FLAME SAFEGUARD CONTROLS

DESCRIPTION

FUEL-BURNING HEATING PLANTS

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1. GENERAL

1.01 This section describes the use of flame safeguard controls in fuel-burning heating plants. Flame-sensing devices, fuel cutoff and metering equipment, combustion air control, types of ignition, position-proving devices, sequential control of fuel-burning apparatus, and pressure, temperature, and flow-sensing devices for fuel and air are included as flame safeguard controls.

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

1.03 The recommendations contained in this section are minimum requirements. Other codes having jurisdiction will apply if they are more stringent, and engineering judgment, based on a specific job, may dictate more stringent requirements.

1.04 The overall function of a flame safeguard system is to provide a safe ignition of the fuel when called upon to start by the operating control, monitor safe firing during the burner on period, and provide a safe shutdown when directed by the operating or safety controls.

1.05 The purpose of safely lighting and monitoring the burning of the fuel is to prevent accumulations of unburned fuel in the combustion chamber and flue passages of the boiler/furnace. Ignition of accumulated unburned fuel causes a "rapid expansion of gas" and, depending on quantity of accumulated fuel, this is called a puff-back or an explosion.

1.06 If the flame safeguard control limits the amount of fuel air mixture admitted to the combustion chamber during the lightoff period and quickly responds to a flame failure during the firing period, the amount of unburned fuel will be kept within acceptable limits.

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2. FLAME-SENSING DEVICES

2.01 All flames resulting from the combustion of gas or oil have similar characteristics that are helpful in designing a flame-sensing device. These are heat, ionization, and radiation.

A. Heat

2.02 Heat can be used to move a bimetallic element that could close or open a switch and prove a flame. Heat used in conjunction with a thermocouple produces an electrical current which can operate a relay and be used to prove a flame. Both methods have been used, but their response time to the presence or absence of flame is slow on the order of up to 3 minutes; consequently, they are limited to the lower firing rates. The heat sensitive device used with an oil burner is the "stack switch" and the device used with a gas-fired burner is the thermocouple.

B. Ionization

2.03 Ionization occurs in an envelope around a flame and as such becomes an electrical conductor. If two electrodes located in the flame have a voltage impressed across them, current will flow. This proof of conductivity is used to prove a flame. Flame response time is very quick, but this system cannot differentiate between leakage current and actual flame current. A false, unsafe signal can be generated. By increasing one electrode to a size approximately four times the other, a rectifying effect on the alternating current takes place and a pulsating direct current is generated. This dc output can be discriminated from alternating current in an electronic network and any electrical short circuit would be detected. This is the principle on which the flame rod type of flame safeguard system works.

C. Radiation

2.04 Radiation from combustion consists of both visible and invisible lightwaves. The visible light can be seen with a ***photoelectric cell***. The signal output of the photoelectric cell, which is also a rectifying type device, can be used to prove flame. The ***cadmium sulfide*** cell is another device which uses visible light to prove flame. In the presence of visible light, the resistance of the device is reduced, which completes the flame-proving circuit. The photoelectric cell and the cadmium sulfide cell can be used on oil flame but not on gas flame, because gas flame does not emit sufficient visible light to cause photo and cadmium cells to function well as a flame safeguard device. In addition to visible light, both gas and oil flames give off infrared radiation. A ***lead sulfide*** detector working in conjunction with an electronic network functions well as a flame safeguard device on either gas or oil. The lead sulfide detector responds to a flickering infrared ray. Steady infrared radiation can appear to flicker if the infrared rays are bent or reflected as they pass through the fuel envelope or a smokey fire. For this reason, care must be taken to ensure that the detector is viewing the flame only.

2.05 Infrared radiation comprises most of the radiated energy in the flame. A smaller component of the radiated energy is ultraviolet. Infrared radiation (long waveband) and ultraviolet radiation (short waveband) are not visible to the human eye. An ultraviolet sensing tube, which responds to ultraviolet working in conjunction with an electronic network, functions well as a flame safeguard system. Electric spark ignition radiates a large amount of ultraviolet; for this reason, the ultraviolet detector must not be sighted on the igniter. It must view the first one-third of the flame, starting at the burner end of the flame.

2.06 In order to limit the amount of fuel admitted to the combustion chamber, a timing device is used which controls the open period of the fuel valves (safety shutoff valves). When flame occurs, and is proven by one of the above flame safeguard devices, the timing device is bypassed. If flameout occurs during the firing period, the flame safeguard will shut off the flow of fuel immediately by closing the safety shutoff valves. Large boilers or warm air furnaces burn more fuel per hour than smaller boilers or furnaces. Because the firing rate is much greater on large units, the flame failure response time, as well as the trial for ignition (TFI) time, must be kept to a minimum to limit the amount of fuel admitted to the combustion chamber without ignition. This is why fuel-firing rates were established as the parameters for trial ignition timing, flame failure response timing, and the number of safety controls and interlocks used.

3. GAS-FIRED SAFETY DEVICES

3.01 The following gas-fired devices are used on steam or hot water boilers and warm air furnaces to safely operate the main burner (Fig. 1). For

more information on gas-fired safety devices, see Table A and Section 760-530-101.*

3.02 The pilot is a small gas burner used to lightoff the main burner. Pilots are classified as constant (standing), intermittent, or interrupted. (See Section 760-530-101.) A standing pilot can be lighted with a match or with a manually controlled electric igniter. Intermittent and interrupted pilots are lighted automatically by electric spark igniters.

3.03 ***DANGER: Electric igniters range from 10,000 volts upwards.*** An electric arc igniter is used to directly lightoff the main burner without the use of a gas pilot. The igniter consists of two electrodes spaced a predetermined distance apart. This distance is called a gap and must be properly maintained to develop the correct arc. High-voltage current is supplied to the electrodes and an arc bridges the gap generating sufficient heat to ignite the fuel.

