

the attention intervals. In a true magazine-feed heater the rate of fuel ignition would be equal to the rate of burning; and self-feeding should operate to move the unburned fuel by gravity flow from the magazine section into the hearth area. However, the ideal balance between rate of ignition and rate of burning is virtually impossible to attain for any solid fuel under normal usage, although self-feeding may be obtained with wood and some free burning coals.

Materials and Construction

There is no accepted code governing the construction of solid-fuel-burning space heaters. In past years cast iron was used predominantly in the construction of coal and wood heaters, with the exception of the so-called *airtight* heaters designed as low-cost wood-burning units with little consideration for long life, and stoves were priced on a poundage basis. The present trend is toward fabricated steel parts and welded assemblies, although cast iron is still used for grates, firebox liners, and parts subject to high temperatures. Refractory firebox liners are also used quite extensively.

Formed sheet steel is used predominantly for the outer jacket of circulator heaters, although heaters with outer casings formed from cast iron are still readily available. Circulator cabinets normally have surfaces finished with a porcelain enamel, while the casing of a radiant heater is finished with an air-dried japan or a baked enamel.

Both welding and stove bolts are used in unit assembly, and stove cement is used on section joints to prevent air leakage. This latter is extremely important to obtain a low rate of combustion when desired.

Testing and Rating

There is no accepted code governing the method of testing and rating solid fuel space heaters. A tentative procedure, TS-3443, has been issued by the Division of Trade Standards, National Bureau of Standards, but is based on use of anthracite as a rating fuel, although bituminous coals are used predominantly as heating fuels. This procedure, which has been the basis of published ratings, consists of determining the heater output, expressed in Btu per hour, by the indirect method. The measurable heat losses: (1) loss due to moisture in the fuel, (2) loss due to heat in the dry flue gases, (3) loss due to unburned carbon monoxide, and (4) loss due to unburned combustible in the ash and refuse, are measured by test. The total of these four measurable losses, plus an assumed value for unaccounted for losses, are then subtracted from the heat input. The difference multiplied by the burning rate in pounds per hour is the heater output. No allowance is made for a radiation loss, as this is useful heat.

When using anthracite as the rating fuel, the unaccounted for loss has been assumed to be zero. It has been accepted practice to use a 20 percent allowance for the unaccounted for losses when burning a bituminous coal. The value of this factor has been under study and, although test work is incomplete, a value of 12 percent of the heat input has been determined as representing the losses due to smoke and unburned hydrocarbons for a surface-fired heater, when burning a high volatile bituminous coal.

Design Considerations

Some important considerations in the design of solid-fuel space heaters are:

1. Suitable protection by baffling or insulation against overheating of floors and walls. Although there are no industry-

accepted standards by which floor and wall temperatures may be determined, some indication of heater performance, with regard to overheating, may be found by the use of the corner booth test arrangement described in *National Bureau of Standards Commercial Standard CS 103-43* and *Underwriters Laboratories Standard*, Subject 896, mentioned in following section on Oil Heaters.

2. Tight heater construction to prevent air leakage, and to enable maintenance of a suitably low minimum burning rate. This includes a ground, paper tight joint between the ashpit door and door frame.

3. Sufficient free air space, between the casing and heat exchanger of circulating heaters, to permit free air flow over all surfaces and maintain a suitably low casing temperature.

4. Protection of all metal parts from deterioration due to high temperature. This may be accomplished by: (a) fabrication of certain parts from cast iron or an alloy iron, (b) protection by a refractory liner, (c) use of high temperature enamel coatings, (d) directing air against hot spots.

5. Proper admission of secondary air to complete the combustion process. Care should be taken to prevent this air from also functioning as primary air.

6. Strength in assembly to prevent transportation and use damage.

Considerable work has been directed toward improvement of the performance of bituminous coal-fired space heaters, with particular reference to smokeless operation under conditions of normal operation such as obtained in homes. A smokeless coal heater has been developed by Bituminous Coal Research, Inc., wherein smokeless combustion is obtained by admitting secondary air through a narrow slot, extending from side to side, above the edge of the fuel bed where the gas leaves to enter a vertical gas passage. Complete mixing of the volatile material, released from the coal in the magazine, with the secondary air supplied is obtained as both streams pass under the bottom of the arch. Complete combustion results from this intimate mixing in a region which maintains itself at high temperatures even during banking periods.

OIL HEATERS

Vaporizing pot-type oil heaters consist of: (1) a metal pot in the bottom of which the oil is vaporized, the vapors burning at or near the top of the pot and (2) a secondary combustion chamber, or heat exchanger, in which combustion is completed. The flue connection is made to this chamber or through a second heat exchanger which may be of the diving-flue type installed to increase efficiency. The burner may be designed for operation with or without mechanical draft.

Blue-flame oil burners differ from the pot-type variety in that removable perforated sleeves are provided above an oil pan instead of a metal pot, and lighting rings or kindlers are used for easy lighting.

