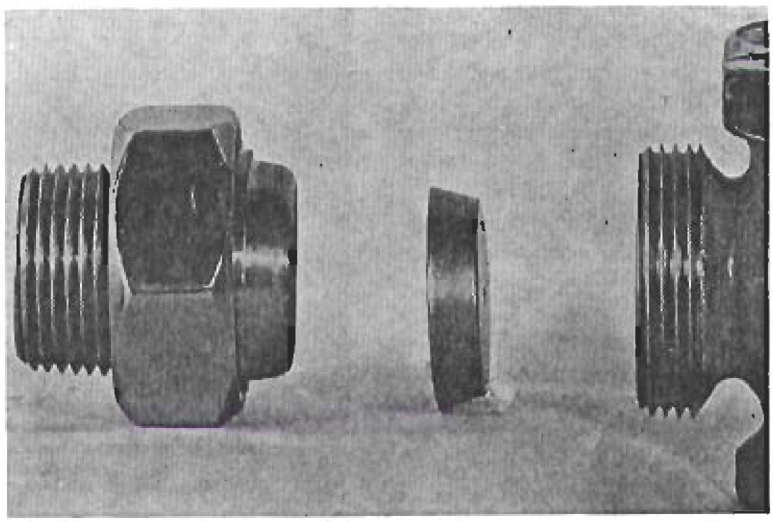
Orifices for Steam Radiators

In the paper read before the American Society of Heating and Ventilating Engineers and published in DOMESTIC ENGINEERING for June 27, 1931, radiator orifices were discussed from the technical standpoint. The following article is devoted to more practical considerations for the benefit of those who wish to install orifices



This photograph shows an orifice and valve assembly

By STERLING S. SANFORD* and CARL B. SPRENGER**

STEAM heating systems must be designed to keep buildings comfortable on the coldest winter day. The size of the radiators is determined by this one condition which exists for but a few days out of the year. Radiators which are just the right size for the extremely cold days are too large for the more moderate weather which makes up the greater part of the heating season. In such weather buildings equipped with ordinary heating systems are overheated if the radiators are filled with steam all of the time. If the size of the radiators could be changed as the weather changes, we would not have to turn off steam to prevent overheating. We would merely enlarge the radiators as the weather grew colder and make them smaller for warmer weather, and we would always have just the right amount of heat being delivered to keep our building at the proper temperature. Obviously this is out of the question. We can, however, accomplish the same result by using only part of the radiator surface when the maximum amount of heat is not needed. By controlling the flow of steam into the radiators we can fill them to whatever extent is needed to keep the building comfortable at the different outside temperatures.

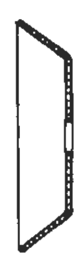


Fig. 1—Orificed stamping used in radiator valve unions

One way of controlling the flow of steam is to insert an orifice plate, a plate with a small hole in it, in the inlet to each radiator. The amount of steam flowing through an orifice depends upon the pressure ahead of the orifice and the difference in pressure between the two sides of the orifice. By controlling the pressures we can regulate the flow of steam so that it is some fractional part of the amount ordinarily needed to keep the radiators full. When the outdoor temperature is 35 deg. Fahr. the radiators need deliver only about 50 per cent of the heat required in zero weather, and thus if the flow of steam is reduced 50 per cent the building will be kept at the proper temperature. At any other outside temperature, the proper indoor temperature can be maintained by correspondingly reducing the amount of steam entering the radiators.

The simplest type of radiator orifice plate is

* Heating Engineer, The Detroit Edison Co.
** Engineer, Central Heating Department, The Detroit Edison Co.

a thin cup-shaped stamping inserted in the radiator valve union in such a way as to act as a gasket. Those who have used this type of plate have had good results with a stamping made of medium brass about 0.018 in. thick. The stampings can be made with conical sides as shown in Fig. 1 and if proper care is used in shaping the die, the stampings will fit in the unions of different makes of valves. The orifices may be punched or drilled and reamed. If drilled they should be drilled somewhat smaller than desired and then reamed to the required size. The orifices should be sized according to the radiators with which they are to be used. The correct sizes for thin stampings are given in Table I and also by the curve in Fig. 2.