3.04 The low fire start interlock is a mechanically operated switch, either mercury tube or pressure contact, that is linked to the fuel control valve. This control has normally open contacts that close when the burner is in low fire position. It will not permit the safety shutoff valves to open until the fuel control valve is in the low fire position. Usually the combustion air damper is linked to the operator of the fuel valve and it is also in the low fire position. This is done to assure the correct fuel/air ratio for lightoff.

3.05 The combustion air interlock is a switch that is operated by a pressure sensor. The pressure sensor proves the presence of combustion air by sensing the pressure, above ambient, in the burner tube and closes the switch. The contacts are normally open and close on a rise in pressure. There is a dampening device, an orifice, in the sensing line. This reduces pressure changes caused by pulsating fires which can cause nuisance shutdowns. This type of switch is used on forced draft burners only.

3.06 The main burner fuel valves (solenoid and motor operated) on gas-fired burners must be redundant (two valves in series) and both must close when de-energized. One valve should be slow opening on atmospheric burners to provide a quiet lightoff.

(a) The solenoid valve is a quick-open, quick-close valve. It is actuated by the magnetic solenoid lifting the armature spring resistance where the valve stem is attached. This action raises the valve disk off the seat and permits the fuel to flow. When the valve is de-energized by the operating or limit controls, the spring closes the valve. This type valve is used as a safety shutoff valve.

(b) Motor-operated valves come in four types:

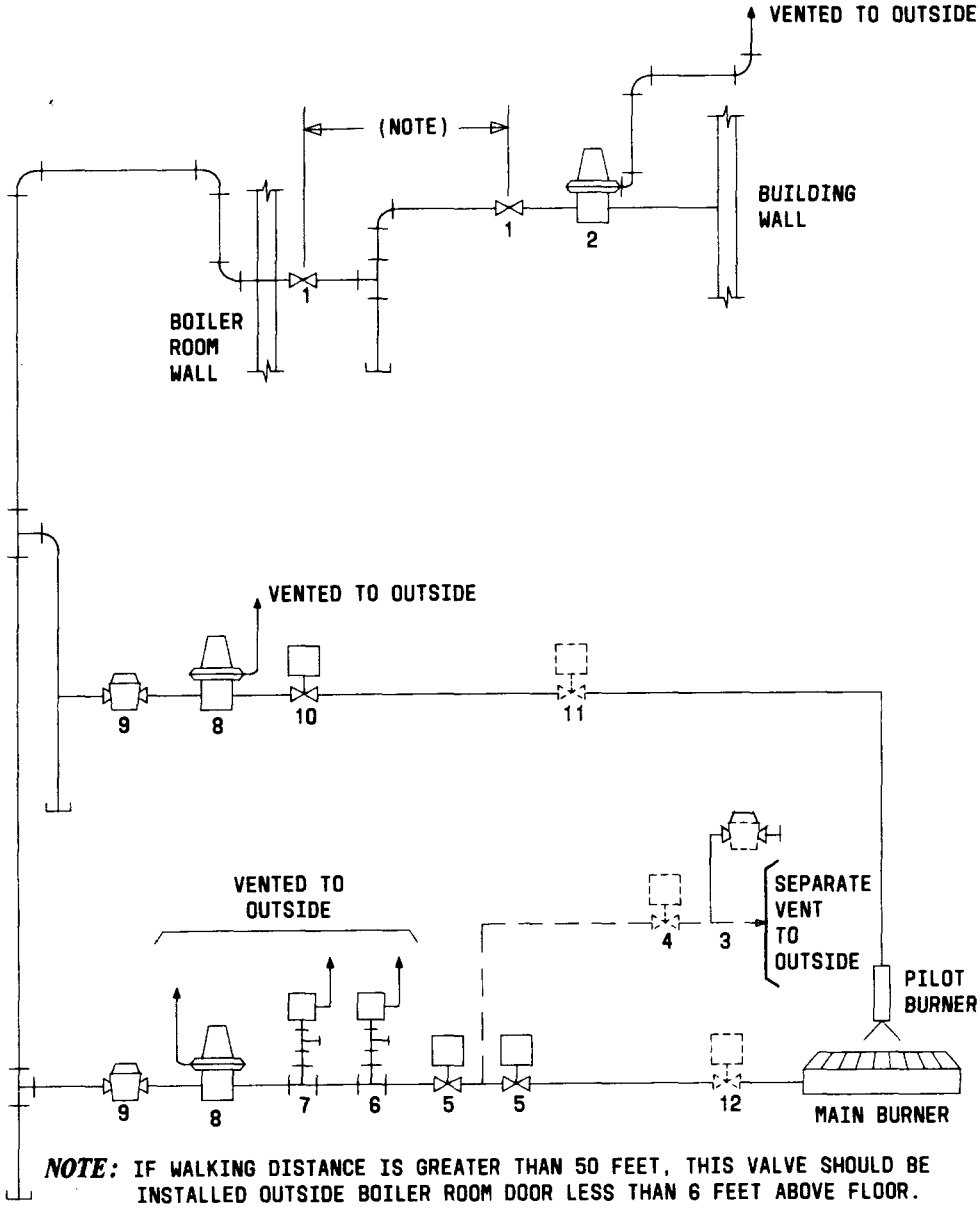
(1) A warp element, similar to a toaster element, warps due to heat and through linkage raises the valve to the open position. When this valve is de-energized, the warp element cools down and returns to the closed position. This is a slow-open, slow-close valve. This valve type is not used as a separate safety shutoff valve because of the slow-close characteristic. It is used, however, in conjunction with a quick-close valve to provide redundancy when installed in a single valve body casting. This is only applicable to burners less than 400 MBh input.