Both types of oil burners operate by the burning of the oil vapor rather than the oil itself, the oil being first fed to a chamber in which the oil is entirely vaporized, then mixed with air introduced through suitably located ports and burning at the top of the pot or perforated sleeves. Such heaters are designed to burn No. 1 oil (See Table 4, Chapter 33) or kerosene (coal oil). At no time should oil heavier than that for which the burner is designed be used, as heavier oils may cause excessive carbonization in the burner or fuel feed line.

Materials and Construction

Formed sheet steel and welded assemblies are used primarily in oil heater construction. Standards governing construction which have been generally accepted are:

Heating Boilers, Furnaces, Space Heaters

1. *Commercial Standard for Plug-Connected Oil-Burning Space Heaters Equipped with Vaporizing Pot-Type Burners*, CS101-43 (National Bureau of Standards).

2. *Standard for Oil-burning Stoves*, Subject 896 (Underwriters Laboratories, Inc.).

3. *Standard for Construction and Performance of Oil Burners for Installation in Stoves and Ranges*, Subject 885 (Underwriters Laboratories, Inc.).

Some states or municipalities have codes which apply locally, but these usually apply primarily to installation, and the Underwriters Laboratories label of approval is sufficient to cover acceptance of the unit.

Testing and Rating

Commercial Standard CS101-43 is intended to provide a uniform standard method for ascertaining the maximum practical heat output in Btu per hour of flue-connected oil-burning space heaters under approximately normal service conditions. This method is based upon the following equations:

$$H_r = A - B \quad (8)$$

and

$$E = H_r/A \quad (9)$$

where

A = total heat of fuel used.
B = heat lost in flue gases.
H_r = net heat delivered to the room.
E = unit efficiency.

The following minimum performance requirements are stipulated:

1. Adequate provision for ease of lighting and insurance against loss of ignition prior to heating of burner.
2. Ease of operation of controls.
3. Proper operation of burner without excessive carbonization with grades of oil recommended by the manufacturer.
4. The heater shall be capable of passing the 35 percent IAM smoke test.
5. The heater shall be capable of operating with an overall efficiency of not less than 70 percent under conditions of test, or at a lower stack draft recommended by the manufacturer.

Design Considerations

Some factors important in the design of oil-burning heaters are:

1. Proper pitch of oil lines from the sump to the burner, thus preventing vapor and air lock.
2. Proper positioning of the oil sump or constant-level valve to maintain the proper oil level in the burners, if factory assembled.
3. Tight construction, not only of oil lines, but of oil tank, sump, and burner to prevent a hazardous condition due to oil leakage.
4. Provision for leveling and aligning the entire heater for maintenance of proper operation. If a separate fuel tank is used, the heater should have provision for secure fastening to the floor to prevent excessive strain on oil supply line, and the consequent danger of leakage of oil.
5. Provision of a draft regulator to prevent abnormal draft fluctuations.
6. Proper shielding of an attached fuel oil supply tank to prevent excessive oil temperatures.
7. All metal parts subjected to the corrosive action of the oil shall be made of noncorrodible metal, or of metal suitably coated to resist corrosion.

8. The heater should have suitable baffling or insulation to prevent overheating of floors and walls.
9. Strength in assembly to prevent transportation and use damage.

GAS SPACE HEATERS

Vented gas space heaters are defined as those capable of removing all of the flue gases through a single flue outlet. All heaters having a gas input rating in excess of 50,000 Btu per hour must be of the vented type in order to meet *American Standard Approval Requirements for Gas-Fired Room Heaters*.

Gas space heaters may be classified by burner type as follows:

1. *Blue Flame Burner* type which employs the energy of a jet of gas to inject air for combustion into the burner and mix it with the gas.
2. *Yellow Flame Burner* type in which secondary air only is depended on for the combustion of the gas.

Vented Gas Recessed Wall Heaters

A vented gas recessed heater is defined as an appliance complete with grilles or equivalent designed for incorporation in or permanent attachment to a wall, floor, ceiling or partition which furnishes heated air circulated by gravity or by fan directly into the space being heated through openings in the casings. Such appliances are not to be provided with duct extensions beyond the vertical and horizontal limits of the casing proper. They must be built to meet *American Standard Approval Requirements for Central Heating Gas Appliances Volume IV, Gravity and Fan Type Vented Recessed Heaters*.

Materials and Construction

Standards covering materials and accessories used in the construction of gas heaters are described in *American Standard Approval Requirements for Gas-Fired Room Heaters* and in applicable Listing Requirements.* Standards covering these same items for recessed wall heaters are described in *American Standard Approval Requirements for Recessed Wall Heaters*.

Efficiency Requirement

Vented gas space heaters having input ratings in excess of 20,000 Btu per hour are required to have a heating efficiency of not less than 70 percent,* based on the total heating value of the gas. Vented gas space heaters having input ratings of 20,000 Btu per hour or less are required to have a heating efficiency of not less than 65 percent.* These efficiencies are based upon the following equation:

$$e_s = 100 - \frac{H_f}{q} \times 100 \quad (10)$$

where

e_s = heating efficiency, percent.
H_f = heat above room temperature carried away by the flue products, Btu per hour.
q = hourly gas heat input, Btu per hour.

Gravity type recessed heaters are required to have a thermal efficiency of not less than 70 percent and fan type gas recessed heaters shall have a thermal efficiency of not