Table 1.... Minimum Stack Areas for Oil and Stoker-fired Boilers[a]

RECTANGULAR			ROUND	
Col. 1 *I=B=R Burner Capacity (Not Over)*	Col. 2 *Nominal Stack Dimensions*	Col. 3 *Inside Dimensions of Liner*	Col. 4 *I=B=R Burner Capacity (Not Over)*	Col. 5 *Inside Diameter of Liner*
Gal	In.	In.	Gal	In.
2.1	8 × 8	6¾ × 6¾	1.3	6
3.5	8 × 12	6½ × 10½	1.8	7
5.3	12 × 12	9¾ × 9¾	2.5	8
7.7	12 × 16	9½ × 13½	4.5	10
11.5	16 × 16	13¼ × 13¼	5.6	11
15	16 × 20	13 × 17	7	12
21	20 × 20	16¾ × 16¾	12	15
26	20 × 24	16½ × 20½	19	18
33	24 × 24	20¾ × 20¾	28	21
41	24 × 28	20¼ × 24¼	40	24
52	28 × 28	24¼ × 24¼	53	27
59	30 × 30	25½ × 25½	69	30
76	30 × 36	25½ × 31½	88	33
100	36 × 36	31½ × 31¼	109	36

[a] Table E, Page 11 of *I=B=R Testing and Rating Code for Low Pressure Cast Iron Heating Boilers* (1958). The inside dimensions or diameter of liner shown in Cols. 3 or 5 are for chimneys lined with a standard clay chimney tile and are the largest standard size that will fit within the dimensions specified for unlined chimney.

ciency 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

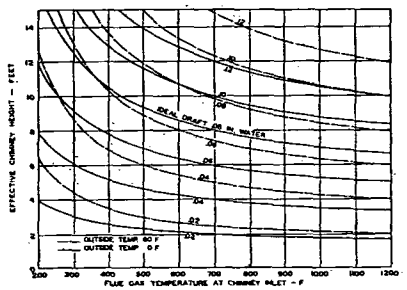


Fig. 9....Ideal Draft for Short Chimneys at Outside Temperatures of 0 F and 60 F

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[9, 11] on several chimneys with liners having nominal outside dimensions: 9-in. diameter, 12-in. diameter, 9 x 9-in., and 9 x 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 3 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[9] 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 x 9-in. chimney

Table 2.... 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	[a]	83–88
	315	[a]	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

[a] Six-inch chimney not recommended for these flow rates.
[b] Internal dia 8-in.; flue gas flow rate 50 to 125 lb/hr; inlet flue gas temp. 200 to 1000 F.

performs best for flow rates from about 200 to 300 lb per hr, and 9 x 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 greater in the horizontal passages in the heating plant, the breeching, and the smokepipe, than in the vertical chimney liner. An increase in the liner diameter of one inch above that required for a clean chimney will probably make adequate allowance for soot deposits in all but the worst cases. Where smoky combustion is likely to occur and the mass flow rates on a clean chimney basis approach those listed in Table 3, the next larger commercial size liner should be used. Smoky combustion with oil-burning devices, particularly with vaporizing oil burners, is likely to be caused by inadequate draft which is often due to insufficient chimney height. For coal, inadequate chimney

Table 3.... *Approximate Flue Gas Flow Rates for Maximum Available Draft in Masonry Chimneys*

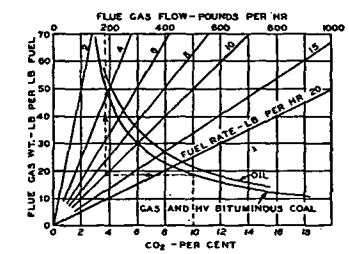
Nominal External Liner Dimensions, In.	Internal Area of Liner Sq. In.	Flue Gas Temperature at Chimney Inlet, F: 200	600	1000	200	600	1000
		Mass Flow Rate, Lb/Hr			Flue Gas Velocity at Chimney Inlet, Fpm		
9 (dia)	38.5	170	150	130	175	250	300
9 x 9	49	215	306	334	175	400	600
12 (dia)	78.5	290	Above 320	Above 320	150	—	—
9 x 13	77	295	Above 320	Above 320	150	—	—

height or chimney area may be a contributing cause, but smoky combustion with coal is related to fuel characteristics and firing methods. Therefore, an increase in chimney area will usually not cure smoky combustion of a coal-burning device, but can be expected to lengthen the interval between cleanings.

New standard sizes of clay flue linings were developed by the industry and approved by the American Standards Association, in order to effect economies that can be derived from coordination of the dimensions of building materials. These linings are known as modular clay flue linings, and the dimensions and tolerances are summarized in *ASA Standard* A62.4-47. As the effective areas of these liners are somewhat smaller than those of the corresponding linings used previously, they cannot be used in certain municipalities where building codes specify minimum areas based on the older dimensions.

DRAFT REQUIREMENTS OF APPLIANCES

Typical flue-gas temperatures and drafts required at rated output for several kinds of domestic heating appliances[12] are contained in Table 4. Chimney height and chimney area for



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

Fig. 10.... Graphical Evaluation of Rate of Flue Gas Flow from Percent CO_2 and Fuel Rate[a]