(2) An electric motor, through a reduction gear train, raises the valve open against a spring. When the valve is in the full open position, it is held open by a latch and end switches stop the motor. When this valve is de-energized, the latch releases and the spring closes the valve. This is a slow-open, quick-close valve and can be used as a safety shutoff valve.

(3) An electric motor driving a hydraulic pump builds up pressure which raises a piston that is attached to the valve which opens the valve against spring pressure. When the valve is in the full open position, an end switch stops the motor. When this valve is de-energized, a dump valve bleeds the oil out instantaneously and the spring closes the valve. This is a slow-open, quick-close valve and can be used as a safety shutoff valve.

(4) Modulating valves are available in both the motorized hydraulic pump and motor driven gear type valve providing off, full open, and any position between. Modulation will permit the burner firing rate to match the load on the boiler/furnace which is a more efficient firing rather than on/off. In addition, some motorized valves have high, low, and off positions which provide for low fire start and a choice between high and low fire to match the load on the boiler or furnace.

*Check Divisional Index 760 for availability.



NOTE: IF WALKING DISTANCE IS GREATER THAN 50 FEET, THIS VALVE SHOULD BE INSTALLED OUTSIDE BOILER ROOM DOOR LESS THAN 6 FEET ABOVE FLOOR.

LEGEND:

1 - GAS COCK EQUIPPED WITH LEVER HANDLE
2 - UTILITY COMPANY PRESSURE REGULATOR -- VENT TO ATMOSPHERE
3 - TEST GAS COCK - USED FOR BUBBLE TEST (PLUGGED) (OPTIONAL)
4 - NORMALLY OPEN VENT VALVE (IF REQUIRED) -- SEPARATE VENT TO ATMOSPHERE
5 - MAIN BURNER -- AUTOMATIC FUEL VALVES
6 - HIGH GAS PRESSURE SWITCH CONTROL -- VENT TO ATMOSPHERE
7 - LOW GAS PRESSURE SWITCH CONTROL -- VENT TO ATMOSPHERE
8 - PRESSURE REGULATOR -- VENT TO ATMOSPHERE
9 - GAS COCK
10 - PILOT BURNER -- AUTOMATIC FUEL VALVE
11 - PILOT BURNER -- AUTOMATIC FUEL VALVE (IF REQUIRED)
12 - MODULATING VALVE (OPTIONAL)

Fig. 1—Typical Gas Fuel Piping

TABLE A

MINIMUM RECOMMENDED FLAME SAFETY CONTROLS
GAS-FIRED BURNERS

SAFETY DEVICE	< 400 MBh	400 TO 2500 MBh	> 2500 MBh
Pilot Required	Yes (A)	Yes (A)	Yes
Intermittent Pilot TFI*	90 Seconds	15 Seconds	Not Permitted
Interrupted Pilot TFI	90 Seconds	15 Seconds	10 Seconds
Flame Failure Response Time	90 Seconds	04 Seconds	04 Seconds
Main Burner TFI Intermittent Pilot	Not Required	15 Seconds	Not Permitted
Main Burner TFI Interrupted Pilot	Not Required	15 Seconds	10 Seconds
Proof of Low Fire Start	Not Required	(B)	(B)
Combustion Air Interlock	Not Required	(B)	(B)
Proof of Fuel Valve Closure	Not Required	Not Required	(C), (D), and (E)
Max. Fuel Valve Closing Time (F)	05 Seconds	05 Seconds	01 Second
Block and Bleed Main Burner	Not Required	Not Required	(E)
Low Gas Pressure Switch	Not Required	Not Required	Required
High Gas Pressure Switch	Not Required	Not Required	Required
Main Burner Pressure Regulator	Required (G)	Required	Required
Pilot Pressure Regulator	Required (G)	Required	Required
Combustion FAI Interlock	Required (H)	Required (H)	Required (H)
Dual Valves	Required (I)	Required	Required
Prepurge	Not Required (J)	Not Required (J)	Not Required (J)
Post-purge	Not Required	Not Required	Not Required
Action on Flame Failure	Recycle (K)	Lockout	Lockout
Flame Detector	Required (L)	Required (M)	Required (N)
Safe Start Check	Required	Required	Required (O)

Legend:

(A) Direct arc ignition permitted if appliance is listed by recognized national test agency.
(B) Required on power gas burner or mechanical draft atmospheric burner.
(C) 2500 to 5000 MBh 2-Safety Shutoff Valve (SSOV) or 1 proof of closure with valve seal overtravel.
(D) 5001 to 12,500 MBh 1-SSOV and 1 proof of closure with valve seal overtravel.
(E) >12,500 MBh 1-SSOV and 1 proof of closure with valve seal overtravel and vent valve (block and bleed).
(F) Time it takes to fully close after valve is de-energized.
(G) When regulator controls main and pilot, it should be suitable for combined flow rate.
(H) If FAI is equipped with a damper or supply fan.
(I) Dual valves in one body permitted.
(J) Required on power gas burner or mechanical draft atmospheric burner – minimum four air changes of furnace and flue system.
(K) Attempt one time.
(L) Rectification or thermocouple detector.
(M) Rectification, ultraviolet, or infrared detectors.
(N) Ultraviolet or infrared detectors.
(O) Continuous self-checking.

*Trial for Ignition.

Burners over 2-1/2 million British Thermal Units (BTUs) per hour firing rate may require a valve with proof of closure, with valve seal over travel. This feature provides an electrical switch with normally closed contacts which open when the valve opens. This prevents the burner from starting if the fuel valve is not closed. In addition, the valve has a secondary valve seal that closes before the main valve seals. The proof of closure switch does not close until the main valve is seated. (See Fig. 2.)

