fuel gases vary. While personal errors involved in CO_2, temperature, and chart determinations, would doubtless more than offset any inaccuracies due to universal use of the alignment charts shown, precise laboratory work may require a more exact method. For more complete information the reader is referred to *Combustion*, 3rd Edition, and *Gaseous Fuels*, (published by *American Gas Association*) and particularly to tables covering various properties of different commercial gases included in these publications.

CONDENSATION AND CORROSION

Sulfur dioxide or sulfur trioxide, formed by the combustion of sulfur in fuels, are the principal corroding substances in flue gases. They become active whenever sufficient moisture is present for the formation of sulfurous or sulfuric acid,[20] and they lower the dew points of flue gases appreciably. Therefore, unless heating equipment is designed for operation at flue gas temperatures below the dewpoint, which is seldom the case, it is always advisable to maintain temperatures above this value in all parts of the appliance. Excessive spot temperatures in the combustion chamber or elsewhere, on the other hand, are also destructive in that they may result in rapid oxidation of ordinary heating surfaces. *American Standard Requirements* for gas furnaces, floor furnaces, and recessed heaters, for example, specify that minimum spot heating surface temperatures during normal operation must neither fall below 178 F (50 F above average dewpoint) nor exceed 830 F to 1230 F on any portion of the heating surface, depending on the type and thickness of the metal. In any event it is usually desirable to maintain flue temperatures within the limits indicated not only throughout the appliance, but in its connecting vent, flue, or chimney as well. Otherwise, excessive condensation and corrosion problems, with resultant customer dissatisfaction, will in all probability be the result. Average dewpoint temperatures of flue gases resulting from the combustion of various fuels, when burned with the amount of excess air normally supplied to insure complete combustion, are shown in Table 10.

TABLE 10. AVERAGE FLUE GAS DEW-POINT FOR VARIOUS FUELS[8]

TYPE OF FUEL	AVERAGE DEW-POINT TEMPERATURE, F
Anthracite	68
Semi-Bituminous Coal	84
Bituminous Coal	93
Oil	111
Natural Gas	127
Manufactured Gas	137
Propane Gas (2500 Btu/cu ft)	119
Butane Gas (3200 Btu/cu ft)	124
Butane-Air Gas Mixture (535 Btu/cu ft)	121

SOOT

The deposit of soot on the flue surfaces of a boiler or heater acts as an insulating layer over the surface, and reduces the heat transmission to the water or air. The *Bureau of Mines Report of Investigations* No. 3272[21] shows that the loss of seasonal efficiency is not so great as has been believed, and usually is not over 6 percent because the greater part of the heat is transmitted through the combustion chamber surfaces. The *Bureau of Standards Report* BMS 54[22] points out that, although the decrease in efficiency of an oil fired boiler, due to soot deposits, is relatively small, the attendant increase in stack temperature may be considerable.

The soot accumulation clogs the flues, reduces the draft, and may prevent proper combustion. Soot can probably be most effectively removed by a jet of compressed air, by means of a brush, or a vacuum cleaner. However, it has been found that copper chloride, lead chloride, tin chloride, zinc chloride, common salt and some other salts are partially effective in removing soot from furnaces and boilers when properly used.[23] A discussion of instruments and methods of evaluating smoke will be found in Chapter 52.

TABLE 11. PERMANENT OPENINGS FOR AIR SUPPLY TO SPACES CONTAINING FUEL BURNING EQUIPMENT

FUEL BURNING EQUIPMENT		FREE AREA OF VENTILATING OPENING[a]	
		AIR INLET	AIR OUTLET
Gross output capacity exceeding 250,000 Btu per hr	Equipment in a large enclosure having adequate air infiltration	None required	None required
	Equipment in a large enclosure having unusually tight construction	Total free area not less than ½ sq in. per (1000 Btu) (hr) furnace input	Total free area not less than ½ sq in. per (1000 Btu) (hr) furnace input
	Equipment in a small enclosure in a building having adequate air infiltration	Opening in party wall or door, above draft hood, with free area of not less than 1 sq in. per (1000 Btu) (hr) furnace input	Opening in party wall or door, below combustion air inlet to appliance with free area of not less than 1 sq in. per (1000 Btu) (hr) furnace input
	Equipment in a small enclosure in a building of unusually tight construction	Grilled opening connecting directly with outdoors, through duct if necessary; free area not less than 1 sq in. per (1000 Btu) (hr) furnace input	Grilled opening connecting directly with outdoor air, through duct if necessary. Area and location same as above.
Gross output capacity not exceeding 250,000 Btu per hr	Equipment in an enclosure having adequate air infiltration	Total free area equivalent to not less than the combined area of the flue outlets of all fuel burning equipment in the space	None required
	Equipment in an enclosure having unusually tight construction	Total free area equivalent to not less than twice the combined area of the flue outlets, of all fuel burning equipment in the space	None required

[a] Operation of exhaust fans, kitchen ventilation systems, fire places, etc. may create conditions requiring special consideration.

AIR SUPPLY TO FUEL BURNING EQUIPMENT

All rooms or spaces containing boilers, furnaces, water heaters or any other fuel burning equipment must be provided with a constant supply of combustion air at adequate static pressure to insure proper combustion in the fuel burners. Additional air is required to replace air entering chimneys through draft hoods and barometric draft dampers, and also to provide ventilation in closely confined boiler and furnace rooms.

Experience has shown that the ventilating air openings required in heater rooms depend not only on the size of the heating plant but also on the type of fuel being burned, the relative size of the equipment room, the