SECTION 760-530-108
Issue 1, May 1983

HEATING PLANT CONTROLS
DESCRIPTION AND INSTALLATION

CONTENTS PAGE

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CONTENTS PAGE

1. GENERAL

1.01 This section describes the physical and functional characteristics of controls used in heating plants and installation of these controls.

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 Every heating plant, whether it is a steam boiler, hot water boiler, domestic hot water heater, or warm air furnace, requires ***operating controls***. ***Limit controls*** are required on all boilers and in some instances on warm air furnaces. This section addresses these types of controls.

2. DESCRIPTION

2.01 Operating controls are devices used to maintain a desired temperature, pressure, flow, sequence, or level of the controlled medium which can be steam, water, air, or fuel. These controls reset automatically.

2.02 Limit controls are used to prevent the unsafe operation of boilers or furnaces. Limit controls back up the operating controls. ***All limit controls are manual reset devices.***

2.03 Electrical switches associated with operating and limit controls are classified as normally open (NO) or normally closed (NC) and are designated as "open" or "close" on a rise in pressure, temperature, or level. A control switch classification of NO or NC is determined by the position it naturally assumes when de-energized. The symbol for a nor-

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mally open switch is ⊣|⊢ and ⊣/⊢ represents a normally closed switch.

2.04 Operating and limit controls are either a mercury tube-type switch or a pressure contact-type switch. If the control has the mercury tube-type switch and is mounted on the boiler using a siphon, this control must be mounted plumb and the face of the control at right angles to the loop of the siphon. (See Fig. 1.) This is done so that the mercury tube is not tilted by expansion of the siphon loop causing the mercury to migrate to the wrong end of the tube so that an electrical contact is made or opened when it should not be.

2.05 All controls are actuated by either pressure, temperature, flow, level, conductivity, or manual action.

2.06 Controls should be selected so that the operating point is at midscale and the upper limit setting is at a point where pressure, temperature, or level will not exceed a safe condition. All controls have a differential, which is the range between opening and closing of the contacts. The differential in most controls is adjustable. The differential selected must not be too small, which would cause the control to stop and start the controlled device an excessive number of times. Conversely, if the differential selected is too great and the control stops and starts the controlled device infrequently, the pressure, temperature, or level will vary greatly.