3.07 Dual fuel valves and a vent valve are required on burners over 12-1/2 million BTUs per hour firing rate. The two fuel valves and vent valve are connected electrically so that they are all energized simultaneously. The fuel valves are normally closed and open when energized. The vent valve is normally open and closes when energized. The vent valve is located between the two fuel valves. The function of this arrangement is to ensure that gas does not leak past the valves and accumulate in the combustion chamber. If the upstream valve is tight and the downstream valve leaks, no gas accumulates. If the upstream valve leaks and the downstream valve leaks, the gas goes out through the vent valve because of less resistance. (See Fig. 1 for piping details.)

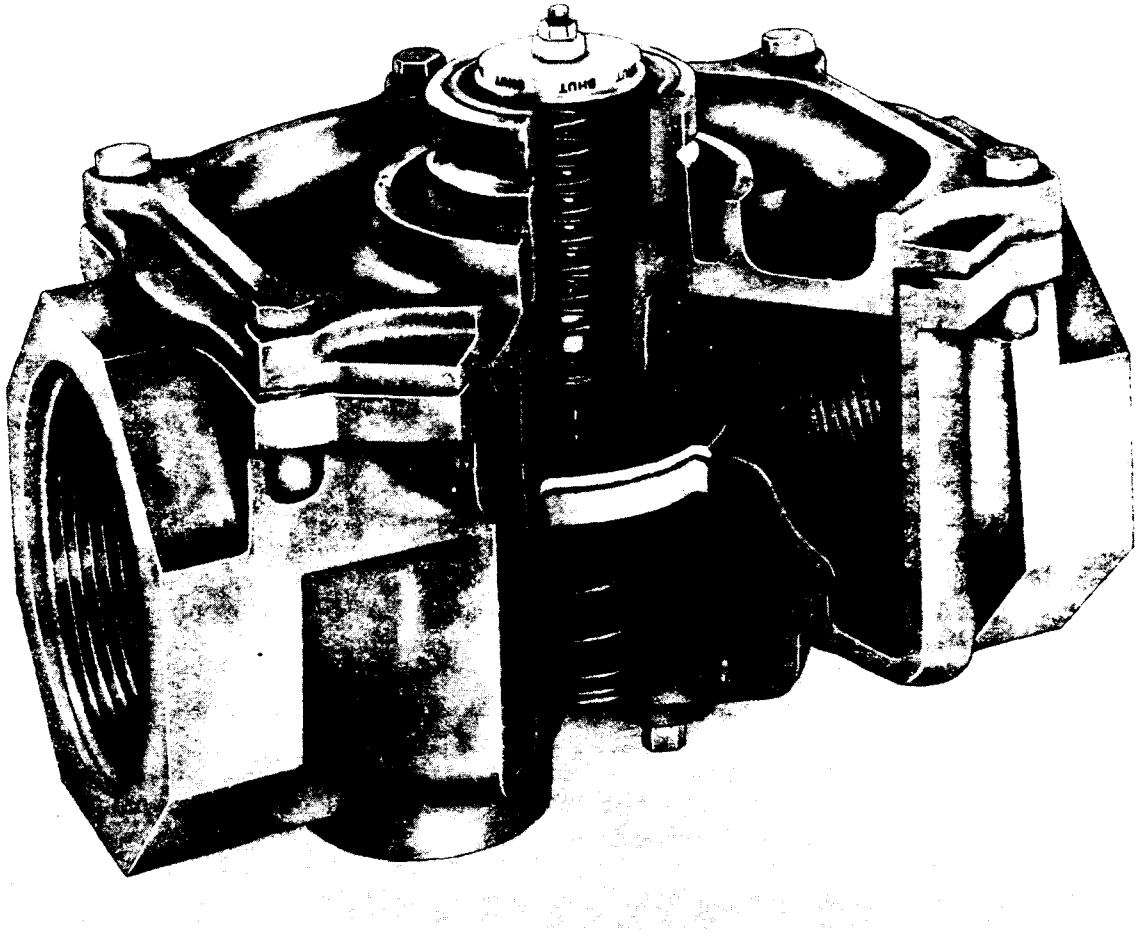


Fig. 2—Valve Seal Overtravel (Reprinted with permission, Honeywell, Inc.)

3.08 Pilot fuel valves on gas-fired burners must be redundant (two valves in series) and both close when de-energized. The exception to this is burners with a fuel input of less than 400 MBh. The pilot fuel valve can be a part of the main burner thermocouple actuated fuel valve. The main burner, in this case, is protected by a redundant valve system.

3.09 ***DANGER: Gas pressure switches and regulator vents are hazardous if vented improperly.*** Vent gas pressure switches and gas pressure regulators to exterior of building and keep clear of all windows, air intakes, doors, and sources of ignition. Venting should be independent of normally open vent valves (Fig. 1).

3.10 The low gas pressure switch control is a pressure-sensing device with normally open contacts that close on a rise in pressure. When the gas pressure reduces to a preset level, the contacts open and shut down the burner. This control can be fitted with another set of contacts that is normally closed and opens on a rise in pressure. These contacts can be used to alarm a low gas pressure condition. This control is a manual reset device and is set to operate at, or slightly above, the burner manufacturer's recommended minimum pressure. The function of this control is to prevent poor or dangerous lightoff of the main burners due to low gas pressure. (See Fig. 1 for location.)

3.11 The high gas pressure switch control is a pressure-sensing device with normally closed contacts that open on a rise in pressure. When the gas pressure rises to a preset level, the contacts open and shut down the burner. This control can be fitted with another set of contacts that is normally open and closes on a rise in pressure. These contacts can be used to alarm a high gas pressure condition. This control is a manual reset device and is set to operate at, or slightly below, the burner manufacturer's recommended maximum gas pressure. The function of this control is to prevent poor or dangerous lightoff of the main burners due to high gas pressure. (See Fig. 1 for location.)

