Chimney Dimensions

The area of cross sections for a chimney depends upon its height, and upon the amount of coal to be burned, or rather the size of the boiler. The table below, by Prof. R. C. Carpenter, has been found to give good results.

The "Spencer" requires no different chimney area than is required by any other reputable boiler. The table is the recognized standard for flues as used by all boiler makers. This can be readily seen from comparisons.

Standard Table of Chimney Dimensions

It is necessary that area and height, thickness of walls, general structure, and the position of the top outlet with reference to the building and other buildings near by should be carefully noted and observed in selecting or building a flue.

The figures given under the varying heights of chimneys are diameter measurements in inches, or the side of a square—the theory being that the spiral ascending column of smoke and gases will make a 12 by 12 inch flue no more extensive in practical working area than a 12-inch round flue. Rectangular shapes may be used if the area is equal and the differences in width and length are not extreme.

Diameter of Chimney in Inches Required for Varying Amounts of Direct Radiation

Direct Radiation		Height of Chimney Flue				
Steam in Square Feet	Water in Square Feet	30 ft.	40 ft.	50 ft.	60 ft.	80 ft.
250	375	8.				
500	750	9.2	8.8	8.2	8.	
750	1150	10.8	10.2	9.6	9.3	8.8
1000	1500	12.	11.4	10.8	10.5	10.
1500	2250	14.4	13.4	12.8	12.4	11.5
2000	3000	16.3	15.2	14.5	14.	13.2
3000	4500	18.5	18.2	17.2	16.6	15.8
4000	6000	22.2	20.8	19.6	19.	17.8
5000	7500	24.6	23.	21.6	21.	19.4
6000	9000	26.8	25.	23.4	22.8	21.2
7000	10500	28.8	27.	25.5	24.4	23.
8000	12000	30.6	28.6	26.8	26.	24.2
9000	13500	32.4	30.4	28.4	27.4	25.6
10000	15000	34.	32.	30.	28.6	27.
		Diameter of Chimney in Inches.				

CHIMNEYS

Their Design and Construction — Common Chimney Faults

(By Courtesy of The Heating and Ventilating Magazine)

Chimneys are one of the oldest and most useful inventions conceived by man. They are of greater and more fundamental importance than anything that any modern inventor has contrived. It takes engineering ability to make a good chimney, and one must understand the laws of nature which apply to their construction and operation. Modern factory chimneys are triumphs of scientific construction, being built tall in order to maintain a large, hot fire, and the heated air and gases pour up through some of them with the velocity of a small hurricane of thirty-five to forty miles an hour.

Each one of us is directly affected by the size of the chimneys used in the world to-day, many of the trials and tribulations of our journey through this vale of tears being directly traceable to them. This, however, is not so much the fault of the chimney as it is of the person who built them and either deliberately transgress nature's laws or are largely ignorant of them.

Most Common Error in Chimney Work

The most common error made in regard to chimneys is that of not distinguishing between the size (which governs the volume of smoke they can handle) and the height (which determines the intensity of the draft). A chimney may be high enough, yet with an area too small to do the work required. On the other hand, it may be large enough but too low to produce a draft of the strength required to pull the air through the fire and up the chimney at a sufficiently rapid rate. Either fault, or a combination of both, will result in unsatisfactory service and will require remedying.

Basic Principles Involved

The easiest way to understand the operation of a chimney is to consider the great law of nature governing its operation, for there is, indeed, nothing so very mysterious about the process. The same force which supports the toy balloon and operates the hot-air furnace causes the draft in the chimney. This is the simple fact that heated air expands and occupies a greater volume than the other air of a lesser temperature. Therefore, if a cubic foot of air outside the chimney weighs 0.07 pounds and a cubic foot of the

chimney gases at their higher temperature weighs only 0.04 pounds, then every vertical foot of air in the chimney means an unbalanced pressure of 0.07 — 0.04 or 0.03 pounds per square foot at the base.

This unbalanced pressure has a tendency to equalize by the rising of the lighter gases, but since their first place is taken by more heated gases coming directly from the fire, the temperature, of course, never does equalize and the action continues its operation as long as the fire is kept burning.

From this basic principle all chimney action is governed, and many chimney failings can be explained. For instance, the draft of a chimney is never as good in summer as in winter—because the outside air is colder in winter, the expansion of the chimney gases at the same temperature is therefore relatively greater and the intensity of the chimney draft is consequently increased.

It is a well-known trouble with chimneys that when out of use for any considerable period trouble is likely to be experienced in "starting the draft." This is easily explained by the fact that, in starting, the cold chimney will cool off the gases to a point where their temperature may be the same, or nearly the same, as the outside air, thus causing them to contract and lose their buoyancy. This, of course, immediately results in killing the draft, as the draft depends absolutely on a temperature difference and the expansion resulting therefrom.

Ordinary residence chimneys have little trouble on account of height owing to the fact that most residence heating systems burn large size anthracite coal which makes a very hot, clear fire and offers little resistance to the passage of air through the fire bed. In fact, many of the older railroad stations and similar places use coal stoves with only a stove pipe extended through the roof, this pipe seldom being over 10 feet in height. But an attempt to burn smaller sizes such as pea and buckwheat would be doomed to failure under such conditions.

The ordinary residence usually employs a chimney between 25 and 60 feet high, the area being proportional to the size of the house, and it is interesting to note that it is possible to burn No. 1 buckwheat coal with chimneys of the heights as mentioned above, if the fire bed is not made too thick. Down-draft boilers should have chimneys at least 60 feet high to operate successfully.

Common Chimney Troubles

The more common troubles may be summarized as

(*a*) Chimney of bad shape—not approximately square or round, or with too many offsets.

(*b*) Too small a chimney.

(*c*) Too low a chimney.

(*d*) A combination of (*a*), (*b*) or (*c*).

(*e*) Too much leakage.

(*f*) Downdrafts.

(*g*) Lack of air supply for fire.

(*h*) Loose connections to chimney.

(*i*) More than one smoke pipe connected.

(*j*) Stoppage in offsets.

(*k*) Inserting smoke pipe too far into chimney.

(*l*) Chimneys with 4-inch walls and flue tile—where flue tile is not cemented solid to brick work.

Chimneys have to overcome their own losses, these losses consisting of the friction of the gases rubbing against the sides in their upward passage. For this reason a circular-shaped flue is most desirable, there being less surface exposed in comparison to the area than in any other shape. Most high stacks where the friction builds up to a considerable amount are, therefore, made round in cross section.

The next most advantageous shape is square, and the next, after that, is oblong with the long side not more than one and a half the length of the short side. In flues where it is necessary to exceed this proportion two separate flues of more desirable shape can sometimes be used with advantage.

With the same idea of reducing the friction of the gases on the sides, it is most desirable to build a chimney flue straight from top to bottom, as all changes in direction, or even in shape, produce an additional friction loss, as does also the condition of the interior surface. The smoother the surface the less the rubbing effect, and for this reason the use of flue tile is advocated, this being tile flue pipe made in various forms and shapes and with a very smooth interior surface. Fig. 1 shows a plain brick chimney without tile and Fig. 2 the construction of a chimney using flue tile.

From the above it can be seen that the most efficient chimney, so far as the draft is concerned, is one built perfectly straight from the bottom up, round (or nearly round) in the shape of the interior flue, and lined with tile, or with the interior surface made as smooth as possible by other means. There is no advantage in tapering the inside of a chimney to a smaller size toward the top, as this retards the flow of the gases.

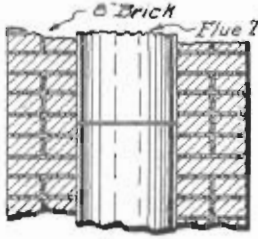

FIG. 1

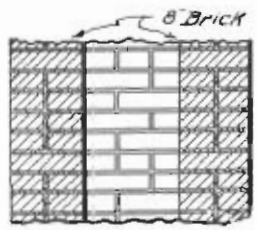

FIG. 2

Having a chimney built upon desirable lines, so far as draft is concerned, it may, of course, still be too small, and in this connection it might be said that no flue should be made less than 8 inches diameter or 8 by 8 inches square. Under ordinary conditions, with steam, furnace or hot water heating, the sizes of flues given in Table 1 will be found to give satisfaction in residences whose cubic footage does not exceed the amounts shown.

Table 1—Sizes of Flues for Residences, Inside Dimensions

Contents of Building Cubic Feet	Round Inches Diameter	Square Inches
20,000	8	8 x 8
40,000	9	9 x 9
60,000	10	10 x 10
110,000	12	12 x 12
120,000	14	14 x 14
130,000	16	16 x 16
150,000	18	18 x 18
200,000	20	20 x 20
250,000	22	22 x 22
300,000	24	24 x 24

All chimney walls should be 8 inches thick to avoid danger of fire from sparks working through the joints, and the building laws in some cases demand not only 8-inch thick walls, but tile linings as well.

Additional Advantages of Round Chimneys

There are also other advantages in building chimneys round (or nearly round) and in the use of flue tile. The gases in their progress upward do not move in a straight line, but assume a swirling spiral motion resembling the rifling of a gun barrel, and in the process of aiding this movement a circular shape is best.

In fact, a square chimney can hardly be figured as having its full area effective, a deduction of 10 per cent. to 15 per cent. being necessary on account of this very movement leaving the corners dead and inactive. In an oblong shape the effect is worse, a deduction of 25 per cent. being none too much. The use of tile flues will not only aid this slightly—owing to their rounded corners—but will also safeguard much of the fire risk otherwise due to mortar falling out between the bricks as time passes and leaving openings through which a spark might pass. As the tile serves to retain the gases and smoke, it also prevents leakage which can spoil a chimney action at any time, no matter how perfectly the flue may otherwise be built, provided tile flue is set in cement and that no air space be left between tile liner and walls.

The height of residence chimneys, as before mentioned, is not so important where the large sizes of anthracite coal are used. The draft, however, ought to approximate in inches of water the various values given in Table 2 after being in use twenty-four hours and with all the inlets suddenly closed.

The figures given are about 90 per cent. efficiency of the theoretical draft which an absolutely tight chimney would show, and a properly constructed chimney should approximate these figures.

Table 2—Draft in Chimneys for Residences

Height in Feet	Temperature of Chimney Gases, Deg. F. 200°	250°	300°
	Inches of Water		
60	0.27	0.32	0.35
55	0.25	0.29	0.32
50	0.23	0.26	0.29
45	0.21	0.23	0.26
40	0.18	0.21	0.23
35	0.16	0.19	0.20
30	0.14	0.16	0.17
25	0.12	0.14	0.14
20	0.09	0.11	0.12

Method of Using Draft Gauge

Measurement of the draft in a chimney is made by a draft gauge, which, in its simplest form, is nothing but a glass tube of U-shape, one end of which is connected to the base of the chimney and the other end is left open to the air.

The suction or draft of the chimney will raise water placed in the tube so that the water in the leg connected to the chimney stands higher than that in the leg open to the atmosphere, this being due to the unbalanced pressure and proportional thereto. The difference in level between the two columns of water is measured in inches, this difference being termed the draft in "inches of water." Some draft gauges have the legs of the U inclined only a few degrees off the horizontal, so that a rise of a small amount causes a large movement horizontally along the inclined tube on which finer graduations can be read.

Ellison Portable Differential Draft Gauge

To take a theoretical draft reading (which is the most accurate method to pursue) see that the temperature of the flue gases is known at the time of taking the reading and that a tight damper can be closed in the smoke pipe. Connect the draft gauge with the chimney, take the flue gas temperature and then quickly close the smoke pipe damper and read the draft gauge as soon as it reaches the highest fixed point.

Chimney Leakage

Leakage may take place not only through the joints of the chimney itself, but through the connections to the chimney. For this reason a separate chimney flue for every connection is advocated.

A stove on the first floor and a heating apparatus in the basement may be connected to the same flue; if it is large enough both may work satisfactorily; but put out the fire in the stove and open the doors, the inrush of cold air into the flue will spoil the draft for the heating apparatus, this inrush of air being simply excessive leakage into the flue all at one point.

The leakage may not even come from the outside air but may come from an adjoining flue, in which case it is just as detrimental in its effect. For this reason chimneys with more than one flue should never be built without a 4-inch brick wall between the flue tiles. The common practice of placing flue tile close together without this brick wall later leads to trouble in many chimneys.

Several boilers may be connected into one flue of sufficient size if they all are properly dampered in the smoke pipe with tight dampers and if these dampers are kept closed when the boilers are out of commission.

Use of Two Flues for One Apparatus

Questions are often asked about using two old flues for one apparatus when it is desired to make alterations in an existing building. In this regard it can be said that reasonably satisfactory operation can be secured from such an installation if the dividing partition is knocked out 5 or 6 feet down from the top of the chimney and up to 5 or 6 feet above the point where the smoke pipe enters the chimney. There must be no other connections to the chimney, however, and the chimney must be in good condition otherwise to serve its purpose; the best results will be obtained where the smoke pipe enters the middle of the enlarged chimney so as to distribute the hot gases as equally as possible into both flues higher up. Of course, the center partition remaining exposes just so much more rubbing surface to the gases, giving a greater friction loss, and the chimney will give better service, otherwise a stronger draft, if the center partition is removed entirely.

Other Chimney Defects

Oftentimes chimney troubles are entirely due to outside causes and not to the construction of the chimney itself. The most frequent of these is the termination of a chimney below the level of the adjacent ridge of the roof or other nearby obstruction. Even nearby buildings or mountains may interfere with the operation of a chimney, the cause in all cases being the wind coming over the higher obstruction and dropping down onto the top of the chimney. As can be easily realized, chimney draft (after deducting the friction in the chimney, in the heating apparatus, and in the fire and smoke pipe) does not possess a great force, and a high wind, with the air dropping down toward the top of the chimney, could readily hold back the action, and, in some cases, even result in "back-drafts."

The best remedy for such trouble is to extend the chimney higher so as to get above the nearby ridge or building if possible. This at the same time will both prevent the wind dropping down onto the top of the chimney and will give the chimney (due to the increase of its height) a stronger draft to resist such action. If this is impractical one of the many types of chimney tops having side or downward outlets will prevent "back-drafts," but these will at the same time slightly retard the chimney action, due to the greater number of turns the gases are forced to make and the additional friction thus produced.

chimney so far as to project into the interior opening as shown in dotted lines—Fig. 4—since this restricts the

A very desirable type of chimney top, where "down-drafts" are not likely to be encountered, consists of finishing off the top at a 45 degree angle all around from the flue outlet to the side of the chimney, as shown in Fig. 3. This results in deflecting horizontal winds upward when blowing across the top of the chimney and gives a slight ejector action, helping to draw the gases up and out of the chimney.

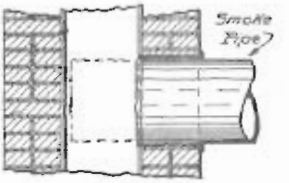

FIG. 3

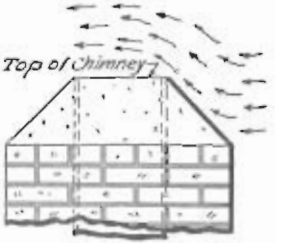

FIG. 4

Trouble with chimneys may also be experienced on certain days when the cellar door comes on the leeside of the building or when the cellar is so air tight that sufficient air does not leak in to replace that lost up the chimney. This results in a partial vacuum in the cellar, which vacuum reacts against the draft that would otherwise be obtained. The remedy for this is to open a cellar window on the windward side, close the opening to the leeward, or else provide some means of allowing air to enter from some other source where the wind action is not encountered.

The connection to the chimney commonly termed the smoke pipe is another factor which must be considered. The smoke pipe should never be reduced below the size of that on the heating apparatus; if more than one smoke pipe is connected into a common pipe before going into the chimney the area of the common pipe should have an area equal to the combined areas of the two entering pipes. A loose connection where the pipe enters the chimney, a loose-fitting clean-out door or other openings leading into the chimney will act the same as a leakage from any other source.

Neither should the smoke pipe be shoved into the

area and if carried to an extreme will shut off the draft entirely. Every smoke pipe should have a tight damper operated by hand for closing down during high winds, for testing and for use when the apparatus is out of service.

Chimneys which have given good service for years and which then gradually fail to have sufficient draft usually are found to need cleaning, and chimneys with offsets at a sharp angle are usually troubled in this way. A cobble stone tied to a rope and dropped down gradually from the top of the chimney, working this up and down as it goes down, will clean out many such troubles at slight expense.

A leaky chimney flue may be easily discovered by placing a bag over its top, then building a fire of paper in the heater, thus filling the flue with smoke. If poorly constructed the smoke will pour out through any cracks or crevices.