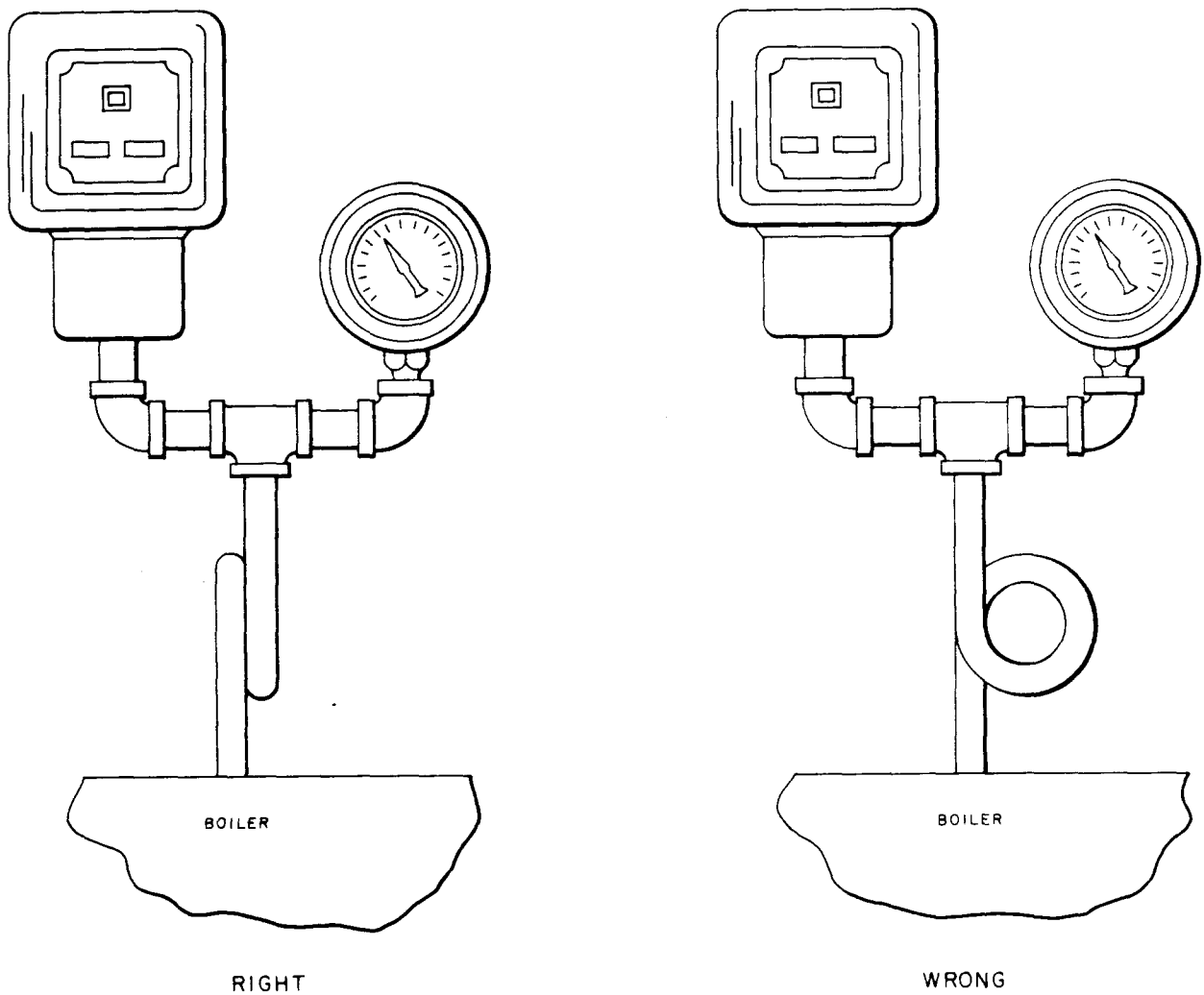

Fig. 1—Pressure Control Installation

BOILERS

A. Operating Controls

2.07 The basic operating sequence for a boiler, either steam or hot water, is as follows: ***The operating control closes contacts when boiler pressure or temperature reaches a preset point and completes the circuit through the various limit controls to start the burner.*** When the pressure or temperature reaches a higher preset point, the operating control opens its contacts and the burner stops. Some controls, called modulating controls, reduce the firing rate of the burner as the pressure or temperature rises. It is desirable to operate the burner at a reduced rate to approximate the heating load on the boiler so that the burner fires continuously. This reduces thermal shock to the boiler and the stack losses that occur during the off cycle.

B. Limit Controls

2.08 In addition to the operating control maintaining a set pressure or temperature range, there is a limit control with a set point, above that of the operating control set point, which will stop the burner if the pressure or temperature exceeds the set point. A limit control will not be called on to shut down the burner if the operating control is working properly. When the limit control functions, it is necessary to manually reset the control by depressing a button or lever after the pressure or temperature has dropped below the limit control set point so that the burner can start up again at the direction of the operating control. The attendant should investigate the operating control to determine the cause of the malfunction.

C. Water Level Controls

2.09 In addition to the operating and limit pressure controls, steam boilers have a float-operated control that maintains the normal water level in the boiler. This control is equipped with an auxiliary contact that will shut down the burner in the event of a below normal water level. This pump controller and low water cutoff permit the burner to restart when the normal water level is reestablished. In addition to this control, steam boilers are equipped with a low water limit control which shuts down the burner when the water level reaches a predetermined level below the setting of the pump controller and low water cutoff. This low water limit control can be either a float or probe type. A probe type is suggested because it provides a second means for verifying water level. The probe type uses conductivity and the float type uses buoyancy to determine the water level. This control requires manual reset.

