*Commercial Standard 113-51* is a method of rating oil-burning floor furnaces by test.

*Commercial Standard CS 104-49* is a method of rating warm air furnaces equipped with pot-type oil burners by test.

Various codes covering the construction and performance of appliances as related to fire hazards have been developed by Underwriter Laboratories, Inc. In addition, there are many municipal codes[10] which regulate construction and installation of furnace equipment.

The yardstick of the *National Warm Air Heating and Air Conditioning Association* provides criteria for evaluating a furnace design and installation against industry accepted standards.

## FURNACE EFFICIENCY

Rating formulas of the *National Warm Air Heating and Air Conditioning Association* are based on 55 percent efficiency for gravity coal furnaces and 65 percent efficiency for forced-air coal furnaces. In the tentative Oil Testing Code the contemplated minimum efficiency is 70 percent for oil-fired forced-air furnaces. Gravity gas furnaces approved by the *American Gas Association* are assigned a rating based on 75 percent efficiency. All *forced-air gas-fired furnaces* approved by *American Gas Association* are assigned a rating based on 80 percent efficiency.

## DESIGN CONSIDERATIONS

Considerations of prime importance in the design of warm air furnaces and some general suggestions to be observed in connection with each, are as follows:

1. *Adequate heat transfer surface.*
   a. Heat transfer rates of 2,000 to 4,500 Btu per (hour) (square foot) of heating surface may be obtained without unduly high metal temperatures.
   b. Fins, pins and bosses are frequently used to add surface and to break down superficial gas films, both on gas-to-metal and metal-to-air surfaces.
   c. Surface and stack (flue gas) temperatures are good indications of the amount and effectiveness of the heating surfaces.
2. *Safe and efficient combustion of fuel.*
   a. Proper mixture of fuel and air is necessary for efficient combustion. This necessitates careful attention to the design of grates, nozzles, burners, air inlet areas and location, and combustion chamber baffling.
   b. Regulation of the quantity and the distribution of the air for combustion should be provided by use of check dampers, draft regulators, draft hoods, air shutters and air orifices.
   c. Total draft loss through appliances should not exceed that available from chimneys which would normally be obtainable in the size of building which the appliance will supply with heat.
   d. The use of ignition safety devices such as safety pilots, hold-fire controls, and the like is recommended.
3. *Fuel capacity of appliance.*
   a. With solid fuels adequate coal capacity should be provided for at least 5 hr of operation at the maximum rated combustion rate.
4. *Adequate circulation of air over heating surface.*
   a. In gravity furnaces, free air space between casing and heat exchanger should be great enough to permit free flow over all surfaces.
   b. Forced air furnace design must include fans having proper capacity and suitable performance characteristics. Internal static pressures must be minimized without losing the advantages of high velocity circulation over the heat exchanger surfaces.
   c. The air flow over the heating surface must be directed to obtain maximum efficiency and to eliminate hot spots and air noises.
   d. Air velocities at bonnet should not be much in excess of 1,000 fpm, and air temperature distribution at the furnace outlet should be uniform within approximately $\pm$ 30 deg.



5. *Durability.*
   a. A minimum metal weight for gas-fired heat exchangers is established as No. 20 U.S. Gage for plain carbon steel by the *A.G.A.* Approval Requirements for Central Heating Gas Appliances, with some municipal codes specifying 18 gage. Cast-iron sectional thicknesses of $\frac{1}{4}$ in. to $\frac{3}{8}$ in. are recommended.
   b. Added strength and reinforced designs may be required to preclude damage in shipment, burning out from overfiring, or corrosion from condensation.
   c. Maximum heat exchanger surface temperatures which may be used vary with the metal. The *American Gas Association* Approval Requirements for Central Heating Gas Appliances specify a maximum of 875 F for cast-iron or steel gas furnaces, and the *National Bureau of Standards* CS 109-44 Code for Forced Air Solid Fuel-Burning Furnaces specifies 1000 F as a maximum surface temperature. These temperatures define the range in which oxidation of non-alloy ferrous metal begins. The use of proper alloy additions increases the temperature resistance properties of metals.
   d. Casing temperatures should be controlled so that they do not become hazards to burn those who touch them, or to create fires.
6. *Serviceability.*
   a. Those parts of the furnace which may be subject to soot, fly-ash, or condensation deposits should be accessible for cleaning.
   b. Parts which may require adjustments or replacements, such as grates, baffles, liners, controls, should be removable.
   c. Furnaces should be so designed that they can be installed with a minimum of difficulty.
7. *Control.*
   a. Thermostatic controls of various types should be used to correlate space temperatures with unit operation.
   b. Controls should be provided wherever possible, to prevent the occurrence of excessive temperatures or other conditions in any part of the unit which might cause unsafe operation.
8. *General design considerations.*
   a. Furnace casings are normally constructed of formed and painted sheet steel or of galvanized iron. The casing should be protection from excessive radiation losses and temperatures by use of insulation or sheet steel air space liners. Liners should extend from the grate level to the top of the furnace and should be spaced from 1 in. to $1\frac{1}{2}$ in. from the outer casing.
   b. The hood or bonnet of the casing above the furnace should be as high as basement conditions will allow, to form a plenum chamber over the top of the furnace. This tends to equalize the pressure and temperature of the air leaving the bonnet through the various openings. It is generally considered advisable to take off the warm air pipes from the side of the bonnet near the top, as this method of take-off allows the use of a higher bonnet and thus provides a larger plenum chamber.
   c. Warm air outlet and return air connections should be designed so that the ductwork may be easily attached. A $\frac{1}{4}$ in. flange is normally used for this purpose.
   d. Suitable provision should be made in appliances so that the controls and humidifiers may be installed in the proper location. When these auxiliary units are installed in the ductwork, detailed instructions should be provided to insure their proper location.
   e. The flue connection should be of integral flue pipe size, and provision should be made to attach the flue pipe to the flue outlet of the furnace.

## HUMIDIFICATION EQUIPMENT

Evaporating pans are usually located in the outlet air. There is a present trend toward heating the water. Equipment for doing this may make use of sprays, or it may take the form of water circulating coils placed within the combustion chamber, and connected by pipes to the humidifier pans where a constant water level is maintained by some separate float device. All humidifiers require provision for removal of dirt and lime.