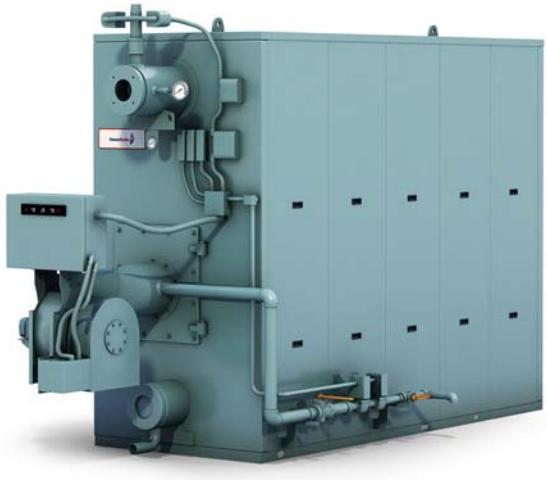
MODEL FLX

PACKAGED BOILER



1,500,000 to 12,000,000 Btu/hr
Hot Water and Steam
Fuel: Light Oil, Gas or Combination

Manual Part No. 750-177 R6 5/2014

MODEL FLX
PACKAGED BOILER
Operation, Service, and Parts Manual

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Please direct purchase orders for replacement manuals to your local Cleaver-Brooks authorized representative

Manual Part No. 750-177 R6

Revised 5/2014

Printed in U.S.A.

⚠ WARNING

DO NOT OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS YOU FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

DO NOT ALLOW OTHERS TO OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS THEY FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

FAILURE TO FOLLOW ALL APPLICABLE WARNINGS AND INSTRUCTIONS MAY RESULT IN SEVERE PERSONAL INJURY OR DEATH.

TO: Owners, Operators and/or Maintenance Personnel

This operating manual presents information that will help to properly operate and care for the equipment. Study its contents carefully. The unit will provide good service and continued operation if proper operating and maintenance instructions are followed. No attempt should be made to operate the unit until the principles of operation and all of the components are thoroughly understood. Failure to follow all applicable instructions and warnings may result in severe personal injury or death.

It is the responsibility of the owner to train and advise not only his or her personnel, but the contractors' personnel who are servicing, repairing or operating the equipment, in all safety aspects.

Cleaver-Brooks equipment is designed and engineered to give long life and excellent service on the job. The electrical and mechanical devices supplied as part of the unit were chosen because of their known ability to perform; however, proper operating techniques and maintenance procedures must be followed at all times. Although these components afford a high degree of protection and safety, operation of equipment is not to be considered free from all dangers and hazards inherent in handling and firing of fuel.

Any "automatic" features included in the design do not relieve the attendant of any responsibility. Such features merely free him of certain repetitive chores and give him more time to devote to the proper upkeep of equipment.

It is solely the operator's responsibility to properly operate and maintain the equipment. No amount of written instructions can replace intelligent thinking and reasoning and this manual is not intended to relieve the operating personnel of the responsibility for proper operation. On the other hand, a thorough understanding of this manual is required before attempting to operate, maintain, service, or repair this equipment.

Because of state, local, or other applicable codes, there are a variety of electric controls and safety devices which vary considerably from one boiler to another. This manual contains information designed to show how a basic burner operates.

Operating controls will normally function for long periods of time and we have found that some operators become lax in their daily or monthly testing, assuming that normal operation will continue indefinitely. Malfunctions of controls lead to uneconomical operation and damage and, in most cases, these conditions can be traced directly to carelessness and deficiencies in testing and maintenance.

It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly and yearly maintenance activities and recording of any unusual operation will serve as a valuable guide to any necessary investigation.

Most instances of major boiler damage are the result of operation with low water. We cannot emphasize too strongly the need for the operator to periodically check his low water controls and to follow good maintenance and testing practices. Cross-connecting piping to low water devices must be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the low water devices. Float bowls of these controls must be inspected frequently to check for the presence of foreign substances that would impede float ball movement.

The waterside condition of the pressure vessel is of extreme importance. Waterside surfaces should be inspected frequently to check for the presence of any mud, sludge, scale or corrosion.

The services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices are essential.

The operation of this equipment by the owner and his or her operating personnel must comply with all requirements or regulations of his insurance company and/or other authority having jurisdiction. In the event of any conflict or inconsistency between such requirements and the warnings or instructions contained herein, please contact Cleaver-Brooks before proceeding.

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CHAPTER 1

General Description

A. General

This manual covers Cleaver-Brooks Model FLX boilers in sizes ranging from 1,500,000 to 12,000,000 Btu/hr input.

Fuel Series

700 - Gas
100 - No.2 Oil
200 - Combination Gas & No.2 Oil

Design Pressure

160 psig hot water
15 psig steam
150 psig steam

⚠ CAUTION

The care taken in placing the boiler into initial service is vital to continuous, reliable operation. If the boiler is to be used for temporary heat (for example in new construction), properly treated water must be used. Failure to do so can be detrimental to the boiler.

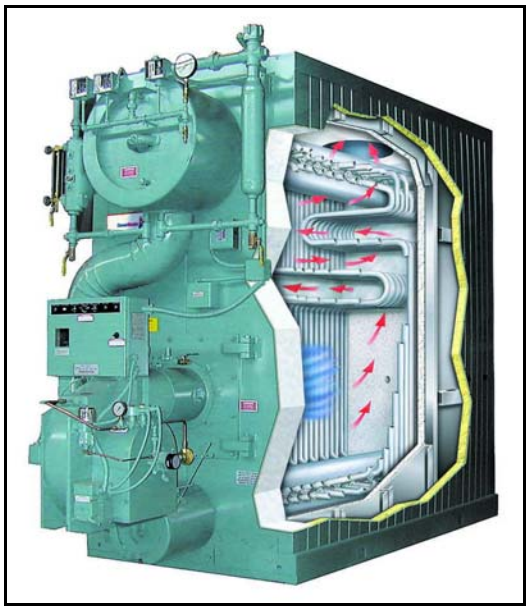


Figure 1-1: FLX cutaway view

B. The Boiler

The Cleaver-Brooks Model FLX is a five-pass steel boiler with flexible watertubes formed and arranged so as to direct the flow of combustion gases through the boiler. The pressure vessel conforms to Section I or IV of the ASME code. The pressure vessel consists of the formed tubes, the external downcomer, and the top and bottom drums to which they connect. The heated area of the pressure vessel is contained within a gas tight insulated casing that is composed of removable formed steel panels.

The boiler and related equipment installation are to be in compliance with the standards of the National Board of Fire Underwriters. Installation should also conform to state and local codes governing such equipment. Prior to installation, the proper authorities having jurisdiction are to be consulted, permits obtained, etc. All boilers comply, when equipped with optional equipment, to Industrial Risk Insurers (IRI), Factory Mutual (FM), or other insuring underwriters requirements.

Always order genuine Cleaver-Brooks parts from your local Cleaver-Brooks authorized representative.

The Model FLX boiler is a packaged watertube boiler of welded steel construction and consists of a pressure vessel, burner, burner controls, forced draft fan, damper, refractory, and appropriate boiler trim.

Steam

Steam boilers are designed for low and high pressure applications. Low pressure boilers are limited to 15 psig design pressure, and are typically used for heating applications. High pressure boilers are limited to 150 psig design pressure, and are typically used for process steam applications.

Hot Water

Hot water is commonly used in heating applications with the boiler supplying water to the system at 180 °F to 220 °F. The operating pressure for hot water heating systems usually is 30 psig to 125 psig.

Steam and hot water boilers are defined according to design pressure and operating pressure. Design pressure is the maximum pressure used in the design of the boiler for the purpose of calculating the minimum permissible thickness or physical characteristics of the pressure vessel parts of the boiler. Typically, the safety valves are set at or below design pressure. Operating pressure is the pressure of the boiler at which it normally operates. The operating pressure usually is maintained at a suitable level below the setting of the pressure relieving valve(s) to prevent their frequent opening during normal operation.

The type of service that your boiler is required to provide has an important bearing on the amount of waterside care it will require.

⚠ CAUTION

Waterside care is of prime importance. For specific information or assistance with your water treatment requirements, contact your Cleaver-Brooks service and parts representative. Failure to follow these instructions could result in equipment damage.

Feedwater equipment should be ready for use upon installation of the boiler. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

The careful observance of water requirements for both steam and hot water boilers is essential. Constant attention to water requirements will pay dividends in the form of longer life, less down-time, and prevention of costly repairs.

Care taken in placing the pressure vessel into initial service is vital. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove accumulations is described in Chapter 3. The operator should be familiar with this chapter before attempting to place the unit into operation.

C. Construction

Steam boilers designed for 15 psig and hot water boilers designed for 250°F at 160 psi or less are constructed in accordance with Section IV, Heating Boilers, of ASME Code. Steam boilers designed for 150 psig are constructed in accordance with Section I, Power Boilers, of the ASME Code.

D. Steam Controls (All Fuels)

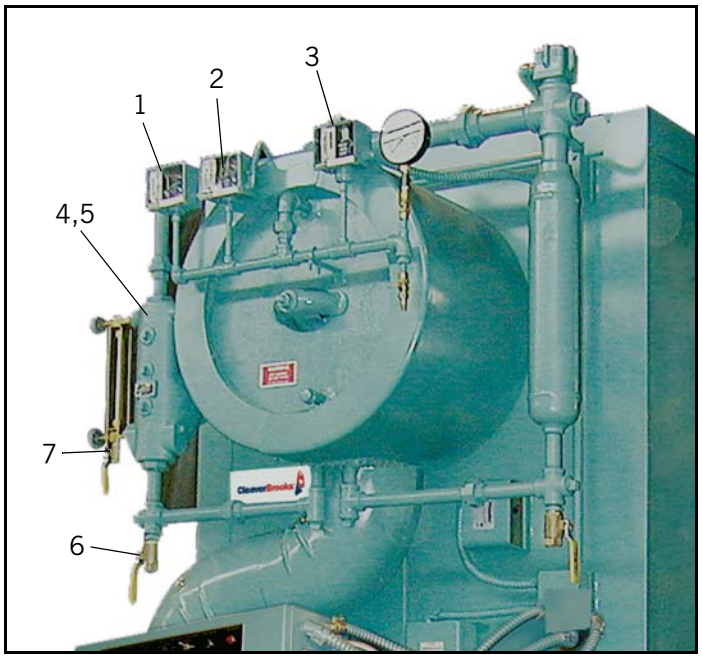


Figure 2-2: Steam Controls

1. High Limit Pressure Control: Breaks a circuit to stop burner operation on a rise of pressure above a selected setting. It is adjusted to stop the burner at a preselected pressure above the operating limit control setting. The high limit pressure control is equipped with a manual reset.
2. Operating Limit Pressure Control: Breaks a circuit to stop burner operation on a rise of boiler pressure at a selected setting. It is adjusted to stop or start the burner at a preselected pressure setting.
3. Modulating Limit Pressure Control: Senses changing boiler pressures and transmits the information to the modulating motor to change the burner firing rate when the manual-automatic switch is set on “automatic.”
4. Low Water Cutoff and Pump Control: Float-operated control responds to the water level in the boiler. It performs two distinct functions:

- Stops firing of the burner if water level lowers below the safe operating point. Energizes the low-water light in the control panel; also causes low-water alarm bell (optional equipment) to ring. Code requirements of some models require a manual reset type of low-water cutoff.
- Starts and stops the feedwater pump (if used) to maintain water at the proper operating level.

⚠ CAUTION

Determine that the main and auxiliary low water cutoffs and pump control are level after installation and throughout the equipment’s operating life. Failure to follow these instructions could result in equipment damage.

5. Water Column Assembly: Houses the low-water cutoff and pump control and includes the water gauge glass and gauge glass shutoff cocks.
6. Water Column Drain Valve: Provided so that the water column and its piping can be flushed regularly to assist in maintaining cross-connecting piping and in keeping the float bowl clean and free of sediment. A similar drain valve is furnished with auxiliary low-water cutoff for the same purpose.
7. Gauge Glass Drain Valve: Provided to flush the gauge glass.

8. Safety Valve(s): Prevent buildup over the design pressure of the pressure vessel. The size, rating and number of valves on a boiler is determined by the ASME Boiler Code. The safety valves and the discharge piping are to be installed to conform to the ASME code requirements. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and code-required drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat area. Apply only a moderate amount of pipe compound to male threads and avoid overtightening, which can distort the seats. Use only flat-jawed wrenches on the flats provided. When installing a flange-connected valve, use a new gasket and draw the mounting bolts down evenly. Do not install or remove side outlet valves by using a pipe or wrench in the outlet.

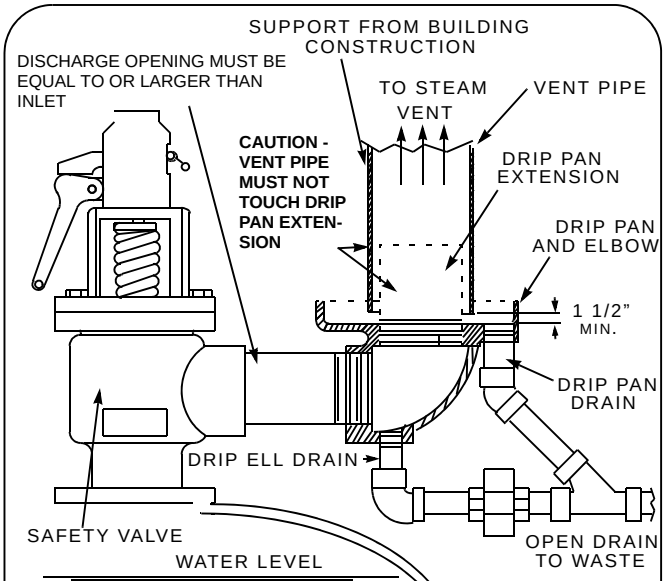


Figure 2-3: Recommended piping for steam relief valve (not furnished by Cleaver-Brooks)

⚠WARNING

Only properly certified personnel such as the safety valve manufacturer's certified representative can adjust or repair the boiler safety valves. Failure to follow these instructions could result in serious personal injury or death

E. Hot Water Controls (All Fuels)

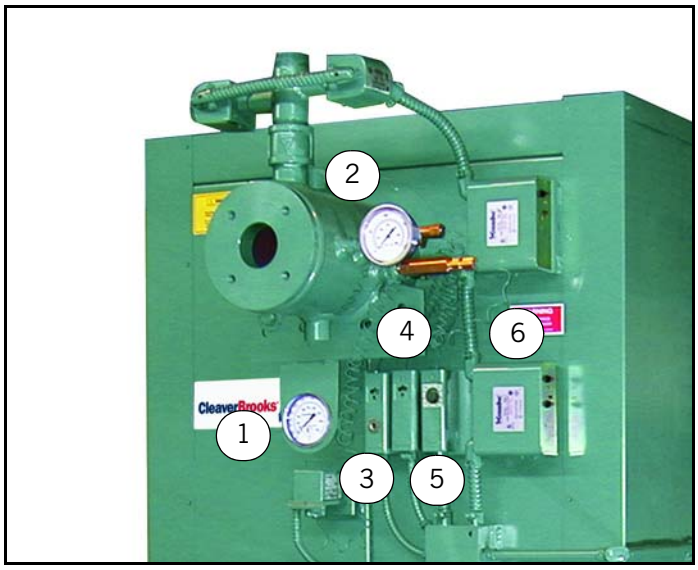


Figure 2-4: Hot Water Controls

1. Water Temperature Gauge: Indicates the boiler internal water pressure.
2. Water Pressure Gauge: Indicates the internal pressure of the boiler.
3. High Limit Temperature Control: Breaks a circuit to stop burner operation on a rise of temperature at a selected setting. It is adjusted to stop burner at a preselected temperature above the operating control setting. The high limit temperature control is equipped with a manual reset.
4. Operating Limit Temperature Control: Breaks a circuit to stop burner operation on a rise of boiler temperature at a selected setting. It is adjusted to stop or start the burner at a preselected operating temperature.
5. Modulating Temperature Control: Senses changing boiler water temperature and transmits the information to the modulating motor to change the burner firing rate when the manual-automatic switch is set on "automatic."
6. Low Water Cutoff: Breaks the circuit to stop burner operation if the water level in the boiler drops below safe operating point, activating low-water light and optional alarm bell if burner is so equipped.

7. Auxiliary Low Water Cutoff (Not Shown) (Optional): Breaks the circuit to stop burner operation if the water level in the boiler drops below the master low-water cutoff point.
8. Safety Valve(s): Prevent buildup over the design pressure of the pressure vessel. The size, rating and number of valves on a boiler is determined by the ASME Boiler Code. The safety valves and the discharge piping are to be installed to conform to the ASME code requirements. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and code-required drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat area. Apply only a moderate amount of pipe compound to male threads and avoid overtightening, which can distort the seats. Use only flat-jawed wrenches on the flats provided. When installing a flange-connected valve, use a new gasket and draw the mounting bolts down evenly. Do not install or remove side outlet valves by using a pipe or wrench in the outlet.

⚠WARNING

Only properly certified personnel such as the relief valve manufacturer's certified representative can adjust or repair the boiler relief valves. Failure to follow these instructions could result in serious personal injury or death.

CHAPTER 2

Profire V Burner

A. Introduction

V series burners are assembled, wired, and tested at the factory. They are listed by the Underwriters Laboratory (UL), CSD-1, NFPA-85, Factory Mutual (FM), including the National Electrical Code (NEC), and associated insurance underwriters. Where applicable, the Canadian Gas Association (CGA) B149 and the Canadian Standards Association (CSA) B140 codes shall prevail. Other regulatory agency control options are available.

⚠ CAUTION

ONLY FACTORY AUTHORIZED BURNER SERVICE PERSONNEL SHOULD START UP, ADJUST, OR SERVICE THIS EQUIPMENT.

DESCRIPTION

The V series burners are designed to operate with natural gas and light oil. The burners are designed for automatic, unattended operation except for periodic inspection and maintenance. The burner and control panel components require little attention except for occasional cleaning.

Model FLX boilers 150-1200 MBTU use the following size burners:

SIZE 1 - FLX 150-300 (Low-High-Low or Full Modulation)
SIZE 2 - FLX 350-550 (Low-High-Low or Full Modulation)
SIZE 3 - FLX 600 (Low-High-Low or Full Modulation)
SIZE 3 & 4 - FLX 700-1200 (Full Modulation)

OPERATING CONTROLS - PANEL

The burner control panel may be integral to the burner or remote, and contains: a flame safeguard programming control, motor relays (starters), and terminal strips mounted internally on a panel subbase.Lights, switches, and a control circuit breaker are mounted externally on the panel.

The following table lists typical panel items. Some or all of the items may be provided depending on the burner configuration selected.

1. **ON-OFF BURNER SWITCH**
2. **FUEL SELECTOR SWITCH - Gas-Off-Oil**
   Gas position: Selects gas as the firing fuel
   Off position: Burner off
   Oil position: Selects oil as the firing fuel
3. **CONTROL CIRCUIT BREAKER**
   Supplementary low overcurrent protection only. No larger than 15 amps.
4. **AUTO-MANUAL MODULATION SELECTOR SWITCH**
   Auto position: Selects boiler modulation control. In this position, the burner will operate automatically in response to load demand.
   Manual position: Selects 135 ohm potentiometer for manual modulating control.
5. **MANUAL MODULATING CONTROL -** 135 ohm (full modulation burners only) increases or decreases the burner firing rate.
6. **SIGNAL LAMPS**
   a) LOAD DEMAND (white): Illuminates when the control circuit is energized (powered).

   b) LOW WATER (red): Illuminates when the water level in the boiler gets too low.

   c) FUEL VALVE (green): Illuminates when the main fuel valve or valves (gas or oil) are energized (open).

   d) FLAME FAILURE (red): Illuminates when the flame safeguard system fails to detect pilot or main flame.

FLAME SAFEGUARD CONTROLS

The flame safeguard controls the burner's operating sequence: pre-purge, trial for ignition, main flame and shutdown. This safety control also includes flame detection system to confirm proper operation or cause a manual reset lockout in the event of a pilot or main flame failure. External controls connected to the flame control's limit circuit, such as the boiler operating control, will trigger normal burner startup, and upon reaching operating set point, normal burner shutdown. Safety devices in the flame control's running interlock circuit, such as the combustion air switch, will cause an immediate safety shut down if conditions are not correct for safe operation.

When a parallel positioning system is furnished, the flame safeguard may be incorporated as an integral component to the parallel positioning control. Consult boiler controls documentation. If using a C-B Hawk control system refer to manual 750-366 (Hawk 1000) or 750-342 (Hawk 4000) and to the flame safeguard manual 750-234 (CB780E) or 750-264 (CB120).

FIRING RATE CONTROLS

LHL burners use a two position actuator and linkage to control the air and gaseous fuels (oil burners control oil flow with electric valves). At startup fire, the air damper and fuel valves are positioned for stable low fire operation. When the actuator is commanded to its second position, the linkage drives the air damper and fuel valves open until high fire is reached. LHL burners typically use a boiler-mounted control that keeps the burner at its low fire rate to prevent thermal shock, until conditions are suitable for high fire.

Full modulation burners are capable of firing at any rate between the burner's low and high fire limits. For “single point” modulating systems, a single rotary actuator controls both air and fuel volume via control arms and linkage attached to its shaft. As the actuator rotates from low to high fire, the linkage opens the air damper

and fuel metering valves increase the firing rate. Optional “CAM” trim provides additional precision to the air/fuel mix with the use of several discrete set point adjustments across the modulation range. Further combustion efficiency may be achieved with the use of parallel positioning controls which use multiple directly-coupled actuators (linkeageless) to position the air damper, fuel metering valves and, if applicable, flue gas recirculation (FGR) across the modulation range.

COMBUSTION AIR HANDLING SYSTEM

1. MOTOR AND BLOWER

The impeller is directly driven by the motor at 3450 rpm.

2. AIR VOLUME REGULATOR

Air dampers are located in the air inlet housing and mechanically linked to the modulating motor.

3. COMBUSTION AIR PROVING SWITCH

A pressure sensitive, differential switch actuated by air pressure created by the blower fan. Contacts close to prove combustion air flow.

4. DIFFUSER

Contained by the burner’s firing head, an air flow diffuser shapes combustion air flow and improves flame stability.

When determining boiler room air requirements, the size of the room, air flow, and velocity of air must be reviewed as follows (fpm = feet per minute; cfm = cubic feet per minute):

Size (area) and location of air supply openings in boiler room:	Two (2) permanent air supply openings in the outer walls of the boiler room are recommended. Locate one (1) at each end of the boiler room, preferably 7 foot or lower. This allows air to sweep the length of the boiler.
	A boiler room vent fan is not recommended. Under certain conditions, these fans can cause a light vacuum and “steal” combustion air from the burner resulting in unsatisfactory combustion performance.
	A vent fan in the boiler room is not recommended, as it could create a light vacuum under certain conditions and cause variations in the volume of combustion air. This can result in unsatisfactory burner performance.
	Under no condition should the total area of the air supply openings be less than (1)square foot.
	Size the openings by using the formula: Area (sq-ft) = cfm/fpm
Amount of air required (cfm):	Combustion Air = Rated bhp x 8 cfm/bhp.
	Ventilation Air = Maximum bhp x 2 cfm/bhp.
	Total recommended air = 10 cfm/bhp – up to 1000 feet elevation. Add 3% more per 1000 feet of added elevation.
Acceptable air velocity in Boiler Room (fpm):	From floor to (7) foot height – 250 fpm
	Above (7) foot height – 500 fpm

Example: Determine the area of the boiler room air supply openings for one (1) 300 hp boiler at 800 feet altitude. The air openings are to be 5 feet above floor level.

1.Air required: 300 x 10 = 3000 cfm
2.Air velocity: Up to 7 feet - 250 fpm
3.Area required: Area = cfm = 3000/250 = 12 sq-ft total
4.Area/Opening: 12/2 = 6 sq-ft/opening (2 required)

B. FIRING HEAD

Two side access covers provide access to the firing head internal components. Figure 2-1 shows a a radial spud firing head typically used on watertube applications

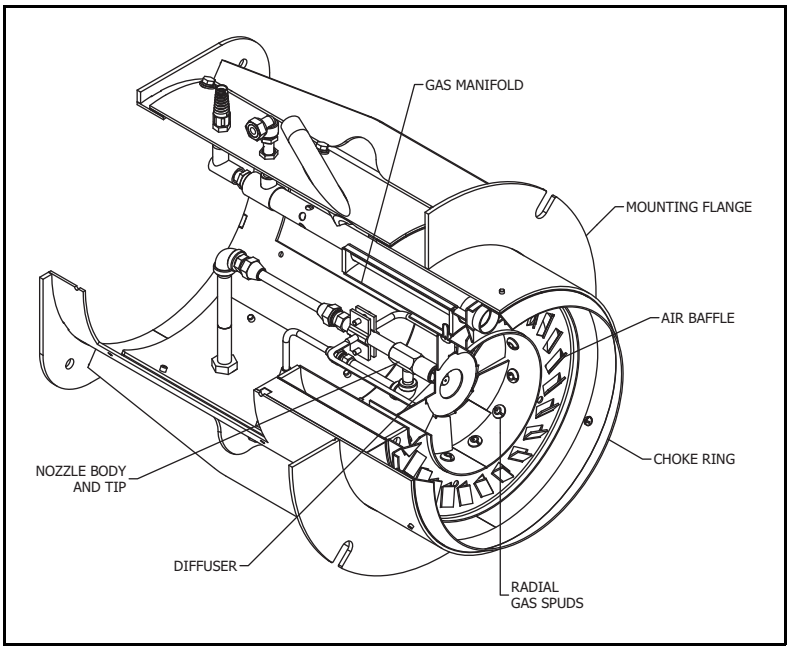


Figure 2-1: Profire V firing head

C. OIL SYSTEM

The V series burners pump high pressure fuel oil to the spray nozzle resulting in combustion-ready finely atomized oil spray.

Oil System Components

Fuel Unit	Standard V13-55 have an oil pump flex-coupled to the blower motor; these units may be optionally equipped with a remote pump.The larger V60-168 use a remote pump with separate motor.
Oil Nozzle	Pump pressurized oil discharges from the nozzle in a fine conical spray pattern. The burner's nozzle is sized to provide the burner's high fire rate, rated gallons per hour (gph). Smaller gph nozzles may be used to match burner output to a heat exchanger's required input. Models V13-34 are supplied with simplex nozzles (return flow nozzles optional on V25-34). Models V35-168 are supplied with return flow nozzles.
Nozzle Adapter	A nozzle adapter provides the means for connecting fuel lines with the nozzle.
Oil Solenoid Valves	Two normally closed (N.C.) and one normally open (N.O.) solenoid valves are part of the oil system on LHO and LHL burners. The two (2) N.C. valves provide positive shutoff of fuel oil while the one N.O. valve cycles the burner to high fire when closed.
Oil Metering Valve	The firing rate is controlled by an adjustable metering valve in the return line. At low fire, the metering valve is open, and is closed at high fire.
Oil Filter	The oil filter prevents foreign matter from entering the burner oil system. This item is provided as an option and shipped loose with the burner.

OPERATION: Fuel oil is delivered to the fuel pump, either by gravity, fuel pump suction, or by a circulating pump, through a fuel oil filter. Pressurized fuel returns to the storage tank until the two solenoid valves open. Straight oil burners (VL13-55) employ direct spark ignition where the oil is ignited when the oil solenoid valves open and the spray contacts the electrical discharge from the direct spark electrodes.

Gas-oil VLG burners use a proven gas pilot where the oil is ignited when the oil solenoid valves open and the oil spray contacts the established gas pilot flame.

On full modulation units, the modulating actuator varies the oil metering valve setting. The metering valve located in the return oil loop reduces the firing rate by opening and allowing more oil to return to the supply tank. Conversely, at high fire, the valve is closed, forcing all oil to exit the spray nozzle.

On LHL units, bypass piping routes most of the oil back to the storage tank while at low fire. At high fire, a valve blocks the return loop and forces all the oil through the nozzle.

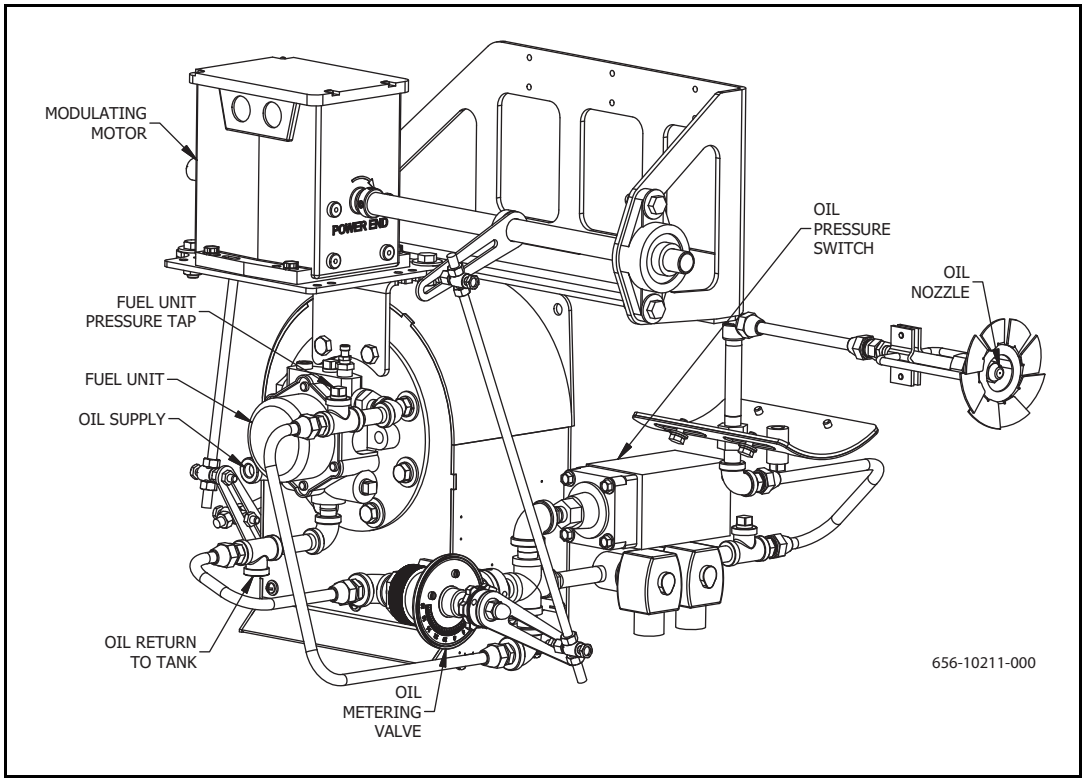


Figure 2-2: Full Modulation Oil System with Integral Pump & Simplex Nozzle (V13-34)

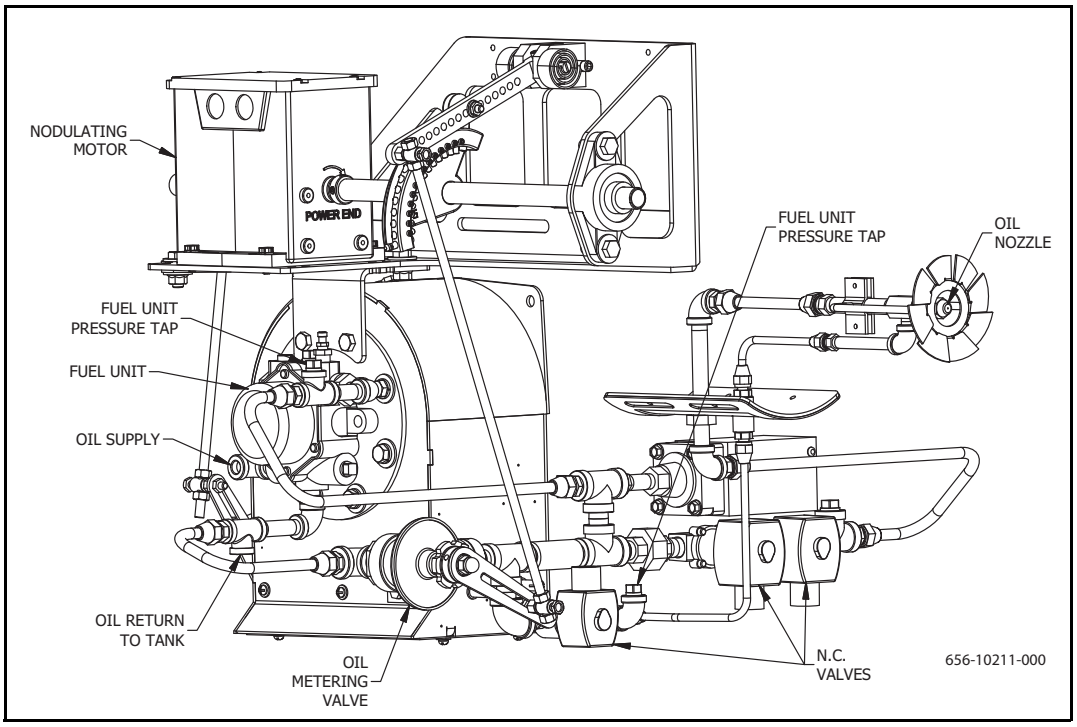


Figure 2-3: Full Modulation Oil System with Integral Pump & Return Flow Nozzle (V13-55)

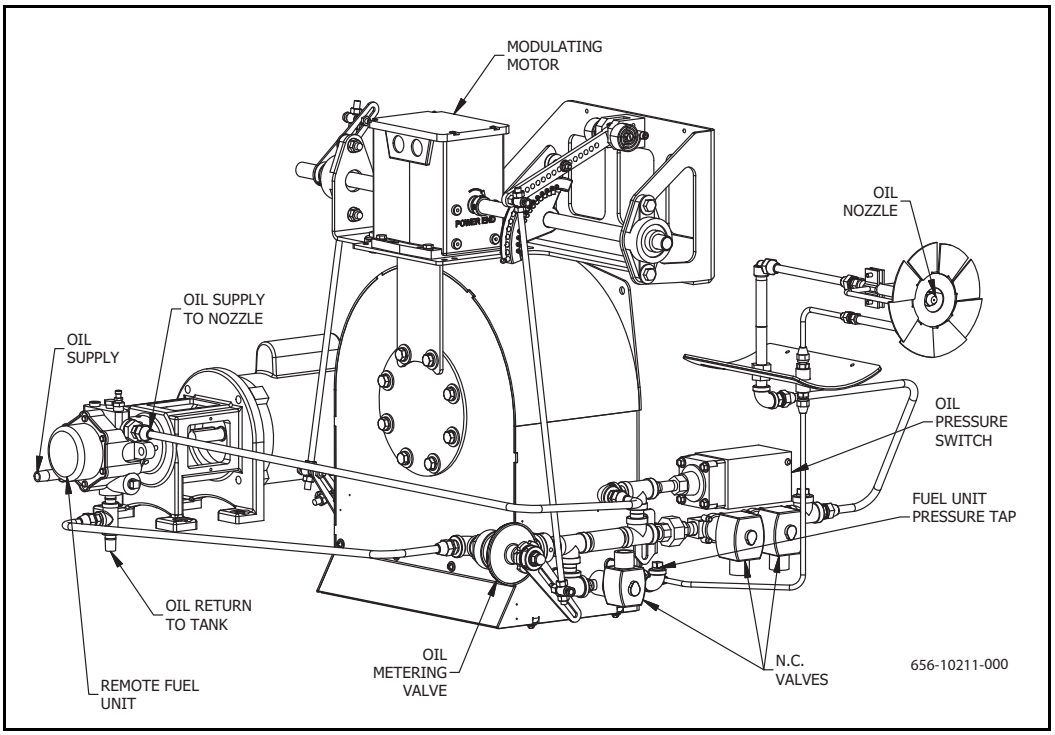


Figure 2-4: Full Modulation Oil System with a Remote Pump (V60-168)

D. GAS SYSTEM

Gas is introduced into the combustion zone from a circular manifold through multiple ports in the manifold.Firing rate is determined by the size and number of ports, by manifold pressure, and by combustion zone pressure. The firing rate is regulated by a rotary, butterfly-type throttling valve at the manifold inlet. The valve is actuated by adjustable linkage from the modulating motor. Depending upon specific requirements, one or two gas safety shutoff valves are provided for installation in the gas train upstream of the butterfly valve. Safety shutoff gas valves are wired into the programming control to automatically open and close at the proper time in the operating sequence.

MAIN GAS TRAIN COMPONENTS

Depending upon the requirements of the regulating authority, the gas control system and gas train mayconsist of some, or all, of the following items:

Gas Volume Valve	The butterfly type valve is positioned by linkage from the modulating motor and controls the gas flow rate.
Main Gas Valves	Electrically operated safety shutoff valve(s) that open to admit gas to the burner.lowfire Standard UL burners include: • Models V13-25: diaphragm gas valve & solenoid valve • Models V30-50: one (1) motorized gas valve w/proof of closure or two (2) safety shutoff valves • Models V55-120: one (1) motorized gas valve w/proof of closure and one (1) safety shutoff valve • Models V126-168: two (2) motorized gas valves (two motorized gas valves can be optionally provided on all models)
Main Gas Regulator	Regulates gas train pressure to specified pressure required at the burner manifold.Input is set by main gas pressure regulator adjustment.
Main Gas Cocks	Used for manual shutoff of the gas supply upstream of the pressure regulator. A second shutoff cock downstream of the main gas valve(s) provides a means of testing for leakage through the gas valve(s).
High Gas Pressure Switch (Models V30-168)	A pressure actuated switch that remains closed when gas pressure is below a selected setting. Should the pressure rise above the setting, the switch contacts will open causing the main gas valve(s) to close. This switch requires manual reset after being tripped.
Low Gas Pressure Switch (Models V30-168)	A pressure actuated switch that remains closed when gas pressure is above a selected setting. Should the pressure drop below this setting, the switch contacts will open, causing main gas valve(s) to close. This switch requires manual reset after being tripped.