2.10 Hot water boilers are filled with water and the normal way of maintaining the system full is with a pressure-activated valve. A low water limit control which shuts down the burner when the water level reaches a predetermined level is required. A probe or float type can be used. See Fig. 2 for a float-type control and Fig. 3 for a probe type.

WARM AIR FURNACES

2.11 The operating control sequence for a warm air furnace consists of a thermostat located in the room and the return air duct or supply air duct which closes its contacts when the air temperature reaches a preset point and completes the circuit through "the limit and fan control" switch to start the burner. When the heat exchanger bonnet reaches a preset temperature, the fan control closes its contacts and starts the air-circulating fan.

2.12 In addition to the thermostat and the fan control, a high temperature control is provided to stop the burner if the discharge air or the bonnet temperature exceeds its set point.

2.13 A high temperature limit control can be provided to stop the burner if the discharge air or the bonnet temperature exceeds the set point of this control. This control is a manual reset type.

2.14 Heating plants that consist of more than one boiler or warm air furnace should be operated sequentially rather than simultaneously. This permits the heating plant to be fired more efficiently by matching the output to the load. Some engineers prefer to vary the sequence in which the heating plant units are fired in order to assure equal operating time. Sequence changing may be done weekly, biweekly, or monthly. This also can be accomplished by automatic sequence controllers.

2.15 The flame safeguard controls and fuel train (valves, controls, and appurtenances) to be installed on steam or hot water boilers and warm air furnaces are described in Section 760-530-110.*

*Check Divisional Index 760 for availability.