Stampings are comparatively inexpensive to make in quantities. The usual charge for making the die is of the order of $40 to $55. The additional cost of the blank stampings is about $10 or $15 per thousand depending upon the size. For an additional cost of about $3 per thousand a small hole for starting the reamer can be punched in the center of the stamping. If there are enough orifices of any one size, the holes can be punched to the size desired without any drilling or reaming. Usually there is such a variety of sizes required that it is more economical to obtain the desired sizes by reaming the holes. If a taper pin reamer is used, one reamer can be used for several sizes of orifices. The punched hole should be made of such size that the small end of the reamer can be inserted in it. By using a stop on the reamer for each size of hole, the orifices can be made very quickly. Care should be used in making the holes round and accurate in size. Table I indicates the accuracy needed. For instance, a 36 sq. ft. radiator requires a 0.147-in. diameter orifice and a 34 sq. ft. radiator requires a 0.143-in. orifice. Thus an error of four thousandths of an inch would be equivalent to changing the size of the radiator by 2 sq. ft.

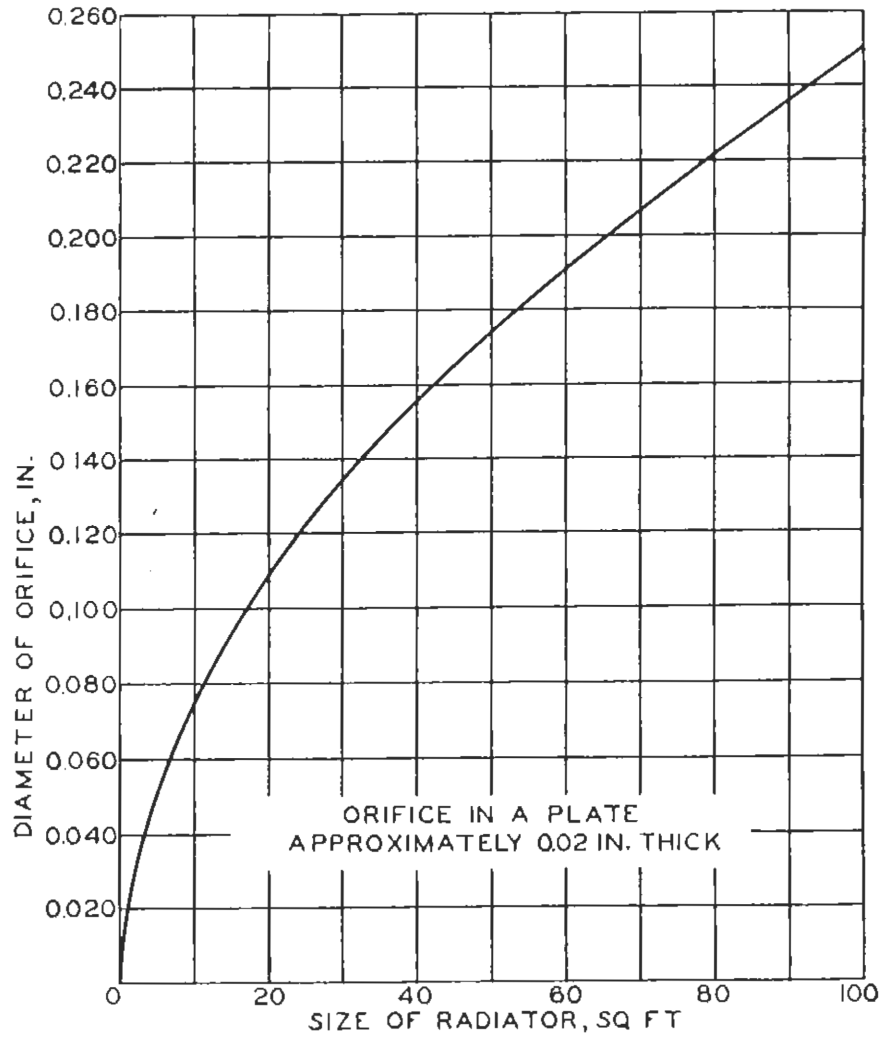


Fig. 2—Size of radiator orifices

The orifice plates just discussed are easy to install. It is necessary merely to break the radiator valve union, slip in the stamping, and tighten the union again. In some cases it is necessary to change the size of some of the orifices after they have been installed because of radiators which overheat or underheat. If some of the rooms are to be heated to a higher or lower temperature than the rest of the building, the proper thing to do is to size the radiators accordingly. However, the desired conditions can be approached by using larger orifices in the rooms where a higher temperature is wanted and smaller orifices in rooms where a lower than average temperature is desired. The gasket-type orifice plate can be changed very easily by breaking the union and slipping the old plate out and the new one in. One large building reports the cost of labor for installing orifices as 10 cents per radiator.

If orifice plates are being installed in a new heating system it is well not to install them until the system has been thoroughly cleaned of scale and dirt and has been in operation for a time. This should greatly decrease the possibility of an accumulation of scale or dirt blocking the holes.