OPERATION: Metered gas flows through the main gas shutoff cock, through the pressure regulator to the automatic gas valves and butterfly valve to the gas manifold.

The butterfly gas valve modulates flow to burner input demand. The butterfly valve is positioned through mechanical linkage by the modulating motor. The air control damper is positioned simultaneously by the modulating motor.

The automatic gas valve(s) cannot be energized unless the combustion air proving switch is closed. The low and high gas pressure switches must be closed to prove proper gas pressure.

A normally open vent valve, if required, is located between the two automatic gas valves. This valve is shut when the automatic gas valves are open. When the automatic valves are closed, the vent valve is open for venting gas to the outside, should any be present.

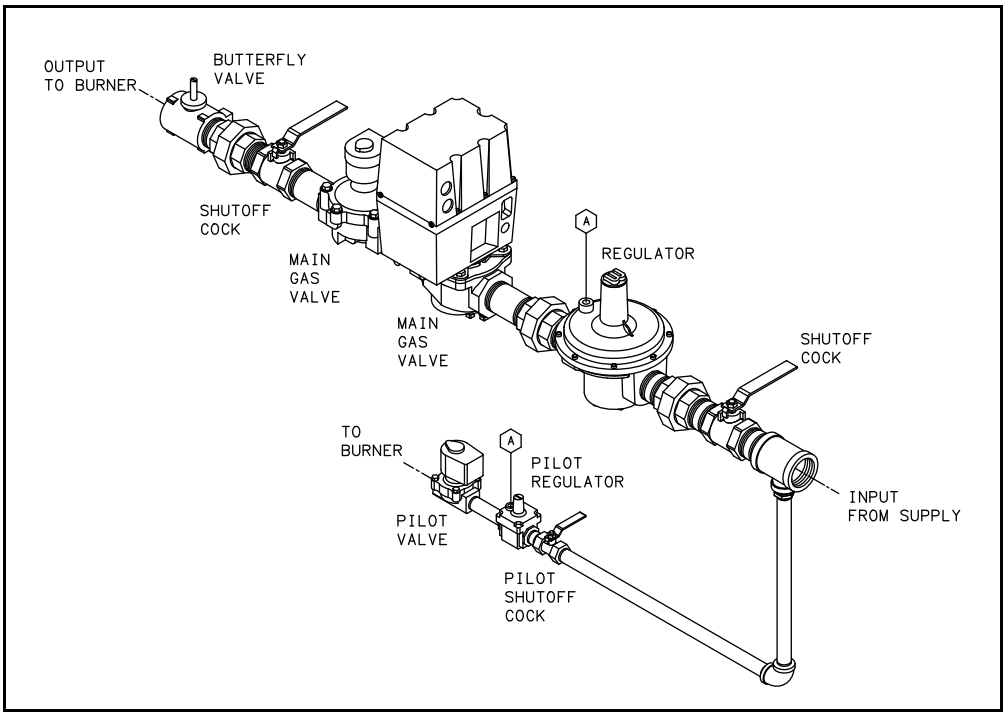


Figure 2-5: Typical Gas Train for Full Modulation System (V13-34)

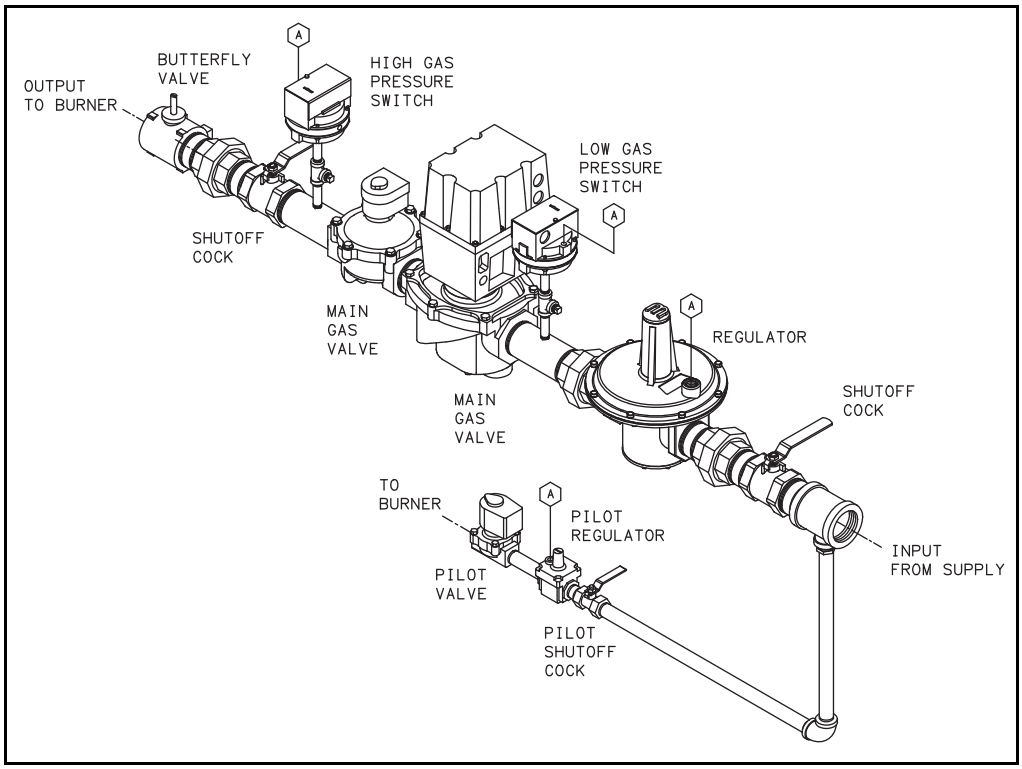
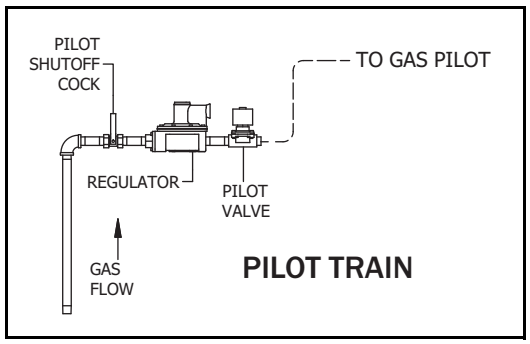


Figure 2-6: Typical Gas Train for LHO/LHL Systems (V35-63) & Full Modulation Systems (V35-168)

PILOT GAS TRAIN COMPONENTS

Models VL 60-168 as well as all VG and VLG models are supplied with a gas pilot system. Oil only models VL 13-55 are supplied with direct spark ignition.

Gas Pilot Valve	A solenoid valve that opens during the ignition period to admit fuel to the pilot. It closes after main flame is established.
Gas Pressure Regulator	Reduces gas pressure to that required by the pilot.
Gas Pilot Shutoff Cock	For manually closing the pilot gas supply.



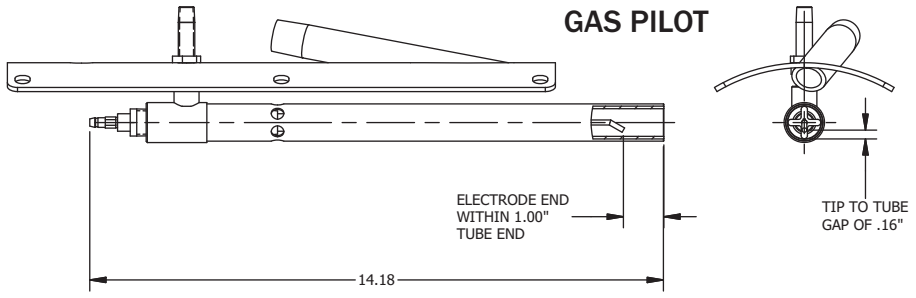


Figure 2-7: Pilot train / Pilot assembly

E. Installation

DRAFT CONDITIONS

A boiler or other heating vessel fired with a V series burner does not depend on chimney draft for proper combustion air. Combustion air is supplied by the burner forced draft blower providing adequate air for any normal combustion condition. Since draft control is essential to maximum efficiency, a draft regulator maybe required when the vessel is connected to a tall stack or where wind conditions may cause erratic draft.Excessive furnace draft contributes to inefficient burner operation. Sealed boilers may be operated under positive firebox pressure within the capability of the burner.

COMBUSTION AIR SUPPLY

The space in which the burner operates must be supplied with adequate fresh air for combustion and ventilation purposes. Fresh air supply must meet or exceed all code requirements. Consult with insurance carrier and/or local authorities for specific regulations.

⚠WARNING

THE BOILER ROOM PRESSURE MUST BE AT LEAST EQUAL TO THE OUTDOOR ATMOSHERIC PRESSURE. WHERE FAN VENTILATION IS USED, AIR MUST BE FORCED INTO THE BOILER ROOM. NEVER EXHAUST AIR FROM THE BOILER ROOM. ADJOINING AREAS HAVING EXHAUST FANS MUST BE POSITIVELY ISOLATED FROM THE BOILER ROOM.

OIL PIPING

The oil only (VL) and gas-oil (VLG) model burners use pressure atomization. Fuel oil is provided by a burner mounted fuel pump directly coupled to the blower motor via a flexible coupling for models V13-55. A remote pump is used for models V60-168. The suction and return line sizes (two-pipe system) are based on the suction rate of the fuel pump and not the burner firing rate. Pipe size must be selected so that suction vacuum is within suitable limits.

A two-pipe system is essential. The suction and return between the storage tank or supply source and the burner must be sized to supply the required quantity of oil circulated, including excess oil returned to the storage tank.

Suction Line Sizing

The suction load is determined by:

- The vertical lift from the oil level in the tank to the pump.
- Pressure drop through valves, fittings, strainers, etc.
- The friction loss due to oil flow. This loss varies with:
  a. Quantity of oil pumped (gph).
  b. Length of suction line (feet).
  c. Diameter of the suction line.
  d. Number of fittings.

Although the gear type pumps used on the V series burners are capable of developing higher suction, it is not desirable to operate above 15 inches of mercury vacuum. If the vacuum is greater, flow may be erratic.

Refer to the manufacturer's table for line sizing.

1. Check suction capacity.
2. Measure total pipe length (horizontal and vertical).
3. Read up from line "total feet of copper tube" to the intersection line of the specific "suction capacity" in gph.
4. Read left to column "inches of vacuum at fuel unit." This is vacuum required to draw oil through pipe listed at given length.
5. Add 1" of vacuum for every foot of lift.
6. Total inches of vacuum (frictional tube loss plus lift).
7. If total exceeds 15", check next larger pipe size.

Return Line Sizing

Generally, the return line should be sized the same as the suction line.

Two Pipe - Multiple Burner System

Several options exist for a multiple burner installation. Figure 2-8 is a typical installation showing separate suction lines for each burner with a common return line.

Figure 2-9 shows multiple burners with separate suction lines. Figure 2-10 shows multiple burners with oil supplied by a transfer pump. The circulating pump is sized in this case for the total suction capacity of all burners. Note that a special pressure regulating valve is required if the fuel unit inlet pressure is above 3 psi.

Figure 2-11 shows an installation using a day tank. A pump supplies oil to the day tank.

Figure 2-12 shows a flooded loop system. The circulating pump is sized according to the maximum burner firing rate for all burner plus a 30% service factor. The burner return lines feed into the common supply line.

Notice: C-B recommends that all oil firing burners be equipped with an oil strainer (if not included with the burner) to prevent particles from clogging the nozzle. It is essential to follow the strainer manufacturer's maintenance schedule to ensure proper filtration.

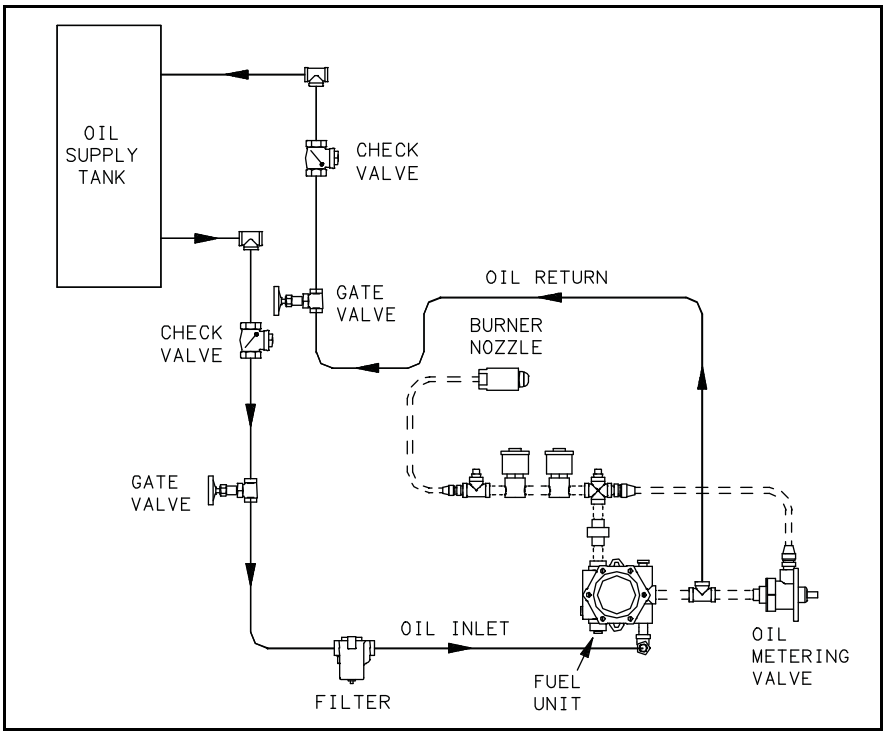


Figure 2-8: Typical No. 2 Oil Loop Single Burner

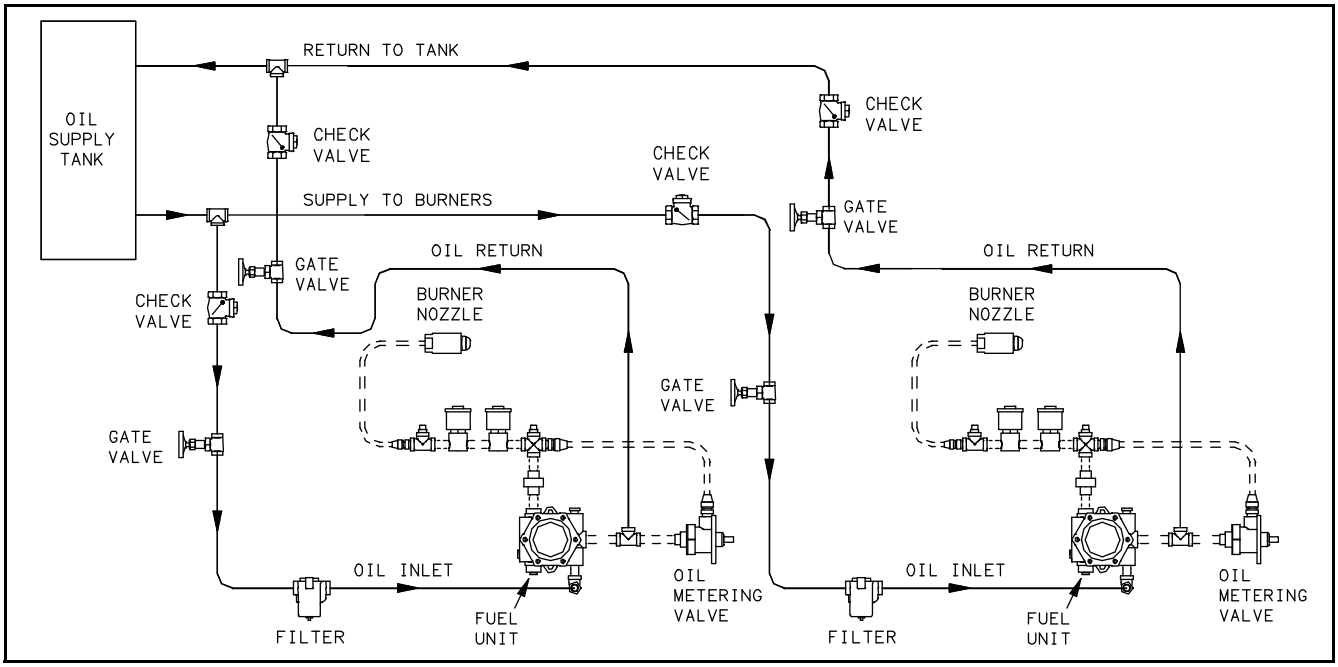


Figure 2-9: Multiple Burners with Separate Suction Lines

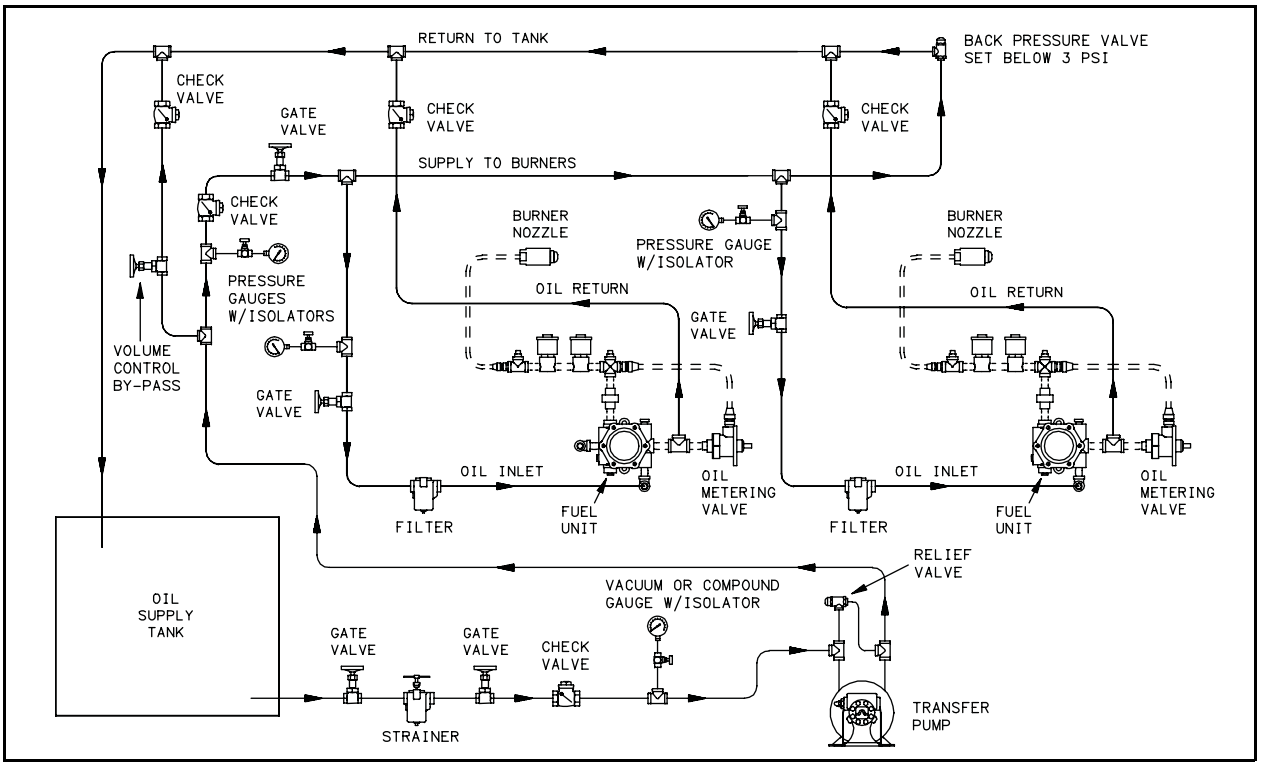


Figure 2-10: Typical Oil Loop for Multiple Burners with Transfer Pump

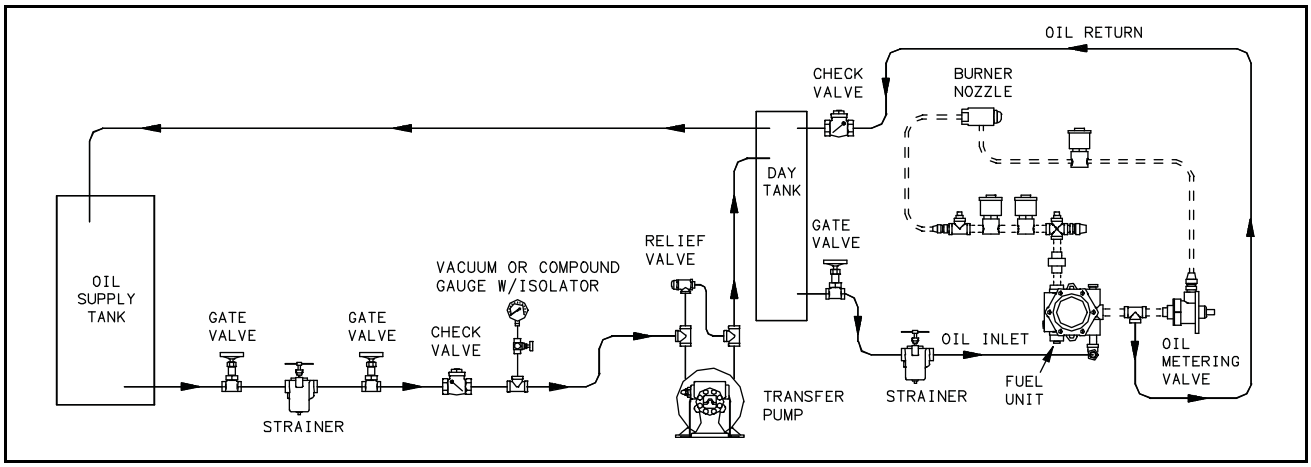


Figure 2-11: Typical Installation Using Day Tank

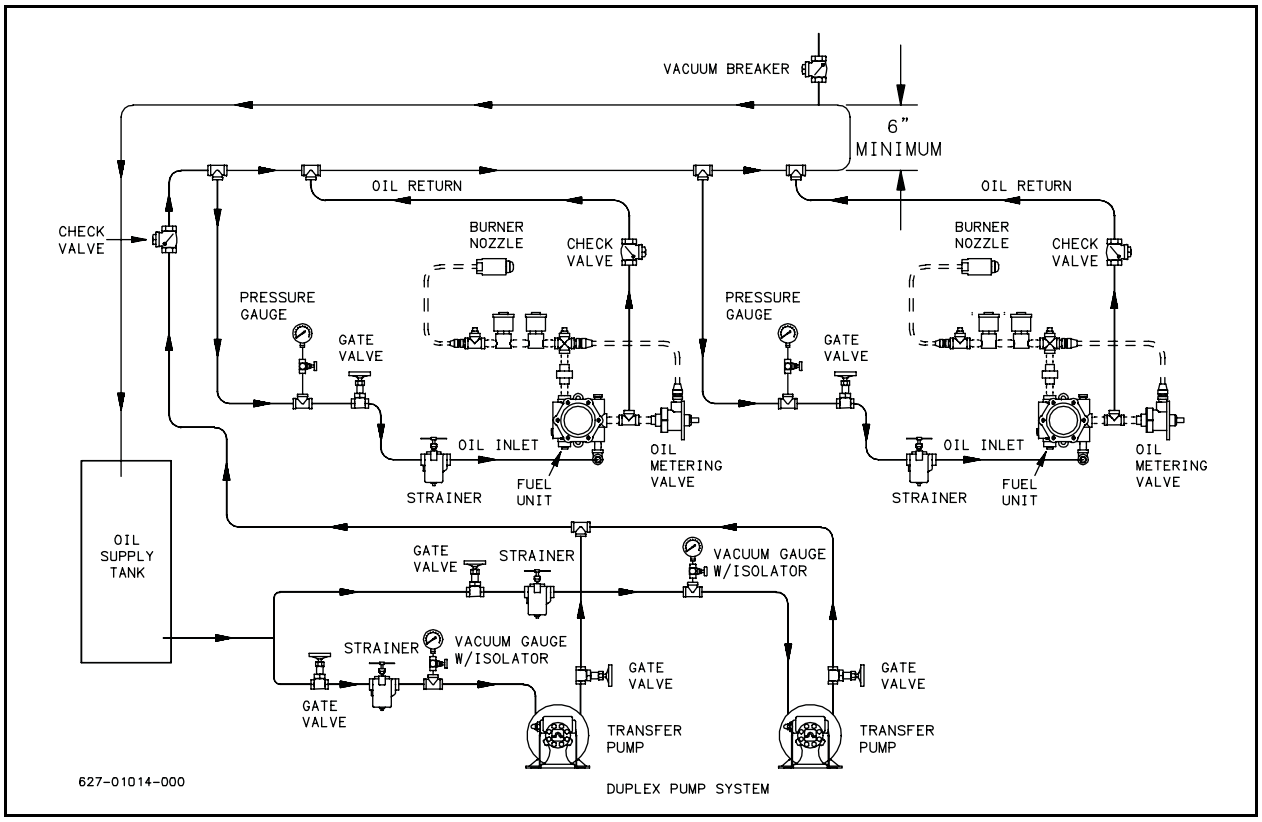


Figure 2-12: Typical Flooded Loop System

GAS PIPING

Refer to Figures 2-5 through 2-6 for typical gas piping arrangements. Normally, the control train is ordered to suit a particular code or insurance regulation, such as UL/cUL, FM, or GAP. Gas service and house piping must supply the quantity of gas demanded by the unit at the pressure required at the burner gas train inlet.

All piping must be in strict accordance with applicable codes, ordinances, and regulations of the supplying utility. In the absence of other codes, piping should be in accordance with National Fuel Gas Code, NFPA No. 54, ANSI No. Z223-1.

Gas train components upstream of the butterfly valve are shipped loose. These components should be mounted by the installer as close to the butterfly valve as practical. If a pre-piped and wired gas train is ordered, the components upstream of the first safety shutoff valve are shipped loose. These components should also be mounted by the installer.

Arrange gas piping at the burner so that the burner is accessible for servicing without disassembly.The pilot gas train is supplied with the burner, and is factory installed. The gas pilot supply line must be connected upstream of the main gas regulator. If a reducing bushing is required between the house piping and the burner piping, it should be close to the burner shutoff valve.

The gas piping must be internally clean and free of foreign material. Before using in service, a leak test must be performed.

INSTALLATION CHECKLIST

1. All burners are carefully assembled and tested at the factory, but before being placed in service all connectors should again be checked for looseness caused during shipment.

   Check:

   a. Electrical terminals in the control panel and on all electrical components.
   b. Pipe fittings and unions.
   c. Tubing connections.
   d. Nuts, bolts, screws.

2. Open all necessary oil shutoff valves. Do not run pumps or fuel unit without oil.
3. Before connecting electrical current to any component, be sure the voltage is the same as that specified on component nameplates.
4. Before burner operation, be sure all motors are rotating in the proper direction.
5. Before firing, make sure the burner firing head and dry areas of the boiler are protected with refractory. The burner mounting flange must be properly sealed against the vessel front plate.
6. Make certain that the operator in charge is properly instructed in operation and maintenance procedures.

⚠ CAUTION

BEFORE OPENING THE MANUAL GAS SHUTOFF VALVES, READ THE REGULATOR INSTRUCTIONS CAREFULLY. THE INSTRUCTIONS ARE IN THE REGULATOR BOX. FOLLOW THE MANUFACTURER RECOMMENDATIONS. OPEN SHUTOFF VALVE ON THE INLET SIDE OF THE REGULATOR SLOWLY AND CAREFULLY TO ALLOW INLET PRESSURE TO BUILD UP SLOWLY IN THE REGULATOR UNTIL IT IS FULLY PRESSURIZED. OPEJNING THE SHUTOFF VALVE QUICKLY WILL DAMAGE THE REGULATOR. DO NOT EXCEED THE REGULATOR PRESSURE RATINGS.

V BURNER FIRING MODES

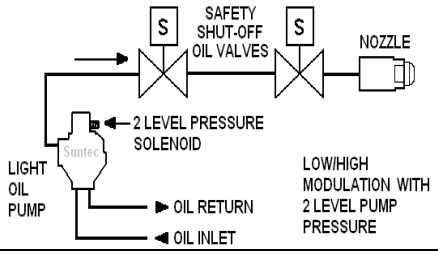
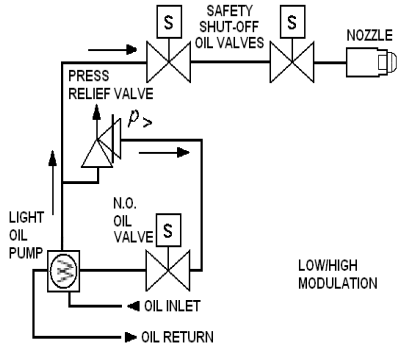
Different modulation modes are available with the Profire V burner. The Model FLX will utilize one of the following:

Low - High -Low (60% damper purge).

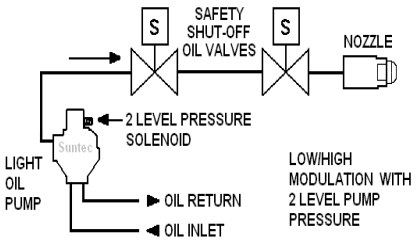
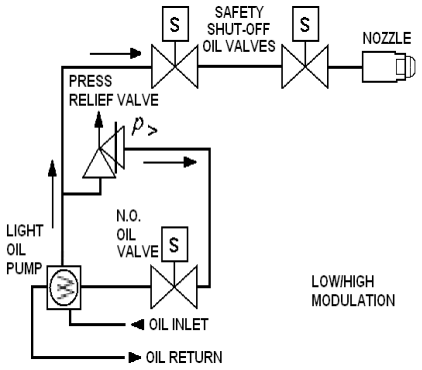
Low - High -Low (open damper purge).

Full Modulation (open damper purge).

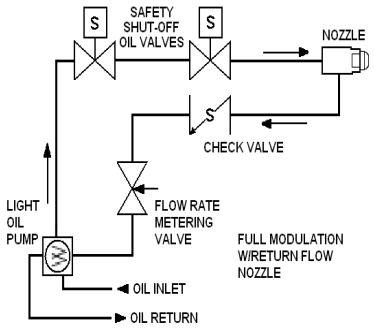
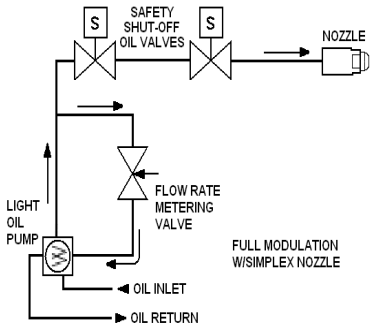
See following pages for operating descriptions of each firing mode.

LOW-HIGH-LOW MOD - LOW or 60% DAMPER PURGE				
		Combustion Air	**Gas**	**Oil**
COMPONENTS DESCRIPTION:		A two blade damper is controlled by a two position, spring return actuator with mechanical linkage. For 60% damper purge a mechanical stop is provided on the damper to ensure sufficient air flow is provided during prepurge. Power to drive the actuator is routed through a low/auto switch and a remote located modulating control. The actuator also contains a limit switch which is used to actuate the second stage of the oil supply system. (see oil at right).	Safety shut off valve(s) are provided to initiate the flow of gas. The primary is a diaphragm or motorized type valve which have delayed opening rates to prevent an "in rush" of gas. A butterfly type gas metering valve is linked directly to the damper actuator and provides gas flow metering during the drive to the high position. A manually adjusted gas regulator limits maximum firing rate.	**Pressure Atomization:** Two solenoid type safety shut off oil valves initiate the flow of oil from the high pressure pump to the nozzle. The oil pump has a built in solenoid controlled two level pressure regulating system. Low and high flow rates are set on the pump based on pressure and the nozzle's flow rating. 
Operating Sequence	**PRE-PURGE:**	Damper is in its closed or low fire position. For 60% damper purge this would be against the mechanical stop.	Valves are closed.	The pump is operational but the valves are closed. Oil is flowing through an internal relief valve and returning to the supply system.
	STARTUP, IGNITION:	Damper remains in its low fire starting position.	Valves open. To prevent a surge the primary gas valve opens at a slowed rate. Gas flow to the manifold is metered based on the butterfly valves low fire setting.	Safety shut off valves open allowing oil to flow from pump to nozzle. Oil pressure at the nozzle is based on the pump's low pressure setting. Excess oil is flowing through an internal relief valve and returning to the supply system.
	RUN, MODULATE:	Damper is driven open in 30 seconds by the two position actuator. Low-High-Low burners will modulate from the low to high rate positions based on the signal from the modulating control and the selection of the low/auto switch.	The gas valves remain in their open position. The actuator begins it's travel to the high fire position opening the gas metering valve. The burner will then modulate from low to high as described in the combustion air column.	The safety shut-off oil valves remain open. The pump's solenoid is energized by the auxiliary switch within the damper actuator as it opens the air damper. Oil pressure is then increased based the pumps high pressure setting. The burner will then modulate from low to high as described in the combustion air column.
	SHUT DOWN, POST-PURGE:	Damper returns to its start position based on the 25 second closure speed of the mechanical actuator.	On shut down all gas valves close within 1 second. The butterfly valve closes in 25 seconds with the two position actuator.	All valves immediately return to their startup or de-energized position. The oil pump is operating with post-purge, but oil is flowing through an internal relief valve and returning to the supply system.
VARIATIONS:		None	None	For pumps without the internal dual pressure solenoid an external pressure relief valve and normally open solenoid valve are used. 

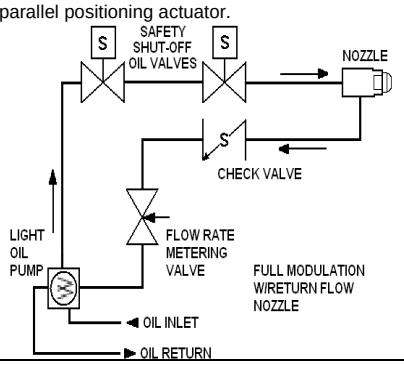
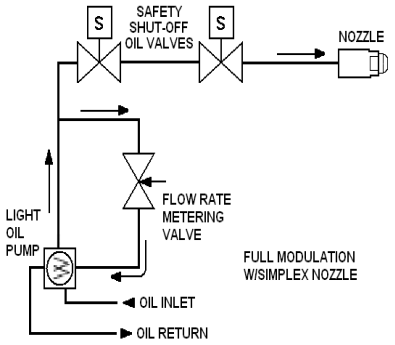
LOW-HIGH-LOW MOD - OPEN DAMPER PURGE

		Combustion Air	Gas	Oil
COMPONENTS DESCRIPTION		A two blade damper is controlled by a two position, spring return actuator with mechanical linkage. Power to drive the actuator is routed through a low/auto switch and a remote located modulating control. The actuator also contains a limit switch which is used to actuate the second stage of the oil supply system. (see oil at right) A second external switch ensures the damper has returned to the low fire position before ignition is initiated.	Safety shut off valve(s) are provided to initiate the flow of gas. The primary is a diaphragm or motorized type valve which have delayed opening rates to prevent an "in rush" of gas. A butterfly type gas metering valve is linked directly to the damper actuator and provides gas flow metering during the drive to the high position. A manually adjusted gas regulator limits maximum firing rate.	**Pressure Atomization:** Two solenoid type safety shut off oil valves initiate the flow of oil from the high pressure pump to the nozzle. The oil pump has a built in solenoid controlled two level pressure regulating system. Low and high flow rates are set on the pump based on pressure and the nozzle's flow rating. 
Operating Sequence	**PRE-PURGE**	From its closed position the damper is driven open by the flame safeguard control where it remains for the duration of the pre-purge cycle.	Valves are closed.	The pump is operational but the valves are closed. Oil is flowing through an internal relief valve and returning to the supply system.
	STARTUP, IGNITION	Damper returns to the low fire position which is proven through the external switch. The burner is now ready for startup.	Valves open. To prevent a surge the primary gas valve opens at a slowed rate. Gas flow to the manifold is metered based on the butterfly valves low fire setting.	Safety shut off valves open allowing oil to flow from pump to nozzle. Oil pressure at the nozzle is based on the pump's low pressure setting. Excess oil is flowing through an internal relief valve and returning to the supply system.
	RUN, MODULATE	Damper is driven open in 30 seconds by the two position actuator. Low-High-Low burners will modulate from low to high rate positions based on the signal from the modulating control and the selection of the low/auto switch.	The gas valves remain in their open position. The actuator begins its travel to the high fire position opening the gas metering valve. The burner will modulate from low to high as described in the combustion air column.	The safety shut-off oil valves remain open. The pump's solenoid is energized by the aux switch within the damper actuator as it opens the air damper. Oil pressure is then increased based the pump's high pressure setting. The actuator begins its travel to the high fire position opening the gas metering valve. The burner will modulate from low to high as described in the combustion air column.
	SHUT DOWN, POST-PURGE	Damper returns to its start position based on the 25 second closure speed of the mechanical actuator.	On shut down all gas valves close within 1 second. The butterfly valve closes in 25 seconds with the two position actuator.	All valves immediately return to their startup or de-energized position. The oil pump is operating with post-purge, but oil is flowing through an internal relief valve and returning to the supply system.
VARIATIONS		None	None	For pumps without the internal dual pressure solenoid an external pressure relief valve and normally open solenoid valve are used. 