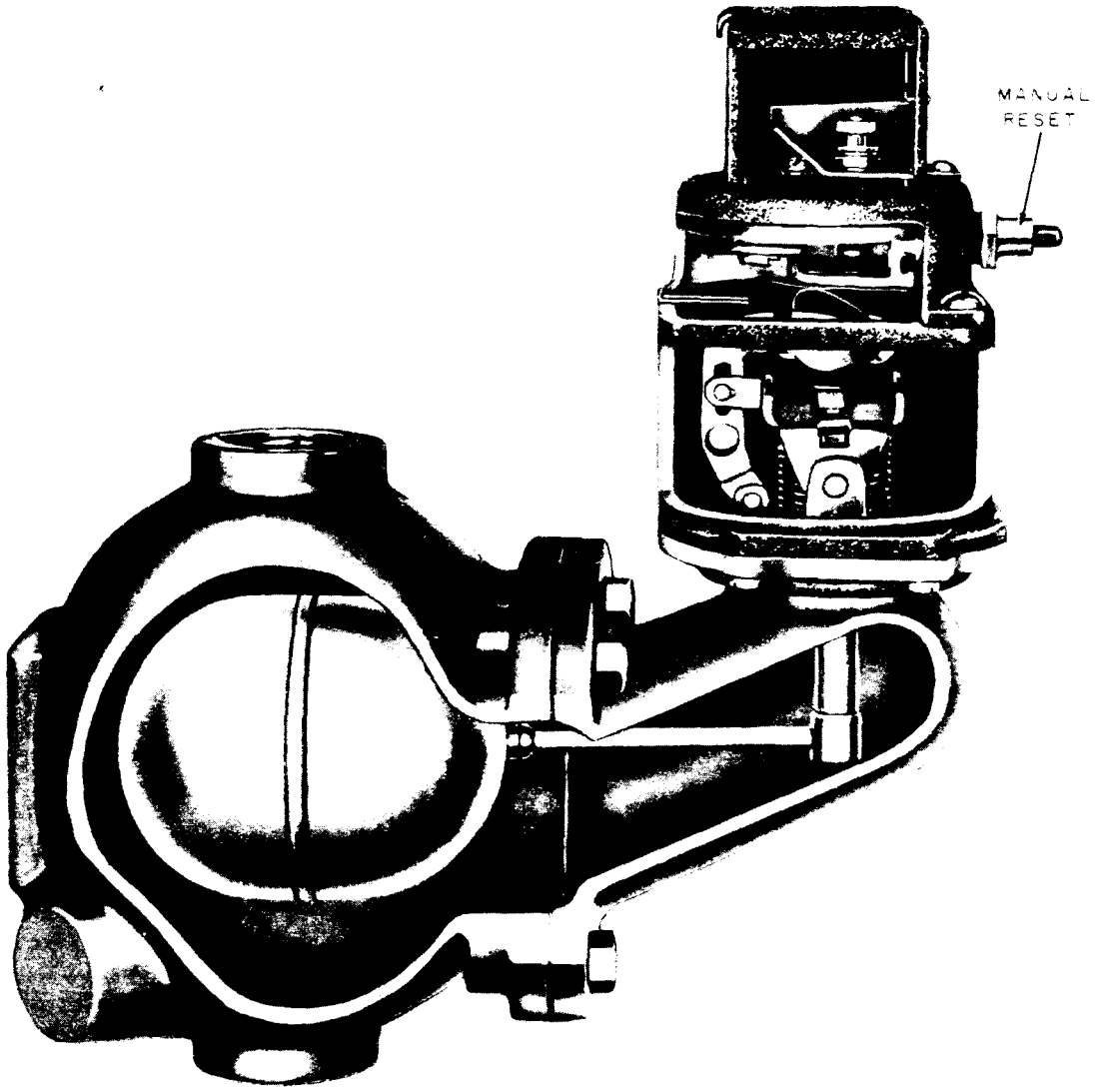

Fig. 2—Low Water Fuel Cutoff With Manual Reset—Mechanical Switch (Reprinted with permission, McDonnell & Miller ITT)

3. OPERATING CONTROLS

STEAM BOILERS

Note: See Section 760-530-102* for more detailed information on steam boilers.

3.01 An operating pressure control is installed on every steam boiler. This control is constructed to prevent a pressure setting above 15 pounds per square inch gauge (psig) or the maximum allowable working pressure of the boiler, whichever is lower. This control has normally closed contacts which open on a rise in pressure. This is an automatic resetting control.

3.02 If this control is on the steam supply header of a multiple boiler installation and can be isolated from the boiler by a valve, the boiler shall be equipped with two high-pressure limit controls. The function of this operating control is to maintain steam pressure on the boiler between preselected limits.

*Check Divisional Index 760 for availability.

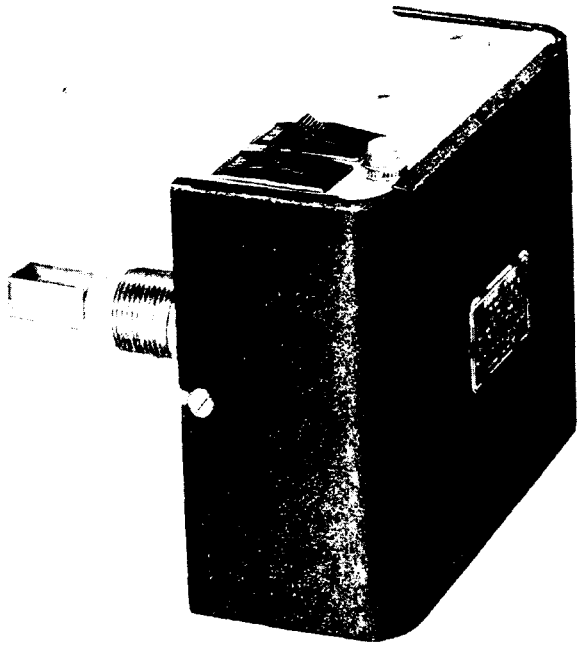

Fig. 3—Probe-Type Low Water Control (Reprinted with permission, McDonnell & Miller ITT)

3.03 An outdoor thermostat is sometimes provided and wired in series with the operating pressure control. This control is installed so that its sensing element is located in the outside air. It has normally closed contacts which open on a rise in temperature. The purpose of this control is to keep the burner inoperative when the outside air temperature is above a preselected point for energy conservation purposes. Consideration of the full impact of keeping a boiler inoperative above a certain outside air temperature must be given to each total building project.