3.12 The pressure regulator is a device designed to maintain a constant pressure to the gas burner, main or pilot. The regulator can be either deadweight or pressure balance type. Weight and lever pressure regulators are not permitted. The pressure regulator has the capability of maintaining ±10 percent outlet pressure throughout all firing rates of the burner. The function of this control is to maintain a constant fuel pressure so that the fuel air ratio is constant to assure safe and efficient combustion. (See Fig. 1 for location.)

3.13 The combustion fresh air intake (FAI) interlock is a switch that is actuated by the position of the FAI damper blades. When the damper blades are in the full open position, the switch is closed. This switch can be either a mercury tube type or pressure contact. The function of this switch is to prevent the burner from starting if the FAI damper is not fully open. This assures that there is sufficient air for safe combustion. Insufficient combustion air causes a fuel rich mixture which could partially burn, leaving some unburned combustible mixture. If more air becomes available, such as the boiler room door being opened, this mixture could ignite rapidly causing an explosion or puff-back.

3.14 The combustion FAI supply fan interlock is either a sail or pressure switch. When the FAI fan runs, either the air velocity deflects the sail or the static pressure actuates the pressure switch closing the contacts. The function of either device is to prevent the burner from starting if the FAI supply fan is not moving sufficient air.

3.15 The flame safeguard device consists of a flame sensor and some form of program controller. The flame-sensing principles were reviewed in Part 2. The program controller is a device that sequences the steps of starting the burner after all safety interlocks have been proven.

(a) ***Start interlocks*** prove that conditions are safe and correct for the burner to start. These interlocks are safety shutoff valve closed, modulating valve and damper in low fire start position, FAI open, FAI fan running, prepurge of combustion chamber complete, flame-sensing control, and any other fuel-burning related equipment that must be pre-positioned prior to lightoff of the burner.

(b) ***Running interlocks*** prove that conditions are safe and correct to keep the burner firing. These interlocks are boiler low water and feeder, burner combustion air proving switch, draft control and proving switch, operating control, and flame-sensing control.

(c) ***Manual reset interlocks*** prevent the burner from starting, or stop it if it is running,

to protect against pressure, temperature, flame, or water level limit problems. These interlocks are boiler high pressure/temperature, flame-sensing control, warm air furnace high temperature, and boiler low water and fuel pressure switches.

3.16 The flame safeguard device, after proving all starting interlocks, starts the burner and fan to purge the combustion chamber, if needed. It then establishes ignition, either direct spark or spark-ignited gas pilot. Some standing pilots (match lit) can still be used, but it is recommended that intermittent or interrupted pilots be used on new equipment designed for it, depending on heating plant size. After ignition is established, the automatic fuel valves open and the burner lights from the ignition source or pilot burner. After the main burner flame is established and proved, the flame safeguard device permits the burner to go to high fire, if it is so equipped. If any of the running or manual reset interlocks operate, the flame safeguard will shut down the burner. This device has either an electrical timer or a microprocessor that maintains the schedule of events.

4. OIL-FIRED SAFETY DEVICES

4.01 The following oil-fired devices are used on steam or hot water boilers and warm air furnaces to safely operate the main burner (Fig. 3). For more information on oil-fired safety devices, see Table B and Section 760-530-101.

4.02 The pilot is a small burner used to lightoff the main burner. Pilots are classified as intermittent or interrupted. They can be gas or oil. The pilot is automatically lighted by an electric spark igniter. Oil pilots burning #2 oil are used to lightoff heavy oil (#5 and #6) burners when gas is not available.

4.03 ***DANGER: Electric igniters range from 10,000 volts upwards.*** An electric arc igniter is used to directly lightoff the main burner without the use of a pilot. The igniter consists of two electrodes spaced a predetermined distance apart. This distance is called a gap and must be properly maintained to develop the correct arc. High-voltage current is supplied to the electrodes and an arc bridges the gap generating sufficient heat to ignite the oil.

4.04 The low fire start interlock is a mechanically operated switch, either mercury tube or pressure contact, that is linked to the fuel control valve. This control has normally open contacts that close when the burner is in low fire position. It will not permit the burner to start up until the fuel control valve is in the low fire position. Usually the combustion air damper is linked to the operator of the fuel valve and it is also in the low fire position. This is done to assure the correct fuel/air ratio for lightoff.

