equal size.

The finned-tube unit can be used with either steam or hot water systems. It has advantages for installation where it is desired to distribute the heat along the entire outside wall, and thereby prevent down drafts along the walls in buildings such as schools, churches, hospitals, and factories.

Normal placement of finned tube is along the walls where the heat loss is greatest. If necessary, the units can be installed in two or three tiers along available wall space to meet the heating requirements. For hot water system installations where two or three tiers are required, a sinuous water flow through the heaters is recommended, because a header connection with parallel flow may permit the water to short circuit along the path of least resistance.

Finned-tube elements may be installed bare in locations where human contact is unlikely; they may be protected by open-type grilles, fabricated of expanded or perforated metal, covering the top and front of the element, or they may be installed in a variety of designs of *covers* or *enclosures*.

A *cover* is a fabricated shield having at least a portion of the front skirt made of solid material. It can be mounted on the finned-tube element so that there is clearance between the wall and the cover, and the rear of the finned-tube element is not completely enclosed. A cover may have a top, front, or inclined outlet.

An *enclosure* is a shield of solid material installed so that the finned-tube element is completely enclosed at both front and rear. An enclosure may have an integral back or may be installed tightly against the wall so that the wall itself forms the back. An enclosure may have a top, front, or inclined outlet.

A multiplicity of enclosures have been developed, in co-operation with architects and designers, to meet the requirements of modern building design. The wide variety of finned-tube elements (tube size and material, fin size, spacing, and material, and multiple tier installation), together with the

Table 4 . . . . Cast-Iron Wall Radiators

Approximate Dimensions—Inches			Heat Output[a]	
Height	Length or Width	Thickness	Sq Ft	Btuh
13¼	16½	3	6½	1560
13¼	22	3	8	1920
22	13¼	3	8	1920
13¼	29	3	11	2640
29	13¼	3	11	2640

[a] These ratings are based on steam at 215 F and air at 70 F. They apply only to installed radiators exposed in a normal manner, not to radiators installed behind enclosures, grilles, or under shelves. For Btu per hour ratings at other temperatures divide table values by factors found in Table 7.

Table 5 . . . . Heat Emission of Pipe Coils Placed Vertically on a Wall (Pipes Horizontal) Containing Steam at 215 F and Surrounded with Air at 70 F

Btu per linear foot of coil per hour (not linear feet of pipe)

Size of Pipe	1 In.	1¼ In.	1½ In.
Single row	132	162	185
Two	252	312	348
Four	440	545	616
Six	567	702	793
Eight	651	796	907
Ten	732	907	1020
Twelve	812	1005	1135

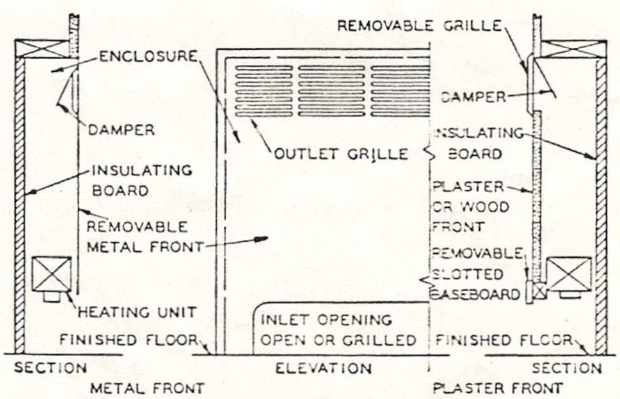


Fig. 1 . . . . Typical Recessed Convector

various heights and designs of enclosures, result in great flexibility of selection for finned-tube units to meet the needs of load, space, and appearance.

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 Direction 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 ASHAE in 1927.[3] 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 desired, divide this output by 240 (which, by definition, is the Btuh equivalent of 1 sq ft EDR). 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:

$$\frac{(\text{Standard temperature difference, steam} - \text{air})^{1.3}}{(\text{Test temperature difference, steam} - \text{air})^{1.3}}$$

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,*[4] 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.[5,6] The additions made for heating effect must be shown in the manufacturer's literature.

Baseboard

The generally accepted method of testing and rating baseboards is covered in the *I = B = R Testing and Rating Code for Baseboard Radiation.*[7] This Code contains details covering construction and instrumentation of the test booth or room, procedures for determining steam and hot water ratings, and licensing provisions for the obtaining of approval of these ratings.