3.04 A pump controller and low water cutoff are installed and set so that the controller maintains the normal water level in the boiler. If the water level falls below its set point, this control operates the feedwater pump. (See paragraph 3.13.) If the water level falls below 2 inches above the lowest permissible water level in the boiler, this control shall stop the burner. When the boiler water level returns to normal, this control will permit the burner to restart.

3.05 A steam pressure gauge is installed on every steam boiler. This gauge shall be a minimum of 4 inches in diameter with the scale evenly graduated in 1-pound increments from 0 to 30 psig. Stop pins are installed at the 0- and 30-psig points. The gauge shall be protected against vacuum.

3.06 A water level gauge is installed on every steam boiler. The level gauge is to be provided with top and bottom shutoff valves equipped with velocity-actuated ball checks to prevent leakage in event of glass breakage. A water level gauge is constructed so that gauge glass replacement is possible when the boiler is under pressure. The level gauge is installed so that the lowest visible part of the water glass is 1 inch above the lowest permissible water level of the boiler.

3.07 Boiler drain valves shall be installed on every steam boiler. Boiler drain valves are sized as indicated in Table A.

TABLE A

BOILER DRAIN VALVE SIZE

MINIMUM SAFETY VALVE RELIEVING CAPACITY (MBh)	DRAIN VALVE SIZE (INCHES NPT)
<501	3/4
501 to 1250	1
1251 to 2500	1-1/4
2501 to 6000	1-1/2
>6000	2

3.08 The boiler drain valve at each drain location can consist of two valves. The valve closest to the boiler is a rising stemgate valve, and the downstream valve is an optional quick-opening levergate valve. All valves are rated for a minimum 125-psig saturated steam service.

3.09 A control drain valve is installed on every float-actuated water level control. Valves can be a rising stemgate valve or a lever-operated ball cock rated for a minimum 125-psig saturated steam service. The drain valve and piping are the same size as the outlet connection on the control to be drained and not reduced in size to the point of discharge.

3.10 A boiler return valve is installed on every steam boiler. The valve is a rising stemgate valve rated for a minimum 125-psig saturated steam service.

3.11 A boiler return check valve is installed on every steam boiler. The valve should be rated for a minimum 125-psig saturated steam service.

3.12 A king valve (main shutoff valve) is installed on every steam boiler. The valve is a rising stemgate valve rated for a minimum 125-psig saturated steam service.

3.13 A steam heating system can be equipped with a feedwater tank set to collect the condensate returning from the system. The boiler is equipped with a pump controller which starts the pump when the boiler water falls to a preset level and stops the pump when the boiler water rises to a preset level. To assure that there is water in the collection tank, a float control operates a water feeder to maintain a preset minimum level.

3.14 A manual feed valve is installed on every steam boiler. The valve is a globe valve rated for a minimum 125-psig saturated steam service.

3.15 An antisiphon or back-flow preventer is installed on the water supply line in accordance with local codes.

HOT WATER BOILERS

Note: See Section 760-530-104* for more detailed information on hot water boilers.

3.16 An operating temperature control is installed on every hot water boiler. This control is constructed to prevent a temperature setting above 250°F. This control has normally closed contacts which open on a rise in temperature. This is an automatic resetting control. If this control is on the supply header of a multiple boiler installation and can be isolated by a closed valve from the boiler, the boiler is equipped with two high temperature limit controls. The function of this operating control is to maintain boiler water temperature between preselected limits.

