air, as they have been tested as built for good combustion and efficiency. In order to insure freedom from carbon monoxide under conditions which may obtain in installations, it is customary to design gas burning appliances for a supply of 30 to 35 percent of excess air. In individual installations in which flue gas analyses are made, the excess air is sometimes reduced to approximately 20 percent. The division of the air into primary and secondary, is a matter of burner design, the pressure of gas available, and the type of flame desired.

The air gas ratio in the burner head has a decided effect upon flame propagation. It is necessary that the gas should flow out of the burner ports fast enough so that the flame cannot travel back into the burner head, *i.e., flash back*, but the velocity must not be so high that it blows the flame away from the port.

The maximum and minimum permissible flow speeds from burner ports are known to be very close together when air-gas mixtures in theoretical proportions are being supplied to the burner. As the air-gas ratio is lowered, and the mixture becomes more *gas rich*, the limiting speeds become farther apart, until with 100 percent gas, in an all-yellow flame, flash back cannot occur and a much higher velocity is needed to blow the flames off the burner ports.

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[6] 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[7] 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.[8]

CONDENSATION AND CORROSION

Sulfur dioxide or sulfur trioxide formed by the combustion of sulfur in fuels, is the principal corroding element in flue gases, and becomes active whenever moisture is present for the formation of sulfurous or sulfuric acid.[9] It is necessary, therefore, to maintain a flue gas temperature in excess of the dew-point temperature of the flue gases in all parts of appliances, unless they are made of materials that will resist these corrosive influences. It is usually desirable to maintain a flue gas temperature above the dew-point temperature throughout the heating appliance and the chimney or smokestack, because of these same corrosive effects. The average dew-point temperatures of the flue gases from the several fuels, when burned with the amount of excess air usually supplied to insure complete combustion, are shown in Table 9.

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