FULL MODULATION - OPEN DAMPER PURGE

		Combustion Air	Gas	Oil
COMPONENTS DESCRIPTION		A two blade damper is controlled by a proportional modulating actuator (or motor) with mechanical linkage. The modulating actuator is capable of stopping at any point along its 90 degree stroke based on a signal from a remotely connected modulating control or from a burner mounted manual potentiometer which is selected through an auto/manual modulation selector switch. The actuator also contains two internal switches that ensure the damper reach the high fire and low fire positions during purge and before ignition is initiated.	Safety shut off valve(s) are provided to initiate the flow of gas. The primary is a diaphragm or motorized type valve which have delayed opening rates to prevent an "in rush" of gas. A butterfly type gas metering valve is linked directly to the damper actuator and provides gas flow metering relative to the actuator position. A manually adjusted gas regulator limits maximum firing rate.	**Pressure Atomization:** Two solenoid type safety shut off oil valves initiate the flow of oil from the high pressure pump to a return flow nozzle. In the return line from the nozzle an adjustable oil metering valve limits the amount of oil allowed to return to the pump. The metering valve is connected to the damper actuator with mechanical linkage. 
Operating Sequence	**PRE-PURGE**	From its closed position the damper is driven open by a signal from the flame safeguard control where the high fire air switch is proven. The damper will remain open for the duration of the pre-purge cycle.	Valves are closed.	The pump is operational but the valves are closed. Oil is flowing through an internal relief valve and returning to the supply system.
	STARTUP, IGNITION	Damper returns to the low fire position which is proven through the internal low fire air proving switch. The burner is now ready for startup.	Valves open. To prevent a surge the primary gas valve opens at a slowed rate. Gas flow to the manifold is metered based on the butterfly valve low fire setting.	Safety shut off valves open allowing oil to flow from pump to nozzle. Oil pressure at the nozzle is based on the pump's pressure setting less the volume of oil returning through the metering valve.
	RUN, MODULATE	Damper is driven by the modulating actuator to a firing rate position as determined by the modulating control or manual potentiometer. Actuator can complete full travel to high fire in 30 seconds. Actuator will then continue to adjust firing rate position based on signals from the modulating control until demand is satisfied.	The gas valves remain in their open position. As the actuator begins it's travel to the firing rate position it is also adjusting the butterfly gas metering valve increasing the flow of gas to the manifold. The burner will continue to modulate as described under the combustion air heading until demand is satisfied.	The safety shut-off oil valves remain open. As the actuator begins it's travel to the firing rate position it is also adjusting the oil metering valve decreasing the amount of oil allowed to return to the pump. This in turn is increasing the pressure and volume of oil at the nozzle. The burner will continue to modulate as described under the combustion air heading until demand is satisfied.
	SHUT DOWN, POST-PURGE	Damper returns to its starting position based on the 30 second closure speed of the mechanical actuator during post purge.	On shut down all gas valves close within 1 second. The butterfly valve closes in 30 seconds with the damper actuator.	All valves immediately close. The metering valve opens to it's low fire position in 30 seconds with the damper actuator. The oil pump is operating with post-purge, but oil is flowing through an internal relief valve and returning to the supply system.
VARIATIONS:		Options are available for 4-20amp modulating signal conversion or 4-20 proportional modulating actuators. Also optional is an actuator with dual low fire start switch positions for improved "turn down" in dual fuel situations.	None	On models with a simplex nozzle oil is diverted from the supply line through the meter and back to the pump before the first safety shut-off valve. 

PARALLEL POSITIONING

		Combustion Air	Gas	Oil
COMPONENTS DESCRIPTION		A two bladed damper is controlled by an independent parallel positioning actuator. The remote mounted modulating control	Safety shut off valve(s) are provided to initiate the flow of gas. The primary is a diaphragm or motorized type valve which have delayed opening rates to prevent an "in rush" of gas. A butterfly type gas metering valve is directly coupled to a parallel positioning actuator. A manually adjusted gas regulator limits maximum firing rate.	**Pressure Atomization:** Two solenoid type safety shut off oil valves initiate the flow of oil from the high pressure pump to a return flow nozzle. In the return line from the nozzle is an adjustable oil metering valve which limits the amount of oil allowed to return to the pump. The metering valve is direct coupled to a parallel positioning actuator. 
Operating Sequence	**PRE-PURGE**	From its closed position the damper is driven open by a signal from the parallel positioning control. The damper will remain open for the duration of the pre-purge cycle.	Valves are closed.	The pump is operational but the valves are closed. Oil is flowing through an internal relief valve and returning to the supply system.
	STARTUP, IGNITION	Damper returns to the low fire position in preparation for startup.	Valves open. To prevent a surge the primary gas valve opens at a slowed rate. Gas flow to the manifold is metered based on the butterfly valves low fire setting.	Safety shut off valves open allowing oil to flow from pump to nozzle. Oil pressure at the nozzle is based on the pump's pressure setting less the volume of oil returning through the metering valve.
	RUN, MODULATE	Damper is driven by its parallel positioning actuator to a firing rate position as determined by the parallel positioning control. The actuator and parallel positioning control will then continue to adjust the damper and fuel actuators position based on signals from remote sensors until demand is satisfied.	The gas valves remain in their open position. The metering valve and actuator increases the flow of gas to the manifold in conjunction with the opening damper however, position adjustments are made based on the fuel "curve" stored in the parallel positioning control's memory. The burner will continue to modulate as described under the combustion air heading until demand is satisfied.	The safety shut-off oil valves remain open. The metering valve and actuator decreases the flow of oil returning to the pump in conjunction with the opening damper however, position adjustments are made based on the fuel "curve" stored in the parallel positioning control's memory. This in turn is increases the pressure and volume of oil at the nozzle. The burner will continue to modulate as described under the combustion air heading until demand is satisfied.
	SHUT DOWN, POST-PURGE	Damper returns to its closed position during or following post purge.	On shut down all gas valves close within 1 second. The butterfly valve returns to it's starting position..	All valves immediately close. The metering valve opens to it's low fire position. The oil pump is operating with post-purge, but oil is flowing through an internal relief valve and returning to the supply system.
VARIATIONS		IC offers several parallel positioning systems. Consult the factory for types and options.	None	On models with a simplex nozzle oil is diverted from the supply line through the meter and back to the pump before the first safety shut-off valve. 

F. Startup and Operation

When the installation is complete and all electrical, fuel, water, and vent stack connections are made, make certain the connections are tight. The operator should become familiar with the burner, boiler controls and components. Adjustment procedures should be reviewed prior to firing. The wiring diagram should also be studied along with the operating sequence of the burner programmer. Check the electrical power supply for accordance with the nameplate specifications for all motors and controls.

Read and understand starting instructions before attempting to operate the burner. The following checks must be made:

BOILER

Check boiler water level. Be sure all boiler valves are installed correctly and positioned properly. Set the high limit control slightly above the operating control. Set operating control at the desired temperature or pressure.

BURNER

For protection in shipment, the flame safeguard control chassis is shipped unmounted. Check all screw connections before attaching flame safeguard chassis to base. The screw must be secure to assure low resistance connections. The relay chassis is mounted on the subbase with a screw which, when tightened, completes the connection between the subbase and chassis contacts. Press manual reset button to be sure safety switch contacts are closed.

Check fuses in main panel and in the burner control cabinet. Check wiring to the burner control cabinet for compliance with the wiring diagram and local codes. The control cabinet components are 120 volt. If a control transformer is supplied, ensure that the supply voltage matches its primary voltage.

Check motor rotation by momentarily closing the starter or relay. Blower rotation is clockwise when viewed from the drive end.

Check the pilot electrode setting.

Check control linkage for proper movement of the air volume damper and fuel metering components. This can be done by loosening the linkage at the actuator lever and manipulating by hand.

Check the air shutter and adjust low-fire setting.

FIRING PREPARATIONS

Check to make certain that all plugs, connections. linkages, etc., are tight. Prior to initial firing, oil flow and pressure should be verified.

Gas Burners

A representative of the gas utility should turn on the gas. Determine by a test gauge upstream of the burner regulator that sufficient pressure exists at the entrance to the gas train. The gas pressure regulator must be adjusted to the pressure required and the pressure setting recorded.

On combination fuel models, set the selector switch to gas. On initial startup it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through pre-purge and pilot sequences to determine that the main gas valve opens. Turn the burner switch OFF and let the programmer finish its cycle. Check to see that the gas valve closes tightly.

On burners equipped with high and low gas pressure switches, set switch pressure actuating levels and record settings for future service reference.

See the burner specification nameplate inside the control panel door for minimum and maximum input rate and required manifold pressure.

When the conditions covered above and in Section 2 are assured, the burner is ready for firing. Refer to Section E for starting and operating information.

Oil Burners

Prior to initial firing, oil flow and pressure should be verified. If the burner is a dual fuel model, make certain that the main gas shutoff cock is closed and the fuel selector switch is set to OIL.

If the oil supply tank is below the level of the oil fuel unit, it is recommended that the suction line be primed with oil prior to starting the pump to avoid the possibility of damage to the pump through operation without lubrication.

To check for proper pump rotation, momentarily energize the starter. With rotation verified, operate the pump to determine that oil circulation exists. Observe the oil burner pressure gauge. If not pressure shows after a few moments, stop the oil pump and re-prime. If the supply tank is lower than the pump, it is possible that the initial priming of the suction line, followed by operation of the pump, will not establish oil flow. This might be caused by obstruction in the suction line, excessive lift, inadequate priming, suction line leaks, etc. Until oil flow is established, avoid prolonged operation of the pump. If oil flow is not established after a second priming, investigation is required.

A vacuum (or compound pressure-vacuum) gauge should be installed at the suction port of the pump. It is advisable that the reading be less than 15" Hg vacuum. Vacuum in excess of this may cause unstable firing.

If the vacuum gauge reads higher than calculated, look for restriction in the suction line, a closed valved, kinked copper tubing, plugged filter, sticking check valve, frozen oil line, undersized oil line, or excessive lift.

When there is a positive head of oil at the fuel unit, either from a gravity or by pump circulation, the pressure must not exceed 3 psi at the fuel unit suction inlet. Special pressure regulating valves are available for suction pressure above 3 psi. The fuel unit discharge pressure should be set at 300 psi.

BURNER SETTINGS

To ensure reliable and safe burner performance, the location and gap setting of the electrode for direct spark igniters, and the relative positions of the burner nozzle, diffuser, and air baffle components must be correctly set. The air damper blades must be adjusted, relative to the established flow rates to provide the correct amount of air for complete efficient combustion.

These items are preset at the factory, but must be checked prior to placing the burner into initial service, or after conducting any service work that may have altered their position.

Fuel and air flow rates are individually adjusted at low-fire and at high-fire to achieve rated heat input, firing rate turndown, optimum efficiency, safe operation, and the ability to cope with environmental changes (including air temperature, humidity, barometric pressure), and fuel property changes. Refer to the nameplate inside the control panel for minimum and maximum fuel input ratings.

TEST EQUIPMENT

The following test equipment should be on site:

- Combustion analyzer with O2 indication.
- U-Tube manometer, or pressure gauge, to measure gas pressures (main and pilot), pressures and vacuum gauge for the oil burners.
- Inclined manometer to measure draft pressures.
- Smoke spot tester for oil burners and CO analyzer for gas fired units.
- Voltmeter/Ammeter.
- Stack Thermometer and Thermocouples

⚠WARNING

TO PREVENT POSSIBLE SERIOUS INJURY OR DEATH, READ THE FLAME SAFEGUARD MANUAL AND FULLY UNDERSTAND ITS CONTENT BEFORE ATTEMPTING TO OPERATE THIS EQUIPMENT.

⚠WARNING

SHOULD A STARTING FAILURE OCCUR FOR ANY REASON, COMBUSTIBLE FUMES MAY FILL THE COMBUSTION CHAMBER. NEVER ATTEMPT TO RE-LIGHT THE BURNER UNDER THESE CONDITIONS WITHOUT PURGING THE CHAMBER.

ELECTRICAL INTERFERENCE TEST

Prior to putting the burner into service, conduct the following test to ascertain that ignition spark will not cause the flame relay to pull in.

Gas Fired

Close the pilot and main line manual gas valves. Start the burner and at time of pilot trial with just the electrical ignition system energized. The flame relay should not pull in (should not be energized).

Upon completion of successful test, proceed with startup procedures.

Oil Fired

Disconnect the electrical power to the burner. Disconnect the electric oil safety shutoff valve. Reconnect electric power. Close the pilot line manual gas valve, if used.

Start burner and at the time of pilot trial, with just the electrical ignition system energized. The flame relay should not pull in.

Upon completion of successful test, disconnect power supply. Reconnect oil safety shutoff valve and turn on manual pilot gas valve. Reconnect power supply and proceed with startup procedures.

BURNER IGNITION ADJUSTMENT

Gas Pilot Flame Adjustment

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 4” to 6” W.C. when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame.

Although it is possible to visibly adjust the size of the pilot flame, obtain a proper DC volt or microamp reading of the flame signal. The flame safeguard amplifier has a meter jack for this purpose. At initial startup and during planned maintenance, test the pilot flame signal, pilot turndown and safety switch lockout.

Gas Pilot Turndown Test

For burners equipped with a gas pilot, conduct the following test:

1. Turn the burner switch “ON”. This will start the blower motor and initiate the pre-purge sequence. Makesure a pressure gauge 0” to 10” W.C. or a manometer is installed in the pilot line to monitor the pilot gaspressure.
2. When the pilot comes on, put the programmer timer on pilot hold by placing the “RUN-TEST” switch onthe flame safeguard to the “TEST” position.
3. Check the flame signal strength. Adjust the flame signal by increasing or decreasing pilot gas pressurewith the reg-

ulator spring. Normal setting is 4" to 6" W.C.

4. Perform a pilot turndown test by reducing the pilot pressure very slowly until the scanner looses sight ofthe flame and gives a flame lockout, then reset the adjustment to normal level. Note the minimumpressure level.
5. After adjusting the pressure back to normal level, set the programmer to the "RUN" position. Main flamewill come on and the burner is in the low-fire position.
6. Start and stop the burner several times to ensure proper pilot setting.

STARTUP SEQUENCE

The programming control sequences the operation of all controls and components through the starting, ignition, firing, and shutdown cycle. The burner and control system are in starting condition when:

- The operating and high limit control (temperature or pressure) are below their cutoff settings
- All power supply switches are closed.
- Power is present at the control panel.

Refer to the controls literature and burner wiring diagrams for detailed information.

1. Begin starting sequence, with burner switch off, and with all manual valves closed. Switch main power on.
2. When firing oil, open the manual oil valves.
3. When firing on gas, open the main manual gas valve.
4. When firing on gas, manually reset the high and low gas pressure switches (if applicable).
5. Place the gas-oil selector switch (if applicable) in position for the desired fuel. With all limit and operating controls calling for heat, the burner will follow the flame safeguard sequence.
6. When the burner motor starts, open the gas cock.
7. If firing on gas, when the main fuel lamp lights indicating pilot flame proven, slowly open the second shutoff cock downstream of the main gas valve(s).

AUTOMATIC SHUTDOWN

Limit or operating controls open:

1. Fuel valves close. Main fuel lamp goes off. Flame safeguard timer starts.
2. Flame safeguard timer and burner motor stop. Burner is ready for startup on the next call for heat.

MANUAL SHUTDOWN

1. Turn selector switch to the off position. The burner shuts down in Automatic Shutdown as above.
2. When the burner motor stops, close all manual valves.

SAFETY SHUTDOWN

If at any time during the operating cycle a flame failure occurs, the burner shuts down as in Automatic Shutdown, with an additional post-purge, and the flame failure lamp is energized. The lockout switch on the flame safeguard control must be manually reset before the burner will fire again.

If a low water condition occurs, the burner shuts down as in Automatic Shutdown.

If a high or low gas pressure condition occurs while firing on gas, the burner shuts down as in Automatic Shutdown. Condition must be corrected and the respective gas pressure switch manually reset before the burner will fire again on gas.

⚠WARNING

Should a starting failure occur for any reason, combustible fumes may fill the combustion chamber. Never attempt to re-light the burner under these conditions. The combustion chamber must first be purged before re-lighting.

⚠WARNING

Keep fingers away from the combustion air intake below the damper. The damper is actuated with sufficient force to cause severe injury. Always make high and intermediate rate adjustments when the burner has reached low fire position. Do not disturb the low fire setting.

STARTUP AND OPERATING

Gas Burners

A gas valve leak test must be performed on the automatic safety shutoff valves located in the main gas train prior to any initial commissioning or subsequent maintenance of the burner and gas train systems, where automatic valve proving systems interlocked with the main burner safety control are not provided. This test should be performed periodically to ensure no leakage of valves in their closed or de-energized position.

The unit should be taken out of service if the unit fails any of the following tests. Any defective part must be replaced prior to putting the equipment back into service.

⚠WARNING

FAILURE TO FOLLOW THIS PROCEDURE MAY RESULT IN EXPLOSION, FIRE, PROPERTY DAMAGE, AND PERSONAL INJURY. THIS PROCEDURE MUST BE PERFORMED ONLY BY AUTHORIZED AND QUALIFIED PERSONNEL.

1. Close the main and pilot gas cocks.
2. Make sure the ON-OFF switch is in the “OFF” position and the fuel selector switch is turned to “GAS.”
3. Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.
4. Set the MANUAL-AUTO switch in the “MANUAL” position.
5. Set the manual potentiometer in the low fire position.
6. Open the gas pilot cock.
7. Set the ON-OFF switch to “ON.” The burner will start and pre-purge. After pre-purge, the ignitiontransformer and the gas pilot solenoid are energized. Before proceeding, conduct electrical interferenceand pilot turndown tests if not previously done (see Section 3.2).
8. On initial startup it is recommended that the main gas shutoff cock remains closed until the programmerhas cycled through pre-purge and pilot sequence. Then determine that the main gas valve opens. Whenthis is confirmed, turn the burner switch “OFF” and let the programmer finish its cycle.
9. Check to see that the gas valve has closed tightly. If ignition does not occur, turn the burner switch“OFF” and allow the programmer to recycle for a new ignition trial.
10. Turn the burner “ON” and after pilot ignition when the flame relay pulls in, the slow opening, motorized,main gas valve is energized. The main flame should ignite at this time. The gas valve and air dampercontinue advancing until high fire is reached.

11. Do not repeat unsuccessful light off attempts without rechecking burner and pilot adjustment. Vent fuelvapors from the combustion chamber after each unsuccessful light off attempt.
12. Set the gas low fire rate by adjusting the butterfly valve and air linkage.
13. When low fire is adjusted, shut down the burner.
14. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start theburner with fuel vapor in the furnace. In case of an emergency, open the main power switches and closeall fuel valves.
15. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normaloperating pressure or temperature.
16. Turn the potentiometer switch to the high fire position. Check high fire at this point using combustioninstruments.
17. Do not disturb established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate settings.

Do not repeat unsuccessful light off attempts without rechecking burner and pilot adjustment. Vent fuel vapors from the combustion chamber after each unsuccessful light off attempt. Set the gas low fire rate by adjusting the butterfly valve and air linkage. Refer to the adjustment section of this manual. Using the combustion analysis instrument, adjust the low fire. Typical combustion analysis for low fire is 5% to 6% O2 on standard turndown systems, and between 6.5% and 9% for higher turndown systems. Verify the minimum input rate by measuring the gas meter.

When low fire is adjusted, shut down the burner. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start the burner with fuel vapor in the furnace. In case of emergency, open the main power switches and close all fuel valves. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normal operating pressure or temperature.

After the boiler has reached operating temperature or pressure, turn the potentiometer switch in small increments to the high fire position. Check high fire at this point using combustion instruments. High fire combustion analysis typically is 3% to 4% O2. Verify maximum input rate by measuring the gas meter.

Do not disturb established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate setting. CO levels should be less than 400 ppm on an air-free basis at all firing rates, with <50 ppm as the target value.

When conditions covered above are assured, refer to NORMAL OPERATION below.

Oil Burners

1. The fuel selector switch should be set to “OIL” and the “ON-OFF” switch is in the “OFF” position.Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.Set the ON-OFF switch to ON. The burner will start and pre-purge. After pre-purge, the ignition transformer will direct spark. If the flame detector proves the presence of a satisfactory pilot, the programmer will proceed to main flame ignition.
2. Set the “ON-OFF” switch to “ON.” The burner will start and pre-purge. After pre-purge, the ignition transformer will direct spark. If the flame detector proves the presence of a satisfactory pilot, the programmer will proceed to main flame ignition.
3. Make initial air shutter settings for smooth ignition. Do not repeat unsuccessful light off attempts without rechecking burner and pilot adjustment. Vent fuel vapors from the combustion chamber after each unsuccessful light off attempt. Set the oil low fire rate by adjusting the oil return pressure and air linkage. Using the combustion analysis instrument, adjust the low fire. Typical combustion analysis for low fire is 5% to 6% O2.
4. When low fire is adjusted, shut down the burner. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start the burner with fuel vapor in the furnace. In case of emergency, open the main power switches and close all fuel valves. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normal operating pressure or temperature.
5. After the boiler has reached operating temperature or pressure, turn the potentiometer switch in small increments to the high fire position. This will cause the metering valve to close, resulting in an increase in the oil pressure feeding the burner nozzle. In high fire the oil metering valve should be in the fully closed position and the fuel oil pressure should be about 300 psi. Check high fire at this point using combustion instruments. High fire combustion analysis typically is 3.5% to 4% O2. Verify maximum input rate by measuring the oil meter if available or by weighing the oil.

The burner should be set up and maintained to yield smoke spot levels less than a #1 spot (ASTM D2156 Shell-Bacharach Scale) to minimize soot buildup in the boiler.

Do not disturb established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate settings.

When conditions covered above are assured, refer to NORMAL OPERATION below.

Combination Gas-Oil Burners

In general, the combination fueled system is to be started first using oil, because, as a fuel, oil has a greater combustion air requirement than natural gas.

Refer to the Gas Burner or Oil Burner adjustment procedures.

Once the adjustments are set for oil, shut down the burner and restart the adjust the natural gas fuel. DO NOT READJUST THE AIR DAMPERS. The adjustment is made by balancing the fuel input rate against the existing flow of combustion air.

When conditions covered above are assured, refer to NORMAL OPERATION below.

Note: SIZE 1 & 2 COMBINATION GAS/OIL UNITS USE A DIRECT COUPLING FROM THE BLOWER MOTOR TO THE OIL PUMP. WHEN FIRING GAS FOR AN EXTENDED PERIOD OF TIME, THE COUPLING SHOULD BE MANUALLLY REMOVED AND REPLACED ONLY WHEN FIRING OIL. IF THE COUPLING IS LEFT CONNECTED TO THE BLOWER MOTOR, ENSURE THAT THERE IS PROPER OIL CIRCULATION AT ALL TIMES TO AVOID DAMAGE AND SEIZURE OF THE PUMP.

NORMAL OPERATION

Normal operation must be with the MANUAL-AUTO switch selector on AUTO.

In automatic operation, the operating cycle always proceeds sequentially through pre-purge, pilot ignition, main flame ignition, run and post-purge. The length of purge and ignition trial vary according to the type of programmer used.

During the run cycle, burner input is regulated to the load demand by the modulating pressure or temperature control on the boiler. The burner will continue to modulate until the operating pressure or temperature is reached.

Programmer control operation should be tested when the burner is initially placed into service, when a control is replaced, and at scheduled intervals in the maintenance program.

SHUTDOWN

When the operating limit control setting is reached or the burner switch is turned OFF, the following sequence occurs:

1. The fuel valve(s) de-energize and flame extinguishes. The blower motor continues running during post-purge (if so equipped with post-purge feature).
2. At the end of the post-purge the blower motor is de-energized. The programmer returns to its starting position and stops. Unit is ready to restart.

Abnormal shutdown might result from motor overload flame outage, low water, current or fuel supply interruption, combustion or atomizing air pressure below minimum level, tripped circuit breakers, blown fuses, or other interlock devices. Check for cause and correct before restarting burner.

Safety shutdown caused by ignition or flame failure will actuate a red indicator light and energize an audible alarm (if so equipped). If the programmer has a non-recycling interlock circuit, any interruption in this circuit during the pre-purge or firing cycle will cause a safety shutdown. This type of shutdown requires manual reset of the programming control and must be corrected before operation can be resumed.

G. Adjustments

While each burner is tested at the factory for correct operation before shipment, variable conditions such as burning characteristics of the fuel used and operating load conditions may require further adjustment after installation to assure maximum operating efficiency.

Prior to placing the boiler into initial service, a complete inspection should be made of all controls, connecting piping, wiring, and all fastenings such as nuts, bolts, and setscrews to be sure that no damage or misadjustments occurred during shipment and installation.

A combustion efficiency analysis made during the initial startup will help to determine what additional adjustments are required in a particular installation.

COMBUSTION ADJUSTMENT ON OIL AND GAS

Flame appearance alone is not sufficient to judge combustion efficiency, although it may help in making preliminary settings.

The proper settings of air-fuel ratios must be determined by flue gas analysis. Combustion gas analysis indicates the air to fuel ratio and the degree of complete combustion. Instruments are available to measure carbon dioxide (CO_2), oxygen (O_2), and carbon monoxide (CO). At no time should CO_2 measurements alone be used to indicate proper excess air levels. Only O_2 measurement can definitively show whether sufficient air has been provided for combustion.

STACK TEMPERATURE

Net stack temperature is obtained by subtracting the ambient temperature from the flue gas temperature. A high net stack temperature indicates wasted heat. Stack temperature should be as low as possible without causing flue gas condensation.

Stack heat loss can be reduced by decreasing either the temperature or the volume of the flue gas, or both. Flue gas temperature is reduced by improving heat transfer or by reducing excess combustion air. A certain amount of excess air is necessary to complete combustion. More efficient burners require minimum excess air.

SMOKE MEASUREMENT

Smoke measurements can be made using a variety of different methods. The standards will vary somewhat according to the equipment used, and instructions accompanying the instrument should be followed.

Smoky combustion can result from:

- improper air delivery
- insufficient draft
- improper fuel viscosity
- improper fuel-air ratio
- excessive air leaks in the combustion chamber
- improper fuel oil temperature

TEST EQUIPMENT

The following test equipment should be used to set up and adjust the burner correctly:

- Combustion analyzer with O_2 indication.
- U-Tube manometer, or pressure gauge, to measure gas pressures (Main and Pilot), vacuum and pressure gauges for oil.
- Inclined manometer to measure draft pressures.
- Smoke spot tester for oil burners and CO analyzer for gas fired units.
- Voltmeter/Ammeter.
- Stack Thermometer and Thermocouples.

GAS ADJUSTMENTS

Low-fire combustion analysis typically is 6% to 9% O_2 and less than .04% CO (400 ppm). High-fire reading typically is 3% to 5% O_2 and less than .04% CO. The V/Series burners are capable of operating at low excess air and less than 50 ppm CO levels at all firing rates.

FUEL OIL ADJUSTMENTS

Adjust for a “clean fire.” Typically for No. 2 oil, O_2 is 5% to 6% at low-fire and 3.5% to 4.5% at high-fire.

GAS PILOT FLAME ADJUSTMENT

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 4” to 6” W.C. when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame.

To adjust pilot gas pressure, unscrew regulator cap and turn the adjusting screw in or out.

Although it is possible to visibly adjust the size of the pilot flame, obtain a proper DC volt or microamp reading of the flame signal.

The flame safeguard amplifier has a meter jack for this purpose. At initial startup and during planned maintenance, test the pilot flame signal, pilot turndown, and safety switch lockout. Refer to the flame safeguard instruction manual.

Check the pilot electrode setting. The pilot is accessible by loosening the four screws on the side of the firing head and disconnecting the gas line.

⚠WARNING

AN ULTRA-VIOLET FLAME SENSOR ELECRICAL SPARK INTERFERENCE TEST MUST BE PERFORMED AFTER FINAL ADJUSTMENT.

DIRECT SPARK (OIL ONLY) ADJUSTMENT

Oil only burner models VL13 to 55 are equipped with a direct spark ignition. Remove the oil drawer assembly and check electrode settings and nozzle size.

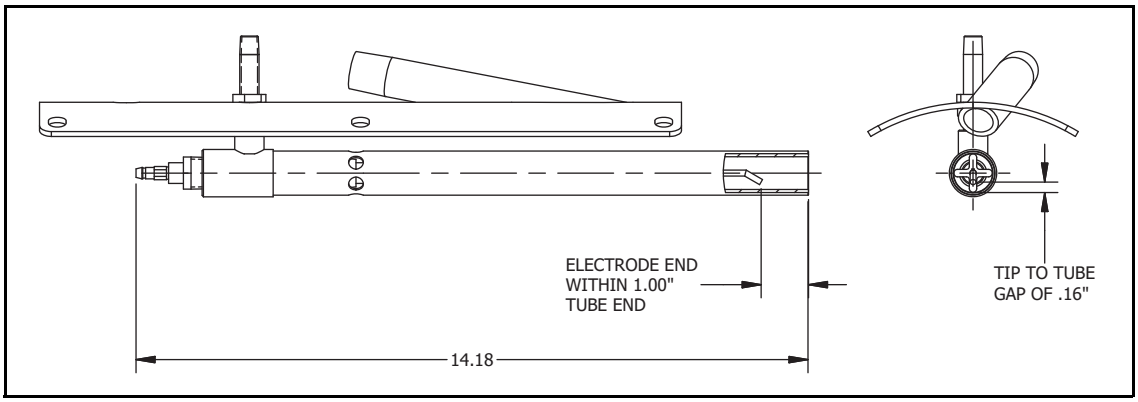


Figure 2-13: Direct Spark Ignition- Oil Only

BURNER PILOT SETTINGS

To ensure reliable and safe burner performance, the location and gap setting of the electrodes, and the relative positions of the burner nozzle, diffuser, and air baffle components must be set correctly. These items are preset at the factory, but must be checked prior to placing the burner into initial service, or after conducting any service work that may have altered their position.

The nozzle/diffuser assembly must be removed from inside the burner to enable measurement and readjustment:

1. Lock out and tag the electrical power supply to the burner to prevent inadvertent operation during checkout or maintenance activities.
2. Disconnect the high voltage power supply from the oil-spark-ignition electrodes (if installed).
3. Disconnect the oil piping from the side of the blast tube.
4. Remove the fasteners that secure the drawer to the side of the burner housing, and remove the complete assembly.

For burners with a gas pilot:

1. Disconnect the pilot line and loosen the locking screws on the pilot access cover located on the side of the blast tube.
2. Disconnect the high voltage ignition cable by pulling it straight back, away from the pilot assembly. The pilot assembly will slide back away from the diffuser.
3. Turn the assembly and retract it through the access hole.
4. Check the electrode position.
5. Re-assemble in reverse order.

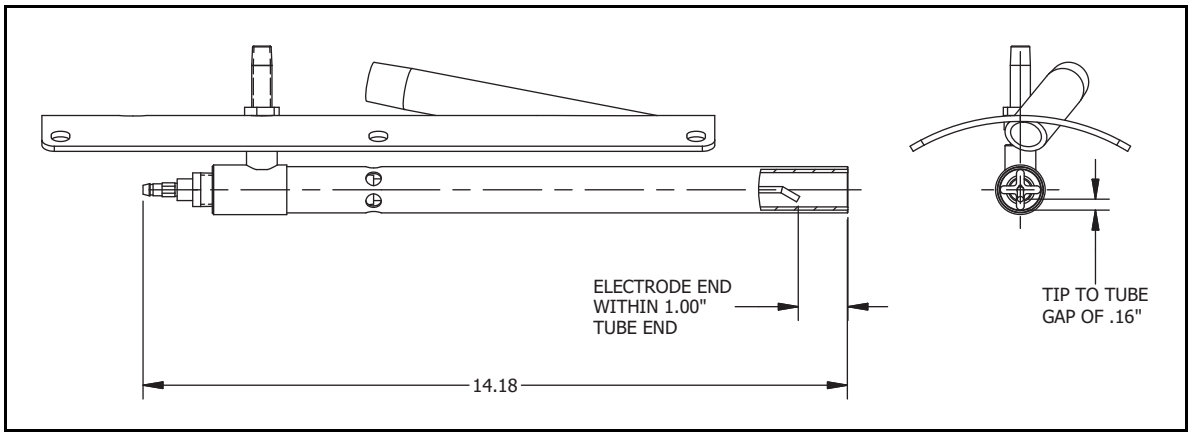


Figure 2-14: Gas Pilot

Measure the position of the tip of the nozzle to the diffuser and compare to the following drawer assembly drawings. To adjust:

1. Loosen the locking screws on the diffuser clamp.
2. Slide the diffuser clamp along the length of the burner pipe until the correct dimension is achieved.
3. Tighten the diffuser clamp securely to the burner pipe. Apply a lock-tight type compound to the screws before tightening.
4. Carefully install the drawer assembly into the burner.
5. Re-connect the oil line and high voltage power cable to the assembly.

Measure the position of the diffuser to the air baffle and compare to the following drawer assembly drawings. To adjust:

1. Measure the distance between the leading edge of the diffuser and the front face of the inner ring on the air baffle assembly.
2. If adjustment is required, loosen the burner pipe locking setscrew located on the rear cap at the top of the fan housing, and slide the burner pipe until the correct dimension is achieved.
3. Tighten the burner pipe locking setscrew securely.