3.17 An outdoor thermostat is sometimes provided and wired in series with the operating temperature control. This control is installed so that its sensing element is located in the outside air. It has normally closed contacts which open on a rise in temperature. The purpose of this control is to keep the boiler inoperative when the outside air temperature is above a preselected level for energy conservation purposes. Consideration of the full impact of keeping a boiler inoperative above a certain outside air temperature must be given to each total building project. In addition, another use of an outdoor thermostat is resetting the hot water temperature control so that hotter water is supplied to the building for heating as the outdoor air temperature drops and cooler water is supplied as the outdoor air temperature rises.

3.18 A feedwater pressure regulator is installed on every hot water boiler heating system. This regulator is equipped with stop valves and a full size bypass valve. This provides for maintenance of the regulator while the system is operating. If the regulator does not have a built-in back-flow preventer, a separate antisiphon back-flow preventer must be provided. This fill connection is made at or near where the compression tank connects to the heating system. The purpose of this control is to maintain design pressure on the hot water heating system.

3.19 A pressure (altitude) gauge is installed on every hot water boiler. This gauge shall be a minimum of 4 inches in diameter with the scale evenly graduated in 2-pound increments from zero to twice the working pressure of the boiler. Stop pins are provided at the zero and maximum psig points. The gauge shall be protected against vacuum.

3.20 A thermometer is installed on every hot water boiler. This thermometer is a dial type having a minimum diameter of 4 inches and a range of 50° to 300°F.

3.21 Air control fittings are installed on every hot water boiler. These fittings consist of a boiler fitting comprised of a dip tube and an air drawoff line and a compression tank fitting which provides for excess air drawoff and water drainage. Do not use this compression tank fitting with a diaphragm-type compression tank. This would cause air to be trapped beneath the diaphragm and not on top where it should be.

3.22 Boiler drain valves are installed on all hot water boilers. Boiler drain valves are sized as shown in Table A. The boiler drain valve at each

*Check Divisional Index 760 for availability.

drain location can consist of two valves. The valve closest to the boiler is a rising stemgate valve, and the downstream valve is a quick-opening levergate valve. All valves are for a minimum 125-psig saturated steam service.

3.23 A control drain valve is installed on every float-actuated water level control. The valve is a rising stemgate valve or a lever-operated ball cock rated for a minimum 125-psig saturated steam service. The drain valve and piping are the same size as the outlet connection on the control to be drained and not reduced in size to the point of discharge.

3.24 Low water limit control cutoff test and check valves can be installed on hot water boilers for routine testing of the low water cutoff control. Testing may be a problem due to the inability to drain water from the float or probe chamber or the large amount of boiler water that must be drained to actuate the control. If shutoff valves are employed, the element of human error can cause the control to be isolated from the boiler which effectively eliminates the low water protection. The test and check valve contains a velocity-actuated flow restrictor valve which operates automatically and eliminates any manual closing and opening of valves. At present, the only known manufacturer is McDonnell & Miller ITT of Chicago, Illinois. This product has been on the market since 1980 and is known as McDONNELL TEST-N-CHECK valve (Fig. 4).

3.25 The king valve (main shutoff valve) is installed on every hot water boiler. The valve is a rising stemgate valve rated for a minimum 125-psig saturated steam service.

3.26 A boiler return valve is installed on every hot water boiler. The valve is a rising stemgate valve rated for a minimum 125-psig saturated steam service.