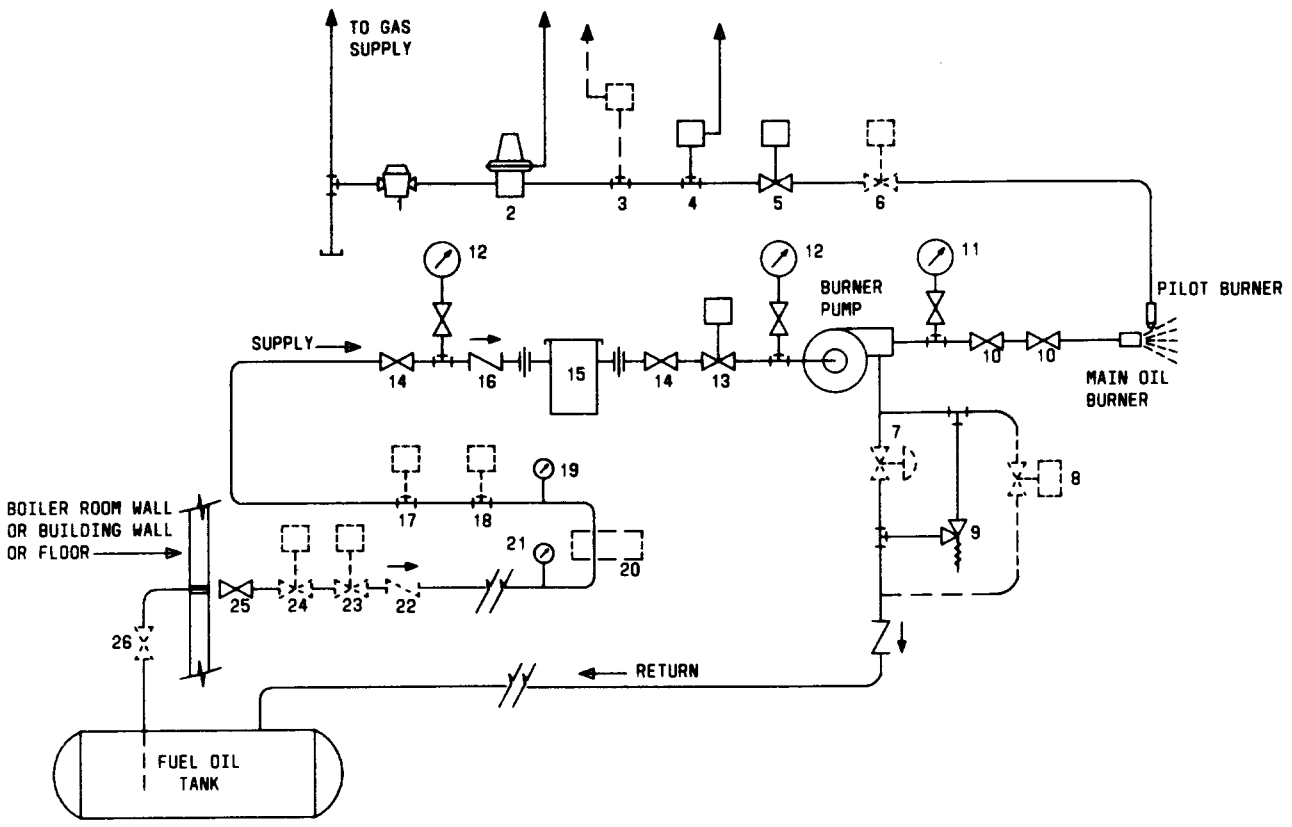
4.05 The combustion air interlock is a switch that is operated by a pressure sensor. The pressure sensor proves the presence of combustion air by sensing the pressure, above ambient, in the burner tube and closes the switch. The contacts are normally open and close on a rise in pressure. There is a dampening device, an orifice, in the sensing line which avoids nuisance shutdowns due to pressure changes caused by pulsing fires. This type of switch is used on forced draft burners only.

4.06 ***DANGER: Some oil burners operate over 300 pounds per square inch gauge.*** The main burner fuel valves (safety shutoff valves) should be solenoid type with National Electrical Manufacturers Association (NEMA) "B" insulation. Two valves will be piped in series and both will close when de-energized on all burners firing over 3 gallons per hour (GPH). Burners firing 3 GPH or less can have one solenoid valve provided there is no prepurge cycle on the flame safeguard control. This valve should be of the delayed opening type with a nominal 5-second delay. This delay allows for the burner motor to come up to speed, establish air pattern and spark, all of which contribute to a good, safe lightoff. Valves are rated for the oil pressure generated by the oil pump. Solenoid valves are normally closed and open when powered. Solenoid coil is to be field replaceable without removing the valve from the oil line. Valves shall be spring loaded to assure closing.

4.07 Pilot fuel valves shall be solenoid valves with NEMA "B" insulation or part of a redundant main gas valve assembly. One valve is required unless the burner firing rate exceeds 300 MBh, then two valves piped in series are required. (See Fig. 3.)

4.08 ***DANGER: Gas pressure switches and regulator vents are hazardous if vented improperly.*** Vent gas pressure switches and gas pressure regulators to exterior of building and keep clear of all windows, air intakes, doors, and sources of ignition. (See Fig. 3.)

4.09 The low gas pressure switch control is not required on pilot gas piping. It can be installed



LEGEND:

1 - GAS COCK
2 - PRESSURE REGULATOR - VENT TO ATMOSPHERE
3 - LOW GAS PRESSURE SWITCH CONTROL - VENT TO ATMOSPHERE (IF INSTALLED)
4 - HIGH GAS PRESSURE SWITCH CONTROL - VENT TO ATMOSPHERE
5 - AUTOMATIC FUEL VALVE - GAS
6 - AUTOMATIC FUEL VALVE GAS (IF REQUIRED)
7 - MODULATING VALVE (IF SUPPLIED)
8 - LOW FIRE START VALVE (IF SUPPLIED)
9 - RELIEF VALVE
10 - AUTOMATIC FUEL VALVE - OIL
11 - PRESSURE GAUGE
12 - VACUUM GAUGE
13 - TEMPERATURE ACTUATED SHUTOFF VALVE
14 - FILTER SHUTOFF VALVE
15 - FILTER
16 - CHECK VALVE
17 - LOW OIL TEMPERATURE INTERLOCK (IF REQUIRED)
18 - HIGH OIL TEMPERATURE INTERLOCK (IF REQUIRED)
19 - OUTLET OIL TEMPERATURE
20 - OIL HEATER (IF REQUIRED)
21 - INLET OIL TEMPERATURE
22 - ANTISIPHON VALVE (IF REQUIRED)
23 - SOLENOID ANTISIPHON (IF REQUIRED)
24 - TEMPERATURE ACTUATED SHUTOFF VALVE (IF REQUIRED)
25 - MANUAL STOP VALVE
26 - MANUAL STOP VALVE (IF REQUIRED)