It has been suggested that the cutting action of the steam might enlarge the orifices if as thin a plate as recommended were used. One such installation has been in service for three years, however, and no wear can be detected so it is not expected that there will be difficulty with other installations.

The orifice sizes given in Table I are such that with a gravity system or with atmospheric pressure in the radiators, the radiators will be just kept full of steam if the pressure in the mains is 6 in. of mercury or about 3 lb. per sq. in. If the pressure is reduced below 3 lb., steam will not flow into the radiators fast enough to keep them filled, and as the pressure is reduced the amount of steam in the radiators is of course decreased, thus making it possible to regulate the amount of heat given off to suit any kind of weather. Table II gives the pressures to carry in the steam mains for different outdoor temperatures when there is atmospheric pressure in the radiators.

Some people prefer to use larger orifices. The pressure required to fill the radiators is then less than 3 lb. The disadvantage of using larger orifices is that the range of steam pressures available for control is decreased. Instead of having a range from 0 lb. to 3 lb. per sq. in. for controlling the system for outside temperatures from 70 deg Fahr. to 0, we are limited to a 2 lb. range or a 1 lb. range depending upon how large the orifices are made. Thus control of the system is made more difficult. The greater the range of pressures available, the greater will be the ease of control. On the other hand, the pressure drop through the orifices must not be large enough to cause excessive noise. A pressure drop of about 3 lb. per sq. in. was selected as a compromise between the two conditions.

Table I

Sizes of Radiator Orifices in Thin Plates

Size of Radiator Sq. Ft.	Orifice Diameter In.	Size of Radiator Sq. Ft.	Orifice Diameter In.
10	0.075	48	0.171
12	0.083	50	0.175
14	0 090	52	0.179
16	0.097	54	0.182
18	0.103	56	0 185
20	0.109	58	0.188
22	0.114	60	0.191
24	0.119	62	0.194
26	0.124	64	0.197
28	0.129	66	0.200
30	0.134	68	0.203
32	0.139	70	0.206
34	0.143	75	0.214
36	0.147	80	0.222
38	0.151	85	0.229
40	0.155	90	0.236
42	0.159	95	0.243
44	0.163	100	0.250
46	0.167		

Another disadvantage of using large orifices and thus a small pressure drop through them is that the flow of steam into radiators in different parts of the system is likely to be unequal unless the orifices are carefully sized to compensate for pressure drop in the piping. It is desirable to use small orifices and thus a high pressure drop through them so that the pressure drop through the orifices will be large in proportion to the pressure drop through the piping. Small differences in pressure in the steam mains in different parts of the system due to pressure drop in the piping will then not cause as much variation in flow through the orifices as if larger orifices were used. If the pressure drop in the mains is unusually high it might be well to use somewhat larger orifices than given in Table I in the radiators at the ends of the mains. For example, if the pressure drop to the farthest radiator is 1.5 in. of mercury and if it is a 36 sq. ft. radiator, the orifice should have a diameter of 0.159 in. instead of 0.147 in. as given in Table I. This is arrived at as follows: If the pressure drop through the mains is 1.5 in. of mercury and the pressure at the control valve is 6 in. of mercury, the pressure in the main at the last radiator will be 4.5 in. of mercury. Referring to Table II we note that this will let enough steam through the orifice to take care of 10 deg. Fahr. weather which is 10/70 or 1/7 less than the amount needed in zero weather for which the control valve is set. The radiator size, which reduced by 1/7 becomes 36 sq. ft., is 42 sq. ft. Referring to Table I we note that a 42 sq. ft. radiator needs a 0.159-in. diameter orifice. If we then put the 0.159-in. orifice in the inlet to the 36 sq. ft. radiator, the flow through it when the pressure at that point is 4.5 in. of mercury will be the same as through a 0.147-in. orifice in a 36 sq. ft. radiator located near the control valve where the pressure is 6 in. of mercury. In the same way the proper orifice sizes for other pressure drops and other sizes of radiators can be worked out.

The steam pressure can be controlled by adjusting a pressure-reducing valve or by throttling a valve in the steam main. Both methods have been used successfully. In either case the pressure should be adjusted accurately. If the returns are well vented to the atmosphere so that atmospheric pressure is carried in the radiators, the steam pressures given in Table II should be used. If, however, there is a vacuum in the return and radiators, the steam pressure should be adjusted so that the difference between the pressure and the vacuum or the pressure drop through the orifices equals the pressure in Table II, as it is the pressure drop rather than the steam pressure alone which determines the flow. As a guide in setting the pressure it is better to use a mercury U-tube than a pressure gage, and in some cases where extreme accuracy is desired it is well to use a water column. The more accurately the pressure is controlled, the better will be the control of temperature in the building. Orifice systems should not be installed in buildings unless there is someone available who can observe the pressure from time to time and readjust the valves when necessary. It is a waste of time and money to install orifices unless the heating system is to be carefully operated afterwards.