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

Average Water Temperature	Factor	Average Water Temperature	Factor
150	0.45	200	0.86
155	0.49	205	0.91
160	0.53	210	0.95
165	0.57	215	1.00
170	0.61	220	1.05
175	0.65	225	1.09
180	0.69	230	1.14
185	0.73	235	1.20
190	0.78	240	1.25
195	0.82		

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 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 units is covered in the *I = B = R Testing and Rating Code for Finned-Tube (Commercial) Radiation.*[8] 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 obtaining approval 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. Table 6 gives factors for converting steam ratings to hot water ratings at various average water temperatures. These factors apply only when the water velocity in the element is 3.0 fps.

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

$$H = c(t_s - t_a)^n \qquad (1)$$

where

H = heat output, Btu per hour (Btuh).
c = a constant determined by test.

Table 7 .... Correction Factors for Various Types of Heating Units[a]

Steam Press. (Approx.)		Temp. of Heating Medium Steam or Water	Cast Iron Radiators					Convectors					Finned Tube					Baseboard				
			Room Temp, F					Inlet Air Temp, F					Inlet Air Temp, F					Inlet Air Temp, F				
Gage Vac., In. Hg.	Abs., Psi		80	75	70	65	60	75	70	65	60	55	75	70	65	60	65	75	70	65	60	55
22.4	3.7	150	0.39	0.42	0.46	0.50	0.54	0.35	0.39	0.43	0.46	0.50	0.36	0.42	0.46	0.51	0.57	0.38	0.42	0.45	0.49	0.53
20.3	4.7	160	0.46	0.50	0.54	0.58	0.62	0.43	0.47	0.51	0.54	0.58	0.45	0.49	0.53	0.59	0.64	0.45	0.49	0.53	0.57	0.61
17.7	6.0	170	0.54	0.58	0.62	0.66	0.69	0.51	0.54	0.58	0.63	0.67	0.53	0.57	0.61	0.67	0.72	0.53	0.57	0.61	0.65	0.69
14.6	7.5	180	0.62	0.66	0.69	0.74	0.78	0.58	0.63	0.67	0.71	0.76	0.61	0.65	0.69	0.75	0.81	0.61	0.65	0.69	0.72	0.78
10.9	9.3	190	0.69	0.74	0.78	0.83	0.87	0.67	0.71	0.76	0.81	0.85	0.69	0.73	0.78	0.84	0.89	0.69	0.73	0.78	0.82	0.86
6.5	11.5	200	0.78	0.83	0.87	0.91	0.95	0.76	0.81	0.85	0.90	0.95	0.77	0.81	0.86	0.92	0.97	0.81	0.86	0.92	0.95	1.00
Psi																						
1	15.6	215	0.91	0.95	1.00	1.04	1.09	0.90	0.95	1.00	1.05	1.10	0.91	0.94	1.00	1.06	1.11	0.91	0.95	1.00	1.05	1.09
6	21	230	1.04	1.09	1.14	1.18	1.23	1.05	1.10	1.15	1.20	1.26	1.03	1.08	1.14	1.19	1.24	1.04	1.09	1.14	1.19	1.25
15	30	250	1.23	1.28	1.32	1.37	1.43	1.27	1.32	1.37	1.43	1.47	1.20	1.26	1.31	1.37	1.43	1.22	1.27	1.32	1.37	1.43
27	42	270	1.43	1.47	1.52	1.56	1.61	1.47	1.54	1.59	1.67	1.72	1.38	1.44	1.50	1.56	1.62	1.43	1.47	1.52	1.59	1.64
52	67	300	1.72	1.75	1.82	1.89	1.92	1.85	1.89	1.96	2.04	2.08	1.67	1.73	1.79	1.86	1.92	1.75	1.82	1.89	1.92	1.96

[a] These correction factors provide means of determining output ratings for radiators, convectors, finned-tube, and baseboard units at operating conditions other than standard and, hence, also provide means of selecting these units to satisfy heating loads for a given space at any given set of operating conditions.