3.27 A compression tank is provided for every hot water boiler. Normally, the compression tank is installed at a higher elevation than the boiler. The following two types of tanks are used:

(a) A compression tank should be located higher than the boiler but can be located at a lower elevation than the boiler if some form of air elimination, either manual or automatic, is provided. The air trapped in the tank during the fill period serves as a cushion against thermal expansion of

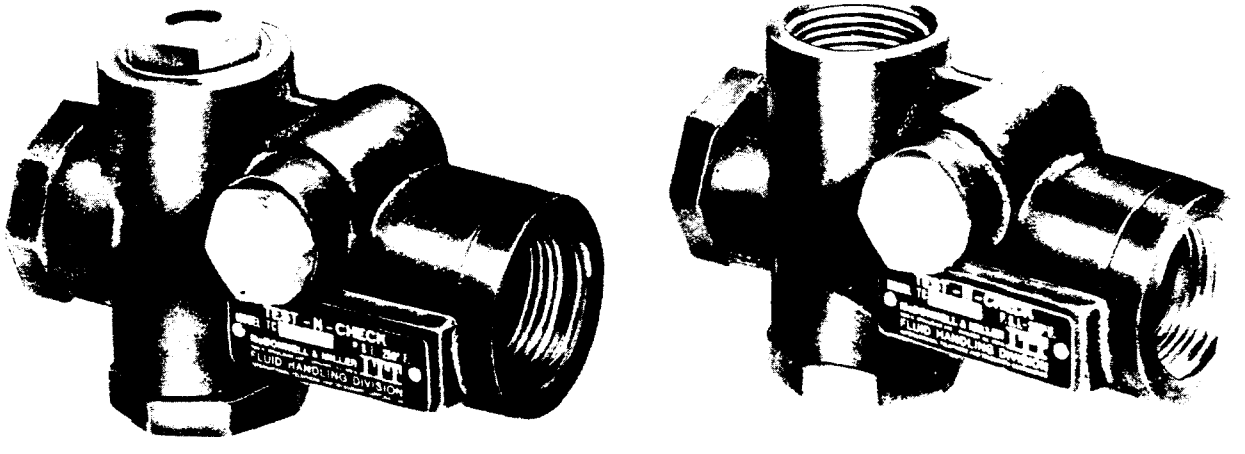

Fig. 4—McDONNELL TEST-N-CHECK Valve (Reprinted with permission, McDonnell & Miller ITT)

the system. If all the air is lost, the tank is waterlogged and thermal expansion causes rapid pressure rises which can cause the boiler relief valve to open.

(b) A diaphragm-type compression tank is similar to the closed compression tank with the exception of a fixed diaphragm separating the water and air. Consult hydronics specialties manufacturers for sizing of compression tanks or refer to 1980 ASHRAE Systems, Chapter 15. Correct sizing of the tank is very important. A tank that is too small results in excessive buildup in pressure due to thermal expansion. A tank that is too large results in insufficient pressure at the high point of the system resulting in restricted circulation and noise.

3.28 A circulating pump is installed on every hot water boiler. The pump is sized to handle the gallons per minute (GPM) at total head in feet that the system requires. Larger systems require a circulating pump for each zone. Each pump is fitted with rising stemgate valves on the inlet and outlet so that the pump can be removed from the system without draining the system. A bypass, fitted with a rising stemgate valve, can be installed to operate the system on gravity flow if the pump is inoperative. Locate the pump so that it pumps the water away from the compression tank connection to the system. See hydronics manufacturers' publications for more detail. Bell and Gossett Bulletin No. TEH-575 is a good reference manual.

WARM AIR FURNACES

Note: See Section 760-530-106* for more detailed information on warm air furnaces.

3.29 An operating control is installed on all warm air furnaces. This control has normally closed contacts that open on a rise in temperature. This is an automatic resetting control. The function of this control is to maintain the temperature of a space between preselected limits.

3.30 An outdoor thermostat is sometimes provided and wired in series with the operating control. This control is installed so that its sensing element is located in the outside air. This control has normally closed contacts that open on a rise in temperature. The function of this control is to keep the warm air furnace inoperative for energy conservation purposes when the outside air temperature is above a preselected level. Consideration of the full impact of keeping a furnace inoperative above a certain outside air temperature must be given to each total building project.