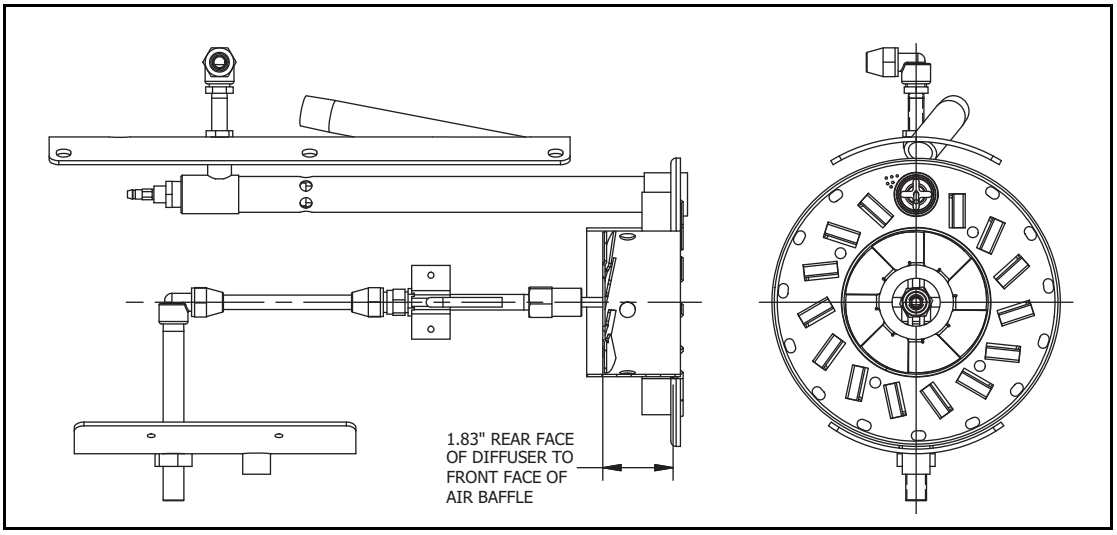


Figure 2-15: Drawer Assembly for (VG) Gas Only (V13-34) - Watertube/

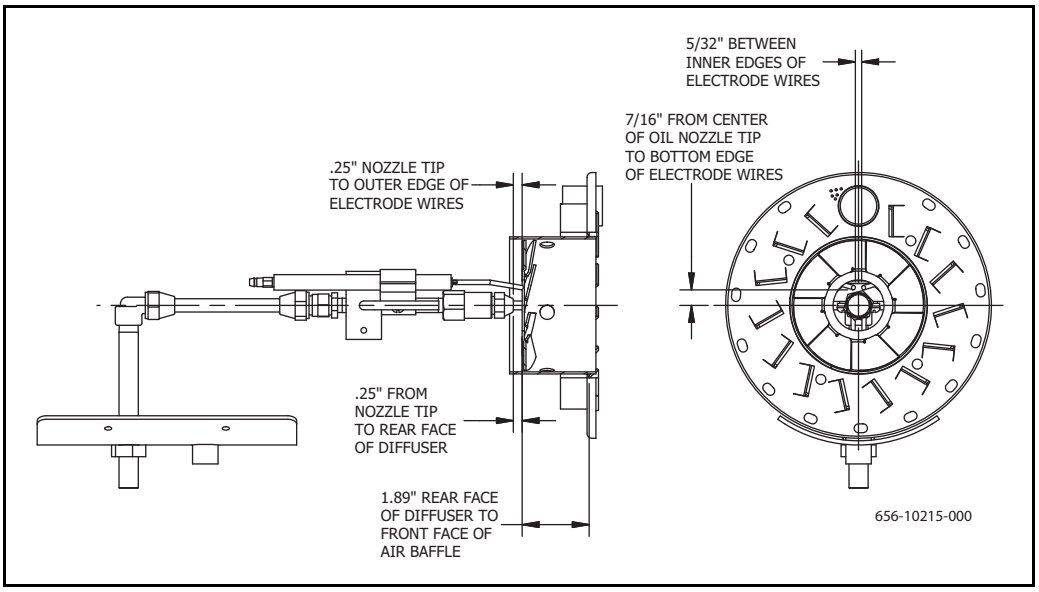


Figure 2-16: Drawer Assembly for (VL) Oil Only (V13-34) - Watertube

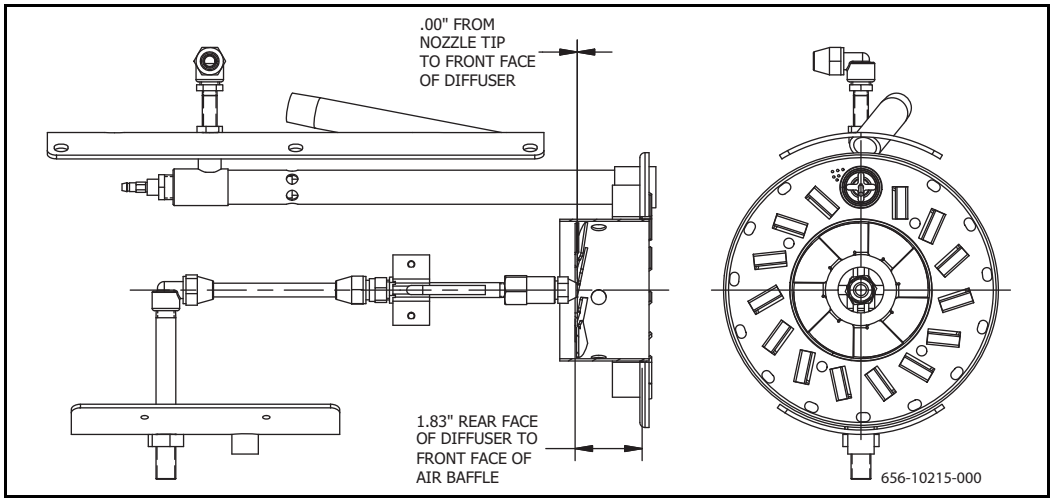


Figure 2-17: Drawer Assembly for (VLG) Gas/Oil (V13-34) - Watertube

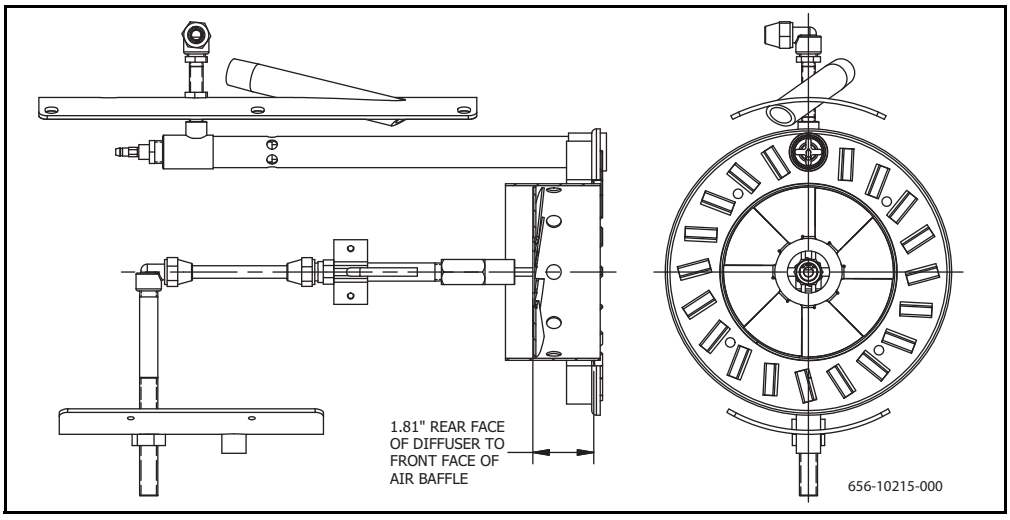


Figure 2-18: Drawer Assembly for (VG) Gas Only (V35-55) - Watertube

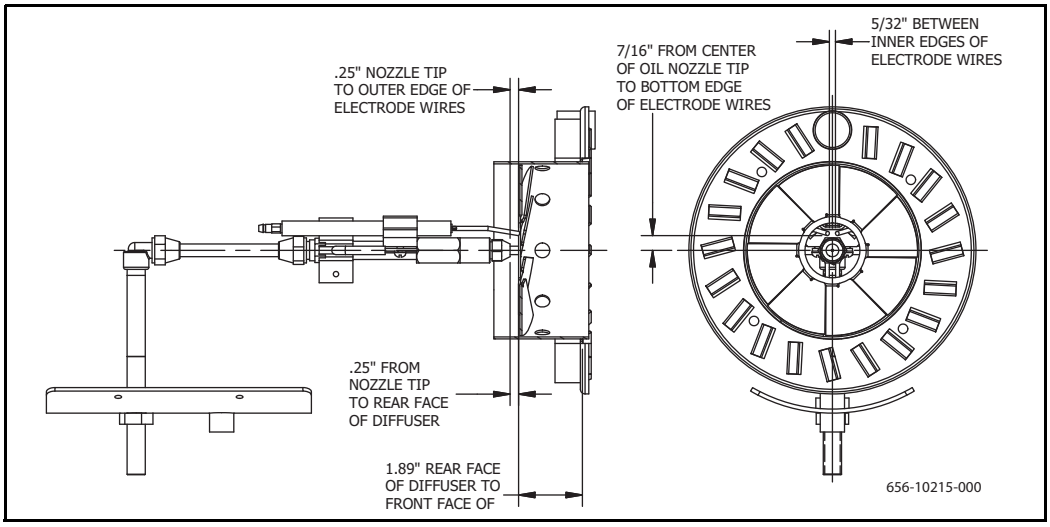


Figure 2-19: Drawer Assembly for (VL) Oil Only (V35-55) - Watertube

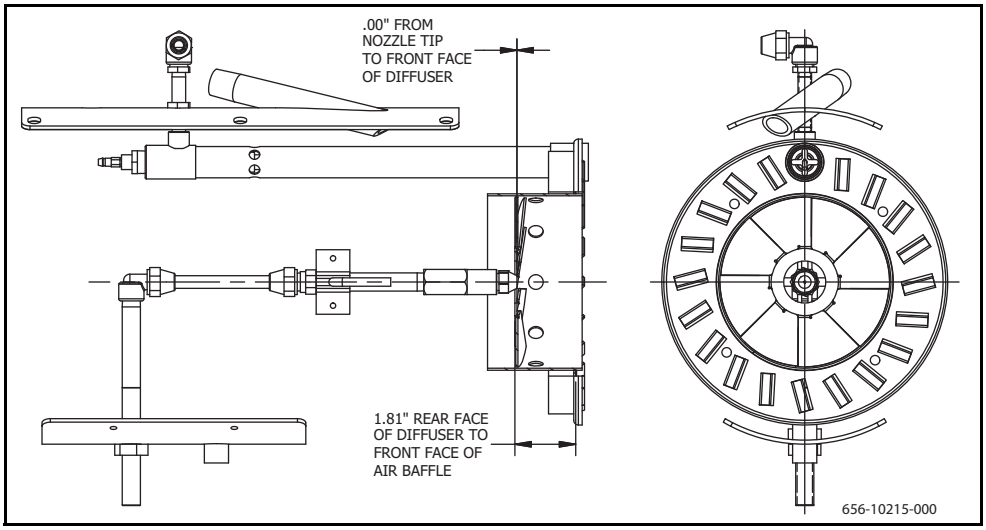


Figure 2-20: Drawer Assembly for (VLG) Gas/Oil (V35-55) - Watertube

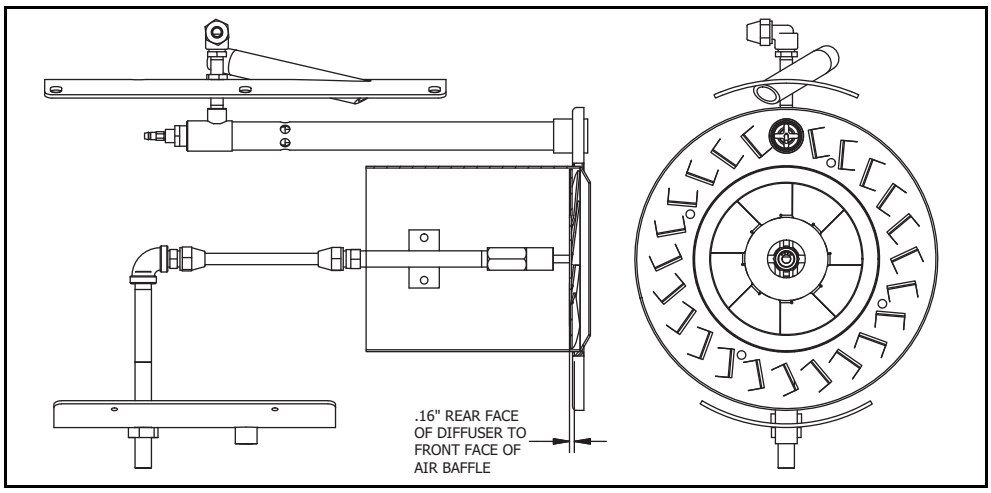


Figure 2-21: Drawer Assembly for (VG) Gas Only (V60-110) - Watertube

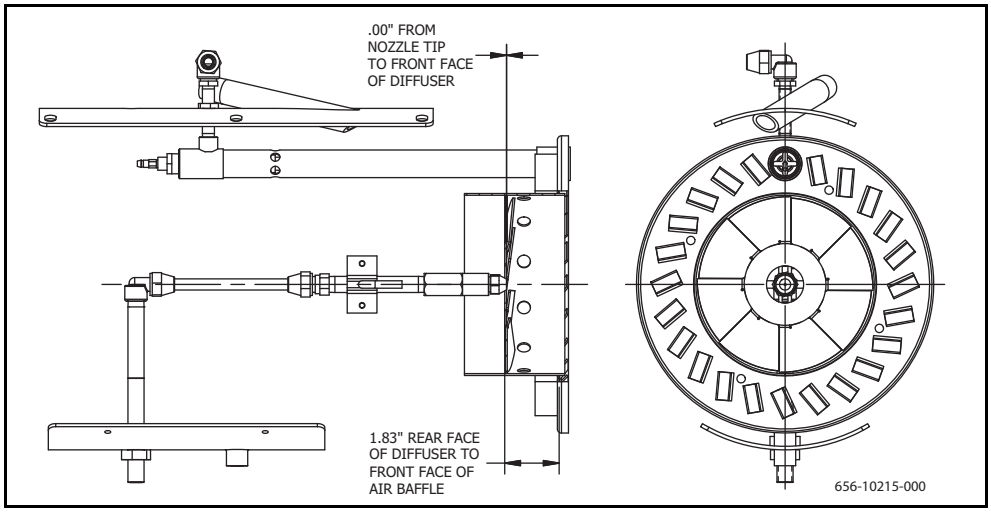


Figure 2-22: Drawer Assembly for (VLG) Gas/Oil (V60-110) - Watertube

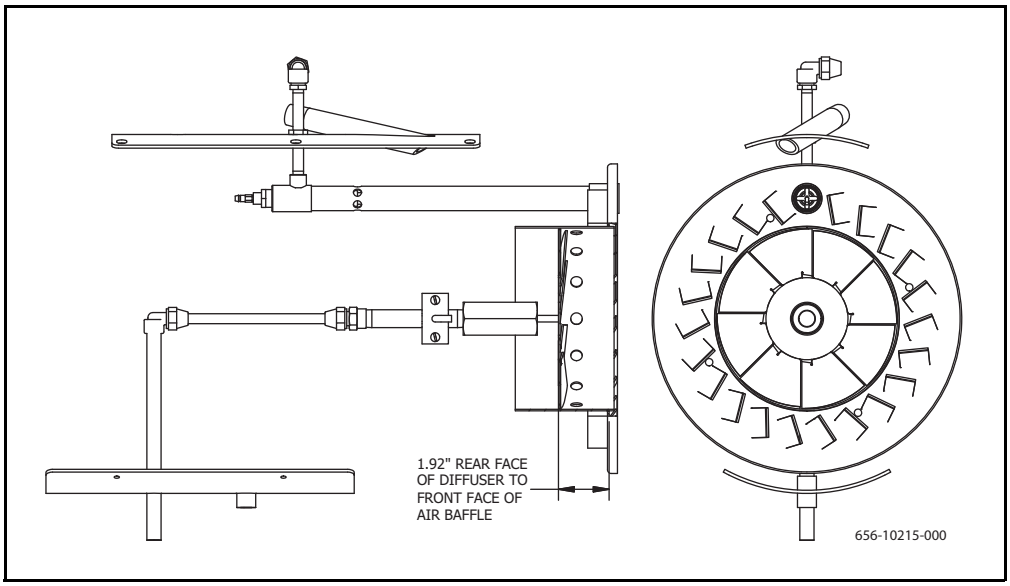


Figure 2-23: Drawer Assembly for (VG) Gas Only (V120-168) - Watertube

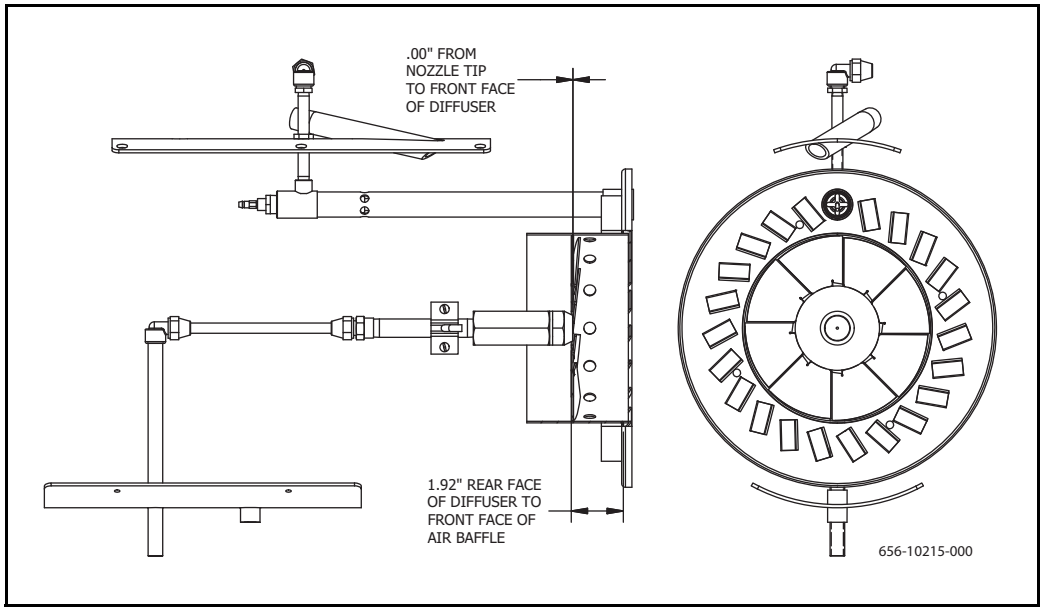


Figure 2-24: Drawer Assembly for (VLG) Gas/Oil (V120-168) - Watertube

H. Gas System Adjustments

Refer to the burner data plate located inside the control panel door. The nameplate will list the following burner information:

- burner and control voltage
- phase
- cycle
- motor amperage
- maximum and minimum fuel input settings
- manifold pressure (at zero furnace pressure - add the furnace pressure to get the correct manifold pressure at maximum firing rate)

These procedures assume that the pre-startup tasks, check list, electrical interference test, and pilot turndown tests have been performed in accordance with the instructions in this manual.

For most efficient combustion, allow the boiler to fully warm up before making adjustments. Refer to the boiler instruction manual for the boiler control settings.

GAS PRESSURE

Gas must be supplied at a pressure high enough to overcome the pressure loss in the burner gas train and furnace pressure while running at full input. Refer to nameplate inside control panel for gas pressure requirements at train inlet and manifold. The pressures listed are based on nominal 1000 Btu/cu ft. natural gas at elevations up to 2000 feet above sea level.

The gas pressure required at the burner manifold is the pressure that is required to fire the burner at its rated capacity. The gas pressure regulator must be adjusted to achieve this pressure to assure full input.

LOW GAS PRESSURE SWITCH

Turn adjusting screw until indicator moves to a pressure setting slightly below the operating gas pressure. The control will break a circuit if pressure is below this set point. The control should be finally adjusted to prevent operation with low gas pressure, but not at a pressure so close to normal operating pressure that unnecessary shutdowns occur. The switch must be manually reset after tripping. To reset, allow gas pressure to rise and press the manual reset button.

HIGH GAS PRESSURE SWITCH

Turn the adjusting screw until the indicator moves to a pressure setting slightly above the maximum operating gas pressure. The control will break a circuit if pressure exceeds this value. The control should be adjusted to prevent operation with excessive gas pressure, but not at a pressure so close to normal operating pressure that unnecessary shutdowns occur. This switch must be manually reset after tripping. To reset, allow gas pressure to drop and press the manual reset button.

GAS FLOW

The volume of gas is measured in cubic feet as determined by a meter reading. The gas flow rate required depends on the heating value (Btu/cu ft). The supplying utility can provide this information as well as pressure

correction factors. To determine the required number of cubic feet per hour of gas, divide burner input (Btu/hr) by the heating value (Btu/cu ft).

NOTE: When checking the input rate, Make sure no other equipment is operating on the same meter.

GAS COMBUSTION ADJUSTMENT

After operating for a sufficient period of time to assure a warm boiler, make adjustments for most efficient combustion.The butterfly gas valve directly controls the rate of flow. The low-fire light-off setting should be regarded as preliminary until proper gas pressure for high-fire operation is established.

Determine the actual gas flow from a meter reading at high-fire. With the butterfly valve open and with regulated gas pressure set, the actual flow rate should be quite close to the required input. If corrections are necessary, increase or decrease the gas pressure by adjusting the gas pressure regulator, following manufacturer's directions for regulator adjustment.

When proper gas flow is obtained, take a flue gas analysis reading.

With the high-fire air-fuel ratio established, the gas pressure regulator needs no further adjusting.

Recheck low-fire and adjust if necessary.

Proper setting of the air-fuel ratios at all rates must be determined by combustion analysis.

NOTE: Check for CO through the entire firing range.

LOW-HIGH-LOW GAS BURNER ADJUSTMENT

The gas burner adjustments on a Low-High-Off system consist of the gas pressure regulator, gas butterfly valve, low and high gas pressure switches and an air damper assembly.

The auxiliary switch inside the M436 Mod motor makes or breaks the high-fire gas. The Low-High-Low boiler control energizes the M436 motor, driving it to high-fire. When the boiler control de-energizes the M436, a built-in return spring drives it to the low-fire position.

All gas only (VG) V13-55 models use a butterfly gas valve to control the gas flow to the burner. The M436 Mod motor controls the position of the valve.

1. Open the manual gas shutoff cocks.
2. Check the gas pressure at the inlet of the regulator and the pressure downstream of the regulator. Make sure they are in accordance with the regulator specifications. The gas pressure required at the manifold is the pressure that is required to fire the burner at its rated capacity. To adjust the regulator, unscrew the cap located on the top and turn the adjustment screw clockwise to increase pressure, or clockwise to decrease pressure.
3. Turn the burner switch to the “ON” position. The burner will start in the low-fire position.
4. After a few seconds, the O2 analyzer should have an accurate reading of the O2 present in the flue gas. Normally, O2 levels are set between 4% to 6% at low-fire for standard turndown systems on gas and 6% to 9% O2 for high turndown systems, with the target value of less than 50 ppm CO. To obtain the proper readings, adjust the air shutter and low-fire regulator pressure.
5. Operate the boiler at low-fire until it is up to operating pressure (steam) or temperature (hot water).
6. Bring the burner to the high-fire position. Adjust the high-fire gas input to match maximum rating. At high-fire, the

butterfly valve should be near the full open position. Adjust the gas regulator so the manifold pressure matches the rating on the burner data plate. Verify and record the readings and pressures. high-fire is typically 3% to 4% O2 with less than 50 ppm CO.

7. Adjust the low and high gas pressure switches by turning the adjusting screw until the indicator moves to a pressure slightly lower than normal operating pressure for the low gas pressure switch, and slightly higher for the high gas pressure switch (usually 20% below and 20% higher than normal pressure).
8. Verify low-fire and high-fire rate by clicking the meter as previously explained.
9. After completing all adjustments, replace the regulators, gaskets, and slotted aluminum screw caps. Tighten all linkages and marked settings. The burner should be adjusted to provide correct fuel flow at a constant rate, as indicated on the burner data plate. Complete the Startup Report.

FULL MODULATION GAS BURNER ADJUSTMENTS

The burner adjustments on a full modulation gas burner consist of the gas pressure regulator, butterfly gas valve, low nad high gas pressure switches (model V30-168), and air dampers.

1. Open the manual gas shutoff cocks.
2. Check the gas pressure at the inlet of the regulator and the pressure downstream of the regulator. Make sure they are in accordance with the regulator specifications. The gas pressure required at the manifold is the pressure that is required to fire the burner at its rated capacity. To adjust the regulator, unscrew the cap located on the top and turn the adjustment screw clockwise to increase pressure, or clockwise to decrease pressure.
3. Set the “MANUAL-AUTO” switch to the “MANUAL” position.
4. Position the manual flame control potentiometer in the “CLOSED” (low-fire) position.
5. Turn the burner switch to the “ON” position. The burner will start and be in the low-fire position.
6. After a few seconds, the O2 analyzer should have an accurate reading of the O2 present in the flue gas. Normally, O2 levels are set between 4% to 6% at low-fire for standard turndown systems on gas and 6% to 9% O2 for high turndown systems, with the target value of less than 50 ppm CO. To obtain the proper readings, adjust the air shutter and low-fire regulator pressure.
7. Operate the boiler at low-fire until it is up to operating pressure (steam) or temperature (hot water). Then increase the fuel input to the boiler by turning the manual flame control potentiometer towards “OPEN” in small increments. This will cause the butterfly valve to open, allowing more gas into the burner.
8. At each point allow the burner to operate for a few minutes before recording the O2, CO, and pressure readings. Observe that the O2 and CO levels remain within an acceptable limit. Adjust the pressure regulator as necessary to correct this situation. Continue to do this until the burner reaches high-fire (the potentiometer is at the “OPEN” position).
9. Adjust the high-fire gas input to match maximum rating. At high-fire, the butterfly valve should be near the full open position. Adjust the gas regulator so the manifold pressure matches the rating on the burner data plate. Verify and record the readings and pressures. high-fire is typically 3% to 4% O2 with less than 50 ppm CO as a target value.
10. Modulate the burner to low-fire. Verify the readings. The burner should be adjusted to provide correct fuel flow at a constant rate, as indicated on the burner data plate.
11. Adjust the low and high gas pressure switches by turning the adjusting screw until the indicator moves to a pressure slightly lower than normal operating pressure for the low gas pressure switch, and slightly higher for the high gas pressure switch (usually 50% below and 50% higher than normal pressure, respectively).
12. Tighten all linkages and marked settings. Complete the Startup Report.
13. Turn the “MANUAL-AUTO” switch to “AUTO”. The burner will now modulate according to the load demand to the boiler.

LOW NOX FULL MODULATION COMBINATION GAS BURNER ADJUSTMENT

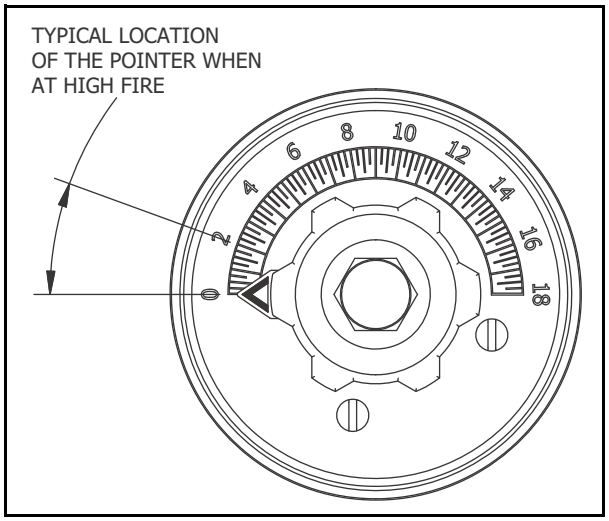
LNV burners are equipped with an FGR (flu gas recirculation) valve to lower the NOx emissions. An adjustable cam is provided to adjust the FGR valve position throughout the firing range on gas. Follow the steps for gas from Section 4.4.12 with the following additions:

1. Make sure the FGR valve is in the nearly closed position.
2. Start the burner and hold at low-fire until the boiler is at the proper operating pressure or temperature.
3. With an analyzer in the stack, adjust the FGR valve cam screw to obtain <30 ppm NOx levels.

NOTE: Do not adjust the burner below <20 ppm. Unstable combustion and high CO emissions will result.

4. Monitor O2 and CO levels during this process. The introduction of FGR into the combustion chamber will lower the flue O2 levels. Too much FGR may induce high levels of CO in the flue gas. It may be necessary to adjust the air damper blades to raise the O2 to proper low-fire values. If the proper NOx values can not be reached by adjusting the cam screw, the FGR linkage will have to be adjusted as well.
5. Once the low-fire setting is complete, continue with the instructions above, adjusting the cam at each screw to obtain the proper NOx values. Verify the values modulating back to low-fire and adjust accordingly.

I. Oil System Adjustments



Refer to the burner data plate located inside the control panel door. The nameplate will list the following burner information:

- burner and control voltage
- phase
- cycle
- motor amperage
- maximum and minimum fuel input settings
- manifold pressure (at zero furnace pressure - add the furnace pressure to get the correct manifold pressure at maximum firing rate)

These procedures assume that the pre-startup tasks and check list have been performed in accordance with the instructions in this manual.

For most efficient combustion, allow the boiler to fully warm up before making adjustments.

ON-OFF OIL BURNER ADJUSTMENT

On-Off burners use the Suntec B2TC-8931 oil pump model. High-fire pressure adjustment is 200 - 300 psi (solenoid energized), and low-fire pressure adjustment is 100 - 200 psi (solenoid de-energized).

1. Briefly push in the starter contact and release to ensure that the blower motor and oil pump are rotating in the correct direction.
2. Turn the burner switch to the “ON” position.
3. Make sure a pressure gauge, 0 - 600 psi range, is installed downstream of the solenoid valves. Adjust the burner

for a smooth ignition of the main flame. Disconnect the wiring to the solenoid on the Suntec B2TC-8931 oil pump. Loosen and remove the knurled nut on the solenoid. Adjust the screw, clockwise to increase the low-fire oil pressure, and counterclockwise to decrease the low-fire oil pressure, until a smooth ignition of the oil flame is obtained and a satisfactory low-fire oil flame is established. Turn the burner off and restart to ensure smooth ignition is obtained at the set low-fire pressure. Replace knurled nut and tighten finger tight.

4. Adjust the high-fire oil input to match the maximum rating. Turn the burner off and reconnect the wiring to the solenoid valve. Restart the burner and allow the burner to go through ignition and low-fire. When the solenoid energizes, the oil pump discharge pressure is at high-fire pressure. The high-fire pressure adjustment screw is located on the oil pump body. Adjust the screw, clockwise to increase the pressure and counterclockwise to decrease the pressure, until the correct amount of oil pressure is obtained. The high-fire oil pressure should be 300 psi. High-fire is typically 3.5% to 4.5% O2, with less than No.1 smoke (Bacharach). The burner should be adjusted to provide the correct amount of fuel flow at a constant rate at high-fire position as indicated on the burner data plate located inside the control panel.
5. Tighten all linkages and marked settings. Complete the Startup Report.

LOW-HIGH-OFF/LOW OIL BURNER ADJUSTMENT

The Suntec B2TD-8842 oil pump is typically incorporated and is a two-stage, two-step oil pump. The lowfire pressure adjustment is 100 - 200 psi (solenoid de-energized). High-fire pressure adjustment is 200 - 300 psi (solenoid energized).

1. Turn the burner switch to the “ON” position.

2. Adjust low-fire with the oil pressure regulating valve to have approximately 100 to 200 psi, and adjust the air shutter for a clean fire. Record the combustion reading from the flue gas analyzer, normally 3.5% to 4.5% O2 and less than No. 1 smoke (Bacharach). To adjust the oil pressure regulating valve, remove the lockscrew and adjust the pressure by turning the allen screw clockwise to increase pressure, and counterclockwise to decrease pressure.

3. Operate the boiler at low-fire until it is up to operating pressure (steam) or temperature (hot water).

4. Adjust high-fire fuel input to match maximum oil pressure. At high-fire, the pressure should be 300 psi. Verify and record the readings and pressures. High-fire is typically 3.5% to 4.5% O2 with less than No. 1 smoke (Bacharach). The burner should be adjusted to provide correct fuel flow at a constant rate, at the low-fire and high-fire position as indicated on the burner data plate.

5. Tighten all linkages and marked settings. Complete the Startup Report.

FULL MODULATION OIL BURNER ADJUSTMENT

The oil burner adjustments consist of the oil metering valve and air damper shutters. The oil metering valve position (indicated by a scale on the valve) will vary the oil pressure to the nozzle. Models V13 to V34 use a simplex oil nozzle, while models V35 to V168 use a return flow oil nozzle. An oil pressure gauge should be installed in the return line to monitor the oil pressure. At low-fire, the pressure range in the return line should be between 40 and 80 PSI with the oil metering valve position set between 6 and 8 on the scale. At highfire, the return line pressure will vary from 135 to 200 PSI dependent upon the brand of the oil nozzle. At high-fire, the oil metering valve position will be approximately 2 on the scale.

1. Set the “MANUAL-AUTO” switch on the “MANUAL” position.
2. Position the manual flame control potentiometer in the “CLOSED” (low-fire) position.
3. Turn the burner switch to the “ON” position. The burner will start and be in the low-fire position.
4. Adjust low-fire with the metering valve position to have approximately 80 to 90 psi, and adjust the lowfire air shutter for a clean fire. Record the combustion reading from the flue gas analyzer, normally 4.5% to 6.5% O2 and less

than No. 1 smoke (Bacharach).

5. Operate the boiler at low-fire until it is up to operating pressure (steam) or temperature (hot water). Then increase the fuel input to the boiler by turning the manual flame control potentiometer towards “OPEN” in small increments. This will cause the metering valve to close, resulting in an increase in the oil pressure feeing the burner nozzle.
6. At each point, allow the burner to operate for a few minutes before recording the O2, CO, smoke, and pressure readings. Observe that your O2 and CO levels remain within an acceptable limit. Adjust the oil pressure as necessary to correct this situation. For burners with the cam trim option, adjust the cam screws throughout the range to obtain correct O2 and CO levels. Continue to do this until the burner reaches high-fire (the potentiometer is at the “OPEN” position).
7. Adjust the high-fire fuel input to match maximum oil pressure. At high-fire, the metering valve should be pressures. high-fire is typically 3.5% to 4.5% O2 with less than No. 1 smoke (Bacharach). Adjust the high-fire excess air rate using the high-fire shutter adjustment.
8. Modulate the burner to low-fire. Verify the readings once again. The burner should be adjusted to provide correct fuel flow at a constant rate, at the low-fire and high-fire position as indicated on the burner data plate.
9. Tighten all linkages and marked settings. Complete the Startup Report.
10. Turn the “MANUAL-AUTO” switch to “AUTO”. The burner will now modulate according to the load demand to the boiler.

J. Combination Gas-Oil System

In general, the combination fueled system is to be started first using oil, because as a fuel, oil has a greatercombustion air requirement than natural gas. After being completely adjusted for oil combustion, the burneris restarted and adjusted using natural gas as fuel. Combustion adjustment of the combination burner fornatural gas involves balancing the input rate only against the existing flow of combustion air, as establishedinitially for oil.

NOTE: Do not readjust the air shutter when tuning the combination burner for combustion of natural gas.

NOTE: For burners equipped with a Siemens modulation motor, fuel-air adjustments for each fuel are independent of each other. Refer to the Siemens modulating motor product literature for proper adjustment.

LOW-HIGH-OFF/LOW COMBINATION GAS-OIL BURNER ADJUSTMENT

1. Turn the fuel selector switch to the “OIL” position.
2. Turn the burner switch to the “ON” position.
3. Proceed with startup and adjustments using the same procedures as explained above for oil burners.
4. After the system has been completely adjusted for oil firing, place the burner switch to “OFF” and position the fuel selector switch to “GAS”.
5. Proceed with startup and adjustments using the same procedures as explained above for gas burners. Do not alter the air settings set for oil. Correct the O2 levels by adjusting the butterfly valve for models V35-55, and the regulators low and high pressures for models V13-34.

FULL MODULATION COMBINATION GAS-OIL BURNER ADJUSTMENT

1. Set the “MANUAL-AUTO” switch to the “MANUAL” position.
2. Position the manual flame control potentiometer in the “CLOSED” (low-fire) position.
3. Turn the fuel selector switch to the “OIL” position.
4. Turn the burner switch to the “ON” position.
5. Proceed with startup and adjustments using the same procedures as explained above for oil burners.
6. After the system has been completely adjusted for oil firing, place the burner switch to “OFF” andposition the fuel selector switch to “GAS”.
7. Proceed with startup and adjustments using the same procedures as explained above for gas burners. Do not alter the air settings set for oil. Correct the O2 levels by adjusting the butterfly valve.

K. Modulation Control

LINKAGE CONTROL ADJUSTMENT

The linkage consists of adjustable cams, levers, rods and ball joints that transmit motion from the modulating motor to the air damper, gas butterfly valve and oil metering unit. When properly adjusted, coordinated movement of the air and fuel control devices provide proper fuel-air ratios through the firing range. In linkage adjustments, several important factors serve as guides:

- The modulating motor must be able to complete its full travel range. Restrictions will damage the motor and/or linkage.
- Lever and rod adjustments should be made with the motor in low-fire position.

The modulating motor will be stopped at the end of its stroke by an internal limit switch. Combustion gas analysis indicates the air to fuel ratio and the degree of complete combustion. The closer the rod comes to parallel with the lever, the slower the rod moves. The angles of the driven levers on the jackshaft can be adjusted to vary the rate of change. The closer the rod to the hub of the lever, the less distance it will travel. Increasing the lever length on the damper, metering unit and valve(s) decreases flow rate.

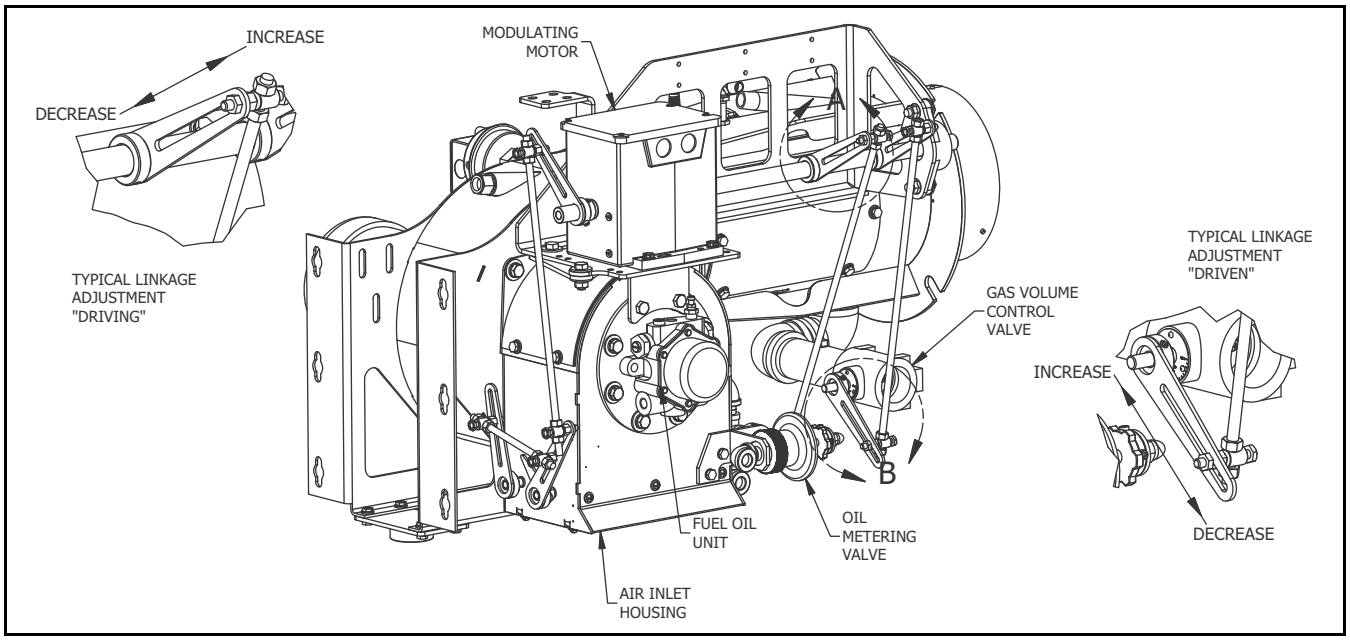


Figure 2-25: Linkage Adjustment

CAM TRIM ADJUSTMENT

After low and high-fire adjustments are complete, final adjustment is made with the cam assembly to obtain a good air-fuel ratio throughout the entire firing range. The input of combustion air is fixed at any given point in the modulating cycle. The fuel input may be varied to obtain correct flue gas readings. The adjustment is made to the metering cam by means of the 14 adjusting screws which are turned in (clockwise from the hex-socket end) to increase the flow of fuel, and out (counterclockwise from the hex-socket end) to decrease it. A 3/32" hex key is required. It will be necessary to cut off the short end of a hex key to approximately 3/8" to adjust the first two socket head setscrews at the low-fire position. Take a combustionan alysis at various points of the cam profile. Adjustment can be made without cycling the burner, then operate the automatic modulating cycle to assure satisfactory results. Tighten the locking setscrews.