Another method of control applicable only to vacuum systems is to control the vacuum in the return system and keep the steam pressure constant. The pressure reducing valve can be set for, say, atmospheric pressure.

Table II

Required Steam for Different Outdoor Temperatures

Outdoor Temperature, F	Steam Pressure, In. Mercury	Steam Pressure, Lb. per Sq. In.
0	6	2 lb., 15 oz.
10	4.5	2 lb., 3 oz.
20	3.2	1 lb., 9 oz.
30	2.1	1 lb., 0 oz.
40	1.2	0 lb., 9 oz.
50	0.5	0 lb., 4 oz.
60	0.1	0 lb., 1 oz.

For zero weather the vacuum would be adjusted for approximately 6 in. of mercury, thus giving a 6-in. pressure drop, and for milder weather a lower vacuum would be carried. The required pressure drop through the orifices for different outside temperatures would be somewhat greater than given in Table II which is for atmospheric pressure in the radiators because reducing the steam pressure reduces the flow through an orifice for a given pressure drop. If this method of control is used, the proper vacuum to carry in the returns for different outside temperatures could be established by experience. It is possible that in zero weather the steam pressure would have to be increased.

(Continued on Page 124)

Orifices for Steam Radiators

(Continued from Page 32)

For best results with radiator orifices the steam piping should be quite ample in size so that the pressure drop through the mains will be small. This will help to make uniform the flow of steam into radiators in different parts of the system. The piping should be well pitched and should be dripped through traps of ample capacity so that water which condenses in the mains and risers will not interfere with the flow of steam. Combination float and thermostatic traps at the ends of long mains give good results. Runouts from radiators and all other return piping should be well pitched and free from pockets so that the piping will drain by gravity. In vacuum systems, lifts should be avoided. The reason for the care with the steam and return piping is that since the flow of steam into every radiator depends upon the difference between the pressure in the radiator and the pressure ahead of the radiator valve everything which tends to alter these pressures should be avoided, otherwise some radiators will get less steam than others and some of the rooms will underheat. A trapped radiator return runout, for instance, will cause the pressure in the radiator to build up and the flow through the orifice into that radiator will be correspondingly decreased. In mild weather when a very low steam pressure is being carried such a radiator may not get any steam.

Radiator orifices as discussed here should not be confused with those used in connection with intermittent heating to prevent unequal heating of rooms located at different distances from the source of supply. In homes having steam heating systems equipped with oil burners, for instance, orifices are sometimes put in the radiator inlets to prevent the radiators in the room where the thermostat is located from quickly filling with steam and causing the thermostat to turn off the burner before the rooms on the second floor are up to the proper temperature. The orifices discussed in this article are intended for use in systems where the steam pressure is maintained continuously during the hours of heating.

Orifices are usually installed to reduce the cost of heating. It is possible to reduce the amount of steam used by installing orifices because the ordinary heating system usually supplies more heat than is needed. This is especially true in mild weather. Building occupants open windows when the rooms become overheated and thus much good heat is wasted. With orifices in the radiators, the building engineer can adjust the pressures so that the quantity of steam supplied is just the right amount needed and no more. As a result windows are kept closed or nearly so, rooms are kept at the proper temperature, and the amount of steam condensed is decreased. There is an additional saving in that when the radiators are not entirely filled with steam the condensate leaves at a much lower temperature than if they were filled, and thus more of the heat in the steam is delivered to the room and less carried away in the condensate. In very mild weather the temperature of the condensate leaving the radiators will be only slightly above room temperature. This of course is of greater advantage in the case of purchased steam than when the condensate is returned to the user's own boiler.

The economy to be obtained with an orifice system depends upon the care with which it is operated. It is believed that it is possible to obtain as good economy as with any other type of system or temperature control. An investigation made this year by the Commercial Relations Committee of the National District Heating Association showed that of the buildings investigated those heated with orifice systems with the pressures manually controlled had a lower average steam consumption than those heated by any other type of system.

To get good results the man operating the system must be well informed about weather conditions and about conditions in different parts of the building. It is of great assistance to have the building equipped with some type of remote-reading temperature indicating system, of which there are several now on the market.

Another advantage of using orifices is that the radiators operate at a lower temperature and therefore people can sit near them in comfort. When radiators are partly filled with steam their tops may be at or near steam temperature, but the rest of the surface is at a lower temperature. When operating the system at a very low differential pressure, the lower part of radiators will be at about room temperature.

◆