Fig. 3—Typical Oil Fuel Piping

TABLE B

MINIMUM RECOMMENDED FLAME SAFETY CONTROLS
OIL-FIRED BURNERS

SAFETY DEVICE	3 GPH	4 TO 20 GPH	> 20 GPH
Pilot Required	No	Yes (A)	Yes (B)
Intermittent Pilot TFI*	Not Required	15 Seconds	Not Permitted
Interrupted Pilot TFI	Not Required	15 Seconds	10 Seconds
Flame Failure Response Time	45 Seconds	04 Seconds	04 Seconds
Main Burner TFI Intermittent Pilot	45 Seconds	15 Seconds	Not Permitted
Main Burner TFI Interrupted Pilot	45 Seconds	15 Seconds	10 Seconds—#2-4 Oil 15 Seconds—#5-6 Oil
Proof of Low Fire Start	Not Required	Permitted (C)	Required
Combustion Air Interlock	Required (D)	Required (D)	Required
Max. Fuel Valve Closing Time (E)	05 Seconds	05 Seconds	05 Seconds
Gas Pilot Pressure Regulator	Not Required	Required	Required
Low Oil Temp. Interlock	Not Required	Required (F)	Required (F)
High Oil Temp. Interlock	Not Required	Required (F)	Required (F)
Combustion FAI Interlock	Required (G)	Required (G)	Required (G)
Dual Fuel Valves	Required (H)	Required	Required
Prepurge	Not Required (I)	Required (J)	Required (J)
Post-purge	Not Required	Not Required	Not Required
Action on Flame Failure	Lockout (K)	Lockout	Lockout
Optical Flame Detector	Required (L)	Required (M)	Required (N)
Safe Start Check	Required	Required	Required (O)

Legend:

(A) Burner is listed by recognized national test agency as acceptable without pilot.
(B) Direct arc ignition acceptable if lightoff less than 20 GPH and listed by recognized test agency.
(C) When provided by manufacturer.
(D) If fan not integral with burner motor and pump shaft.
(E) Time it takes to fully close after valve is de-energized.
(F) On preheat oil systems only.
(G) If FAI is equipped with a damper or supply fan.
(H) Single valve only if no programmed prepurge — delayed opening type.
(I) Use delayed opening oil solenoid valve.
(J) Minimum four air changes of furnace and flue system.
(K) Relight permitted if ignition occurs in 0.8 second.
(L) Cadmium, photo, infrared, and ultraviolet cell detectors.
(M) Photo, infrared, and ultraviolet cell detectors.
(N) Ultraviolet and infrared detectors.
(O) Continuous self-checking.

*Trial for Ignition

if the burner manufacturer deems it necessary. (See Fig. 3.)

4.10 The high gas pressure switch control is a pressure-sensing device with a normally closed set of contacts that opens on a rise in pressure. When the gas pressure rises to a preset level, this control shuts down the burner. This control can be fitted with another set of contacts that is normally open and closes on a rise in pressure. These controls can be used to alarm a high gas pressure condition. This control is a manual reset device and is set to operate at, or slightly below, the burner manufacturer's recommended maximum gas pressure. The function of this control is to prevent poor or dangerous lightoff of pilot and main burners. (See Fig. 3.)

4.11 The pressure regulator is a device designed to maintain a constant pressure to the gas pilot burner. The regulator can be either deadweight or pressure balance type. Weight and lever pressure regulators are not permitted. The pressure regulator has the capability of maintaining ±10 percent outlet pressure throughout all firing rates of the burner. The function of this control is to maintain a constant fuel pressure so that the fuel air ratio is constant to assure safe and efficient combustion. (See Fig. 3.)

4.12 The combustion FAI interlock is a switch that is actuated by the position of the FAI damper blades. When the damper blades are in the full open position, the switch is closed. This switch can be either a mercury tube type or pressure contact. The function of this switch is to prevent the burner from starting if the FAI damper is not fully open. This assures that there is sufficient air for safe combustion. Insufficient combustion air causes a fuel rich mixture which could partially burn, leaving some unburned combustible mixture. If more air becomes available, such as the boiler room door being opened, this mixture could ignite rapidly causing an explosion or puff-back.

4.13 The combustion FAI supply fan interlock is either a sail or pressure switch. When the FAI fan runs, either the air velocity deflects the sail or the static pressure actuates the pressure switch closing the contacts. The function of either device is to prevent the burner from starting if the FAI supply fan is not moving sufficient air.

4.14 The low oil temperature interlock is a temperature-sensing device installed on the heavy oil systems requiring oil preheating. This control has normally open contacts that close on a rise in temperature. When the fuel oil temperature drops to a predetermined level, the contacts open and shut down the burner. When the oil temperature rises, the contacts close and permit the burner to start, providing all other controls are calling for start. This is an automatic resetting device. (See Fig. 3.)

4.15 The high oil temperature interlock is a temperature-sensing device installed on the heavy oil systems requiring oil preheating. This control has normally closed contacts that open on a rise in temperature. When the fuel oil is overheated and rises to a preset temperature, the contacts open and shut down the burner and the oil preheater. This control can have another set of normally open contacts which closes on a rise in temperature. These contacts can be used to alarm a high fuel oil temperature condition. This control is a manual reset device. (See Fig. 3.)

4.16 A fuel oil heater is installed on the heavy oil systems requiring oil preheating. These heaters can be electric, steam, or hot water. The majority of the heaters are electric and mounted on the oil burner assembly. Some very large heating boiler installations use steam or hot water. Care must be exercised so that the condensate or hot water return is collected in a separate tank with filtering capability to remove any oil contaminant before it is returned to the boiler. These heaters are equipped with temperature sensors in the oil leaving line and adjust the heating medium to maintain a preselected leaving oil temperature. Provide entering and leaving oil thermometers. (See Fig. 3.)

4.17 The temperature actuated shutoff valve should be a spring-loaded, normally closed lever gate valve that is held open by a wire with a low melting point link. This can be used adjacent to the burner to shut off oil to the burner in the event of a fire at the burner. In addition, this type of valve is installed in the fuel supply piping adjacent to the exterior basement wall when there is a long run of exposed fuel supply piping. (See Fig. 3.)

