Table 2 .... 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	—	—

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[4] 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[5] 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 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 2, 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 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 recently 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[23] are contained in Table 3. Chimney height and chimney area for cast-iron boilers are specified in the $I = B = R$ *Testing and Rating Code* of the Institute of Boiler and Radiator Manufacturers.

Mechanically-fired devices such as oil burners and stokers are equipped with blowers, and therefore, the chimney is not required to overcome the resistance of the fuel bed or burner. Nevertheless, a draft in the firebox, of about 0.03 in. of water, is desirable so that leakage, if any, will be into the firebox rather than outward from it.

Insufficient draft for natural-draft appliances is likely with installations in attics or in one-story basementless houses. Automatic oil-burning space heaters, floor furnaces, and warm air furnaces employing natural-draft vaporizing burners require a draft of 0.06 to 0.08 in. water for outdoor temperatures of 60 F. Coal-burning heaters and furnaces which attain design rating at 0 F outdoor temperature would require about the same draft. For such requirements, data from Figure 8 and Table 1 show that an effective chimney height, above chimney inlet, should be a minimum of 8 to 12 ft. Because temperature drop and friction loss in the flue pipe cannot be calculated accurately,[7] and the resistance of various chimney connections is uncertain, the minimum calculated heights should have a generous factor of safety applied to allow for these and other uncertainties. Where ample height cannot be provided, forced or induced draft should be provided. Extreme care should be used in the application of forced draft to avoid producing a pressure in combustion

Table 3 .... Drafts Required by Typical Residential Heating Devices or Appliances

Device	Draft, In. Water	Stack Temperature[a] F
Space Heater, Oil-Burning, Pot Burner	0.06 to 0.08	1000
Warm Air Furnace, Oil-Burning, Pot Burner	0.06	880
Warm Air Furnace, Hand-Fired	0.06[b]	900
Floor Furnace, Oil-Burning, Pot Burner	0.06	860
Mechanical Oil Burner, Less than 5 gph	0.03[c]	—
Mechanical Oil Burner, More than 5 gph	0.05[c] or less	—
Cooking Stove, Solid-Fuel	0.04[b]	400
Space Heater, Coal-Burning	0.06[b]	900

[a] Draft in firebot. [b] For chestnut sized anthracite.
[c] 18 in. from heater.

chambers, because they are not usually designed to prevent the outward leakage of toxic gases which might result.

Induced draft by means of motor-driven fans or blowers will solve low-draft problems, but would usually be employed for residential systems only as a last resort. Operation of a blower entails some cost, introduces maintenance requirements, and may be dangerous in event of power failure unless suitable protective devices are used. Induced draft fans designed to resist effects of high temperature and corrosion are available. Fans not carefully designed or modified to meet these conditions should not be applied to this service.

CHIMNEYS FOR GAS APPLIANCES

The Approval Requirements of the American Gas Association are such that a gas-fired appliance must be able to operate at its rated input (plus 10 or 15 percent) without a chimney connection, and without producing carbon monoxide. The primary functions of the chimney for the gas-fired appliance are to remove the products of combustion from the living space and to assure safety to the building. The chimney therefore becomes essentially a vent and, in fact, the vents tested and listed by Underwriters' Laboratories for use only with gas appliances were for some time designated as *Type B* Gas Appliance Vents. Their use is limited to appliances approved by the American Gas Association and operating with flue-gas temperatures not in excess of 550 F at the outlet of the draft hood. A draft hood is always required in connection with a *Type B* flue. The *Type B-W* gas flue is further limited to the venting of wall heaters having an input of not more than 50,000 Btu per hr.

Because of the low temperatures to which gas flues are limited care should be taken to ascertain that the appliance

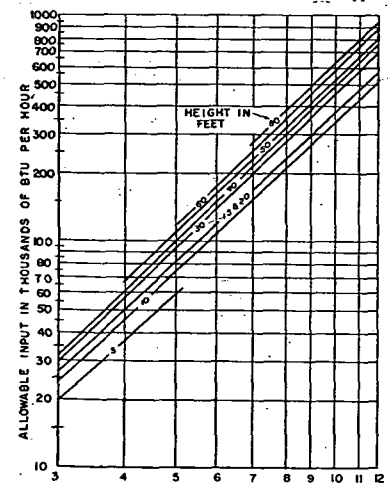

Fig. 10 .... Capacity in Btu per Hour for Gas Appliance Flues or Vents

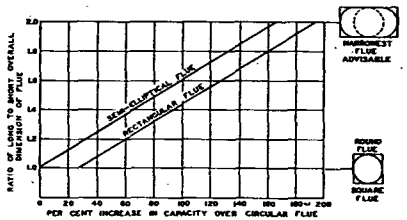

Fig. 11 .... Capacity of a Rectangular Flue or a Semi-Elliptical Flue, with Semi-Circular Ends Having Its Minimum Width Equal to the Diameter of a Circular Flue, Compared with the Capacity of the Circular Flue

is not convertible to fuels other than gas and that the appliance is approved by the American Gas Association. It is well also to be certain that gas fuel will continue to be available to the building.

Chimneys for venting appliances designed for burning gas, can therefore be low in height, but must have adequate area. The height is usually established by the building height. Chimney sizes are usually selected on the basis of heat input of the appliance. The minimum flue or vent sizes adopted by the American Standards Association and the National Board of Fire Underwriters in 1950 for gas appliances[23] are shown in Fig. 10.

Additional provisions of *ASA Standard* Z21.30-1950 relating to chimney size are:

1. In no case shall the vent area be less than the area of a 3-in. diameter pipe.
2. When more than one appliance vents into a flue or vent, the flue or vent area shall be not less than the area of the largest flue or vent connector plus 50 percent of the areas of the additional flue or vent connectors.
3. Any-shaped flue or vent may be used provided its flue gas venting capacity is equal to the capacity of the round pipe for which it is substituted.

Since Fig. 10 has been prepared for circular flues, relative capacities for rectangular and semi-elliptical flues[24] are shown in Fig. 11.

Heating appliances designed to burn gas, as well as appliances converted to gas burning, except those equipped with power-type burners and excepting conversion burner installations in excess of 400,000 Btu per hour input in large steel boilers, are always equipped with a draft hood attached to the flue outlet of the appliance. This draft hood is required if the appliance is to meet the approval requirements of the American Gas Association and the American Standards Association, and is essential for safe operation. It is designed to prevent excessive chimney draft which would lower appliance efficiency, to prevent a blocked flue or a downdraft in the chimney from impairing combustion, to provide a relief opening for the products of combustion during downdraft or blocked-flue conditions, and to prevent spillage of the products of combustion to the space surrounding the appliance, if there is a chimney draft equivalent to that provided by a 3-ft chimney. As the draft hood is designed without moving parts, the relief opening is always open, and consequently some air is drawn into the chimney. This air lowers