

lent cleanout plug should be provided in the case of a single return connection.

Blowoff or drain connections should be made near the boiler, and so arranged that the entire system may be drained of water by opening the drain cock. In the case of two or more boilers separate blowoff connections must be provided for each boiler, on the boiler side of the stop valve on the main return connection.

Water service connections must be provided for both steam and water boilers, for refilling and for the addition of make-up water to boilers. This connection is usually of galvanized steel pipe, and is made to the return main near the boiler or boilers.

Fitting connections for pressure gage piping, water gage connections, and safety valves, should be made in accordance with the ASME Boiler Construction Code for Low Pressure Heating Boilers.

Smoke Breaching and Chimney Connections. The breaching or smoke pipe from the boiler outlet to the chimney should be airtight and as short and direct as possible, preference being given to long-radius and 45-deg instead of 90-deg bends. The breaching entering a brick chimney should not project beyond the flue lining, and where practicable it should be grouted from the inside of the chimney. A thimble or sleeve usually is provided where the breaching enters a brick chimney.

Where a battery of boilers is connected into a breaching, each boiler should be provided with a tight damper. The breaching for a battery of boilers should not be reduced in size as it goes to the more remote boilers. Good connections made to a good chimney will usually result in a rapid response by the boilers to demands for heat.

ERECTION, OPERATION, AND MAINTENANCE

The directions of the boiler manufacturer should always be read before the assembly or installation of any boiler is started, even though the contractor may be familiar with the boiler. All joints requiring boiler putty or cement, which cannot be reached after assembly is complete, must be finished as the assembly progresses.

Five precautions that should be taken in all installations to prevent damage to the boiler are:

1. There should be provided proper and convenient drainage connections for use if the boiler is not in operation during freezing weather.
2. Strains on the boiler, due to movement of piping during expansion, should be prevented by suitable anchoring of piping, and by proper provision for pipe expansion and contraction.
3. Direct impingement of too intense local heat upon any part of the boiler surface, as with oil burners, should be avoided by protecting the surface with firebrick or other refractory material.
4. Condensation in steam systems must flow back to the boiler as rapidly and uniformly as possible. Return connections should prevent the water from backing out of the boiler.
5. Automatic boiler feeders and low water cut-off devices, which shut off the source of heat if the water in the boiler falls below a safe level, are recommended for mechanically-fired boilers.

Boiler Troubles

A complaint regarding boiler operation generally will be found to be due to one of the following:

1. *The boiler fails to deliver enough heat.* The cause of this condition may be: (a) poor draft; (b) poor fuel; (c) inferior attention or firing; (d) boiler too small; (e) improper piping;

(f) improper arrangement of sections; (g) heating surfaces covered with soot; (h) insufficient radiation installed; or (i) with mechanical firing, fuel-burning equipment too small.

2. *The water line is unsteady.* The cause of this condition may be: (a) grease and dirt in boiler; (b) water column connected to a very active section and therefore, not showing actual water level in boiler; or (c) boiler operating at excessive rate of output.

3. *Water disappears from the gage glass.* This may be caused by: (a) priming due to grease and dirt in boiler; (b) too great pressure difference between supply and return piping preventing return of condensate; (c) valve closed in return line; (d) connection of bottom of water column to a very active section or thin waterway; or (e) improper connections between boilers in battery permitting boiler with excess pressure to push returning condensate into boiler with lower pressure.

4. *Water is carried over into steam main.* This may be caused by: (a) grease and dirt in boiler; (b) insufficient steam dome or too small steam liberating area; (c) outlet connections of too small area; (d) excessive rate of output; (e) water level carried higher than specified.

5. *Boiler is slow in response to operation of dampers.* This may be due to: (a) poor draft resulting from air leaks into chimney or breaching; (b) inferior fuel; (c) inferior attention; (d) accumulation of clinker on grate; or (e) boiler too small for the load.

6. *Boiler requires too frequent cleaning of flues.* This may be due to: (a) poor draft; (b) smoky combustion; (c) too low a rate of combustion; or (d) too much excess air in firebox causing chilling of gases.

7. *Boiler smokes through fire door.* This may be due to: (a) defective draft in chimney or incorrect setting of dampers; (b) air leaks into boiler or breaching; (c) gas outlet from firebox plugged with fuel; (d) dirty or clogged flues; or (e) improper reduction in breaching size.

8. *Low carbon dioxide.* This may be due to oil burning boilers to: (a) improper adjustment of the burner; (b) leakage through the boiler setting; (c) improper fire caused by a fouled nozzle; or (d) to an insufficient quantity of oil being burned.

Cleaning Boilers

All boilers are provided with flue cleanout openings through which the heating surface can be reached by means of brushes or scrapers. Flues of solid fuel boilers should be cleaned often to keep the surfaces free of soot or ash. Gas boiler flues and burners should be cleaned at least once a year. Oil-burning boiler flues should be examined periodically to determine when cleaning is necessary.

The grease used to lubricate the cutting tools during erection of new piping systems serves as a carrier for sand and dirt, with the result that a scum of fine particles and grease accumulates on the surface of the water in all new boilers, while heavier particles may settle to the bottom of the boiler and form sludge. These impurities tend to cause foaming, preventing the generation of steam and causing an unsteady water line.

This unavoidable accumulation of oil and grease should be removed by blowing off the boiler as follows: If not already provided, install a surface blow connection of at least 1 1/4-in. nominal pipe size with outlet extended to within 18 in. of the floor or to sewer, inserting a valve in this line close to boiler. Bring the water line to center of outlet, raise steam pressure, and while fire is burning briskly open valve in blowoff line. When pressure drops, close valve and repeat process adding water at intervals to maintain proper level. As a final operation bring the pressure in the boiler to about 10 psi, close blowoff, draw the fire or stop burner, and open drain valve. After boiler has cooled partly, fill and flush out several times before filling it to proper water level for normal service.