4.18 The string switch is a spring-loaded, normally open switch mounted on the burner assembly or boiler front. This switch is held closed by a combustible string working against a spring. The string is threaded through eyelets around the burner. In the event of a burner front fire, the string burns through and the switch opens, de-energizing the burner which

stops. This type of switch is recommended for use on rotary burners with secondary air features, which at times catch fire because of oil drip through the air passage in the brick firebox floor.

4.19 The antisiphon valve is installed in the supply piping when the fuel oil storage tank is at a higher elevation than the burner. It is installed adjacent to the exterior building wall. One of two types of valves is used.

(a) ***Electric solenoid,*** normally closed, which is energized by the flame safeguard control at the same time the burner motor starts. In the event of a broken line at the oil burner when the burner is not running, oil is prevented from siphoning from the fuel tank through the leak in the pipe and flooding the boiler room with oil. In the event that the supply oil pipe breaks while the burner is operating, the burner shuts down on loss of oil causing a flameout and the solenoid valve is de-energized. This will not protect against a small leak that does not affect the oil supply to the burner. (See Fig. 3.)

(b) ***Adjustable spring-loaded check valve*** which is normally closed. The suction of the oil pump causes the spring-loaded check to open and oil flows normally. If the oil line breaks and oil leaking out of the pipe starts a siphon action, the spring-loaded check stays closed because the siphon suction is not sufficient to open the check valve. These valves must be set very carefully. If there is too little spring tension, the valve will permit siphoning in the event of a broken line. If there is too much spring tension, the oil burner pump suction will not be able to overcome the spring loading and no oil will flow to the burner. (See Fig. 3.)

4.20 The manual stop valve should be installed where the supply fuel oil line enters through the building wall or floor. This can be a combination fusible valve. In addition, if fuel oil storage is not buried, a manual stop valve should be located in the supply line at the tank. A manual stop valve should not be installed in the return oil line. (See Fig. 3.)

4.21 The flame safeguard device consists of a flame sensor and some form of program controller. The flame-sensing principles were reviewed in Part 2. The program controller is a device that sequences the steps of starting the burner after all safety interlocks are proven.

(a) ***Start interlocks*** prove that conditions are safe and correct for the burner to start. These interlocks are safety shutoff valve closed, modulating valve and damper in low fire start position, FAI open, FAI fan running, prepurge of combustion chamber complete, flame-sensing control, and any other fuel-burning related equipment that must be pre-positioned prior to lightoff of the burner.

(b) ***Running interlocks*** prove that conditions are safe and correct to keep the burner firing. These interlocks are boiler low water and feeder, burner combustion air proving switch, draft control and proving switch, operating control, and flame-sensing control.

(c) ***Manual reset interlocks*** prevent the burner from starting, or stop it if it is running, to protect against pressure, temperature, flame, or water level limit problems. These interlocks are boiler high pressure/temperature, flame-sensing control, warm air furnace high temperature, and boiler low water and fuel pressure switches.

4.22 The flame safeguard device, after proving all starting interlocks, starts the burner and fan to purge the combustion chamber, if needed. It then establishes ignition, either direct spark or spark ignited gas pilot. Some standing pilots (match lit) can still be used, but it is recommended that intermittent or interrupted pilots be used on new equipment designed for it, depending on heating plant size. After ignition is established, or concurrently, the automatic fuel valves open and the burner lights from the ignition source or pilot burner. After the main burner flame is established and proved, the flame safeguard device permits the burner to go to high fire, if it is so equipped. If any of the running or manual reset interlocks operate, the flame safeguard will shut down the burner. This device has either an electrical timer or a microprocessor that maintains the schedule of events.

5. DRAFT CONTROLS

5.01 Draft controllers for burners are divided into two groups: natural and mechanical. The natural draft controllers are usually barometric dampers. These are weight balanced to maintain a steady over-the-fire draft by opening to admit boiler room air in the chimney or breeching if the draft in the chimney increases due to barometric conditions. It is

most important that they are installed per manufacturer's recommendations and the weights adjusted to maintain the proper over-the-fire draft. On large boilers when the draft is excessive, a mechanical damper can be used. This damper positions itself by sensing the over-the-fire draft. The damper must be electrically interlocked to prove that it is in the open position before permitting the burner to operate. This arrangement is also used with an induced draft fan. The induced draft fan starts with the burner and maintains a steady over-the-fire draft. The fan capacity should be adjustable to provide the recommended over-the-fire draft. It is important that the controls be wired so that the burner will shut down in case of a failure of the induced draft fan.

5.02 Draft hoods are used with atmospheric gas burners and are sheet metal devices built on to a boiler/furnace with a passage open to the boiler/furnace room. The flue gases leave the heating unit and pass through the draft hood to the flue pipe and/or chimmey. This open passage provides for the ready escape of flue gases in the event of no draft, backdraft, or blockage downstream of the draft hood. In addition, it will prevent a backdraft from entering the combustion chamber and blowing out the gas burner as well as reduce the excess draft effect of the chimney.

5.03 Draft proving controls for forced draft burners are sensitive pressure controllers that measure the over-the-fire draft. If there is insufficient draft, the control will not allow the burner to fire; or if draft is lost during firing, the control will shut down the burner.

6. REFERENCES

6.01 The following references are recommeneded for anyone responsible for installing, testing, or maintaining flame safeguard systems:

- ***Flame Safeguard Controls—A Honeywell Textbook,*** First Edition, 354 pages, Form #71-97558, July 1979.

- ***Application of Fireye Flame Detectors for Flame Failure Controls,*** Fireye Division of Electronics Corporation of America, 28 pages, Bulletin C.G. 106, 1975.