3.31 A fan control is installed on all warm air furnaces except duct furnaces. This control is factory installed with its sensing element responding to the heat exchanger bonnet temperature. This control has normally open contacts that close on a rise in temperature. The function of this control is to prevent the air-circulating fan from starting until the heat exchanger reaches temperature to assure a warm air discharge from the furnace.

3.32 A high temperature control is installed on all warm air furnaces. This control is factory installed and provided with a fixed stop which limits the outlet air temperature to 200°F. This control has normally closed contacts that open on a rise in temperature. The function of this control is to shut down the burner or de-energize the heating element when the control reaches its preset point. This is an automatic reset control.

3.33 An air-proving switch can be installed on all electric warm air furnaces except unit heaters. The function of this switch is to prove sufficient air movement over the heating element and avoid hot spots which can lead to a burnout of the element. In the case of duct heaters, the switch is usually field installed. Either a pressure differential or a sail switch can be used with a set of normally open contacts that closes when sufficient air movement is evident.

4. LIMIT CONTROLS

STEAM BOILERS

Note: See Section 760-530-102 for more detailed information on steam boilers.

4.01 A high-pressure limit control is installed on every steam boiler. This control is constructed to prevent a pressure setting above 15 psig or the maximum allowable working pressure of the boiler, whichever is lower. This control has one set of normally closed contacts which opens on a rise in pressure. This control also can have one set of normally open contacts which closes on a rise in pressure. This set of additional contacts can be used to indicate a

*Check Divisional Index 760 for availability.

high-pressure condition alarm. This control is a manual reset device. If the action of the control is dependent on being level, a vertical indicator should be provided in the control. This would apply to mercury tube contacts in particular. If the operating control is on the header in a multiple boiler installation and can be isolated from the boiler by a valve, each boiler should be equipped with two high-pressure limit controls.

4.02 A low water limit control is installed on every steam boiler. This control is set so that if the water level falls below 1 inch above the lowest permissible water level in the boiler, it will stop the burner. This control has one set of normally closed contacts which opens on a drop in water level to stop the burner. This control also can have one set of normally open contacts that closes on a drop in water level to alarm a low water condition. This control is a manual reset device. This control is on the opposite side of the boiler from the pump controller and low water cutoff.

HOT WATER BOILERS

Note: See Section 760-530-104 for more detailed information on hot water boilers.

4.03 A high temperature limit control is installed on every hot water boiler. This control is constructed to prevent a water temperature setting above 250°F. This control has one set of normally closed contacts which opens on a rise in temperature to stop the burner. This control also can have one set of normally open contacts which closes on a rise in temperature. This additional set of contacts can be used to indicate a high temperature condition alarm. This control is a manual reset device. If the action of the control is dependent on being level, a vertical indicator should be provided in the control. This would apply to mercury tube contacts in particular. If the operating control is on the header in a multiple boiler installation and can be isolated from the boiler by a valve, each boiler should be equipped with two high temperature limit controls.

4.04 A low water limit control is installed on every hot water boiler. If the control is mounted on the boiler, it is set so that the burner is shut off before the water level drops to the lowest permissible water level as established by the boiler manufacturer. This control has one set of normally closed contacts which opens on a drop in water level to stop the burner. This control can have one set of normally open contacts which closes on a drop in water level. This set of contacts is used to indicate a low water condition alarm. This control is a manual reset device.

WARM AIR FURNACES

4.05 A high temperature limit control can be installed on warm air gas- or oil-fired furnaces as described in Section 760-530-106. This control is factory installed and provided with a fixed stop which limits the outlet air temperature to 200°F. The function of this control is to shut down the burner or de-energize the heating element when the control reaches its preset point. This control has one set of normally closed contacts which opens on a temperature rise to stop the burner or de-energize the heating element. This control also can have one set of normally open contacts which closes on a rise in temperature. This set of contacts is used to indicate a high temperature condition alarm. This control is a manual reset device.