Where the outlined blowing-off procedure does not remove the grease and dirt and obtain clear boiler water, it may be

Heating Boilers, Furnaces, Space Heaters

necessary to use a detergent type of cleaner in which case the boiler manufacturer as well as cleaner manufacturer should be consulted regarding procedure to be followed.

When addition of water to a system becomes necessary it is advisable to operate the boiler or at least to raise the water temperature to the boiling point in order to permit escape of oxygen and other dissolved gases that would be corrosive if the boiler is out of operation.

Treatment of Boiler Water

Corrosion on the water side of a boiler can be prevented by proper treatment of the boiler water. Generally, treatment which will remove the dissolved oxygen and carbon dioxide and maintain a minimum pH of 11 (slightly alkaline water) will effectively prevent corrosion. A pH higher than 11 may be used although the boiler water is more likely to foam and cause wet steam with the greater concentration of alkali. A number of compounds are being marketed for this purpose. The Steel Boiler Institute adopted a conditioning compound for use with steel boilers after an extensive cooperative study and many members of the Institute either supply this compound with their boilers or have it available.

It should be emphasized that when the character of the water is such that treatment is required, the treatment should be administered immediately after the boiler and system have been cleaned. It is not good practice to fill a boiler with fresh water and allow it to stand idle as the dissolved gases in fresh water available in many localities can start corrosive action in a very short time. After refilling a system it is advisable to elevate the temperature close to the boiling point to drive off the dissolved gases immediately.

Care of Idle Heating Boilers

Heating boilers are often seriously damaged during summer months due chiefly to corrosion resulting from the combination of sulfur in the soot with the moisture in the cellar air. At the end of the heating season the following precautions should be taken:

1. All heating surfaces should be cleaned thoroughly of soot, ash, and residue, and the heating surfaces of steel boilers should be given a coating of lubricating oil on the fire side.
2. All machined surfaces should be coated with oil or grease.
3. Connections to the chimney should be cleaned, and in case of small boilers, the pipe should be placed in a dry place after cleaning.
4. If there is much moisture in the boiler room, it is desirable to drain the boiler to prevent atmospheric condensation on the heating surfaces of the boiler when they are below the dew-point temperature. Due to the hazard that someone may inadvertently build a fire in a dry boiler, however, it is safer to keep the boiler filled with water, particularly in residential installations. Air can be excluded from a steam boiler by raising the water level into the steam outlets. A hot water system usually is left filled to the expansion tank.
5. The grates and ashpit should be cleaned.
6. Clean and repack the gage glass if necessary.
7. Remove any rust or other deposit from exposed surfaces by scraping with a wire brush or sandpaper. After boiler is thoroughly cleaned, apply a coat of preservative paint where required to external parts normally painted.
8. Inspect all accessories of the boiler carefully to see that they are in good working order. In this connection, oil all door hinges, damper bearings, and regulator parts.
9. If a system has been drained and refilled with fresh water, the boiler should be fired long enough to elevate the water temperature close to the boiling point to drive off dissolved oxygen and carbon dioxide. These gases can be responsible for excessive corrosion if allowed to remain in the system.

WARM AIR FURNACES

Warm air heating furnaces of a number of types and a wide range of sizes are listed and illustrated in the Catalog Data Section.

Warm air furnaces may be classified in several different ways:

1. According to method of heat distribution—these are either gravity or mechanical (blower) furnaces.
2. According to fuels for which the furnaces are designed—these are coal hand-fired or stoker-fired, oil, gas, or wood.
3. According to materials of construction—they are cast iron, low carbon steel, and occasionally high temperature steel alloys.
4. According to design or construction, such as drum and radiator, tubular, horizontal, etc.

Gravity Warm Air Furnaces

A gravity furnace is one in which the motive head producing air flow depends upon the difference in density between the heated air leaving the top of the casing and cooled air entering the bottom of the casing. Since this gravity head is relatively low, the furnace must have low internal resistance to the flow of air, and relatively large areas must be available for free circulation within the furnace casing. It is common practice to provide approximately 50 percent free-air area through gravity-type furnaces.

Furnaces for gravity-type systems are available in designs suitable for central heating, pipeless furnace, or unit floor-furnace installations. Booster fans are sometimes used, in conjunction with gravity systems, to increase air circulation. Where a fan is to be used with a furnace casing sized for gravity air flow, some form of baffling must be employed to restrict the free area within the casing and to force impingement of the air against the heating surfaces. Where square casings are used, the corners must be baffled.

Mechanical Warm Air Furnaces

Mechanical or forced warm-air furnaces include fans or blowers as integral parts, for the purpose of circulating the air, and usually include air filters.

Centrifugal fans with either backward- or forward-curved blades are the type most commonly used. Motors may be mounted on the fan shaft or connected to the fan by a belt drive. Adjustable pulleys are desirable to provide means of regulating the quantity of air distributed to the heated spaces. Either the motor load or the noise considerations may limit the maximum operating fan speed. Two-speed motors have given successful operating results. Motors and mountings must be carefully selected for quiet operation. Electrical conduit and water piping must not be fastened to, nor make contact with, the fan housing.

Filters

Several types of filters are available for mechanical warm air furnace applications, and are discussed in Chapter 24. For maximum efficiency and life under operating conditions, filters should not be subjected to a temperature in excess of 150 F. Filters should have at least 80 percent average efficiency on an 8-hr test at a maximum resistance of 0.25 in. of water. Filter resistance rises rapidly with the accumulation of dirt, and may reduce the air circulation over heating surfaces. In domestic furnaces, the maximum velocity, based on nominal filter area, should not exceed 300 fpm.