NOTE: It is essential that the cam spring, cam follower bearing wheel, and cam follower arm at the pivot point be greased sparingly every month to ensure smooth operation of the cam assembly. Regular automotive bearing grease should be used.

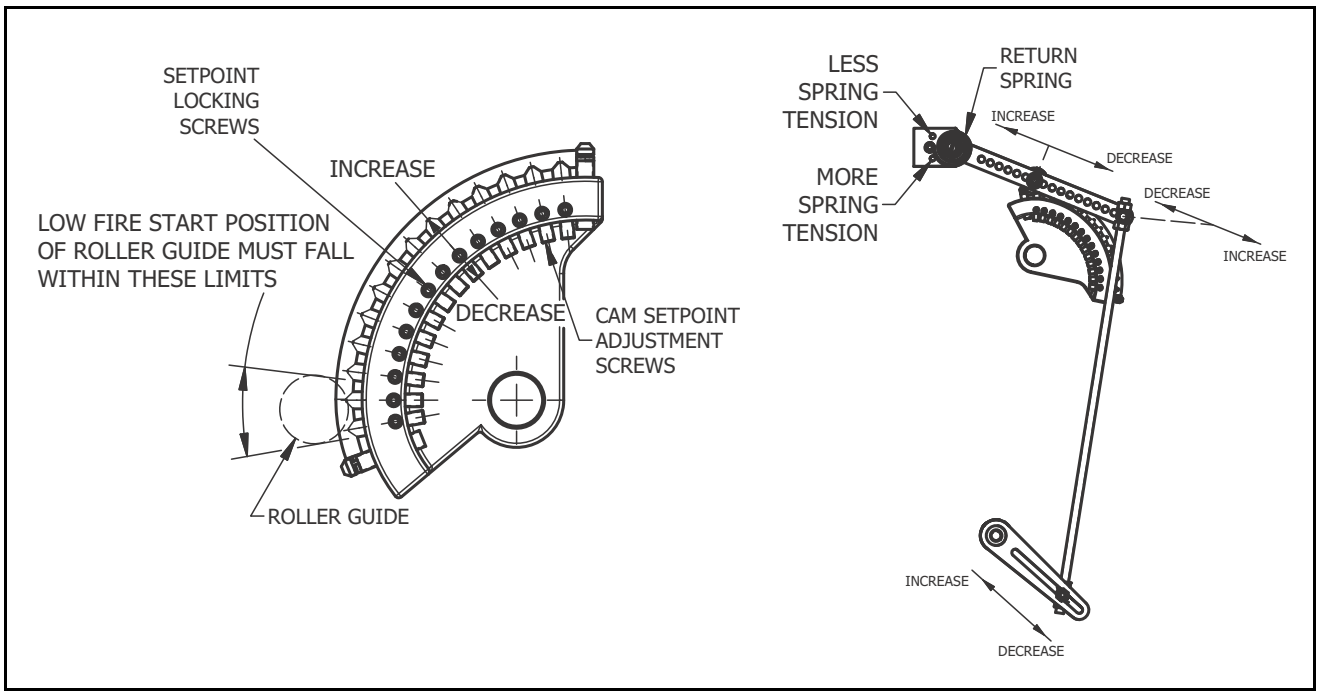


Figure 2-26: Cam Trim Adjustment

PARALLEL POSITIONING ADJUSTMENT

For parallel positioning systems refer to the controls documentation and to the accompanying wiring diagram for information on adjusting the system. For C-B Hawk systems, see the following manuals:

Hawk 1000 — 750-366

Hawk 4000 — 750-342

In a properly tuned parallel positioning system the independent actuators for fuel, air, and FGR (if so equipped) will be coordinated to provide optimum combustion throughout the firing range.

L. Air and Fuel Controls

The V series burners have a two-blade air shutter design. Both blades are coupled together and are attached to the modulation motor. Changing the positions of the linkage rods on the linkage control arms will change the way the damper blades open and close.

Fuel and air flow rates can be individually adjusted at low-fire and high-fire to achieve rated heat input, firing rate turndown, optimum efficiency, safe operation, and the ability to cope with environmental changes (air temperature, humidity, barometric pressure), and fuel property changes. Adjustments may be required to meet certain environmental emissions criteria, such as NOx or CO. Combustion adjustments also vary with specific system applications.

Turndown capability for oil is less than that of natural gas. On combination fueled burners, gas turndown performance may be restricted by the excess air and fuel turndown levels set for oil combustion.

Excess air (O2) and unburned fuel (CO) levels in boiler flue gases are used to determine combustionefficiency and fuel and air input adjustments. The system should be adjusted to a minimum excess airquantity that provides low levels of unburned fuel with sufficient remaining O2 to cope with normal atmospheric and fuel related changes. Unburned fuel is measured as CO when burning natural gas, and smoke spots when burning oil.

The burner should be set up and maintained to yield smoke spot levels less than No. 1 spot (ASTM D2156 Shell Bacharach Scale) to minimize soot and buildup in the boiler.

⚠WARNING

Keep fingers away from the air inlet area of the damper. The damper is actuated with sufficient force to cause severe injury.

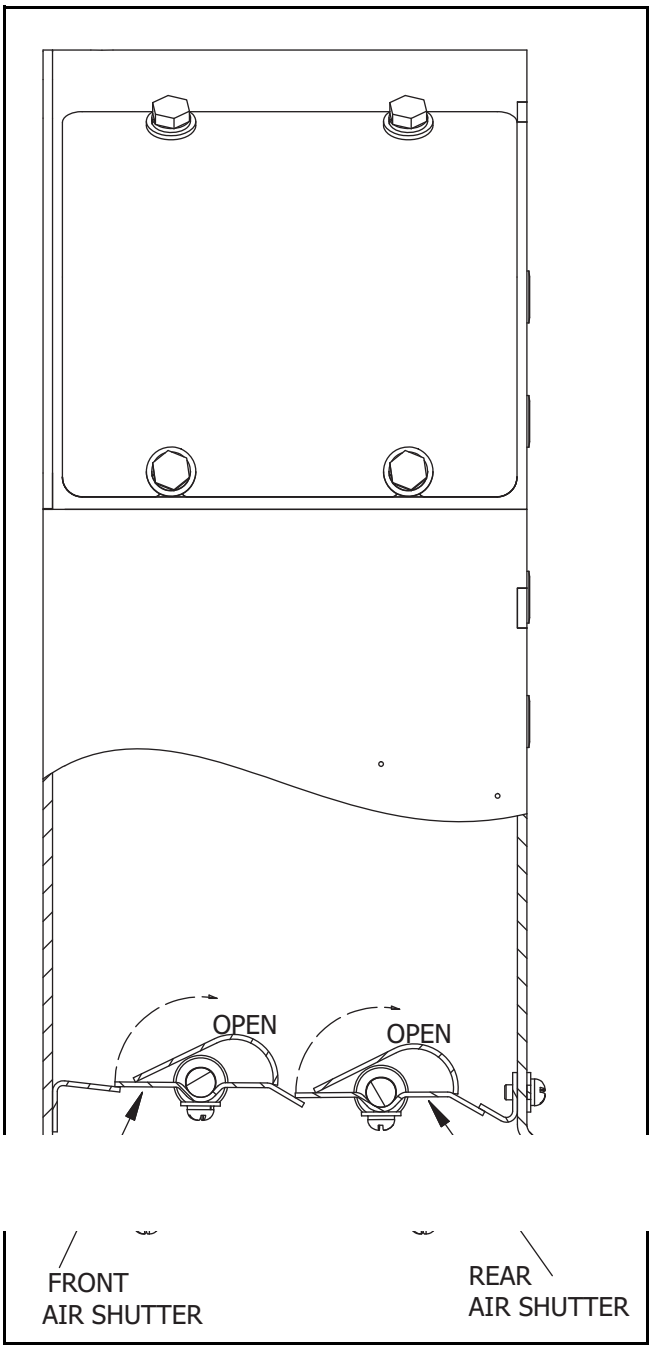


Figure 2-27: Air Shutters

M. Maintenance

A maintenance program avoids unnecessary downtime, costly repairs, and promotes safety. It is recommended that a record be maintained of daily, weekly, monthly, and yearly maintenance activities.

Electrical and mechanical devices require systematic and periodic inspection and maintenance. Any "automatic" features do not relieve the operator from responsibility, but rather frees him from certain repetitive chores, providing time for upkeep and maintenance.

Unusual noise, improper gauge reading, leak, sign of overheating, etc. can indicate a developing malfunction requiring corrective action.

⚠WARNING

ONLY FACTORY AUTHORIZED BURNER SERVICE PERSONNEL SHOULD START UP, ADJUST, OR SERVICE THE EQUIPMENT.

⚠WARNING

ANY COVER PLATES, ENCLOSURES, OR GUARDS ANCHORED TO THE BURNER, OR ANY BURNER RELATED EQUIPMENT, MUST REMAIN IN POSITION AT ALL TIMES. ONLY DURING MAINTENANCE AND SERVICE SHUTDOWN CAN THESE COVER PLATES, ENCLOSURES, OR GUARDS BE ALLOWED TO BE REMOVED. THEY MUST BE REPLACED, AND SECURELY ANCHORED BEFORE TESTING, ADJUSTING, OR RUNNING THE BURNER OR BURNER RELATED EQUIPMENT.

CONTROL SYSTEM

Most operating controls require very little maintenance beyond regular inspection. Examine electrical connections. Keep the controls clean. Remove any dust from the interior of the control. Covers should be left on controls at all times. Keep the control cabinet doors closed. Dust and dirt can damage motor starters and relay contacts. Starter contacts are plated with silver and are not harmed by discoloration. Never use files or abrasive materials such as sandpaper on contact points.

PROGRAMMING CONTROL

This control requires no adjustment, nor should any attempt be made to alter contact settings or timing logic. Those programmers with contacts may require occasional cleaning. If so, follow instructions given in the manufacturer's bulletin. Never use abrasive materials. The manufacturer's bulletin also contains troubleshooting information. The flame detector lens should be cleaned as often as conditions demand.

A periodic safety check procedure should be established to test the complete safeguard system. Tests should verify safety shutdown with a safety lockout upon failure to ignite the pilot or the main flame, and upon loss of flame. Each of these conditions should be checked on a scheduled basis. The safety check procedures are contained in the manufacturer's bulletin.

AIR HANDLING SYSTEM

A balanced blower wheel requires minimal maintenance. Check for dirt buildup and clean the blades as required. Inspect the impeller hub and blades for cracks. Replace if any are noticed. Make sure the air inlet cone fits inside the impeller.

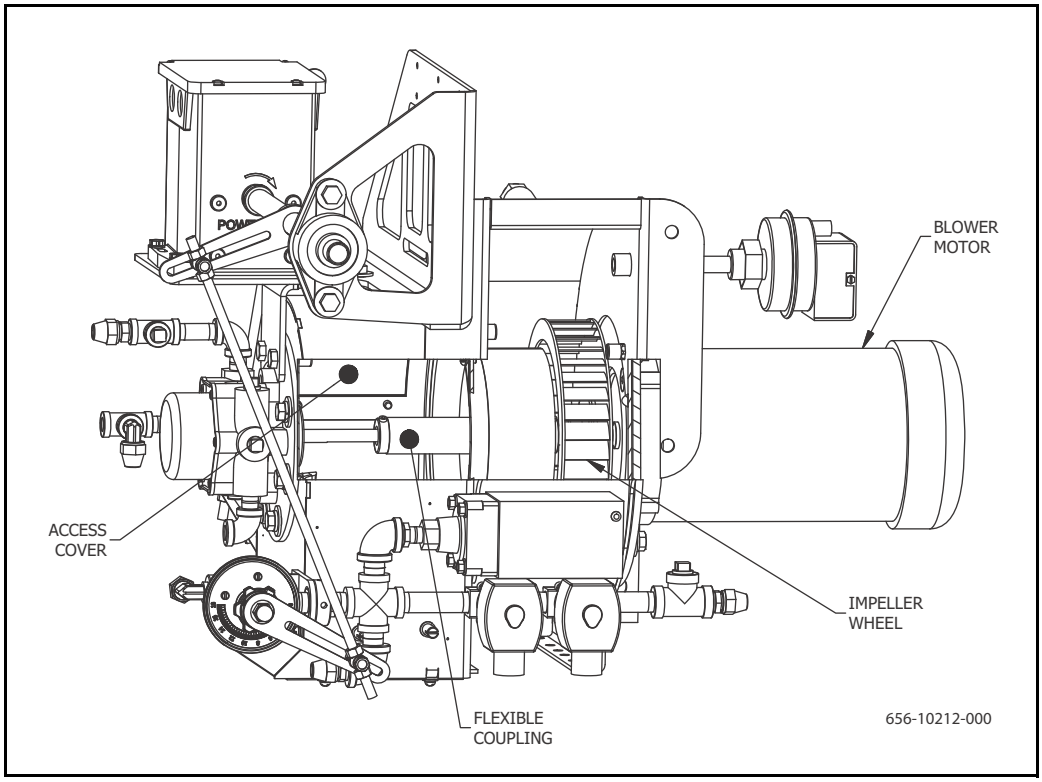


Figure 2-28: Air Handling System

IMPELLER AND INLET CONE

Proper clearance between the impeller and the inlet housing set at 3/8" nominal. Adjust the inlet cone so itis centered in the inlet of the impeller and tighten the bolts. There should be no contact between the inlet cone and the impeller. Inserting a bar through the impeller blade and using it as a lever will only damage the blade.

FIRING HEAD INSPECTION

Open side access panels to view the drawer assembly. Inspect the lead wire to the ignition electrode. It must be firmly attached and the insulation should be clean and free of cracks. The oil nozzle should be inspected periodically.

If fibrous material is discovered in the gas spud ports, remove the gas spud and back flush with shop air. Further inspection of gas piping and gasket connections must be made to isolate the contaminate source. Be sure to orientate the gas spuds in the correct position when reassembling the gas spuds.

The drawer assembly may be removed for inspection and/or service. For drawer assembly drawings, refer to Figures 2-15 to 2-24.

1. Shut off the burner; position the switch to "Off".
2. Shut off all electric power to the burner.
3. Disconnect the fuel lines from the drawer assembly access cover.

4. After making note of where the bolts are located in relationship to the access cover slots, remove the drawer assembly access cover bolts. Pull the drawer partially out of the housing. Reach inside todisconnect the ignition cables from the electrodes for direct spark applications. Pull the drawer assembly completely out of the housing.
5. To reinstall the drawer assembly, insert it part way into the housing, connect the ignition cables, if applicable, and seat the assembly fully. Install the access cover bolts loosely. Slide the cover into the original location and tighten the bolts. Reconnect the fuel lines.

PILOT AND IGNITION ELECTRODE

Failure to keep the ignition electrode clean and properly set can cause faulty operation. Not only must the gap be correct, but the electrode points must be carefully located with respect to the nozzle. Sometimes difficulty in securing the electrodes in their clamps can be corrected by using light metal shims around the porcelain. Defective or cracked porcelains require replacement to prevent short circuiting of the spark. A gradual wearing away of the electrode tips may require re-spacing of the points or replacement of the electrode.

The pilot should be checked monthly for loosening of components and carbon buildup. Before removing the pilot, ensure that the fuel supply is shut off.

On direct spark oil units, once the drawer assembly has been removed, check the electrode to nozzle gap and adjust if necessary.

For burners equipped with a gas pilot, the pilot is located on the side opposite to the main gas entrance.

1. Close the gas pilot cock.
2. Disconnect the pilot gas supply line.
3. Remove the screws on the pilot access plate.
4. Disconnect the pilot gas supply line.
5. Remove the screws on the pilot access plate.
6. Disconnect the high voltage ignition cable by pulling it straight back, away from the pilot assembly.
7. The pilot gun assembly will slide back away from the flame side of the burner.
8. Once the pilot assembly is clear of the burner head bracket, turn the pilot assembly and retract it through the access hole.
9. Inspect the electrode and adjust the gap if necessary.
10. Thoroughly clean and adjust the porcelain insulated electrodes.
11. Correct all variations from the clearance dimensions.
12. If the insulation on the high voltage cables becomes cracked or charred, install new cables. Ignition cable should not be exposed to moisture, abrasion, or rough handling.
13. See that the connectors are in perfect contact with the cable end. Unscrewing the snap portion of the connector will show whether this is true.

FLAME SCANNER

The scanner must be clean. Even a small amount of contamination will reduce the flame signal. Wipe the scanner lens with a clean soft cloth. Check pilot and flame signal strength.

To insure proper atomizing, the tip must be screwed in tightly with the swirler seating spring pressing the swirler tight against the nozzle tip. Turn the swirler a few times to be sure it fits snugly in the nozzle and the spring is pressing the two parts firmly together. When reinstalling, be sure the nozzle is centered with the proper distance from the diffuser.

OIL NOZZLE

The nozzle should be checked. Inside the nozzle lies a small screen that keeps out any particle not caught by the strainer. These particles will interfere with the normal oil flow pattern exiting the nozzle. A distorted flame can indicate a clogged nozzle. Inspect and clean the nozzle and screen. To clean the screen, swirler, and tip, unscrew the tip from the nozzle body. Clean the nozzle parts in solvent. Never use wire or sharp metal tools to clean the nozzle orifice. A metal tool will distort the orifice and ruin the nozzle. Reassemble the nozzle. The tailpiece must be screwed in with the swirler seating tight against the tip to ensure proper atomization. Reassemble the nozzle into the nozzle body. If a nozzle is replaced, it must be an identical nozzle (make, size, and spray angle).

DIFFUSER

The diffuser is factory set and does not require attention under normal operating conditions. If fouled with carbon, the diffuser should be removed for cleaning:

1. First remove the electrode leads, the gas pilot assembly, air and oil tubes before you attempt to remove the diffuser.
2. Mark the diffuser relative position to the blast tube, with a scribed or pencil line where the three mounting screws are located, to insure that the diffuser is placed back in the same position.
3. Remove the screws holding the diffuser to the blast tube and slowly pull the diffuser along the blast tube towards the firing head.
4. Clean all carbon from the diffuser vanes and reinstall in reverse order of disassembly aligning the diffuser with the scribed marks.
5. When reinstalling, be sure the diffuser is centered with the proper distance.

FIRING RATE CONTROLS

Check all rods and linkages. Make sure all connections are tight. Adjust if necessary. Perform a combustion test and readjust the burner if necessary.

BURNER MOUNTING INSPECTION

The seal between the burner flange and furnace front plate must not permit combustion gases to escape. Periodic inspection is important.

OIL SYSTEM

Little maintenance is required on the oil systems other than cleaning the oil filter. This procedure should bedone at regular intervals. Increased inlet vacuum reading may indicate a clogged filter. Follow the strainer manufacturer’s maintenance schedule.

Maintenance checks on the flexible coupling between the fuel unit and motor for alignment, tightness and wear and oil piping connection tightness should also be made at regular intervals. You access the coupling by removing the airbox cover and loosening the two setscrews on the flex coupling.

GAS SYSTEM

Check the gas train for leaks. Check the gas valves and verify the low and high gas pressure settings.

⚠ CAUTION

All power must be disconnected before servicing the valves.

SOLENOID VALVES

A faint hum from the solenoid is normal when the coil is energized. Should the valve fail to operate, check that there is voltage at the valve coil. If there is no voltage at the coil, check for loose wiring connections. If there is proper voltage at the valve coil and the valve still fails to open, replace the coil. Refer to manufacturer's bulletin for correct procedure in coil replacement.

Should it become necessary to replace the complete valve, be sure that the flow is in the direction of the arrow on the valve body.

Test for gas leaks and check valve action several times to ensure proper operation before attempting to relight burner.

MOTORIZED MAIN GAS VALVES

Should the valve fail to operate, check for voltage at the valve. Make certain that the main shutoff cock is closed prior to testing. The actuator is not field repairable nor should it be disassembled. Replace the actuator if valve fails to operate.

After replacement, cycle the valve with the fuel shut off to determine that it opens and closes. If the valve has a visual indicator, observe its position for correct operation.

ELECTRIC MOTORS

Motor supply voltage must not vary more than 10 percent from nameplate ratings. At initial startup and atleast once a year thereafter, check the motor current with a meter while the burner is in high-fire position. Ifthe reading exceeds the nameplate rating plus service factor, determine the cause and correct it immediately. In dusty locations, clean the motor regularly to assure adequate cooling. Lubricate in accordancewith the manufacturer's instructions.

CHECKING FLAME FAILURE

Pilot Flame Failure

1. Shut off the main fuel supply and close the gas pilot shutoff cock.
2. The pilot ignition circuit will be energized at the end of the pre-purge period. There should be an ignition spark, but no flame. Since there is no flame to be detected, the program relay will signal the condition.
3. The ignition circuit will de-energize and the control will lock out on a safety shutdown and the flame failure light will be activated.
4. The blower will run through post-purge and stop. Turn the burner switch off and reset the safety switch. Re-open the gas pilot shutoff cock and re-establish main fuel supply.

Main Flame Failure

1. Shut off the main fuel supply and leave the gas pilot shutoff cock open.
2. Turn the switch on. The pilot will light upon completion of the pre-purge period. The main fuel valves will be energized, but there should be no main flame.
3. The fuel valves de-energize within four seconds after the main burner ignition trial ends. The control will lock out on a safety shutdown.
4. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop. Turn the burner switch off and reset the safety switch. Re-establish main fuel supply.

Loss of Flame

1. With the burner in normal operation, shut off the main burner fuel supply to extinguish main flame.
2. The fuel valves will be de-energized and the relay will signal the condition within four seconds. Thecontrol will then lock out on a safety shutdown.
3. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge period and stop.

Turn the burner switch off and reset the safety switch. Re-establish the main fuel supply.

EXTENDED SHUTDOWN

When shutting down the burner for an extended period of time, the operator should use the following general guidelines to protect the burner from its surrounding elements. This will add to the operating life of the burner:

1. Turn the main electrical disconnect switch to the burner to “Off.”
2. Close all main fuel valves.
3. If the burner operates in a damp environment, cover it with plastic to protect all electrical components from moisture. Remove burner control and store in a dry area.

RECOMMENDED MAINTENANCE SCHEDULE

ITEM	SERVICE BY	REMARKS
DAILY		
Gauges, Monitors, and Indicators	Operator	Make visual inspection and record readings in log.
Instrument and Equipment Settings	Operator	Make visual check against recommended specifications.
Low Water, Fuel Cutoff, and Alarms	Operator	Refer to instructions.
WEEKLY		
Firing Rate Control	Operator	Verify factory settings.
Igniter	Operator	Make visual inspection. Check flame signal strength.
Pilot and Main Fuel Valves	Operator	Open limit switch. Make audible and visual check. Check valve position indicators, and check fuel meters.
Flame Failure Controls	Operator	Close manual fuel supply for (1) pilot and (2) main fuel cock and/or valve(s). Check safety shutdown timing. Record in log.
Flame Signal Strength Controls	Operator	Read and log the flame signal for both pilot and main flame. Notify service if readings are very high, very low, or fluctuating.
Linkages	Operator	Check all burner linkages for tightness. Tighten if required.
MONTHLY		
Low Fan Pressure Interlock	Operator	Manually adjust until switch opens.
High and Low Gas Pressure Interlocks	Operator	Refer to instructions. Manually adjust until switch opens.
Scanner and Diffuser	Operator	Check, inspect, and clean for soot buildup.
Pilot Assembly	Operator	Check for loosening of components, erosion, or carbon buildup.
QUARTERLY		
Burner Mounting Flange	Operator	Check tightness of burner mounting flange and burner drawer.
Handhole Covers	Operator	Check tightness of handhole plates on upper and lower drum.
Sight Glass (steam only)	Operator	Check for leaks around sight glass packing nuts.
ANNUALLY		
Strainer (Oil Units)	Operator	Replace or clean the oil strainer element.
Impeller	Operator	Inspect and clean the combustion impeller.
Combustion Test	Service Technician	Perform complete combustion test. Adjust burner if necessary. Read and log data.
Pilot Turndown Test	Service Technician	Required after any adjustment to flame, scanner, or pilot adjustment.
Operating Controls	Service Technician	Refer to instructions.

N. Troubleshooting

PROBLEM	SOLUTION
Burner Does Not Start	1. No voltage at program relay pwoer input terminals. a. Main disconnect switch open. b. Blown control circuit fuse. c. Loose or broken electrical connection.
	2. Program relay safety switch requires resetting.
	3. Limit circuit not completed - no voltage at end of limit circuit program relay terminal. a. Pressure or temperature is above setting of operation control. b. Water below required level. •Low-water light (and alarm horn) should indicate this condition. •Check manual reset button, if provided, on low-water control. c. Fuel pressure must be within settings of low pressure and high pressure switches. d. Check burner air proving switch and high-fire limit switch.
	4. High or low gas pressure - investigate and repair.

PROBLEM	SOLUTION
No Ignition	1. Lack of spark. a. Electrode grounded or porcelain cracked. b. Improper electrode setting. c. Loose terminal on ignition cable, cable shorted. d. Inoperative ignition transformer. e. Insufficient or no voltage at pilot ignition circuit terminal.
	2. Spark but no flame. a. Lack of fuel - no gas pressure, closed fuel valve, empty tank, broken line. b. Too much air flow. c. No voltage to pilot solenoid. d. Defective pilot solenoid. e. Improperly positioned electrode (direct spark models).
	3. Low -fire switch open in low-fire proving circuit. a. Damper motor not closed, slipped cam, defective switch. b. Damper jammed or linkage binding.
	4. Running interlock circuit not completed. a. Combustion proving switches defective or not properly set. b. Motor starter interlock contact not closed.
	5. Flame detector defective, sight tube obstructed, or lens dirty.

PROBLEM	SOLUTION
Pilot Flame, But No Main Flame	1. Insufficient pilot flame.
	2. Gas fired unit. a. Manual gas cock closed. b. Main gas valve inoperative. c. Gas pressure regulator inoperative.
	3. Oil fired unit. a. Oil supply cut off by obstruction, closed valve, or loss of suction. b. Supply pump inoperative c. No fuel. Broken, loose or missing oil pump coupling. d. Main oil valve inoperative. e. Check oil nozzle, gun and lines.
	4. flame detector defective, sight tube obstructed or lens dirty.
	5. Insufficient or no voltage at main fuel valve circuit terminal.

PROBLEM	SOLUTION
Burner Stays in Low-Fire	1. Pressure or temperature above modulating control setting.
	2. Manual-automatic switch in wrong position.
	3. Inoperative modulating motor.
	4. Defective modulating control.
	5. Binding or loose linkages, cams, setscrews, etc.

PROBLEM	SOLUTION
Shutdown Occurs During Firing	1. Loss or stoppage of fuel supply.
	2. Defective fuel valve, loose electrical connection.
	3. Flame detector weak or defective.
	4. Scanner lens dirty or sight tube obstructed.
	5. If the programmer lockout switch has not tripped, check the limit circuit for an opened safety control.
	6. If the programmer lockout switch has tripped: a. Check fuel lines and valves. b. Check flame detector. c. Check for open circuit in running interlock circuit. d. The flame failure light is energized by ignition failure, main flame failure, inadequate flame signal, or open control in the running interlock circuit.
	7. Improper air/fuel ratio. a. Slipping linkage. b. Damper stuck open. c. Fluctuating fuel supply. •Temporary obstruction in the fuel line. •Temporary drop in gas pressure.
	8. Interlock device inoperative or defective.
	9. air in the oil lines. Bleed lines.

PROBLEM	SOLUTION
Modulating Motor Does Not Operate	1. Manual-automatic switch in wrong position.
	2. Linkage loose or jammed.
	3. Motor does not drive to open or close during pre-purge or close on burner shut-down. a. Motor defective. b. Loose electrical connection. c. Damper motor transformer defective.
	4. Motor does not operate on demand. a. Manual-automatic switch in wrong position. b. Modulating control improperly set or inoperative. c. Motor defective. d. Loose electrical connection. e. Damper motor transformer defective.

O. Burner Specs

Model FLX Burner Characteristics

Model No.	Burner Maximum Input MBH	Burner Model	Fan Motor (3450 RPM) Voltage
FLX-150	1500	PFVLG-15	115/230/1/60
FLX-200	2000	PFVLG-20	115/230/1/60
FLX-250	2500	PFVLG-25	115/230/1/60
FLX-300	3000	PFVLG-30	115/230/1/60
FLX-350	3500	PFVLG-35	208/230/1/60
FLX-400	4000	PFVLG-40	208/230/1/60
FLX-450	4500	PFVLG-45	208-230/460/3/60
FLX-500	5000	PFVLG-50	230/460/3/60
FLX-550	5500	PFVLG-55	230/460/3/60
FLX-600	6000	PFVLG-60	460/3/60
FLX-700	7000	PFVLG-70	460/3/60
FLX-800	8000	PFVLG-80	460/3/60
FLX-900	9000	PFVLG-90	460/3/60
FLX-1000	10000	PFVLG-100	460/3/60
FLX-1100	11000	PFVLG-110	460/3/60
FLX-1200	12000	PFVLG-120	460/3/60

Notes:

1. Burner model selection shown is subject to changed and is based on actual application (altitude, gas pressure, reduced

NOx, etc.)

2. Standard voltage for Canadian application is 575/3/60.
3. Burner operation is Full Modulation on Elite Series and for the Econo series Low-High-Low for units 150 - 600 and modulated firing on 700 and greater.
4. Burner models shown are for combination gas/oil firing. For straight gas, delete the letter L, and for straight oil, delete the letter G.

Model FLX Minimum Required Gas Pressure

Model No.	Std. Gas Train Size (In.) Note 3	Min. Gas Pressure (in WC) Note 4	Min. Gas Pressure (in WC) Note 5	Burner Model
FLX-150	1	11.2	12.5	PFVG-15
FLX-200	1	19.4	21.7	PFVG-20
FLX-250	1.5	12.4	15.7	PFVG-25
FLX-300	1.5	15.9	20.7	PFVG-30
FLX-350	1.5	15.5	22.0	PFVG-35
FLX-400	1.5	18.7	27.2	PFVG-40
FLX-450	2	16.0	26.7	PFVG-45
FLX-500	2	17.6	21.0	PFVG-50
FLX-550	2	22.9	27.1	PFVG-55
FLX-600	2	20.0	24.9	PFVG-60
FLX-700	2	25.2	31.9	PFVG-70
FLX-800	2.5	19.9	22.2	PFVG-80
FLX-900	2.5	24.7	27.7	PFVG-90
FLX-1000	2.5	31.6	31.6	PFVG-100
FLX-1100	2.5	37.3	37.3	PFVG-110
FLX-1200	2.5	38.2	38.2	PFVG-120

Notes:

1. Table is based on 1,000 Btu/cu. ft. natural gas and elevation of 1,000 feet.
2. Minimum gas pressure also applies to 200 fuel series.
3. As an option, the standard gas train can be replaced with an oversized design to reduce inlet gas pressure requirements.
4. Use this column for all U.S. installations.
5. Use this column for all Canadian installations.

START-UP / SERVICE REPORT

The following information should be filled in by the service technician at start-up or after any adjustment to the burner.

A copy of the start-up report MUST be returned to CB in order to validate the warranty of the burner.

Burner Model _____ Serial Number _____ Start-up Date _____

Test Conducted	GAS Low	GAS 50%	GAS High	OIL Low	OIL 50%	OIL High
Firing Rate MMBtu / gph						
Stack Temp (Gross) ^{O}F						
Room Temp ^{O}F						
O2%						
CO2%						
CO (PPM)						
NOx (PPM)						
Smoke (Bacharach)						
Combustion Eff.%						
Stack Draft "W.C.						
Furnace Pressure "W.C.						
Blast tube Pressure "W.C.						
Steam Pressure PSIG						
Water Temperature ^{O}F						
Supply oil pressure PSIG						
Return oil pressure PSIG						
Vacuum oil pump "HG						
Oil Temperature						
Atom. air pressure						
Gas Pressure @ Burner Manifold "W.C.	Inner Manifold					
	Outer Manifold					
Center Gas pressure "W.C.						
Gas Pressure @ Regulator Inlet PSIG						
Gas Pressure @ Regulator Outlet PSIG						
Pilot Gas Pressure @ Regulator Outlet "W.C.						
Flame Signal Main	Low		50%		High	

Control Checks	Test	Set Point
Low Water Cut Off		
Aux. LWCO		
High Water Cut Off		
Operating Limit		
High Limit		
Operating Control		
Stack Temp Interlock		
Flame Failure		
Combustion Air Switch		
High Purge Switch		
Low Fire Interlock		
Oil Pressure Switch		
Oil Valve with P.O.C. Interlock		
High Gas Pressure Switch		
Low Gas Pressure Switch		
Gas Valve P.O.C. Interlock		
Pilot Turndown Test		
Flame Signal Pilot		

(For Low NOx Burners)

Blast Tube Temp. Interlock		
FGR Line Purge Switch		
FGR Valve P.O.C. Switch		

Electric Motors	Voltage L1	Voltage L2	Voltage L3	Amperage L1	Amperage L2	Amperage L3
Control Voltage						
Blower Motor						
Air Compressor						
Air-Oil or Metering						

Adjusted by:

Date:

Accepted by:

(Signature Required)

CB-8209

CHAPTER 3

Pressure Vessel Care

A. GENERAL

This chapter is devoted primarily to the waterside care of the pressure vessel.

Proper water supply and treatment are essential to boiler life and length of service. Proper water treatment will pay dividends in the form of longer life, less downtime, and prevention of costly repairs.

Hot water boilers require proper circulation. The system must be operated as intended by its designer in order to avoid the possibility of thermal shock with severe stress to the pressure vessel.

Although it is of prime importance, the subject of water supply and treatment cannot adequately be covered in this manual. For specific information or assistance with your water treatment requirements, contact your local Cleaver- Brooks authorized representative.

B. WATER REQUIREMENTS (HOT WATER BOILERS)

Air Removal

The hot water outlet (Figure 3-1) is located in the top drum of the boiler. This location reduces the possibility of released air (which is trapped at the top of the drum) from entering the system. Any air (or oxygen) that may be released in the boiler will collect at the top of the upper drum, where it will escape through the air vent tapping. The tapping must be properly piped to the expansion tank or a stand pipe and air bleeder to remove gases that collect at the top of the drum.

A. HOT WATER OUTLET
B. AIR VENT TAPPING
C. PRESSURE/TEMPERATURE GAUGES

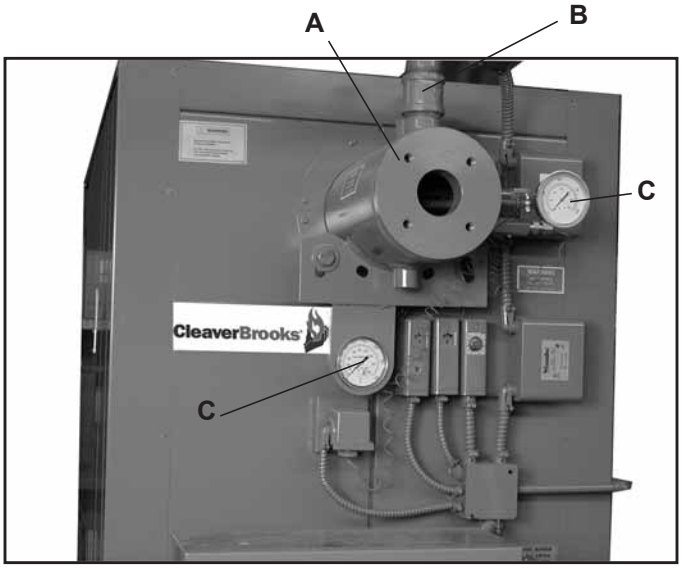


Figure 3-1: Upper Drum (Hot Water)

Continuous Flow

The system must be piped and the controls arranged so that there will be water circulation through the boiler under all operating conditions. Constant circulation through the boiler eliminates the possibility of stratification within the unit.

Refer to Table 3-1 to determine the minimum continuous flow rate through the boiler.