Standard conditions for a radiator are 215 F heating medium temperature and 70 F room temperature (at the center of the space and at the 5 foot level). Standard conditions for convectors, finned-tube and baseboard units are 215 F heating medium temperature and 65 F inlet air temperature. It should be noted that 65 F inlet air for convectors, finned-tube or baseboard units represent the same room comfort conditions as 70 F room air temperature for a radiator.

To determine the output of a heating unit under conditions other than standard, multiply the standard heating capacity by the appropriate factor for the actual operating heating medium and room or inlet air temperatures.

t_s = 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 heating medium temperatures. Correction factors to convert outputs at standard rating conditions to outputs at other conditions are given in Tables 6 and 7.

APPLICATIONS

In general, radiators, convectors, finned-tube, and baseboard units are installed in areas of greatest heat loss—under windows, along cold walls, or at doorways.

These units may be used in any type of steam or low temperature water system, and in some medium temperature water systems. However, units with different performance characteristics should not be installed in the same zone, i.e., cast-iron radiators should not be mixed with finned-tube type baseboards, see Chapters 10 and 11 of the 1964 Guide and Data Book.

Present trends in the design of hot water heating systems indicate two basic changes which affect the application of finned-tube and baseboard units. The first of these is the increasing popularity of medium- and high-temperature water systems, see Chapter 12 of the 1964 Guide and Data Book. Associated with this is the use of relatively large temperature drops through the system, drops of as much as 60 to 80 deg in low-temperature systems and as high as 200 deg in high-temperature systems. These higher temperature drops result in lower water velocities in the finned-tube elements, which necessitate an understanding of the resulting effect on heat output.

The Institute of Boiler and Radiator Manufacturers sponsored a test program at the University of Illinois to determine the effect of water velocity on heat output of various sizes of finned-tube elements. Fig. 2 is a plot of the results of this program showing rating factors versus velocity. There is little significant variation in output over the range from 0.5 fps to 6.0 fps (factors from 0.93 to 1.03 where 1.0 is at 3.0 fps). However, at a point between 0.4 and 0.25 fps, the factor drops rapidly. This is the critical velocity range, at which flow changes from turbulent to streamline. Little testing has ever been done on output of finned-tube radiation under streamline flow. It is obvious, therefore, that velocities below these points should be avoided in a hot water heating system, since results could not be accurately predicted.

The designer should check water velocity throughout the system and select finned-tube or baseboard element on the basis of velocity as well as average temperature. Manufacturers of finned-tube and baseboard today offer a variety of tube sizes, ranging from $\frac{1}{2}$ in. copper tubes for small baseboard elements to 2 in. IPS for large finned-tube units, which permit considerable latitude in selection, to aid in maintenance of turbulent flow conditions over a wide range of flows.

In areas where zone control, rather than individual room control, can be employed, it is advantageous to place all finned-tube units in the zone in series, to help maintain turbulent flow. It should be remembered in such a series loop installation that temperature drop must be considered in selecting the element for each separate room in the loop.

Primary-secondary pumping or the use of a secondary heat

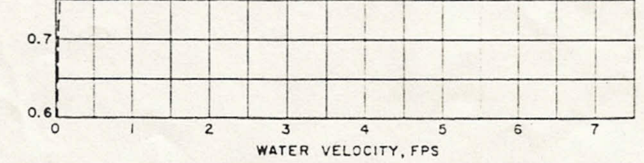


Fig. 2 .... Effect of Water Velocity on Finned Tube Output

exchanger (see Chapters 10 and 12 of the 1964 GUIDE AND DATA BOOK) can also help in the application of finned-tube units to systems using high temperature drops. The designer should also give more careful consideration to the effects of high temperature and large drops on the problems of control, balancing, expansion, and installation of finned-tube and baseboard units.

Enclosure, Paint, Humidity Effect

The general effect of an enclosure placed around 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.[6,9]

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.[10,11,12]

Some commercial enclosures and shields for use on direct radiators are equipped with water pans for the purpose of adding moisture to the air in the room. Tests[13] show that an average evaporative rate of about 0.235 lb per (hr) (sq ft of water surface) may be obtained from such pans, when a radiator is steam heated and the relative humidity in the room is between 25 and 40 percent. This source of supply of moisture alone is not adequate to maintain a relative humidity above 25 percent on a zero day.

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