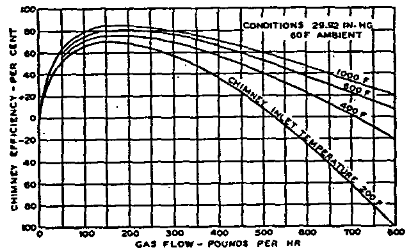


* Derived from temperature plots. Liner 8 x 8 in. outside, 6¾ x 6¾ inside. Height 13 ft.

Fig. 7 . . . . Effect of Gas Flow on Chimney Efficiency*

chimneys can be used, with slight error, for chimneys made of shale tile, concrete block, or cinder block.[8]

SHORT CHIMNEYS

The application of heating systems to one-story houses without basements requires special consideration because the chimneys in such houses are often made so low in height for architectural reasons that they produce insufficient draft for some kinds of heating systems. Gas-burning devices do not necessarily require a chimney for proper combustion of the gas, but the chimney must be of adequate size and height to carry the flue gases out of the building since it is undesirable and contrary to American Standards to have the products of combustion discharged in the living space. If a natural-draft oil-burning device is operated with insufficient draft because of a short chimney, smoky combustion usually occurs, pulsations are possible in the combustion chamber, the chimney or smokepipe may become blocked with soot, and the capacity of the heating equipment may be reduced to the point of inadequacy. Insufficient draft is not ordinarily the cause of smoky combustion in coal-burning heaters, but too short a chimney can cause slow pickup of the fire and insufficient heating capacity of the device.

Based on the amount of draft usually required for present-day heating systems at rated output, any chimney with an effective height of less than 15 ft above the center line of the thimble should be regarded as a short chimney. In short chimneys every precaution should be taken to attain the highest possible average temperature in the chimney and the lowest practicable friction loss. Short chimneys of conventional construction are likely to produce from 60 to 90 percent of the ideal draft and, therefore, the draft would only be increased from 10 to 40 percent if all friction and cooling could be eliminated.

The available draft for short chimneys can perhaps be determined most readily by using Equation 13, Fig. 8, and Table 1. Fig. 8 shows the relationship between effective chimney height, inlet flue-gas temperature, and the ideal draft that would be produced for two values of outdoor temperature if there were neither friction nor cooling of the gases as they traversed the chimney. After obtaining the ideal draft for a given chimney height and entering flue-gas temperature from Fig. 8 and selecting the appropriate efficiency value from Table 1, the available draft can be computed from Equation 13. Fig. 8 can be used in reverse in conjunction with

Table 1 . . . . Efficiency of Short Chimneys

A. Masonry Chimneys

Height h ft	Flue Gas Flow Rate lb/hr	Internal Liner Size, in. 7 (dia)	7 x 7	7 x 11 and 10 (dia)
		Efficiency, Percent		
5 to 15	90	75–82	65–76	65–80
	200	83–84	67–85	82–88
	315	75–89	67–86	81–89
		(Inlet Flue Gas Temp. 200 to 1000 F)		

B. Uninsulated Metal Chimneys

Height h ft	Flue Gas Flow Rate lb/hr	Internal Diameter, in. 6	8
		Efficiency, Percent	
4 to 8	90	90–100	85–95
	200	*	83–88
	315	*	70–80
		(Inlet Flue Gas Temp. 200 to 600 F)	

C. Metal Chimneys[b]

Height h ft	Uninsulated	1-in. insulation with dead air space around chimney	1-in. insulation with 1-in. open air space around chimney
	Efficiency, Percent		
8 to 14	76	85	81

* Six-inch chimney not recommended for these flow rates.
[b] Internal dia 6-in.; flue gas flow rate 50 to 125 lb/hr; inlet flue gas temp. 200 to 1000 F.

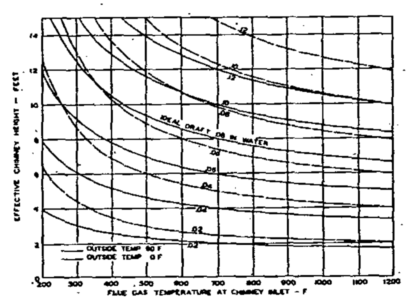


Fig. 8 . . . . Ideal Draft for Short Chimneys at Outside Temperatures of 0 F and 60 F

efficiency values from Table 1 to determine what chimney height is required to produce the required draft at rated output for a given heating appliance.

Fig. 7 shows that the efficiency of a given chimney varies with the mass flow rate of gases and with the entering flue-gas temperature. The efficiency also varies with the height for a given construction and depends somewhat on the method used to connect the smokepipe to the chimney and the amount of exposure to the outdoor air. Experimental data are not sufficiently complete to tabulate efficiencies that take into account all of these variables. However, recommended values of efficiency for several sizes of domestic chimneys of masonry materials and of metal have been selected from the literature[6, 7, 8, 9] and summarized in Table 1 for use with Fig. 8 in determining the available draft produced by short chimneys of 15 ft in height or lower. In parts A and B of Table 1 the value of efficiency chosen from the range cited should be increased as the chimney inlet temperature increases over the applicable range. In part C of Table 1 the efficiency values listed will yield the available draft for the range of mass flows, inlet flue gas temperatures, and chimney height shown within 10 percent.