Table: 3-1 Minimum Flow Rates for Hot Water Boilers

MODEL NO.	DT = 20°F		DT = 40°F		DT = 60°F		DT = 80°F		DT = 100°F	
	DP (PSIG)	GPM	DP (PSIG)	GPM	DP (PSIG)	GPM	DP (PSIG)	GPM	DP (PSIG)	GPM
FLX-150	1.14	122.0	0.30	61.1	0.13	41.1	0.08	30.8	0.05	24.4
FLX-200	1.14	162.3	0.30	81.1	0.13	54.1	0.08	40.6	0.05	32.5
FLX-250	1.77	202.8	0.46	101.4	0.21	67.6	0.12	50.7	0.08	40.6
FLX-300	1.85	243.4	0.48	121.7	0.22	81.1	0.12	60.9	0.08	48.7
FLX-350	2.49	284.0	0.65	142.0	0.29	94.7	0.17	71.0	0.11	56.8
FLX-400	1.35	324.5	0.35	162.3	0.16	108.2	0.09	81.1	0.06	64.9
FLX-450	1.71	365.1	0.44	182.6	0.20	121.7	0.11	91.2	0.08	73.0
FLX-500	2.03	405.7	0.54	202.8	0.25	135.2	0.14	101.4	0.09	81.1
FLX-550	2.50	446.3	0.67	223.1	0.31	148.7	0.17	111.5	0.11	89.2
FLX-600	2.99	486.8	0.77	243.4	0.35	162.3	0.20	121.7	0.13	97.4
FLX-700	1.75	567.9	0.45	284.0	0.21	189.3	0.12	142.0	0.08	113.6
FLX-800	2.27	649.1	0.59	324.5	0.27	216.4	0.15	162.3	0.10	129.8
FLX-900	2.85	730.2	0.74	365.1	0.33	243.4	0.19	182.6	0.12	146.0
FLX-1000	4.08	811.4	1.02	405.6	0.42	270.4	0.25	202.8	0.15	163.6
FLX-1100	4.42	892.6	1.15	446.2	0.48	297.4	0.28	223.0	0.18	178.4
FLX-1200	6.20	973.6	1.60	486.8	0.59	324.6	0.31	243.4	0.22	194.8

⚠ CAUTION

In order to avoid damage to the equipment, a circulating pump should be interlocked with the burner so that the burner cannot operate unless the circulating pump is running.

It is recommended that the system circulating pumps be kept running, even though the heat users do not require hot water. The relief device or bypass valve will allow continuous circulation through the boiler and will help prevent rapid replacement of boiler water with “cold” zone water.

⚠ CAUTION

The operator should determine that a circulation of water exists through the boiler before initial firing or when firing after the unit has been drained and refilled. A reduced circulation of water or no water circulation through the boiler when the burner is operating may result in damage to the equipment.

System Pressure

The design of the system and the usage requirements often will dictate the pressure exerted upon the boiler. Some systems are pressurized with nitrogen. Caution must be exercised to make sure that the proper relationship of pressure to temperature exists within the boiler so that all of its internal surfaces are fully wetted at all times. It is for this reason that the internal boiler pressure, as indicated on the water pressure gauge, must be held to the level shown in Figure 3-2.

It is advisable to install a thermometer in the return line to indicate return water temperature. With the return water temperature and the supply water temperature to the system known, the temperature differential will be established. Knowing the flow rate, the operator easily can detect any excessive load condition and take appropriate corrective action.

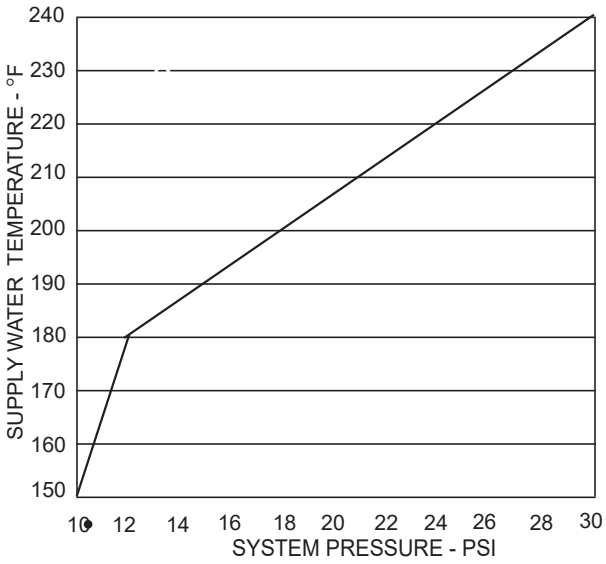


Figure 3-2: Minimum System Operating Pressure

Pressure Drop

There will be a pressure drop of less than 4 psi through all standardly equipped Cleaver-Brooks boilers operating in any system that has more than the 20°F temperature drop. This drop will vary with boiler size and circulation rate. For specific information, refer to table 3-1, Minimum Flow Rates for Hot Water Boilers.

Minimum Boiler Water Temperature

The recommended **minimum boiler water temperature** (outlet or supply) should be no less than 160°F (71°C) when the boiler is operating. This is specifically relevant during times when there is little load or during intermittent firing. The recommended **minimum system return water temperature** shall be 140°F (60°C) when firing natural gas or 150°F (66°C) when firing oil. And for special burner applications firing digester gas, minimum return water should always be above 160°F (71°C) and supply outlet temperature greater than 170°F (77°C).

These recommendations are provided to reduce or minimize the formation of condensation on the fireside of the boiler. Failure to do so will lead to corrosion of the boiler tubes and will not be covered by warranty. When supply temperature is lower than 160°F (71°C), the combustion gases are cooled to the point where the water vapor in the gases condenses. When this occurs, fireside corrosion may result if the condensed moisture stays on the steel fireside surfaces. This may occur more frequently during seasonal or light load conditions and specifically if the boiler is oversized for the system load.

If the system water temperature requirement is to be less than 160°F (71°C), mixing valves or blend pump should be employed to mix the supply water with return water. **NOTE:** When system 3-way valves are used, they should be set so that the boiler is not by-passed, thus impairing circulation within the boiler when the burner is firing. This could lead to over-temperature and nuisance shutdowns, as the high limit control will trip, requiring a manual reset of the control. Repeated overheating could lead to other damage.

Multiple Boiler Installations

When multiple boilers of equal or unequal size are installed, care must be taken to ensure proportional flow through the boilers. Proportional flow can best be accomplished by use of balancing cocks and gauges in the supply line from each boiler. If balancing cocks or orifice plates are used, a significant pressure drop (for example, 3-5 psi) must be taken across the balancing device to accomplish proportional flow.

Variations in water temperature and firing rates will result if care is not taken to ensure proportional flow through the boilers. In extreme cases, differences in firing rates could result in a net header water temperature below the desired temperature.

C. WATER REQUIREMENTS (STEAM BOILERS)

Deaeration

The most important factor in the life of a steam pressure vessel is the proper conditioning of the boiler feed water. Corrosive gasses, such as oxygen and carbon dioxide, must be removed from the feed water in order to prevent degradation of the pressure vessel. For this reason Cleaver- Brooks recommends the use of a deaeration system as an integral part of a complete boiler installation. If circumstances do not allow the implementation of a deaeration system, then serious consideration should be given to effective alternatives such as a feed water preheater combined with a chemical oxygen scavenger. Complete boiler water chemistry parameters are given in Table 3-3.

Feed Water Supply

The internal dynamics of the Model FLX steam boilers require the capability to deliver large quantities of feed water to the boiler on demand. (Feed water inlet Figure 3-3.) Sudden changes in firing rate or operating pressure of the boiler will initiate a "call for water" from the make-up controller, which will require that the feed water be delivered to the boiler in sufficient quantities to prevent a low water cutoff trip. Table 3-2 lists the minimum feed water flow requirements for the various boiler models. In addition, feed water must be warmed to a minimum of 60°F. in order to ensure reliable operation of the boiler. The feed water supply should be adjusted to deliver water to the boiler at or above these minimum rates.

Figure 3-3: Feed Water Inlet Steam Boiler

Table: 3-2 **Minimum Boiler Feed Water Flow Rates (Steam Boiler)**

BOILER MODEL	150	200	250	300	350	400	450	500	550	600	700	800	900	1000	1100	1200
Minimum Feed Rate (gpm)	4.9	6.6	8.2	9.9	11.6	13.2	14.9	16.5	18.2	19.8	23.1	26.4	29.7	33.0	36.3	39.6

Note: Feedwater to the boiler must be at least 60 °F for minimum performance; 212 °F is preferred.

D. Water Treatment

Properly treated boiler water will result in maximum effectiveness and long trouble-free life of the pressure vessel. Contact your local Cleaver-Brooks Representative or water management consultant for complete information on how to prevent damage resulting from inadequate water treatment.

The objectives of water treatment in general are to:

- Prevent hard scale and soft sludge deposits that inhibit heat transfer and that could lead to overheated metal and costly downtime and repairs.
- Eliminate corrosive gases in the supply or boiler water.

To accomplish these objectives, the boiler requires proper water treatment before and after introduction of water into the unit. The selection of pretreatment processes depends upon the water source, its chemical characteristics, the amount of makeup water needed, system operation practices, etc.

Because of the variables involved, no one boiler compound can be considered a cure-all; nor is it advisable to experiment with homemade treating methods. A sound treatment program should include a periodic analysis of the water in the system.

The internal or waterside surfaces of the pressure vessel should be inspected at sufficient intervals to detect the presence of any corrosion, pitting, contamination, or accumulations of foreign matter. If any of these conditions are detected, contact your local Cleaver-Brooks authorized representative for advice on corrective action. It is recommended that a properly sized water meter be installed in the raw water makeup line to accurately determine the amount of raw water admitted to the boiler. It is a false assumption that a hot water boiler does not require water treatment. Even though a hot water unit generally operates on a closed system and blowdown seldom is practiced, the need remains to be alert to system water losses. Knowing the amount of makeup water admitted to the system will aid in maintaining proper waterside conditions.

E. Blowdown

A steam boiler requires periodic blowdown of the boiler and water column (Figure 3-4). Blowdown is the removal of some of the concentrated water from the boiler and the water level control system, in order to lower the concentration of solids in the water.

Solids are introduced to the boiler with the feedwater, even though this water may be treated prior to use. These solids become less soluble when the water is heated and evaporated, and tend to accumulate on heating surfaces.

Periodic blowdown and chemical treatment are necessary to prevent concentration of solids in the boiler water, and attachment of these solids to waterside heating surfaces (scaling).

Figure 3-4: Low Water Cutoff and Gauge Glass with Blowdown Valve

Scale has a low heat transfer value and acts as an insulating barrier on heating surfaces. A buildup of scale will result in lower operating efficiency and, consequently, higher fuel consumption. More importantly, scale buildup can result in overheating of boiler metal. This can result in tube failures or other pressure vessel damage.

⚠ CAUTION

Boiler and water level control blowdown must be performed on a regular basis to ensure that concentrated solids are removed from the boiler and in order to avoid damage to the equipment.

Water column and gauge glass blowdown valves are located on the water column assembly. The boiler blowdown tapping(s) can be found at the bottom of the lower drum.

Most blowdown lines are provided with two valves. These are generally a quick-opening valve nearest the boiler and a slow-opening globe-type valve downstream. Valves will vary depending upon pressure involved and the make or manufacturer.

Blowdown Procedure

Blowdown is most effective when the boiler water is hot and the burner is being fired at the lowest rate. This ensures that the water in the boiler is being circulated, and that the solids in the water are in suspension.

⚠ CAUTION

Be sure that the blowdown piping is in good condition, the discharge vents are clear of obstruction, and that the waste is piped to a safe point of discharge, in order to avoid serious personal injury or death.

If a quick-opening valve and globe-type or slow-opening valve are installed, the quick-opening valve is normally opened first and closed last. Control of the water released from the boiler is accomplished with the slow-opening valve.

⚠ CAUTION

When initially opening the blowdown valve, open the valve slowly to heat the discharge piping. Failure to follow this procedure could result in rapid expansion and damage to the piping.

The drop of the water level in the gauge glass can be used in determining the length of time that the blowdown valve is left open. This is to be used as a reference only, as proper water analysis on a regular basis will serve as an indicator of the effectiveness of the blowdown procedures used.

⚠ CAUTION

Do not pump the lever action valve open and closed when draining water during blowdown. The hydraulic forces resulting from this pumping action could break the valve bodies or pipe fittings in the blowdown lines.

Blowdown valves should be closed in a specific order after draining water for blowdown. Close the downstream (slow opening) valve first, followed by the quick-opening valve next to the boiler. Open the downstream valve slightly to release the water trapped between the valves, then close the valve again.

The water column and gauge glass should be blown down by draining until the water in the gauge glass is clear. Open and close the water column and gauge glass blowdown valves slowly, allowing the water in the gauge glass to rise to a normal level before repeating the process.

Under no circumstances should a blowdown valve be left open and unattended during the blowdown operation.

Frequency of Blowdown

In practice, the boiler blowdown valve(s) should be opened periodically in accordance with a set operating schedule. Frequency and duration of the blowdown are to be determined by chemical analysis of boiler water and waterside boiler condition, as observed during regular inspections.

From an economy standpoint, frequent short blowdown is preferred to irregularly scheduled, lengthy blowdown. This is particularly true when the suspended solids content of the water is high.

F. Cleaning

Although it may be necessary to clean the system, information in this chapter deals primarily with cleaning the boiler under isolated conditions.

System piping connected to the boiler may contain oil, grease, or other foreign matter. These impurities must be removed to prevent damage to the heating surfaces of the pressure vessel. Chemical cleaning generally is necessary in this case and the entire system should be drained after cleaning. Consult your local Cleaver-Brooks authorized representative for recommended cleaning compounds and application procedures. For information on Boilout, see Section G, in this chapter.

Pressure Vessel

Cleaning of the waterside of the pressure vessel should be done during the course of initial installation. The waterside of the pressure vessel must be cleansed of grease, sludge, and foreign material. Such deposits will shorten the life of the pressure vessel and interfere with the efficient operation and function of control or safety devices. In addition, deposits might cause unnecessary and expensive rework, repairs, and downtime.

The pressure vessel and the hot water system represent in effect, a closed system. Although individual components of the system may already have been cleaned, it is possible that:

- The cleaning was not adequate.
- An old system was partially or totally involved.
- Conditions may have prevented an adequate cleaning of the piping.

Therefore, it is recommended that the entire system be cleaned after installation of all components is completed. The pressure vessel waterside should be inspected on a periodic basis. An inspection will reveal the true internal conditions and will serve as a check against conditions indicated by chemical analysis of the boiler water. An inspection should be performed 3 months after the initial start up, then at regular 6, 9, or 12 month intervals thereafter. The frequency of periodic inspections will depend upon the internal conditions found, the particular installation, and the operating conditions that the boiler is subjected to.

If any deterioration or unusual conditions are observed, contact your local Cleaver-Brooks authorized Representative for recommendations.

Table: 3-3 **Water Capacity**

Boiler Size	150-250	300-350	400-600	700-900	1000-1200
Water Capacity (US gal.) Hot Water	91	106	174	228	269
Water Capacity (US gal.) Steam - Flooded	194	215	293	464	562

G. Boilout

Any oil, grease, or other contamination found to be present on waterside heating surfaces should be removed promptly by boiling out the unit with an alkaline detergent solution.

Note: Before boiling out, the burner must be ready for firing. Refer to CHAPTER 2 - Profire V Burner.

There are several chemicals suitable for boilout. One combination often used is soda ash (sodium carbonate) and caustic soda (sodium hydroxide) at the rate of 3 to 5 pounds each per 1,000 pounds of water, along with a small amount of laundry detergent added as a wetting agent.

If the system is to be cleaned with the boiler, consider the additional water content of the system in determining the amount of chemical required. The water capacity of Cleaver- Brooks FLX Boilers is listed in Table 3-3.

Boilout Procedure

1. Prepare the boiler for firing by taking the standard precautions. Check for any situations that might present a hazard.
2. Remove upper and lower drum handhole covers and inspect all internal waterside surfaces. Remove debris and wash all internal surfaces, including tubes. It may be necessary to use a high pressure hose or a wash out lance to flush out inaccessible areas. Reinstall the lower drum handhole cover. (Use standard service gaskets during the boilout procedure.)
3. The relief valve(s) must be removed before adding the boilout solution so that neither the solution nor the contaminants that it may carry can come in contact with the valve(s). Use care in removing, handling, and reinstalling these valves.

   Note: For relief valve installation information, refer to Chapter 8, Section E. "Controls."
4. Replace the regular gauge glass with a temporary gauge glass that can be discarded after the cleaning (steam boilers).
5. An overflow pipe should be connected to one of the top boiler openings and routed to a safe point of discharge. A relief valve tapping is usually used for this purpose. The overflow connection to the boiler should incorporate a tee fitting for adding cleaning solution to the boiler.

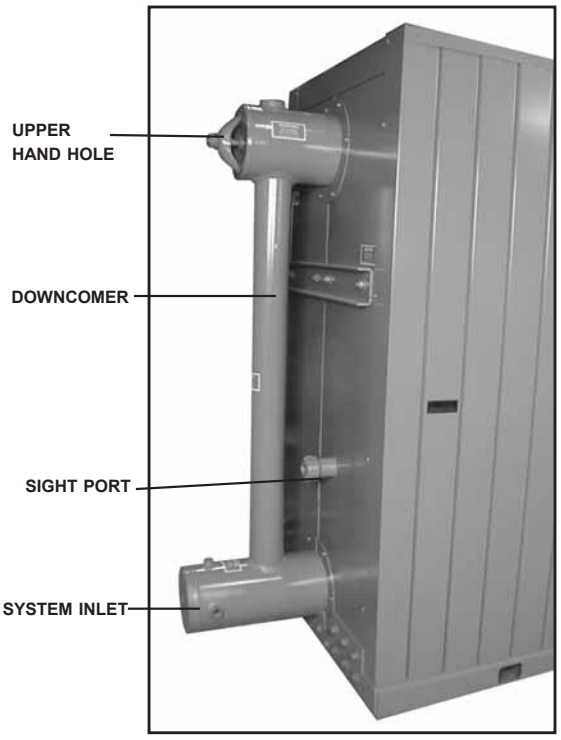


Figure 3-5: Rear Panel (Hot Water Boiler

6. Fill the unit with clean water to a point just below the access port in the upper drum. It is important that the water used for the filling process is at a temperature of 70°F or above.
7. Add the boilout solution using a chemical pump.

⚠WARNING

The chemicals used in this procedure are corrosive to eyes and skin. Always refer to the Material Safety Data Sheet to ensure that the proper safety equipment and precautions are present. Failure to heed this warning could result in serious personal injury or death.

8. Reinstall the upper handhole cover.
9. Continue to fill the boiler until it is full (indicated by flow from the overflow connection).
10. Recheck the burner, gauge glass, pressure gauge, feedwater supply and the position of all valves. Make sure that all water feeding and level indicating apparatus are in proper working condition.
11. Fire the boiler intermittently at the burners lowest fire rate until the water reaches the boiling point. The water should be held at this temperature for at least five hours.

    Note: Do not produce pressure in the boiler.
12. Throughout the entire process, each blow-down point or valve should be blown at least once every two hours. The total amount of water blown from all points each time should be approximately one-half gauge glass, this amount being equally divided among the various manual blowdown points and continuous blowdown system. Blow the surface and/or continuous blow-down points first, followed by the other blowdown points lower on the boiler. After each blowdown cycle, the water level should be brought back to full. If the total alkalinity in the cleaning solution falls to a level below 3000 ppm, it may be necessary to add additional solution, using a chemical pump.

13. Allow a small amount of fresh water to enter the boiler in order to create a slight overflow that will carry off surface impurities. Continue to boil and overflow until the water clears.
14. It is difficult to provide specific recommendations regarding the duration of the cleaning process. In general, a period of 18 to 36 hours will prove sufficient to internally clean the water-side of the boiler. The condition of the water blown from the boiler is the best indicator as to whether the cleaning process is complete.
15. Discontinue firing, and allow the water to cool. After letting the water cool to 120°F or less, drain the boiler.

⚠WARNING

Be sure to drain the hot water to a safe point of discharge to avoid the possibility of scalding, serious personal injury or death.

16. Remove the drum handhole cover, and wash the waterside surfaces thoroughly, using a high pressure water stream. Direct the water stream into each individual tube. If possible, this washing should be done from the bottom up. A wash out lance is available from your local Cleaver-Brooks authorized representative.
17. Inspect the waterside surfaces. If they are not clean, repeat the boilout procedures.
18. Replace the handhole covers (using new gaskets) and reinstall the relief valve(s).
19. If the boiler is to be put into service immediately, fill the boiler with clean, treated water and fire the burner until the water has been heated to at least 180°F to drive off any dissolved gases that might otherwise corrode the metal.
20. If the boiler is not to be put into immediate service, refer to the section on boiler layup procedures in this chapter.

H. Washing Out

Depending on system integrity, feedwater quality, or operating conditions, the water side of the boiler may need to be washed out on occasion.

In theory, a hot water system and boiler that have been initially cleaned, filled with clean, treated water, and with no makeup water added, will require no further cleaning or treatment. However, minor system leaks may allow the admission of additional water or air into the boiler.

Introduction of raw (untreated) makeup water or air to a hot water boiler may lead to pitting, corrosion, or formation of sludge, sediment, or scale on the pressure vessel waterside.

The waterside condition of steam boilers can be likewise affected by feedwater quality, load demands, operating conditions, or blowdown practices.

The waterside of a hot water or steam boiler should be cleaned and inspected no later than three months after the boiler is put into service. Subsequent cleaning of waterside surfaces should be performed as indicated through periodic inspection.

In order to thoroughly wash out the waterside of the pressure vessel, the handhole covers at the ends of the upper and lower drums must be removed. The interior surfaces of the drums should be washed with a high pressure hose. Tubes should be cleaned by directing a high pressure stream of water into the end of each tube, first from the bottom, and then from the top drum.

Note: A washout lance for this purpose is available from your local Cleaver- Brooks authorized representative.

Control and water column connections on steam boilers should be checked for accumulated deposits, and cleaned as required.

After waterside cleaning has been completed, replace the handhole covers, using new gaskets.

Note: Handhole cover gaskets are installed dry; that is, without application of a sealing compound.

I. Periodic Inspection

Insurance regulations or local codes and good maintenance will require that the pressure vessel be inspected periodically by an authorized inspector. Sufficient notice is generally required to allow removal of the boiler from service and preparation for inspection. An internal inspection may be required before cleaning or flushing.

Have the following information available for the inspector: boiler design, dimensions, generating capacity, operating pressure and temperature, time in service, defects found previously, and any repairs or modifications made to the unit. Reference records of previous inspections also should be available. Be prepared to perform any testing required by the inspector, including a hydrostatic test.

When shutting down a boiler, the load should be reduced gradually and the pressure vessel should be cooled at a rate that avoids a temperature differential that can cause harmful stresses. Normally, all pressure should be relieved before a vessel is drained in order to prevent uneven contraction and temperature differential that can cause tubes to leak. Draining the unit too quickly may cause the baking of deposits that may be present on the heating surfaces.

Note: Check to see that system valves, feedwater valves, all fuel valves, expansion tank, and electrical switches are shut off prior to opening the handholes or the burner access door. After proper cooling and draining of the vessel, flush out the waterside with a high pressure water stream. Remove any scale or deposits from the waterside surfaces and check for internal or external corrosion or leakage.

Fireside surfaces also should be cleaned so that metal surfaces, welds, joints, tube fittings, and any previous repairs can be readily checked.

⚠WARNING

To avoid the hazard of electrical shock, which could cause serious personal injury or death, the use of a low voltage flashlight is recommended during an internal inspection.

Fireside Inspection

Access for inspection of the firing chamber, or furnace, is gained through the hinged burner door. Inspection of the upper pass requires removal of the side casing panels and second and fourth pass cover plates. Refer to Chapter 8, Section C, “Fireside Cleaning,” for information regarding outer and inner casing removal.

Fireside tube surfaces should be checked for corrosion or accumulation of soot. Use a vacuum cleaner and wire brush to remove light corrosion or soot.

Localized, heavy corrosion on fireside tube surfaces may indicate a leaking tube or ferrule connection. If a tube or tube ferrule leak is indicated, the source of the leakage must be found and repaired before putting the boiler back in service. A leak from a tube-to-drum connection may require removal and reseating of the tube. A heavily corroded or leaking tube must be replaced in order to assure continued reliable operation of the boiler. Information regarding tube replacement can be obtained from your local Cleaver-Brooks authorized representative.

Waterside Inspection

Check all water piping and valves for leaks, wear, corrosion, and other damage. Replace or repair the piping and valves as necessary. Inspection covers at one end of the upper and lower drums provide access to the interior of the drums for visual inspection or washout. The interior surfaces of the drums should be examined for any sign of corrosion or accumulation of deposits.

J. Preparation for Extended Layup

Many boilers used for heating or seasonal loads or for standby service may have extended periods of non-use. The procedures outlined in this section are designed to allow a boiler to be kept off line for any period of time without damage to the unit. Special care must be taken so that neither waterside nor fireside surfaces are allowed to deteriorate from corrosion. Operating boilers can be protected from corrosion and scale by applying various chemical treatments and monitoring the system on a regular basis. However, boilers that are taken off line, even for short intervals, are susceptible to oxygen attack. Boiler drums and/or tubes may sustain pitting type damage during either wet or dry layup if proper precautions are not taken.

Oxygen solubility at ambient (off-line) temperatures can be many times that of normal boiler operating temperatures. The higher the oxygen concentration, the greater the oxygen corrosion potential. Problems also can occur as a result of improper shutdown procedures, where settled solids can dry in a hard, adherent deposit.

Care must be take to prevent fireside corrosion, especially when firing oil that contains sulfur. Dormant periods, and even frequent shutdowns, expose the fireside surfaces to condensation during cooling. Moisture and any sulfur residue can form an acid solution. Under certain conditions, and especially in areas with high humidity, the corrosive effect of the acid can be serious. An acid solution could eat through or severely damage boiler tubes or other metal heating surfaces during the time that a boiler is out of service.

Too many conditions exist to lay down definite rules for individual installations. In general, there are two methods of storage: wet or dry. Your local Cleaver-Brooks authorized representative can recommend the better method based on the circumstances of your particular installation. Regardless of the method employed, the boiler should be thoroughly cleaned and inspected prior to storage. With either method, common sense dictates a periodic recheck of fireside and waterside conditions during layup to meet the requirements of special or job site conditions.

Preparing The Boiler For Layup

To prepare a boiler for layup, thoroughly clean the fireside by removing any soot or other products of combustion from the tubes, exposed drum surfaces, and refractory.

⚠ CAUTION

The insulating refractory covering the top of the bottom drum must be protected from damage when work is being done in the boiler furnace area. Damage to the insulation may eventually cause damage to the boiler itself.

Generally, a good brushing will clean fireside surfaces. Use a wire brush for metal surfaces and a soft bristle brush for the refractory. Sweep away or vacuum any accumulation.

To prevent condensation from forming in the control cabinet, keep the control circuit energized. For extended layup periods, especially where high humidity or large swings in ambient temperature occur, the flame safeguard control should be removed and stored in a dry atmosphere.

It is recommended that the burner air inlet be blocked to prevent the flow of warm, moist air through the boiler.

⚠ CAUTION

A label should be affixed to the burner advising that the air inlet has been blocked. Failure to remove the air inlet block when attempting to operate the burner may result in damage to the equipment.

Dry Storage

Dry storage generally is used for boilers that are to be out of service for some time or for boilers that might be subjected to freezing conditions. With the dry storage method, the boiler must be thoroughly dried because any moisture would cause corrosion. Drying can be accomplished by the use of a small stove or heater.

Both fireside and waterside surfaces must be cleaned of all scale, deposits, soot, and other combustion products as soon as possible after shutdown.

All openings to the pressure vessel, such as handholes or inspection ports, should be closed tightly. Feedwater and system valves should be closed. Dampers should be closed to prevent air from reaching the fireside surfaces.

Steps must be taken to eliminate moisture by placing moisture-absorbing materials on trays inside the boiler. Two moisture-absorbing materials are: quick-lime (at 2 pounds for 3 cubic feet of volume) or silica gel (at 5 pounds for 30 cubic feet of volume). As soon as the material is in place, close all boiler openings and blank all connections.

⚠WARNING

Materials described in this section may be considered hazardous under the U.S. Occupational Safety and Health Act of 1970. Material Safety Data Sheets should be obtained and understood prior to the use of these products to avoid the possibility of serious personal injury or death.

Wet Storage

Note: It is always best to consult with a water treatment consultant before proceeding with extended layup.

Wet storage is used when the boiler will be out of service for shorter periods of time, when a boiler is held in standby conditions, or in cases where dry storage is not practical. The boiler held in wet storage can be brought back into service more quickly than one held in dry storage. However, the possibility of freezing temperatures must be considered. Again, take care to protect metal surfaces. Because of the number of variables, it is difficult to offer definite recommendations. However, it is suggested that the pressure vessel be drained, thoroughly cleaned internally, and refilled to overflowing with treated water.

If deaerated water is not available, the unit should be fired to boil the water for a short period of time in order to drive off oxygen in the water.

Tightly close all connections and apply a small positive pressure to compensate for the vacuum that will develop as the unit cools to room temperature. Internal water pressure should be maintained at greater than atmospheric pressure. Nitrogen often is used to pressurize the vessel.

The boiler water should be tested weekly as long as the unit is in storage. Additional chemicals may be required to prevent internal corrosion. If more chemicals are added, it is desirable to circulate the boiler water for a short time by means of an external pump.

Contact your local Cleaver-Brooks authorized representative for water treatment chemicals or for assistance as needed.

CHAPTER 4

Sequence of Operation

A. GENERAL

Chapter 4 outlines the electrical sequencing of various controls through the pre-purge, ignition, run, and shutdown cycles of the burner.

The program relay establishes the sequence of operation and directs the operation of all other controls and components to provide an overall operating sequence.

Note: The make or model of the program relay provided will vary depending upon job specifications. The following sequence applies regardless of the make or model. Please refer to the Wiring Diagram prepared by Cleaver-Brooks for your specific installation.

Abbreviations for the various electrical components are listed in Table 4-1. The sequences outlined in Chapter 4 employ specific nomenclature to aid in applying the text to the wiring diagram.

The burner and control system are in starting condition when the following conditions exist:

- Boiler water is up to the correct level, closing the low-water cutoff switch.
- The low-water light (panel) is off.
- The operating limit pressure control (steam boiler) or the operating limit temperature control (hot water boiler) and high limit pressure or temperature control are below their cutoff setting.
- All applicable limits are correct for burner operation.
- The load demand light glows.

All entrance switches are closed and power is present at the line terminals of:

- Blower motor starter
- Oil pump motor starter (if provided).

B. CIRCUIT AND INTERLOCK CONTROLS

The burner control circuit is a two-wire system designed for 115 Vac, 60 Hz, single-phase power.

The electrical portion of the boiler is made up of individual circuits with controls that are wired in a manner designed to provide a safe workable system. The program relay provides connection points for the interconnection of the various circuits.

The controls used vary depending upon the fuel oil or gas and the specific requirement of applicable regulatory bodies. Refer to the boiler wiring diagram to determine the actual controls provided. The circuits and controls normally used in the circuits follow and are referred to in the following sequence of operation.

Limit Circuit:

- Burner switch (BS)
- Operating limit control (OLC) - pressure or temperature
- High limit control (HLC) - pressure or temperature
- Low-water cutoff (LWCO)
- Gas-oil selector switch (GOS) - (Combination burner only)
- Low gas pressures switch (LGPS)
- High gas pressure switch (HGPS)

Fuel valve interlock circuit

- Main gas valve auxiliary switch (MGVAS)
- Oil valve auxiliary switch (OVAS)

Blower Motor Starter Circuit

- Blower motor starter (BMS)

Running Interlock Circuit

- Blower motor starter interlock (BMSI)
- Combustion air proving switch (CAPS)

Low Fire Proving Circuit

- Low fire switch (LFS)

Pilot Ignition Circuit

- Gas pilot valve (GPV)
- Ignition transformer (IT)
- Gas pilot vent valve (GPVV) (if provided)

Flame Detector Circuit

- Flame detector (FD)
- Main fuel valve circuit
- Main gas valve (MGV)
- Main gas vent valve (MGVV) (if provided)
- Oil valve (OV)
- Main fuel valve light (FVL)

Firing Rate Circuit

- Damper motor transformer (DMT)
- Modulating damper motor (MDM)
- Manual-automatic switch (MAS)
- Manual flame control (MFC)
- Modulating control (MC)

To comply with requirements of insurance underwriters such as Factory Mutual (FM), Industrial Risk Insurers (IRI) or others, additional interlock devices may be used in addition to the circuits mentioned in Section B.

High Fire Proving Circuit

- High fire switch (HFS)

Running Interlock and Limit Circuit

- Low oil pressure switch (LOPS)
- High oil pressure switch (HOPS)
- Auxiliary low-water cutoff (ALWCO)

C. SEQUENCE OF OPERATION - OIL OR GAS

On a combination fuel unit, the gas/oil switch must be set for the proper fuel.

The following sequence occurs with power present at the program relay (PR) input terminals and with all other operating conditions satisfied.

Pre-Purge Cycle - When the burner switch (BS) is turned "on," and controls wired in the "limit" and "fuel valve interlock" circuits are closed and no flame signal is present, the "blower motor start circuit" is powered energizing the blower motor starter (BMS). The load demand light (LDL) turns on.

At the same time, the program relay signals the modulating damper motor (MDM) to open the air damper. The damper begins to open and drives to its full open or high fire position. Opening the damper motor allows a flow of purging air through the boiler prior to the ignition cycle.

On certain boilers the circuitry will include a high fire switch (HFS). The purpose of the switch is to prove that the modulating damper motor (MDM) has driven the damper to the open position during the pre-purge cycle. In this instance, the "high fire proving circuit" is utilized.

The controls wired into the "running interlock circuit" must be closed within 10 seconds after the start sequence. In the event any of the controls are not closed at this time, or if they subsequently open, the program relay will go into a safety shutdown.

At the completion of the high fire purge period, the program relay signals the modulating damper motor (MDM) to drive the air damper to its low fire position.

To assure that the system is in low fire position prior to ignition, the low fire switch (LFS) must be closed to complete the "low fire proving circuit." The sequence will stop and hold until the modulating damper motor (MDM) has returned to the low fire position and the contacts of the low fire switch (LFS) are closed. Once the low fire switch is closed, the sequence is allowed to continue.

> **Note: The ignition trial cannot be started if flame or a flame simulating condition is sensed during the pre-purge period. A safety shutdown will occur if flame is sensed at this time.**

Ignition Cycle - The ignition transformer (IT) and gas pilot valve (GPV) are energized from the appropriate pilot ignition terminal.

> **Note: An oil-fired burner may be equipped with a direct spark rather than a gas pilot. The ignition sequence of both is identical.**

The pilot flame must be established and proven by the flame detector (FD) within a 10 second period in order for the ignition cycle to continue. If for any reason this does not happen, the system will shut down and safety lockout will occur.

> **Note: Depending upon the requirements of the regulatory body, insurer or fuel being burned, either the 10 or 15 second pilot ignition terminal may be used. Both provide the same function but differ in time interval allowed for proving main flame ignition. Refer to the boiler wiring diagram.**

With a proven pilot, the main fuel valve(s) (OV or MGV) is energized and the main fuel valve light (FVL) in the panel is lighted. The main flame is ignited and the trial period for proving the main flame begins. It lasts 10 seconds for light oil and natural gas. At the end of the proving period, if the flame detector still detects main flame, the ignition transformer and pilot valve are deenergized and pilot flame is extinguished.

Note: If the main flame does not light, or stay lit, the fuel valve will close. The safety switch will trip to lock out the control. Refer to flame loss sequence (section D) for description of action.

⚠WARNING

The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart. Failure to follow these instructions could result in serious personal injury or death

Run Cycle - With main flame established, the program relay releases the modulating damper motor (MDM) from its low fire position to control by either the manual flame control (MFC) or the modulating control (MC), depending upon the position of the manual-automatic switch (MAS). This allows operation in ranges above low fire.

With the manual-automatic switch (MAS) set at automatic, subsequent modulated firing will be at the command of the modulating control (MC), which governs the position of the modulating damper motor (MDM). The air damper and fuel valves are actuated by the motor through a linkage and cam assembly to provide modulated firing rates.

Note: Normal operation of the burner should be with the manual-automatic switch in the automatic position and under the direction of the modulating control. The manual position is provided for initial adjustment of the burner over the entire firing range. When a shutdown occurs while operating in the manual position at other than low fire, the damper will not be in a closed position, thus allowing more air than desired to flow through the boiler. Excess air flow subjects the pressure vessel metal and refractory to undesirable conditions.

The burner starting cycle is now complete. The (LDL) and (FVL) lights on the panel remain lit. Demand firing continues as required by load conditions.

Burner Shudown-Post Purge - The burner will fire until steam pressure or water temperature in excess of demand is generated. With modulated firing, the modulating damper motor (MDM) should return to the low fire position before the operating limit control (OLC) opens. When the limit control circuit is opened, the following sequence occurs:

The main fuel valve circuit is deenergized, causing the main fuel valve (MGV) or (OV) to close. The flame is extinguished. The control panel lights (LDL) and (FVL) are turned off. The blower motor continues to run to force air through the boiler for the post purge period.

The blower motor start circuit is deenergized at the end of the post purge cycle and the shutdown cycle is complete.

The program relay is now ready for subsequent recycling, and when steam pressure or water temperature drops to close the contacts of the operating control, the burner again goes through its normal starting and operating cycle.

D. FLAME LOSS SEQUENCE

The program relay will recycle automatically each time the operating control closes, or after a power failure. It will lockout following a safety shutdown caused by failure to ignite the pilot, or the main flame, or by loss of flame. Lockout will also occur if flame or flame simulating condition occurs during the prepurge period.

The control will prevent start-up or ignition if limit circuit controls or fuel valve interlocks are open. The control will lock out upon any abnormal condition affecting air supervisory controls wired in the running interlock circuit.

⚠ CAUTION

The lockout switch must be manually reset following a safety shutdown. The cause for loss of flame or any unusual condition should be investigated and corrected before attempting to restart. Failure to follow these instructions could cause damage to the equipment.

1. No pilot flame

The pilot flame must be ignited and proven within a 10-second period after the ignition cycle begins. If not proven within this period, the main fuel valve circuit will not be powered and the fuel valve(s) will not be energized. The ignition circuit is immediately deenergized and the pilot valve closes, the reset switch lights and lockout occurs immediately.

The blower motor will continue to operate. The flame failure light and the alarm bell (optional) are energized 10 seconds later.

The blower motor will be deenergized. The lockout switch must be manually reset before operation can be resumed. (Refer to the previous caution.)

2. Pilot but no main flame

When the pilot flame is proven, the main fuel valve circuit is energized. Depending upon the length of the trial-for-ignition period, the pilot flame will be extinguished 10 or 15 seconds later. The flame detecting circuit will respond to deenergize the main fuel valve circuit within 2 to 4 seconds to stop the flow of fuel. The reset switch lights and lockout occurs immediately. The blower motor will continue to operate.

The flame failure light and alarm bell (optional) are energized 10 seconds later.

The blower motor will be then deenergized. The lockout switch must be manually reset before operation can be resumed. (Refer to the previous caution.)

3. Loss of flame

If a flame outage occurs during normal operation and/or the flame is no longer sensed by the detector, the flame relay will trip within 2 to 4 seconds to deenergize the fuel valve circuit and shut off the fuel flow. The reset switch lights and lockout occurs immediately. The blower motor continues operation. The flame failure light and alarm bell (optional) are energized 10 seconds later.

The blower motor will be deenergized. The lockout switch must be manually reset before operation can be resumed. (Refer to the previous caution.)

If the burner will not start, or upon a safety lockout, the trouble shooting section in the operating manual and the technical bulletin should be referred to for assistance in pinpointing problems that may not be readily apparent.

The program relay has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the control bulletin for specifics and suggested remedies. Familiarity with the program relay and other controls in the system can be obtained by studying the contents of the manual and this bulletin.

Knowledge of the system and its controls will make troubleshooting much easier. Costly down time or delays can be prevented by systematic checks of the actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

Remember, a safety device, for the most part, is doing its job when it shuts down or refuses to operate. Never attempt to circumvent any of the safety features.

Preventive maintenance and scheduled inspection of all components should be followed. Periodic checking of the relay is recommended to see that a safety lockout will occur under conditions of failure to ignite either pilot or main flame, or from loss of flame.

Table: 4-1 Electrical Nomenclature

MNEMONIC	DESCRIPTION
	A
A	Amber (Color Of Pilot Light)
AAFL	Atomizing Air Failure Light
AAFR	Atomizing Air Failure Relay
AAPL	Atomizing Air Proven Light
AAPS	Atomizing Air Proving Switch
AAPS-B	Atomizing Air Proving Switch- Burner
AAPS-C	Atomizing Air Proving Switch- Compressor
AASS	Atomizing Air Selector Switch
AB	Alarm Bell
ACCR	Air Compressor Control Relay
ACM	Air Compressor Motor
ACMCB	Air Compressor Motor Circuit Breaker
ACMF	Air Compressor Motor Fuses
ACMS	Air Compressor Motor Starter
ACMSI	Air Compressor Motor Starter Interlock
AH	Alarm Horn
ALFR	Assured Low Fire Relay
ALWCO	Auxiliary Low Water Cutoff
AM	Ammeter
AMS	Atomizing Media Switch
AOV	Auxiliary Oil Valve
APR	Air Purge Relay
APV	Air Purge Valve
AR	Alarm Relay
AS	Auxiliary Switch (Suffix)
ASR	Alarm Silencing Relay
ASS	Alarm Silencing Switch
ASV	Atomizing Steam Valve
AT	Annunciator Transformer
AWCBDS	Auxiliary Water Column Blowdown Switch
	B
B	Blue (Color of Pilot Light)
BC	Bias Control
BDCS	Breeching Damper Closed Switch
BDOS	Breeching Damper Open Switch
BDRS	Blowdown/Reset Switch
BFPL	Boiler Feed Pump Light
BFPM	Boiler Feed Pump Motor
BFPMCB	Boiler Feed Pump Motor Circuit Breaker
BFPMF	Boiler Feed Pump Motor Fuses
BFPMS	Boiler Feed Pump Motor Starter
BFPS	Boiler Feed Pump Switch
BFTS	Back Flow Temperature Switch
BHS	Boiler - Header Switch
BIOL	Boiler in Operation Light
BIOR	Boiler In Operation Relay
BM	Blower Motor
BMCB	Blower Motor Circuit Breaker
BMCR	Blower Motor Control Relay
BMF	Blower Motor Fuses
BMPR	Blower Motor Power Relay
BMPS	Blower Motor Purge Switch
BMR	Blower Motor Relay

Table: 4-1 Electrical Nomenclature (Continued)

MNEMONIC	DESCRIPTION
BMS	Blower Motor Starter
BMSI	Blower Motor Starter Interlock
BMSS	Boiler Master Selector Switch
BS	Burner Switch
BSS	Boiler Selector Switch
BWPM	Booster Water Pump Motor
BWT	Booster Water Thermostat
	C
CAFL	Combustion Air Failure Light
CAFR	Combustion Air Failure Relay
CAP	Capacitor
CAPS	Combustion Air Proving Switch
CCCB	Control Circuit - Circuit Breaker
CCF	Control Circuit Fuse
CCRS	Control Circuit Reset Switch
CCT	Control Circuit Transformer
CIPL	Changeover In Progress Light
CL	Canopy Light
CLS	Canopy Light Switch
COPS	Changeover Pressure Switch
COR	Changeover Relay
COTD	Changeover Time Delay
CPOL	Control Power on Light
CR	Control Relay
CSSS	Control System Selector Switch
CWPM	Circulating Water Pump Motor
CWPMCB	Circulating Water Pump Motor Circuit Breaker
CWPMF	Circulating Water Pump Motor Fuses
CWPMS	Circulating Water Pump Motor Starter
CWPMSI	Circulating Water Pump Motor Starter Interlock
CWPR	Circulating Water Pump Relay
CWPS	Circulating Water Pump Switch
CWSV	Cooling Water Solenoid Valve
	D
D	Denotes Digester Gas Equipment (Prefix)
DCVM	Direct Current Voltmeter
DG	Draft Gauge
DGHPV	Digester Gas Housing Purge Valve
DHWC	Deaerator High Water Control
DHWL	Deaerator High Water Light
DHWR	Deaerator High Water Relay
DISC	Disconnect (Entrance Switch)
DLWC	Deaerator Low Water Control
DLWL	Deaerator Low Water Light
DLWR	Deaerator Low Water Relay
DM	Damper Motor
DMT	Damper Motor Transformer
DNS	Day-Night Switch
DODE	Delay On Deenergization (Timer)
DOE	Delay On Energization (Timer)
DPS	Damper Positioning Switch
DS	Door Switch
	E
EDS	Emergency Door Switch
ESS	Emergency Stop Switch
ETM	Elapsed Time Meter

Table: 4-1 Electrical Nomenclature (Continued)

MNEMONIC	DESCRIPTION
	F
FADM	Fresh Air Damper Motor
FADR	Fresh Air Damper Relay
FD	Flame Detector
FDJB	Flame Detector Junction Box
FDPS	Flow Differential Pressure Switch
FFA	Flame Failure Alarm
FFL	Flame Failure Light
FFR	Flame Failure Relay
FGR	Flue Gas Recirculation
FGRCDTD	Flue Gas Recirculation Cool Down Time Delay
FGRCPS	Flue Gas Recirculation Cam Position Switch
FGRFM	Flue Gas Recirculation Fan Motor
FGRFMS	Flue Gas Recirculation Fan Motor Starter
FGRFMSI	Flue Gas Recirculation Fan Motor Starter Interlock
FGRMVLS	Flue Gas Recirculation Manual Valve Limit Switch
FGRTD	Flue Gas Recirculation Time Delay
FORS	First Out Reset Switch
FPM	Feed Pump Motor
FPMS	Feed Pump Motor Starter
FPR	Feed Pump Relay
FPS	Feed Pump Switch
FRI	Firing Rate Interface
FRP	Firing Rate Potentiometer (O2 Trim)
FS	Flow Switch
FSS	Fuel Selector Switch
FSSM	Flame Signal Strength Meter
FVEL	Fuel Valve Energized Light
FVL	Fuel Valve Light
FVR	Fuel Valve Relay
FWC	Feed Water Control
FWVT	Feed Water Valve Transformer
	G
G	Green (Color Of Pilot Light)
GGL	Gauge Glass Light
GOL	Gas Operation Light
GOR	Gas-Oil Relay
GOS	Gas-Oil Switch
GOR	Gas-Oil Relay
GPS	Gas Pressure Sensor
GPV	Gas Pilot Valve
GPVV	Gas Pilot Vent Valve
GR	Gas Relay
GSSV	Gas Sensor Solenoid Valve
GVEL	Gas Valve Energized Light
GVTS	Gas Valve Test Switch
	H
HATC	High Ambient Temperature Control
HBWTC	High Boiler Water Temperature Control
HBWTL	High Boiler Water Temperature Light
HFAV	High Fire Air Valve
HFGV	High Fire Gas Valve
HFL	High Fire Light
HFOV	High Fire Oil Valve
HFPS	High Furnace Pressure Switch
HFS	High Fire Switch

Table: 4-1 Electrical Nomenclature (Continued)

MNEMONIC	DESCRIPTION
HFS-A	High Fire Switch - Air
HGPL	High Gas Pressure Light
HGPR	High Gas Pressure Relay
HGPS	High Gas Pressure Switch
HHFL	Header High Fire Light
H/LWA	High Low Water Alarm
HLC	High Limit Control
HLFC	High-Low Fire Control
HLPC	High Limit Pressure Control
HLTC	High Limit Temperature Control
HMC	Header Modulating Control
HOPL	High Oil Pressure Light
HOPR	High Oil Pressure Relay
HOPS	High Oil Pressure Switch
HOLC	Header Operating Limit Control
HOTL	High Oil Temperature Light
HOTR	High Oil Temperature Relay
HOTS	High Oil Temperature Switch
HPCO	High Pressure Cutoff
HSPC	High Steam Pressure Control
HSPL	High Steam Pressure Light
HSPR	High Steam Pressure Relay
HSTC	High Stack Temperature Control
HSTL	High Stack Temperature Light
HSTS	High Stack Temperature Switch
HWAR	High Water Alarm Relay
HWC	High Water Control
HWCO	High Water Cutoff
HWL	High Water Light
	I
(I.C.)	Instantaneously Closed
(I.O.)	Instantaneously Open
IL	Ignition Light
INT	Interval (Timer)
IR	Ignition Relay
IT	Ignition Transformer
	J
JPP	Jackshaft Position Potentiometer
	L
LAMPS	Low Atomizing Media Pressure Switch
LASPS	Low Atomizing Steam Pressure Switch
LDL	Load Demand Light
LDPS	Low Differential Pressure Switch
LDS	Low Draft Switch
LFAV	Low Fire Air Valve
LFGV	Low Fire Gas Valve
LFHTD	Low Fire Hold Time Delay
LFL	Low Fire Light
LFOV	Low Fire Oil Valve
LFPS	Low Fire Pressure Switch
LFR	Low Fire Relay
LFS	Low Fire Switch
LFS-A	Low Fire Switch - Air
LFS-F	Low Fire Switch - Fuel
LFS-G	Low Fire Switch - Gas
LFS-O	Low Fire Switch - Oil

Table: 4-1 Electrical Nomenclature (Continued)

MNEMONIC	DESCRIPTION
LFTC	Low Fire Temperature Control
LGPL	Low Gas Pressure Light
LGPR	Low Gas Pressure Relay
LGPS	Low Gas Pressure Switch
LIAPS	Low Instrument Air Pressure Switch
LLPC	Low Limit Pressure Control
LLPR	Low Limit Pressure Relay
LLR	Lead Lag Relay
LLTC	Low Limit Temperature Control
LLTR	Low Limit Temperature Relay
LOPL	Low Oil Pressure Light
LOPR	Low Oil Pressure Relay
LOPS	Low Oil Pressure Switch
LOTL	Low Oil Temperature Light
LOTR	Low Oil Temperature Relay
LOTS	Low Oil Temperature Switch
LPAPS	Low Plant Air Pressure Switch
LPCO	Low Pressure Cutoff
LPS	Low Pressure Switch
LSPAR	Low Steam Pressure Alarm Relay
LSPC	Low Steam Pressure Control
LSPL	Low Steam Pressure Light
LSPR	Low Steam Pressure Relay
LSPS	Low Steam Pressure Switch
LTS	Lamp Test Switch
LWA	Low Water Alarm
LWAR	Low Water Alarm Relay
LWCO	Low Water Cutoff
LWFL	Low Water Flow Light
LWL	Low Water Light
LWR	Low Water Relay
LWRR	Low Water Reset Relay
	M
MA	Milli-amp
MAS	Manual - Automatic Switch
MAM	Micrometer
MC	Modulating Control
MCS	Manual Control Switch
MDM	Modulating Damper Motor
MDMAS	Modulating Damper Motor Auxiliary Switch
MFC	Manual Flame Control (Potentiometer)
MFGRTS	Minimum Flue Gas Recirculation Temperature Switch
MFVL	Main Fuel Valve Light
MFWV	Motorized Feed Water Valve
MGV	Main Gas Valve
MGVAS	Main Gas Valve Auxiliary Switch
MGVEL	Main Gas Valve Energized Light
MGVV	Main Gas Vent Valve
MLC	Modulating Level Control
(MOM)	Momentary
MOV	Main Oil Valve
MOVAS	Main Oil Valve Auxiliary Switch
MOVEL	Main Oil Valve Energized Light
MPC	Modulating Pressure Control
MPCB	Main Power Circuit Breaker
MPP	Manual Positioning Potentiometer

Table: 4-1 Electrical Nomenclature (Continued)

MNEMONIC	DESCRIPTION
(MR)	Manual Reset
MTC	Modulating Temperature Control
MVA	Make-Up Valve Actuator
	N
N	Denotes Natural Gas Equipment (Prefix)
(N.C.)	Normally Closed
(N.O.)	Normally Open
NFL	No Flow Light
NFR	No Flow Relay
NGHPV	Natural Gas Housing Purge Valve
	O
ODA	Outlet Damper Actuator
ODM	Outlet Damper Motor
ODMAS	Outlet Damper Motor Auxiliary Switch
ODMT	Outlet Damper Motor Transformer
ODS	Oil Drawer Switch
OH	Oil Heater
OHCB	Oil Heater Circuit Breaker
OHF	Oil Heater Fuses
OHR	Oil Heater Relay
OHS	Oil Heater Switch
OHT	Oil Heater Thermostat
OLC	Operating Limit Control
OLPC	Operating Limit Pressure Control
OL'S	Thermal Overloads
OLTC	Operating Limit Temperature Control
OMPM	Oil Metering Pump Motor
OMPMF	Oil Metering Pump Motor Fuse
OOL	Oil Operation Light
OPM	Oil Pump Motor
OPMCB	Oil Pump Motor Circuit Breaker
OPMF	Oil Pump Motor Fuses
OPMS	Oil Pump Motor Starter
OPPM	Oil Purge Pump Motor
OPR	OIl Purge Relay
OPRL	Oil Pump Running Light
OPRS	Oil Pressure Sensor
OPS	Oil Pump Switch
OPSPM	Oil Pump Supply Pump Motor
OPV	Oil Purge Valve
OR	Oil Relay
ORV	Oil Return Valve
OSOV	Oil Shutoff Valve
OSPS	O2 Set Point Switch
OSS	Oil Selector Switch
OT	Outdoor Thermostat
OTS	Oil Temperature Sensor
OV	Oil Valve
OVAS	Oil Valve Auxiliary Switch
OVEL	Oil Valve Energized Light
	P
P	Denotes Propane Gas Equipment (Prefix)
PAASV	Plant Air Atomizing Solenoid Valve
PAPS	Purge Air Proving Switch
PC	Pump Control
PCL	Purge Complete Light

Table: 4-1 Electrical Nomenclature (Continued)

MNEMONIC	DESCRIPTION
PCR	Pump Control Relay
PFCC	Power Factor Correction Capacitor
PFFL	Pilot Flame Failure Light
PFFR	Pilot Flame Failure Relay
PFPS	Positive Furnace Pressure Switch
PHGPS	Pilot High Gas Pressure Switch
PIPL	Purge in Progress Light
PIS	Pilot Ignition Switch
PLC	Programmable Logic Controller
PLGPS	Pilot Low Gas Pressure Switch
POL	Power On Light
POV	Pilot Oil Valve
PPL	Pre-Purging Light
PPR	Post Purge Relay
PPTD	Post Purge Time Delay
PR	Program Relay
PRL	Purge Ready Light
PRPTD	Pre-Purge Time Delay
PR	Program Relay
PRPTD	Per-Purge Time Delay
PS	Power Supply
PSF	Power Supply Fuse
PSS	Pump Selector Switch
PSV	Purge Solenoid Valve
PT	Purge Timer
PTS	Pump Transfer Switch
PUCR	Purge Complete Relay
PUR	Purge Relay
	R
R	Red (Color of Pilot Light)
RAR	Remote Alarm Relay
RATD	Remote Alarm Time Delay
RES	Resistor
RML	Run Mode Light
RMR	Release To Modulate Relay
RS	Range Switch
RSR	Remote Start Relay
RTD	Resistance Temperature Detector
	S
SBFPL	Stand By Feed Pump Light
SBFPM	Stand By Feed Pump Motor
SBFPMCB	Stand By Feed Pump Motor Circuit Breaker
SBFPMF	Stand By Feed Pump Motor Fuses
SBFPMS	Stand By Feed Pump Motor Starter
SBOV	Surface Blow Off Valve
SBPS	Sootblower Pressure Switch
SBR	Sootblower Relay
SC	Scanner
SCTS	Supervisory Cock Test Switch
SDL	Steam Demand Light
SHT	Steam Heater Thermostat
SHV	Steam Heater Valve
SLCL	Safety Limits Complete Light
SPIR	System Pump Interlock Relay
SPS	Steam Pressure Sensor
SS	Selector Switch

Table: 4-1 Electrical Nomenclature (Continued)

MNEMONIC	DESCRIPTION
SSC	Sequencing Step Controller
SSL	Safety Shutdown Light
SSR	Solid State Relay
SSV	SpanSolenoid Relay
STHWC	Surge Tank High Water Control
STHWL	Surge Tank High Water Light
STHWR	Surge Tank High Water Relay
STLWC	Surge Tank Low Water Control
STLWL	Surge Tank Low Water Light
STLWR	Surge Tank Low Water Relay
	T
(T.C.)	Timed Closed
(T.O.)	Timed Open
TB	Terminal Block
T/C	Thermocouple
TC	Time Clock
TCR	Time Clock Relay
TD	Time Delay
TDAS	Time Delay Auxiliary Switch
TFWR	Transistorized Feedwater Relay
TPL	Transfer Pump Light
TPM	Transfer Pump Motor
TPMCB	Transfer Pump Motor Circuit Breaker
TPMF	Transfer Pump Motor Fuses
TPMS	Transfer Pump Motor Starter
TPS	Transfer Pump Switch
	U
UVFD	Ultra-Violet Flame Detector
	V
V	Voltmeter
VDR	Voltage Differential Relay
	W
W	White (Color of Pilot Light)
WC	Water Column
WCBDS	Water Column Blow Down Switch
WF	Water Feeder
WFNL	Water Flow Normal Light
WLC	Water Level Control
WO	Denotes Waste Oil Equipment (Prefix)
WTS	Water Temperature Sensor
	Y
Y	Yellow (Color of Pilot Light)

CHAPTER 5

Adjustment Procedures

A. GENERAL

Each Cleaver-Brooks boiler is tested for correct operation before shipment from the factory. However, variable conditions such as burning characteristics of the fuel and operating load conditions may require further adjustment after installation to assure maximum operating efficiency and economy.

A combustion efficiency analysis made during the initial start-up will help to determine what additional adjustments are required in a particular installation.

Prior to placing the boiler into service, a complete inspection should be made of all controls, connecting piping, wiring, and all fastenings such as nuts, bolts and setscrews to be sure that no damage has occurred, or that adjustments have not changed during shipment and installation.

The adjustment procedures in Chapter 6 apply to standard components furnished on steam or hot water boilers fired with gas and/or the various grades of oil.

B. LINKAGE - MODULATING MOTOR AND AIR DAMPER

The linkage consists of various arms, connecting rods, and swivel ball joints that transmit motion from the modulating motor to the metering valve, to the air damper, and to the gas butterfly valve, if used.

When properly adjusted, a coordinated movement of the damper and metering valves within the limits of the modulating motor travel is attained to provide proper fuel-air ratios through the firing range.

In linkage adjustments there are several important factors that must serve as guides.

1. The modulating motor must be able to complete its full travel range.

⚠ CAUTION

Do not restrict the full travel of the modulating motor. Failure to follow these instructions could result in equipment damage.

2. Initial adjustment should be made with the motor in full closed position, that is with the shaft on the power end of the motor in its most counterclockwise position.
3. The closer the linkage rod connector is to the drive shaft, the less the arm will travel; the closer the connector is to the driven shaft, the farther that arm will travel.

Prior to initially firing a boiler it is advisable to check for free movement of the linkage. The damper motor must be allowed to complete its full stroke and the damper must move freely from low to high fire position.

C. MODULATING MOTOR

The modulating motor has a 90° shaft rotation. The motor manufacturer also provides a 160° stroke model for other applications. If a replacement is obtained from someone other than a Cleaver-Brooks Service or Parts representative, it may have an incorrect stroke. To prevent damage, verify the 90° stroke prior to installing a replacement.

The stroke may be determined by powering the motor and connecting terminals R-B to actually determine the stroke as motor drives to an open position.

D. MODULATING MOTOR SWITCHES - LOW FIRE AND HIGH FIRE

The modulating motor contains either one or two internal switches depending upon application. The microswitches are actuated by adjustable cams attached to the motor shaft.

Factory replacement motors have the cams preset. The low fire start switch is set to make the red and yellow leads at approximately 8° on motor closing. The high fire purge air proving switch (located in the modulating motor) is set to make red and blue tracer leads at approximately 60° the on motor opening. Normally the settings are left as is, but job conditions may require readjustment. If the cams require adjustment or resetting, follow the instructions in the manufacturer's technical manual.

E. BURNER OPERATING CONTROLS - GENERAL

Note: Adjustments to the boiler operating controls should be made by an authorized Cleaver-Brooks Service Technician. Refer to the appropriate boiler Operation and Maintenance manual for specific information on boiler startup and operation.

The standard boiler operating control package consists of three separate controls, the High Limit Control, Operating Limit Control and the Modulating control.

The High Limit Control senses the hot water temperature or steam pressure. It is used as a safety limit to turn the burner off in the event the operating limit control fails. The high limit control should be set sufficiently above the operating limit control to avoid nuisance shutdowns.

The Operating Limit Control senses temperature or pressure and automatically turns the burner on to initiate the start-up sequence when required and turns the burner off to initiate the shutdown sequence when the demand is satisfied. The control must be set to initiate startup only at the low fire position.

The Modulating Control senses changes in the hot water temperature or steam pressure and signals the modulating motor to control the flow of fuel and air to the burner. With either steam or hot water boilers, the modulating control must be set to ensure the burner is at its minimum low fire position before the operating limit control either starts or stops the burner.

When adjusting or setting controls, first be sure all control devices are securely mounted and level. With the temperature sensing control, make sure the sensing bulb is properly bottomed in its well and is secured against movement. Be sure the connecting tubing is not kinked.

The dial settings are generally accurate; although it is not unusual to have a slight variation between a scale setting and an actual pressure gauge or thermometer reading. Always adjust control setting to agree with pressure gauge or thermometer readings. Accurate instrument readings are required. When necessary use auxiliary test equipment to set controls.

Burner controls correctly set to match load demands will provide operational advantages and achieve the following desirable objectives:

- The burner will be operating in low fire position prior to shut down.
- The burner will operate at low fire for a brief period on each start during normal operation.
- Eliminates frequent burner on-off cycling.

Separate and independent controls affect modulated firing and burner on-off cycling. Figure 5-3 depicts a typical setting relationship of the operating limit control, modulating control and the high limit control.

The burner will be “on” whenever the pressure or temperature is less than point **B** and “off” whenever pressure or temperature is greater than point **A**. The distance between points **A** and **B** represents the “on-off” differential of the operating limit control.

In normal operation, the burner will shut down whenever the pressure or temperature rises above setting **A**. At that point the switch in the operating limit control will open. As the pressure or temperature drops back to **B**, the operating limit control closes and the burner will restart. The modulating control will signal the modulating motor to be in a low fire position. If the load demands exceed the low fire input potential, the modulating control will increase the firing rate proportionately as pressure or temperature falls toward point **D**. The modulating motor will stop at any intermediate point between **C** and **D** whenever the fuel input balances the load requirement.

As the load requirement changes, the firing rate will change accordingly. Thus it is referred to as **modulated firing.**

Point **D** represents the maximum firing rate of the burner, or highfire. In the event pressure or temperature drops while the burner is firing at highfire, it indicates that the load exceeds the capacity of the boiler.

The firing graph (Figure 5-1) shows that point **B** and point **C** do not coincide. Extreme load conditions could require the points be closely matched.

When set as shown, with a time lag between **B** and **C**, the burner will be in a low fire position upon a restart and will fire at that rate for a short period of time before falling pressure or temperature requires an increase in the firing rate.

⚠ CAUTION

Excessive cycling increases the potential and severity of internal condensation. On-Off cycling should be limited to eight (8) cycles or less per hour to keep the blower motor from overheating and excessive wear on the switch gear and pilot. Failure to follow these instructions could result in damage and premature failure of the equipment.

If points B and C overlap when restart occurs, the burner would drive to a higher firing position immediately after the main flame was proven.

Note: It is not recommended that the boiler controls be set so as to overlap the modulating control range and operating control range.

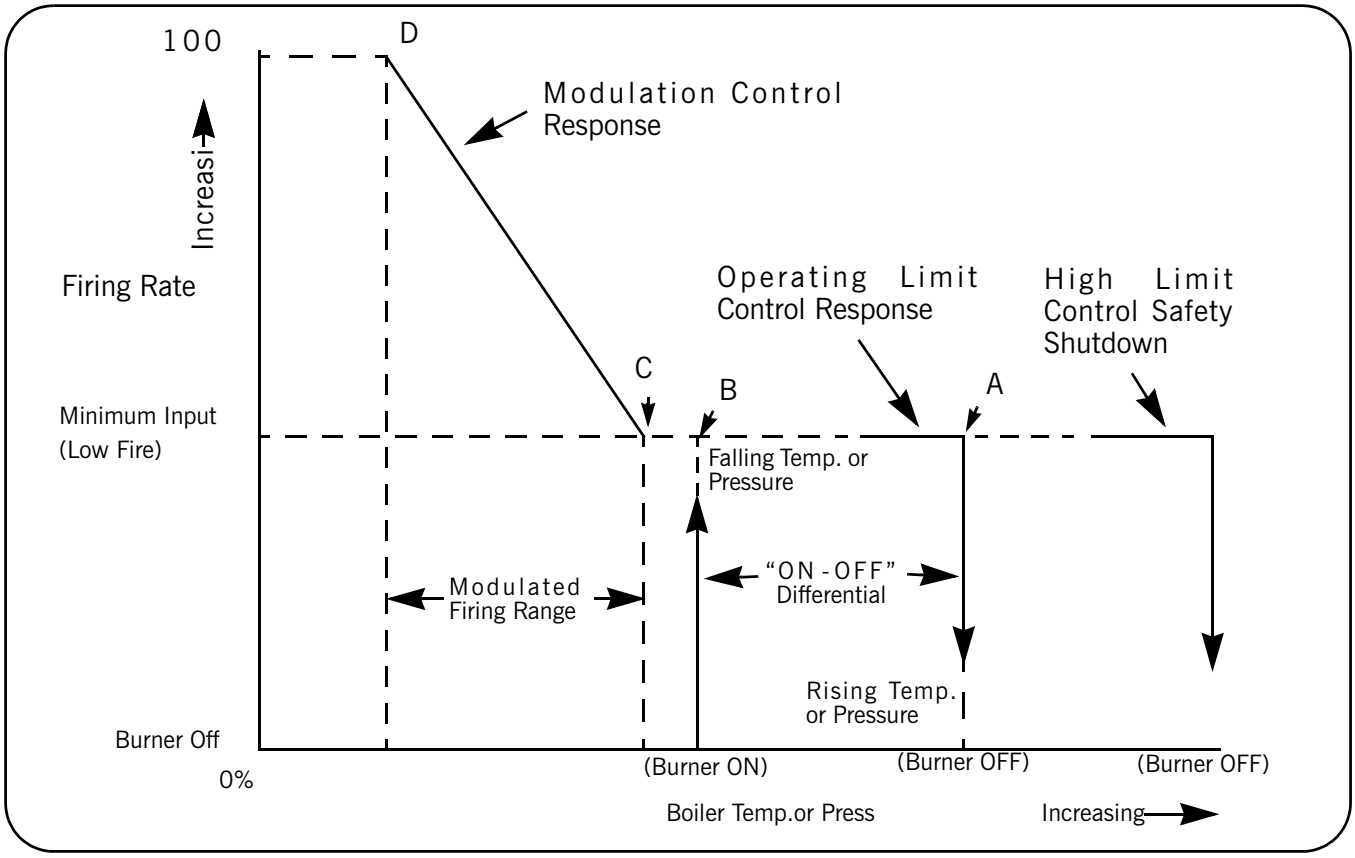


Figure 5-1: Firing Graph

When firing a cold boiler, it is recommended that the burner be kept at low fire, under manual flame control, until normal operating pressure or temperature is reached. If the burner is not under manual control on a cold start, it will immediately move toward high fire as soon as the program control releases the circuit that holds the burner in low fire. The modulating control will be calling for high fire and the burner will move to that position as rapidly as the damper motor can complete its travel.

Note: Rapid heat input can subject the pressure vessel metal and refractory to undesirable conditions.

Do not operate the boiler in excess of 90% of the safety valve relief setting. The closer the operating pressure is to the safety valve relief pressure, the greater the possibility of valve leakage. Continued leakage, however slight, will cause erosion and necessitate early safety valve replacement. The control settings on a hot water boiler must be within the temperature limits of the boiler.

Ideally, the boiler operating controls should be set under actual load conditions. Especially under new construction conditions, the boiler is initially started and set to operate under less than full load requirements. As soon as possible thereafter, the controls should be reset to provide maximum utilization of the modulating firing system. To accomplish maximum utilization, and assuming that air/fuel combustion ratios have been set, make the required adjustments to the controls to bring the boiler pressure or temperature up to meet the load requirements.

To properly set the modulating control, carefully adjust it under load conditions, until the load is maintained with the burner firing at a steady rate. The firing rate at that point may be full high fire or slightly less, depending upon the relationship of the boiler size to the load.

When the modulating control is set and the burner is in full high fire, the scale setting of the modulating pressure control on a steam boiler will indicate the low point of the modulating range. The scale setting of the modulating temperature control on a hot water boiler will have a reading that indicates the midpoint of the modulating range.

The operating limit control should now be adjusted and the differential established. In an installation that does not require a very close control of steam pressure or water temperature the adjustable differential (Figure 5-3 A to B) should be set as wide as conditions permit, since a wide setting will provide less frequent burner cycling.

The high limit control provides a safety factor to shut the burner off in the event the operating limit control should fail. The setting of the control should be sufficiently above the operating limit control to avoid nuisance shutdowns. The setting, however, must be within the limits of the safety valve settings and should not exceed 90% of the valve setting. The control requires manual resetting after it shuts off the burner.

In the setting of the controls, consideration must be given to the time required for a burner restart. Each start, requires a prepurge period, plus the fixed time required for proving the pilot and main flame. In addition, approximately one-half minute is required for the damper motor to travel from low to high fire. The time lag may allow pressure or temperature to drop below desirable limits.

F. MODULATING PRESSURE CONTROL (Steam)

Turn the adjusting screw until the indicator is opposite the low point of the desired modulating range. Modulated firing will range between the low point and a higher point equal to the modulating range of the particular control. In 0-15 psi controls the range is 1/2 psi.

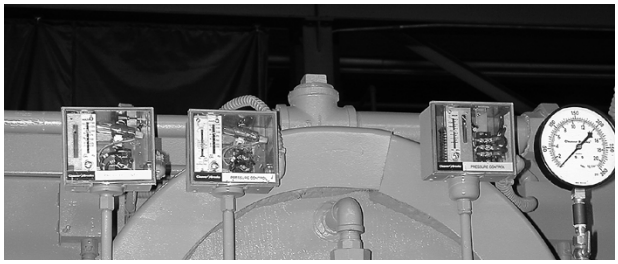


Figure 5-2: Steam Controls

⚠ CAUTION

To prevent burner shutdown at other than low-fire setting, adjust the modulating pressure control to modulate to low fire BEFORE the operating limit pressure control shuts off the burner. Failure to follow these instructions could result in damage to the equipment

G. OPERATING LIMIT PRESSURE CONTROL (Steam)

Set the “cut-out” (burner-off) pressure on the main scale using the large adjusting screw. Set the differential on the short scale by turning the small adjusting screw until the indicator points to the desired difference between cut-out and cut-in pressures. The “cut-in” (burner-on) pressure is the cut-out pressure MINUS the differential. The cut-out pressure should not exceed 90% of the safety valve setting.

H. HIGH LIMIT PRESSURE CONTROL (Steam)

Set “cut-out” (burner off) pressure on the main scale using the adjusting screw. The control will break a circuit when pressure reaches this point. The setting should be sufficiently above the operating limit pressure control to avoid shutdowns, and preferably not exceed 90% of safety valve setting. The control requires manual resetting after tripping on a pressure increase. To reset, allow pressure to return to normal and then press the reset button.

I. MODULATING TEMPERATURE CONTROL (Hot Water)

Turn the knob on the front of the case until the pointer indicates the desired setpoint temperature. The desired set point is the center point of a proportional range. The control has a 3 to 30° differential and may be adjusted to vary the temperature range within which modulating action is desired. With the cover off, turn the adjustment wheel until pointer indicates desired range.

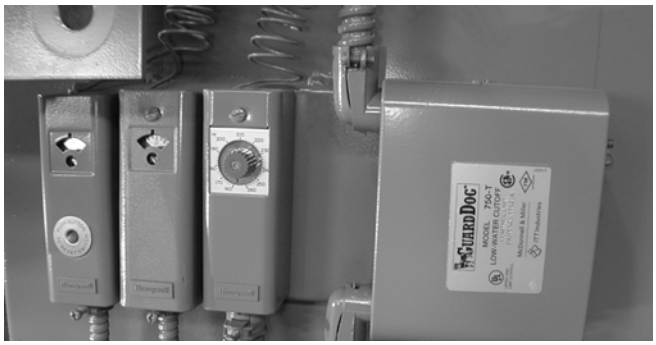


Figure 5-3: Hot Water Controls

⚠ CAUTION

To prevent burner shutdown at other than low-fire setting adjust modulating temperature control to modulate low fire BEFORE operating limit temperature control shuts off burner. Failure to follow these instructions could result in damage to the equipment.

J. OPERATING LIMIT TEMPERATURE CONTROL (Hot Water)

Set “cut-out” (burner off) temperature on the scale by inserting a screwdriver through the cover opening to engage the slotted head adjusting screw. The “cut-in” (burner on) temperature is the cut-out temperature MINUS the differential. The differential is adjusted from 5 to 30° F.

K. HIGH LIMIT TEMPERATURE CONTROL (Hot Water)

Set the “cut-out” (burner off) temperature on scale using the adjusting screw. The control will break the circuit and lock out on a rise in water temperature above the setting. The setting should be sufficiently above the operating limit temperature to avoid unnecessary shutdowns. The control requires manual resetting after tripping on a temperature increase. To reset, allow the water temperature to drop below the cut-out setting less differential, and then press the manual reset button.

L. LOW WATER CUTOFF DEVICES (Steam and Hot Water)

No adjustment is required since LWCO controls are preset by the original manufacturer. However, if the water level is not maintained, inspect the devices immediately and replace as required.

M. COMBUSTION AIR PROVING SWITCH

Air pressure against the diaphragm actuates the switch which, when made, completes a circuit to prove the presence of combustion air. Since the pressure of the combustion air is at its minimum value when the damper is full closed, the switch should be adjusted under that situation. It should be set slightly below the minimum pressure, but not too close to that point to cause nuisance shutdowns.

The run/test switch on the program relay should be set to TEST. Turn the burner switch on. The blower will start (provided that all limit circuits are completed) and the programmer will remain in the low-fire (damper closed) portion of the prepurge.

Slowly turn down the air switch adjusting screw until it breaks the circuit. Here the programmer will lock out and must be manually reset before it can be restarted. Add a half turn or so to the adjusting screw to remake its circuit.

Recycle the program relay to be sure that normal operation is obtained. Return the test switch to the RUN position.

N. GAS PILOT FLAME ADJUSTMENT

The size of the gas pilot flame is regulated by adjusting the gas flow through the pilot gas regulator. The flame must be sufficient to ignite the main flame and to be seen by the flame detector. But an extremely large flame is not required. An overly rich flame can cause sooting or carbon buildup on the igniting electrode. Too small a flame can cause ignition problems.

Although it is possible to visibly adjust the size of the pilot flame, it is preferable to obtain a microamp or voltage reading of the flame signal.

The correct voltage or microamp readings can be found in the information supplied with the flame safeguard system.

The program relay used may be of the type that provides message information that includes a constant flame signal of dc voltage. In this case a separate dc voltmeter is not required.

O. GAS PRESSURE AND FLOW INFORMATION

Because of variables in both the properties of gas and the supply system, it will be necessary to regulate the pressure of the gas to a level that produces a steady, dependable flame that yields highest combustion efficiency at rated performance yet prevents overfiring. Once the optimum pressure has been established, it should be recorded and periodic checks made to verify that the regulator is holding the pressure at this level. Occasional modification in fuel composition or pressure by the supplier may, at times, require readjustment to return the burner to peak efficiency.

Pressure

The gas supplied must provide not only the quantity of gas demanded by the unit, but must also be at a pressure high enough to overcome the pressure-loss due to the frictional resistance imposed by the burner system and the control valves.

The pressure required at the entrance to the burner gas train for rated boiler output is termed “inlet pressure.” The gas pressure regulator must be adjusted to achieve the pressure to assure full input.

The inlet pressure requirement varies with boiler size, and types of gas train. Refer to Table 6-3 for pressure require-ments.

The pressures listed are based on 1000 Btu/cu-ft natural gas at elevations up to 700 feet above sea level.

The volume of gas flow is measured in terms of cubic feet and is determined by a meter reading. The gas flow rate required for maximum boiler output depends on the heating value (Btu/cu-ft) of the gas supplied (Table 5-1).

Pressure Correction

The flow rate outlined in Section P is based on a “base” pressure, which is usually atmospheric or 14.7 psia.

Meters generally measure gas in cubic feet at “line” or supply pressure. The pressure at which each cubic foot is measured and the correction factor for the pressure must be known in order to convert the quantity indicated by the meter into the quantity which would be measured at “base” pressure.

To express the volume obtained from an actual meter reading into cubic feet at base pressure, it is necessary to multiply the meter index reading by the proper pressure factor obtained from Table 6-2

As An Example:

Assume that a 500Flextube boiler is rated for 5MMBtu/hr input is installed and equipped with a standard gas train; and that 1,000 Btu natural gas is available with an incoming gas pressure of 3 psig. The flow requirements can be determined as follows:

Flow

Since the gas flow rate is based on standard conditions of flow, correction must be made for the supply pressure through the meter of 3 psig. Determine the flow rate by dividing the Btu content of the gas into the burner input (Table 6-1) and "correct" this answer by applying the correction factor for 3 psig (Table 6-2).

Btu/hr Input = CFH (Cubic feet/hour) Required
Btu/cu-ft

OR

5,000,000 = 5,000 CFH (At 14.7 Ib-atmospheric base 1,000 pressure)

THEN

5,000 = 4237 CFH
1.18

This is the CFH (at line pressure) that must pass through the meter so that the equivalent full input requirement of 5,000 CFH (at base pressure) will be delivered.

Checking Gas Flow

Your gas supplier can generally furnish a gas meter flow chart from which gas flow can be determined. After a short observation period, the information aids in adjusting the regulator to increase or decrease flow as required to obtain the rating.

Final adjustment of the gas fuel is carried out by means of Fine tuning the linkage adjustments, while performing a combustion efficiency analysis. See Section O for details.

Note: The information given in this section is for all practical purposes sufficient to set and adjust controls for gas input. Your gas supplier can, if necessary, furnish exact correction factors that take into consideration Btu content, exact base pressure, specific gravity, temperature, etc., of the gas used.

P. GAS FUEL COMBUSTION ADJUSTMENT

After operating for a sufficient period of time to assure a warm boiler, adjustments should be made to obtain efficient combustion.

Burner efficiency is measured by the amount or percentage of O_2 present in the flue gas. O_2 readings determine the total amount or excess air in the combustion process, above the point of stoichiometric combustion or perfect combustion. Stoichiometric combustion is a term used to describe a condition when there is the exact amount, molecule for molecule, of air for the fuel attempting to be burned. This can be accomplished under laboratory conditions, however it's not practical to attempt to meet this condition in a boiler. Stoichiometric combustion however, is the reference point used when setting fuel/air ratios in a boiler.

There must always be excess air in the combustion process to account for changes in boiler room temperature and atmospheric conditions, and to ensure the combustion is on the proper side of the combustion curve.

Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion or flue gas analyzer. The appearance or color of the gas flame is not an indication of its efficiency, because an efficient gas flame will vary from transparent blue to translucent yellow.

Most flue gas analyzers in use today measure the content, by percentage of oxygen (O_2) and carbon monoxide (CO) either by percent or parts per million (ppm). Carbon dioxide (CO_2) is not normally measured with todays flue gas analyzers, but may be displayed via a calculation.

The O_2 levels through the entire firing range of the burner, low fire to high fire should be tested. Cleaver-Brooks recommendations on turndown should also be followed and the turndown range of the burner should not be exceeded.

It's important to understand what the readings shown on an instrument refer to when setting combustion in a boiler. To assist with this understanding Figure 5-5 shows the relationship between O_2 levels (excess air) and the products of combustion for a typical flue gas analysis (natural gas).

One of the products of combustion is CO_2 (Carbon Dioxide). This is shown in percentage.

Another product of combustion is CO (carbon monoxide) and is shown in both percentage and parts per million (ppm). The maximum CO level standardly allowed is less than 400 ppm. However, this may change subject to local regulations.

The percent O_2 recorded on an instrument equates to percent excess air, I.E. 3% O_2 is approximately 15% excess air and 4% O_2 is approximately 20% excess air. The exact percentage of excess air is a mathematical calculation based on an ultimate fuel analysis of the fuel being fired.

It is generally recommended that O_2 readings of between 3% to 5% be attained with less than 400 ppm CO, at high fire.

Using information from Section O, determine the standard conditions of gas pressure and flow for the size boiler and the gas train on it. Calculate the actual pressure and flow through the use of correction factors that compensate for incoming gas pressure and altitude.

Basically, gas adjustments are made with a gas pressure regulator, which controls the pressure and with the butterfly gas valve which directly controls the rate of flow.

The low fire setting should be regarded as tentative until the proper gas pressure for high fire operation is established.

To reach the high fire rate, turn the manual flame control switch toward "OPEN" in minor increments while monitoring combustion for overly rich or lean conditions.

At high fire, the gas butterfly valve should be open as wide as indicated by the slot on the end of the shaft.

Determine the actual gas flow from a meter reading. (See Section O). With the butterfly valve open and with regulated gas pressure set at the calculated pressure, the actual flow rate should be close to the required input. If corrections are necessary, increase or decrease the gas pressure by adjusting the gas pressure regulator, following the manufacturer's directions for regulator adjustment.

When proper gas flow is obtained, take a flue gas reading. The O_2 should be between 3% and 5% at high fire.

If the fuel input is correct, but the O_2 values do not fall within this range, the air damper settings may need to be adjusted. Adjustment of the air damper linkage is described in Section B of Chapter 6.

With the high-fire air/fuel ratio established, the gas pressure regulator needs no further adjusting.

After being certain that the air control damper and its linkage are correctly adjusted to provide the proper amount of secondary air, and after adjusting the gas pressure regulator, final adjustment can be made, if necessary obtain a constant air/fuel ratio throughout the entire firing range.

Input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of gas fuel at that setting. Standard Burner Low Fire Adjustment

The fuel input should be adjusted using the linkage to approximately 33% of that at high fire. At low fire the O_2 flue gas reading should be between 3-5%.

If the air damper needs to be adjusted in order to provide the correct low fire air/fuel ratio, combustion must be rechecked at higher firing rates and adjusted as required.

Q. LOW GAS PRESSURE SWITCH

Adjust the scale setting to slightly below the normal burning pressure. The control circuit will be broken when pressure falls below this point. Since gas line distribution pressure may decrease under some conditions, shutdowns may result if the setting is too close to normal. However, regulations require that the setting may not be less than 50% of the rated pressure downstream of the regulator.

Manual resetting is necessary after a pressure drop. Press the reset lever after pressure is restored. Be sure that the mercury switch equipped control is level.

R. HIGH GAS PRESSURE SWITCH

Adjust the scale setting to slightly above the normal burning pressure. The control circuit will be broken when pressure exceeds the normal operating pressure. Unnecessary shutdowns may result if the setting is too close to normal; however, regulations require that the setting may not be greater than 150% of rated pressure.

Manual resetting is necessary after a pressure rise. Press the reset lever after pressure falls. Be sure that the mercury switch equipped control is level.

S. FUEL OIL PRESSURE AND TEMPERATURE - GENERAL

Variations in burning characteristics of the fuel oil may occasionally require adjustments to assure highest combustion efficiency. The handling and burning characteristics may vary from one delivery of oil to another. Therefore, it is recommended that the oil system be inspected from time to time to verify that pressures and viscosity are at the proper operating levels.

Because of variation in oils, including chemical content, source, blends, and viscosity characteristics, the temperatures and pressures listed in Chapter 5, and mentioned in the adjusting of the controls in the following paragraphs, will vary and thus may be regarded as tentative and to be changed to provide best firing conditions. Review of the applicable maintenance instructions given in Chapter 8 will aid in maintaining an efficient fuel system.

Table: 5-1 Fuel Consumption (Natural Gas)

MODEL NO.	150	200	250	300	350	400	450	500	550	600	700	800	900	1000	1100	1200
Fuel Consumption Gas (cfh)[A]	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	8000	9000	10000	11000	12000

A. Natural Gas @ 1000 Btu/cu-ft.

REGULATOR INLET PRESSURE (PSIG)	PRESSURE FACTOR
1	1.05
2	1.11
3	1.18
4	1.25
5	1.32
6	1.39
7	1.45
8	1.53
9	1.59
10	1.66
11	1.72
12	1.81
13	1.86
14	1.93
15	2.00

MODEL NO.	STD GAS TRAIN SIZE (IN.) Note 3	MIN. GAS PRESSURE (IN.W.C.) Note 4	MIN. GAS PRESSURE (IN.W.C.) Note 5	BURNER MODEL
FLX-150	1	11.2	12.5	PFVG-15
FLX-200	1	19.4	21.7	PFVG-20
FLX-250	1.5	12.4	15.7	PFVG-25
FLX-300	1.5	15.9	20.7	PFVG-30
FLX-350	1.5	15.5	22.0	PFVG-35
FLX-400	1.5	18.7	27.2	PFVG-40
FLX-450	2	16.0	26.7	PFVG-45
FLX-500	2	17.6	21.0	PFVG-50
FLX-550	2	22.9	27.1	PFVG-55
FLX-600	2	20.0	24.9	PFVG-60
FLX-700	2	25.2	31.9	PFVG-70
FLX-800	2.5	19.9	22.2	PFVG-80
FLX-900	2.5	24.7	27.7	PFVG-90
FLX-1000	2.5	31.6	31.6	PFVG-100
FLX-1100	2.5	37.3	37.3	PFVG-110
FLX-1200	2.5	38.2	38.2	PFVG-120

Notes:

1. Table is based on 1,000 Btu/cu.ft natural gas and elevation to 1000 feet.
2. Minimum gas pressure also applies to 200 fuel series.
3. As an option, the standard gas train can be replaced with an oversized design to reduce inlet gas pressure requirements.
4. Use this column for all U.S. Installations.
5. Use this column for all Canadian Installations.

T. FUEL OIL COMBUSTION ADJUSTMENT

After operating for a sufficient period of time to assure a warm boiler, adjustments should be made to obtain efficient combustion.

Burner efficiency is measured by the amount or percentage of O_2 present in the flue gas. O_2 readings determine the total amount or excess air in the combustion process, above the point of stoichiometric combustion or perfect combustion. Stoichiometric combustion however, is the reference point used when setting fuel/air ratios in a boiler.

There must always be excess air in the combustion process to account for changes in boiler room conditions and to ensure the combustion is on the proper side of the combustion curve .

Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion gas analyzer. Efficient combustion cannot be solely judged by flame condition or color, although they may be used in making approximate settings. Combustion settings should be done so that there is a bright sharp flame with no visible haze.

Most flue gas analyzers in use today measure the content, by percentage, of oxygen (O_2) and in some cases, smoke. Carbon dioxide (CO_2) is not normally measured with modern gas analyzers, but may be displayed as a calculation.

The O_2 levels through the entire firing range of the burner, low fire to high fire should be tested. Cleaver-Brooks recommendations on turndown should also be followed and the turndown range of the burner should not be exceeded.

It is required to set the burner to operate with a reasonable amount of excess air to compensate for minor variations in the pressure, temperature, or burning properties of oil. Fifteen to 20% excess air is considered reasonable. This would result in an O_2 reading of 3% to 4%, at high fire.

Final adjustment to fuel input must be made to produce a minimum of smoke. A maximum smoke spot density of a No. 2 for light oil, as measured in conformance to ASTMD 2156-63T.

Through the use of the manual flame control, slowly bring the unit to high fire by stages while monitoring combustion for overly rich or lean conditions. At the high fire position, the air damper should be fully opened.

U. LOW OIL PRESSURE SWITCH

The L.O.P.S. prevents burner ignition, or stops its operation, when the oil pressure is below the setpoint. Adjust the control by turning the screw on top of control case to an indicated pressure 10 psi below the established primary oil pressure setting indicated on the oil supply pressure gauge. The switch will remain in a closed position as long as the oil pressure exceeds this setting. The control normally used automatically resets when pressure is restored after a drop.

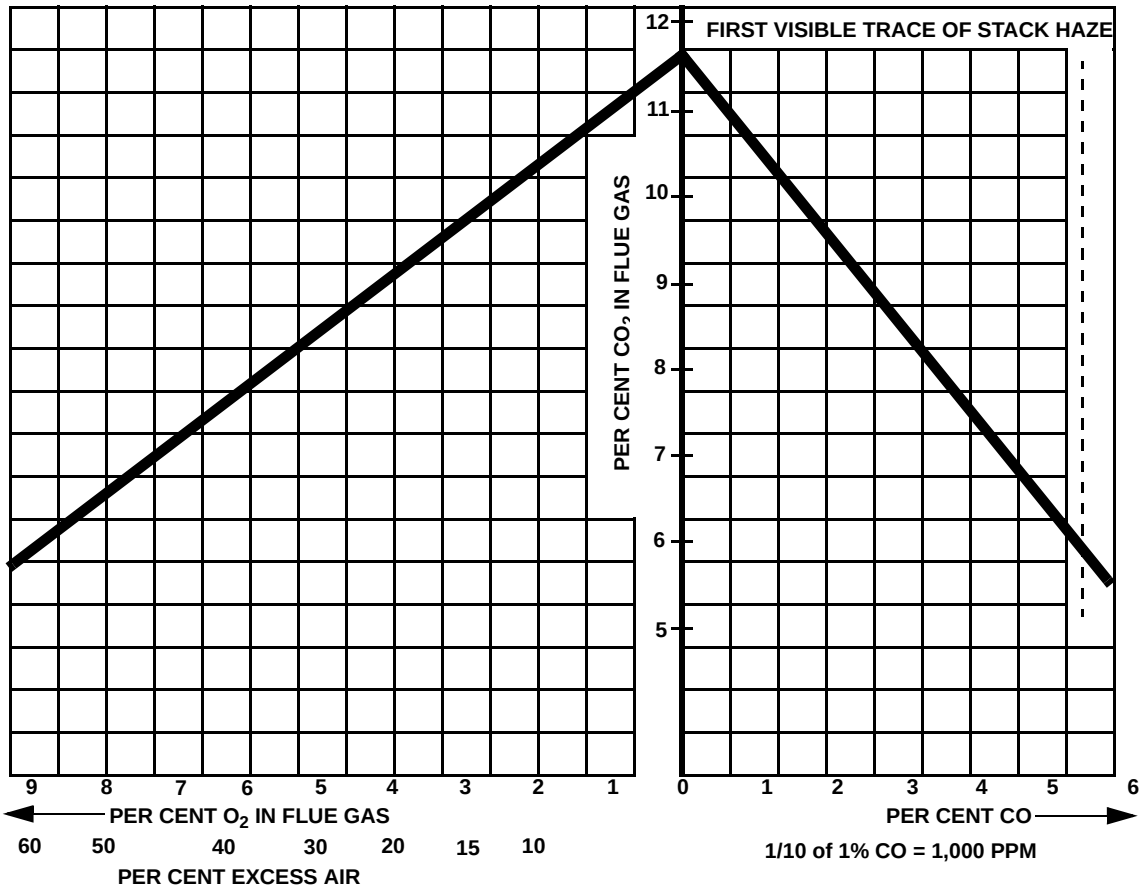


Figure 5-4: Flue Gas Analysis Chart for Natural Gas

CHAPTER 6

Troubleshooting

⚠WARNING

Troubleshooting should be performed only by personnel who are familiar with the equipment and who have read and understand the contents of this manual. Failure to follow these instructions could result in serious personal injury or death.

⚠WARNING

Disconnect and lock out the main power supply in order to avoid the hazard of electrical shock.Failure to follow these instructions could result in serious personal injury or death.

Chapter 7 assumes that the unit has been properly installed and adjusted, and that it has been running for some time. It is further assumed that the operator has become thoroughly familiar with both burner and manual by this time. The points under each heading are set down briefly as possible causes, suggestions or clues to simplify locating the source of trouble. Methods of correcting the trouble, once it has been identified, may be found elsewhere in this manual.

If the burner will not start or operate properly, the trouble shooting chapter should be referred to for assistance in pinpointing problems that may not be readily apparent.

The program relay has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the control bulletin for specifics and suggested remedies.

Familiarity with the programmer and other controls in the system may be obtained by studying the contents of this manual. Knowledge of the system and its controls will make trouble shooting much easier. Costly down-time or delays can be prevented by systematic checks of actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

If an obvious condition is not apparent, check the continuity of the circuits with a voltmeter or test lamp. Each circuit can be checked and the fault isolated and corrected. Most circuitry checking can be done between appropriate terminals on the terminal boards in the control cabinet or the entrance box. Refer to the schematic wiring diagram for terminal identification.

Problem	Solution
BURNER DOES NOT START	1. No voltage at program relay power input terminals. A. Main disconnect switch open. B. Blown control circuit fuse. C. Loose or broken electrical connection.
	2. Program relay safety switch requires resetting.
	3. Limit circuit not completed—no voltage at end of limit circuit program relay terminal. A. Pressure or temperature is above setting of operation control. (Load demand light will not glow.) B. Water below required level. 1). Low-water light (and alarm horn) should indicate this condition. 2). Check manual reset button, if provided, on low-water control. C. Fuel pressure must be within settings of low pressure and high pressure switches.
	4. Fuel valve interlock circuit not completed. A. Fuel valve auxiliary switch not enclosed.
NO IGNITION	1. Lack of spark. A. Electrode grounded or porcelain cracked. B. Improper electrode setting. C. Loose terminal on ignition cable; cable shorted. D. Inoperative ignition transformer. E. Insufficient or no voltage at pilot ignition circuit terminal.
	2. Spark but no flame. A. Lack of fuel - no gas pressure, closed valve, empty tank, broken line, etc. B. Inoperative pilot solenoid. C. Insufficient or no voltage at pilot ignition circuit terminal. D. Too much air.
	3. Low fire switch open in low fire proving circuit. A. Damper motor not closed, slipped cam, defective switch. B. Damper jammed or linkage binding.
	4. Running interlock circuit not completed. A. Combustion air proving switch defective or not properly set. B. Motor starter interlock contact not closed.
	5. Flame detector defective, sight tube obstructed, or lens dirty.

Problem	Solution
PILOT FLAME, BUT NO MAIN FLAME	1. Insufficient pilot flame.
	2. Gas Fired Unit. A. Manual gas cock closed. B. Main gas valve inoperative. C. Gas pressure regulator inoperative.
	3. Oil fired unit. A. Oil supply cut off by obstruction, closed valve, or loss of suction. B. Supply pump inoperative. C. No fuel. D. Main oil valve inoperative. E. Check oil nozzle, gun and lines.
	4. Flame detector defective, sight tube obstructed or lens dirty.
	5. Insufficient or no voltage at main fuel valve circuit terminal.
BURNER STAYS IN LOW FIRE	1. Pressure or temperature above modulating control setting.
	2. Manual-automatic switch in wrong position.
	3. Inoperative modulating motor.
	4. Defective modulating control.
	5. Binding or loose linkage, setscrews, etc.
SHUTDOWN OCCURS DURING FIRING	1. Loss or stoppage of fuel supply.
	2. Defective fuel valve; loose electrical connection.
	3. Flame detector weak or defective.
	4. Lens dirty or sight tube obstructed.
	5. If the programmer lockout switch has not tripped, check the limit circuit for an opened safety control.
	6. If the programmer lockout switch has tripped: A. Check fuel lines and valves. B. Check flame detector. C. Check for open circuit in running interlock circuit. D. The flame failure light is energized by ignition failure, main flame failure, inadequate flame signal, or open control in the running interlock circuit.

Problem	Solution
SHUTDOWN OCCURS DURING FIRING cont'd	7. Improper air/fuel ratio (lean fire). A. Slipping linkage. B. Damper stuck open. C. Fluctuating fuel supply. 1). Temporary obstruction in fuel line. 2). Temporary drop in gas pressure. 8. Interlock device inoperative or defective.
MODULATING MOTOR DOES NOT OPERATE	1. Manual-automatic switch in wrong position.
	2. Linkage loose or jammed.
	3. Motor does not drive to open or close during pre-purge or close on burner shutdown. A. Motor defective. B. Loose electrical connection. C. Damper motor transformer defective.
	4. Motor does not operate on demand. A. Manual/automatic switch in wrong position. B. Modulating control improperly set or inoperative. C. Motor defective. D. Loose electrical connection. E. Damper motor transformer defective.
EXCESSIVE RUST ON TUBES	1. Condensation of the flue gases on cool tubes is causing rust. A. Change system so return temperatures are above 120 °F or install blend pump to assure water temperatures entering boiler are above 120 °F.
	2. Open stack or condensate running down stack or breeching. A. Stack should be offset. Insulate and drain stack.
	3. Frequent cold starts. A. Reset controls for less cycling.

Problem	Solution
WATER ON BASE	1. A cold environment and/or intermittent firing may allow inner casing to heat up above the condensation temperature of the flue gasses. A. Increase temperature of the cold boiler room if possible. B. Verify insulation is in place between inner and outer casing and replace if missing. C. Reset controls for less cycling to allow boiler to run for longer periods of time to heat inner casing above condensation temperature.
	2. Cold system startup. A. Any time a boiler is started with a cold system, it will produce condensate until internal surface temperatures exceed 130 °F. Internal condensation will not be produced once a boiler has warmed up. Condensate will dry up after a short time. Limit number of cold starts.
	3. Cold return temperatures. A. Return temperatures below 120 °F. will continually produce condensation. Raise return temperatures above 120 °F.
	4. Gasket leaks allow gases to escape and condence on relatively cool base. A. Gasket may need to be replaced or inner casing not installer per instructions. Install inner casing and gasket per instructions outlined in Chapter 8, SectionD.

CHAPTER 7

Inspection and Maintenance

A. General

A well-planned maintenance program will help to avoid unnecessary downtime or costly repairs, promote safety, and aid boiler inspectors in performing required periodic inspections. An inspection schedule with a listing of procedures should be established. It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly, and yearly maintenance activities provides a valuable guide and aids in obtaining safe, economical and lengthy service from your Cleaver-Brooks equipment. It is important to realize that the frequency of inspection will depend on variable conditions such as load, fuel, system requirements, boiler environment, etc.

⚠WARNING

Shut off electrical power to the boiler when performing any service or maintenance work or work that requires removal of covers or component parts. Failure to heed this warning could result in electrical shock, serious personal injury or death.

Good housekeeping practices help maintain a professional appearing boiler room. Only trained and authorized personnel should be permitted to operate, adjust, or repair the boiler and related equipment. The boiler room should be kept free of all material and equipment not necessary to the operation of the boiler or heating system.

Even though the boiler has electrical and mechanical devices that make it automatic or semiautomatic in operation, the devices require systematic and periodic maintenance. Any "automatic" feature does not relieve the operator from responsibility. Automatic features do free the operator of certain repetitive chores, thus providing more time to devote to upkeep and maintenance.

Alertness in recognizing an unusual noise, improper gauge reading, leaks, etc., can make the operator aware of a developing malfunction, permitting prompt corrective action that may prevent extensive repairs or unexpected downtime. Any leaks - fuel, water, steam combustion gases - should be investigated and repaired with all due consideration of the necessary safety precautions.

Preventative maintenance measures such as regularly checking the tightness of connections, locknuts, setscrews, packing glands, etc., should be included in regular maintenance activities.

⚠WARNING

Inspection and maintenance should be performed only by trained personnel who are familiar with the equipment. Failure to heed this warning could result in serious personal injury or death.

B. Periodic Inspection

Insurance regulations or local codes may require a periodic inspection of the pressure vessel by an authorized inspector. Inspections are usually scheduled for periods of normal boiler downtime such as during an off season. The major inspection can often be used to accomplish maintenance, replacement, or repair tasks that cannot easily be done at other times. This also serves as a good basis for establishing a schedule for annual, monthly, or other periodic maintenance programs.

While the inspection pertains primarily to the waterside and fireside surfaces of the pressure vessel, it provides the operator with an excellent opportunity to perform a detailed check of all components of the boiler, including piping, valves, pumps, gaskets, refractory, etc. Complete cleaning, spot painting or repainting, and the replacement of expendable items, should be planned for and taken care of during this time. If possible, any major repairs or replacements that may be required should be taken care of during the boiler shutdown.

Replacement spare parts, if not on hand, should be ordered well in advance of a shutdown.

Note: Cleaver-Brooks genuine parts should be used to ensure proper operation and to avoid damage to the equipment.

Cleaver-Brooks boilers are designed, engineered and built to give long life and excellent service. Good operating practices and consistent maintenance and care will promote efficiency and economy of operation and contribute to many years of reliable performance from the equipment.

Cleaver-Brooks offers a Planned Maintenance Program that covers many of the items included on this chapter. For more information on the Planned Maintenance Program, contact your local Cleaver-Brooks authorized representative.

C. Fireside Cleaning

Soot and other noncombustible deposits are effective insulators and, if allowed to accumulate on boiler heat exchanger surfaces, will reduce heat transfer to the water and increase fuel consumption. Soot and other deposits can absorb moisture and may attract moisture in the form of corrosive acids that will deteriorate fireside metal.

Inspection and cleanout should be performed at frequent intervals, depending upon the boiler's load, type and quality of fuel, internal boiler temperature, and combustion efficiency. Stack temperature can be used as a guide to determine cleanout intervals, since an accumulation of soot deposits will raise the stack temperature.

Access to the furnace for tube and refractory cleaning is provided through a hinged burner door at the front of the boiler. When opening the burner door, first shut off the electrical and fuel supplies and then disconnect all fuel lines at the burner watching to see that there is no interference with field installed piping, wiring, or other obstructions. A temporary platform must be placed inside the furnace in order to protect the bottom drum insulating refractory when working inside the furnace.

⚠WARNING

To avoid the hazard of electrical shock, which could cause serious personal injury or death, the use of a low voltage flashlight Is recommended when working Inside the boiler furnace area.

Tubes should be brushed with a wire brush to remove any soot or other accumulations. Refractory surfaces should be cleaned, if necessary, with a soft bristle brush. Loose material should be vacuumed from the bottom of the furnace.

D. Upper Pass Cleaning

Upper pass access is gained through removal of the inner and outer side casing. To remove the outer casing panels, first disconnect and remove any electrical conduit, boxes and brackets attached to the side outer casing. Match mark the outer panels for repositioning. Remove screw (if installed) from frame above each outer panel. Starting with center panel, slide panel up, swing bottom of panel away from boiler and then slide down from the upper frame and set panel aside. After the center panel(s) are removed, the end panels can be slid (approximately 1") towards the center until they free from the corner frame and then removed in the same manner as the center panel(s). It there are only two outer panels (Models 150 through 350), then slide one end panel further into the corner frame to allow the other panel to slide free from the corner frame. If obstructions are present, such as the gas train, there may not be enough room to slide the panel out from under the upper frame. In this case, unscrew the upper frame from the roof and side frames and remove it also.

Match mark all inner casing panels for repositioning later. Inner casing panels must be removed in sequence starting from either end. Remove nuts, washers and clamp angles from the end and bottom of panels. Remove nuts, washers and bolt bars from vertical seams. Loosen nuts on top clamp angles but don't remove until panel is ready to be removed. Inner casing panels can not be removed by pulling panel straight out from boiler because of a 1" gasket retaining strip that overlaps behind the panels. Remove inner casing panels by sliding or angling panel away from remaining panels until the 1" retaining strip has cleared panel and then panel can be removed and set aside.

After removing the inner side casing, the pass cover plates (2nd pass only) must be removed. The cover plates are screwed together and are held in place by tabs inserted between the tubes. Remove the insulation by starting at one end and carefully rolling it up. The insulation blocks can now be removed from the pass opening. Keep the insulation blocks in order once they have been removed so they can be re-installed in the same position. Insulation is removed from the 4th pass in the same manner.

Now that the 2nd (left side) and 4th (right side) pass openings are exposed, cleaning can be done in the same way as the furnace area. Since the 3rd pass is only open on the ends, cleaning is done by pushing a wire brush mounted on a long handle through from each end. Since the arc of movement is restricted, cleaning the 3rd pass must be done from both sides of the boiler. The fifth pass is cleaned from above the tubes. As in the furnace, loose material should be removed by vacuuming after brushing. The pressure vessel should be inspected for any signs of deterioration after cleaning.

The flue outlet and stack should also be inspected annually and cleaned as necessary. Commercial firms are available to perform this work. The stack should also be inspected for damage and repaired as required.

Once everything has been cleaned and inspected the boiler can be put back together. Install insulation blocks in the 2nd and 4th pass openings in their previous positions. Spray adhesive on tubes above and below pass opening and install blanket insulation over opening. Install cover plates on 2nd pass (left) side only. If any insulation was removed from under the tubes at bottom of boiler it should be replaced at this time.

Prior to installing the inner casing, inspect studs on boiler and bolt bars for any thread damage. Any damaged threads should be cleaned and chased with a 3/8"-16 die. Apply a small amount of Cleaver-Brooks "Never-Seez" (p.n. 797-1814 or 797-1816) on each stud.

Before the inner casing can be installed, the old gaskets must be removed from the panels and around the perimeter of the boiler and replaced with new ones. After removing the gaskets, the surfaces should be cleaned to allow the new gasket to seal properly. The gasket around the perimeter of the boiler should be one piece with the ends overlapping side by side somewhere along the upper (roof) surface. A small amount of silicone will be required to fill gaps and valleys where the gasket crosses. This includes the roof to end wall seams and the base angle to end wall gaps. It is important that the entire gap between the end wall and the base angle be completely sealed. The seal along the base of the end wall should also be checked and resealed if necessary. The gasket should be positioned to the inside of the studs with a 1/4" gap between the studs and the gasket.

Install gasket on side casing panels so it extends past the top and bottom by 1/4" or more and 1/16" to 1/8" out the back at the top and bottom of the panel. (See Figure 7-1). Starting from one end, set panel edge 1/8" to 1/4" from the studs on the end wall. Install the first lower clamp angle over the respective studs, install washers and start nuts. Any nuts that are difficult to install should be replaced. Place the upper clamp angle

over the top studs and install washers and nuts but don't tighten. The end clamp can now be installed and nuts on the end clamp can be snugged up but not completely tightened. Before installing the next panel, apply a small amount of teflon paste to the area where the vertical gasket and the horizontal gaskets will overlap at the top and bottom. This will help ensure an air tight seal. Install the next panel in line being careful to slide the 1" gasket retaining strip behind the panel but under the insulation. Install the bottom and top clamp angles to hold panel in place, but don't tighten. Install the bolt strips, washers and nuts which clamp the panels together. Pull panels together evenly and tighten nuts to 250 to 300 in-lbs. Repeat until all panels are installed and securely bolted together. Now panels can be evenly pulled toward boiler with clamp angles. Tighten all nuts to 250 to 300 in-lbs.

The outer casing panels can now be installed starting with the end panels. Slide each end panel under the upper frame and push the bottom section into the boiler and allowing it to slide down to catch the bottom clamp angle. Then slide the end panels under the corner frames and install any remaining center panels.

The fireside should be thoroughly cleaned prior to any extended layup of the boiler. Depending upon circumstances, a protective coating may be required. See Chapter 3, Section J "Preparation for Extended Layup".

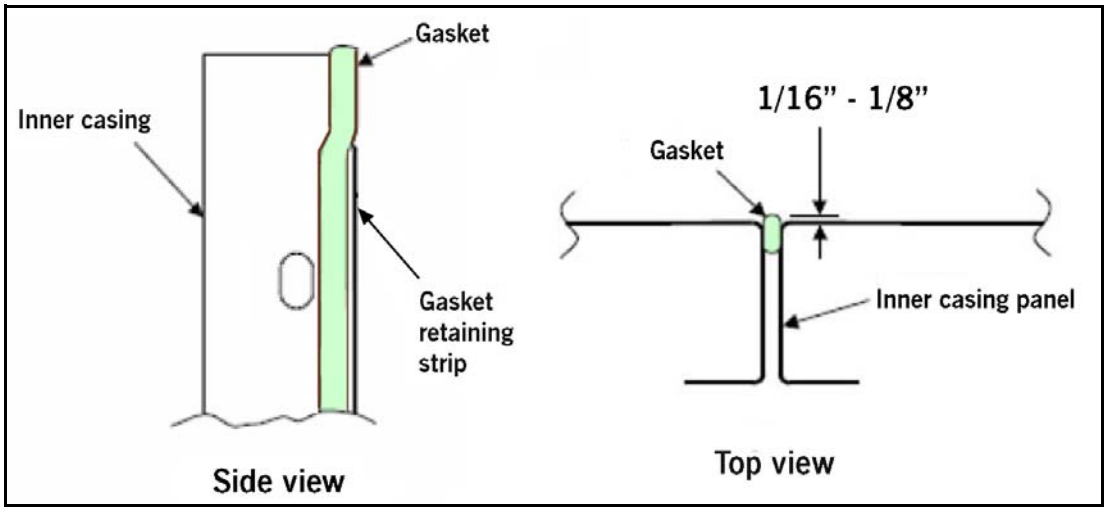


Figure 7-1: Gasket application to inner casing

E. Controls

Relief Valves

The relief valve is a very important safety device and deserves attention accordingly. Proper removal, installation or handling of a relief valve is of primary importance. Exercise care when removing, installing or handling a relief valve to ensure proper operation, long service life, and to ensure that the valve functions as designed.

⚠WARNING

Improper removal, handling or installation of a relief valve may adversely affect the valve's operation, resulting in serious personal injury or death.

Observe the following precautions when removing, handling or installing relief valves.

- Use only flat jawed wrenches on the flats of the valve
- Do not use a pipe threaded into the outlet to turn a valve
- Apply only a moderate amount of pipe compound to male threads
- Avoid over tightening, which can distort valve seating surfaces

- Do not paint, oil or otherwise cover any interior or working parts of the valve. A relief valve does not require any lubrication or protective coating to work properly.
- Discharge piping must be properly arranged and supported so that its weight does not bear on the relief valve.
- Handle with care a valve that has been removed from the boiler. A dropped valve should be considered as damaged until it has been inspected and passed by the valve manufacturer's authorized representative.

⚠WARNING

Only properly certified personnel such as the relief valve manufacturer's representative should adjust or repair the boiler relief valves. Failure to heed this warning could result in serious personal injury or death.

Relief valves should be operated only often enough to assure that they are in good working order. Follow the recommendations of your boiler inspector regarding valve inspection and testing. The frequency and method of testing should be based on the recommendation of your boiler inspector and/or the valve manufacturer, and should be in accordance with Section IV of the ASME Boiler and Pressure Vessel Code.

Low Water Controls (Hot Water)

Most instances of major boiler damage result from operating with low water. Since low water cutoff devices are set by the original manufacturer, no attempt should be made to adjust these controls in order to alter the point of low water cutoff. If a low water cutoff should become erratic in operation, immediately replace it or contact your local Cleaver-Brooks authorized representative for assistance.

It is essential to verify proper operation of low water cutoff devices as frequently as possible. However, it is impractical to perform daily and monthly maintenance on some models of the low water cutoff devices on a hot water boiler. Hot water systems are fully closed. Daily or monthly maintenance on some models of the low water cutoff devices would involve draining the entire water content of the system and would require makeup and additional feedwater treatment that might not otherwise be necessary.

To verify the proper operation of float style low water cutoff devices, the system must be drained. Remove the operating mechanism from the bowl and check and clean the float ball, internal moving parts, and the bowl housing. