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 verti-

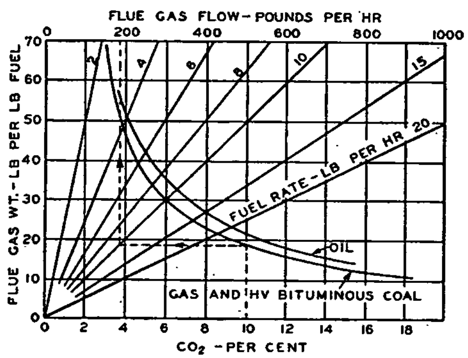

FIG. 9. GRAPHICAL EVALUATION OF RATE OF FLUE GAS FLOW FROM PERCENT CO_2 AND FUEL RATE[a]

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

cally 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 × 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

TABLE 2. APPROXIMATE FLUE-GAS FLOW RATES FOR MAXIMUM AVAILABLE DRAFT IN MASONRY CHIMNEYS

Nominal External Liner Dimensions	Internal Area of Liner, Sq In	Flue Gas Temperature at Chimney Inlet, Fahr.					
		200	600	1000	200	600	1000
		Mass Flow Rate, LB/HR			Flue Gas Velocity at Chimney Inlet, FPM		
9 in. Dia.	38.5	170	150	130	175	250	300
9 in. x 9 in.	49	215	306	334	175	400	600
12 in. Dia.	78.5	290	Above 320	Above 320	150	—	—
9 in. x 13 in.	77	295	Above 320	Above 320	150	—	—

recent tests[8, 11] on several chimneys with liners having nominal outside dimensions: 9 in. diameter, 12 in. diameter, 9 × 9 in., and 9 × 13 in. These tests showed that for flue gas rates up to 200 lb per hr, and entering flue gas temperatures from 200 to 1000 F, the 9-in round liner provided an available draft equal to, or greater than, that produced by the other three larger liners. When the flue gas rate was increased to 320 lb per hr, the three larger liners produced a little more draft than the smallest one for entering flue gas temperatures above 600 F. Other data[9] show that metal chimneys with an internal diameter of 6 in. should not be used for mass flow rates greater than 130 lb per hr.

Table 2 shows approximate values of the mass flow rates and flue-gas velocities at the chimney inlet that produce the maximum available draft for masonry chimneys[8] of several conventional sizes and with an effective height of 15 ft. This table shows that a 9-in. round chimney is best suited to mass flow rates from 130 to 170 lb per hr, a 9 × 9-in. chimney performs best for flow rates from about 200 to 300 lb per hr, and a 9 × 13-in. and 12 in. round chimneys are best suited to flow rates above 300 lb per hr. These results were obtained with clean chimneys, so that conclusions about chimney areas require some modification if soot deposits are taken into consideration.

Soot deposits in chimneys reduce the effective area of the liner and may in some cases entirely close the passage Soot deposits are likely to be