In the application of short chimneys, observance of the following precautions will assist in obtaining the highest practicable draft and may cure unsatisfactory operation of the chimney and heating plant in certain instances:

1. Use a minimum length of horizontal smokepipe between the heater and chimney.
2. Insulate the smokepipe and the chimney itself, if made of metal. Insulation of the chimney liner in masonry chimneys reduces the heat loss from the flue gases and the infiltration of cold air.
3. Do not use an oversized chimney because larger chimneys produce greater cooling of the flue gases.
4. Avoid downdrafts by proper construction above the roof or by the use of a suitable chimney cap.
5. Avoid the use of barometric dampers in the smokepipe of natural-draft heaters since most barometric dampers permit enough cold air to leak into the chimney to reduce the draft appreciably.
6. Avoid air leaks in the smokepipe and chimney.
7. Avoid connecting more than one heating device to a single chimney.
8. Use construction materials of low heat capacity if the chimney draft must increase quickly for an intermittently-fired heating device.
9. Do not operate a kitchen exhaust fan unless an air intake of ample area is used to prevent lowering the house pressure.
10. Avoid tight utility closets so the chimney draft will not be required to do the added work of drawing combustion air into the closet from the surroundings.

DETERMINING RESIDENTIAL CHIMNEY SIZES

The flue sizes for small residential chimneys are governed by the *National Building Code* of the National Board of Fire Underwriters for gas-burning appliances. Chimney areas for liquid- and solid-fuel-burning devices are selected primarily to meet the requirements of local building codes, but these requirements are not determined by any rigorous formula based on physical principles.

By calculating the available draft for the chimney in question, and comparing it with the performance values of the heating unit (either natural or forced draft type) at the desired output, it is possible to determine whether the chimney is adequate in height for the particular heating unit it serves.

For calculations where the fuel rate and the percentage CO_2 are the only known factors, the flue gas rate can easily be determined for coal, oil, and gas from Fig. 9. By entering Fig. 9 at the percentage CO_2, moving vertically to the curve for the type of fuel, and then moving horizontally to the fuel rate, the flue gas rate in pounds per hour may be determined for any fuel.[7]

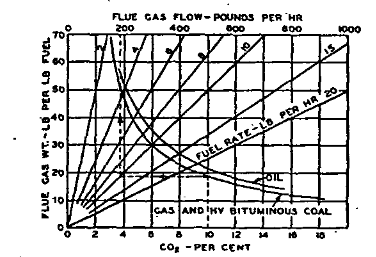
Any of the described methods of determining available draft may be used, but a graphical solution to the problem may be had for the 8 x 8-in. chimney from Figs. 6, 7, and 9. This solution can be best explained by a numerical example.

Example 3: Determine whether a 13-ft, 8 x 8-in. nominal-size flue is sufficient for a coal-heating unit rated at 0.03 in. of water draft at 400 F inlet temperature, fuel rate being 10 lb per hr of bituminous coal, with 10 percent CO_2.

Solution: From Fig. 9, a flue gas rate of approximately 180 lb per hr is obtained. The available draft for a 180 lb per hr fuel rate, and an inlet temperature of 400 F, obtained from Fig. 6, is 0.056 in. of water. This indicates that the chimney is adequate.

The selection of chimney areas for liquid- and solid-fuel-burning devices is difficult because of the variability in efficiency of different models, the possibility that soot on the lining will restrict the chimney area, and the variation in combustion air requirements of different solid fuels. Figs. 6 and 7 show that a given chimney produces a maximum available draft and a maximum efficiency for some intermediate mass flow rate for any selected inlet flue gas temperature. For mass flow rates lower than the optimum the greater cooling of the gases in the chimney causes lower available draft, whereas for mass flow rates above the optimum the greater friction losses reduce the available draft. A chimney for a given heating system should probably be designed to operate at its point of maximum efficiency and maximum available draft for its full rated output. A chimney would have an accelerating effect[10] on the combustion rate of a solid-fuel burning device if it were operating to the left of the optimum point in Fig. 6 because an additional increment in mass flow rate would increase the available draft a small amount and tend to increase the mass flow still more. On the other hand, a chimney operating to the right of the optimum point in Fig. 6 would tend to decelerate the combustion rate for any small increase in mass flow rate.

Data are not complete for the selection of proper chimney areas for heating plants of different capacities, but some information on the effect of cross-section area on the capacity of masonry chimneys is provided by tests[8, 11] on several chimneys with liners having nominal outside dimensions: 9-in.



* Average density gas 0.0845 lb per cu ft, 62 F. Average weight oil 7.08 lb per gal, 60 F.

Fig. 9 . . . . Graphical Evaluation of Rate of Flue Gas Flow from Percent CO_2 and Fuel Rate*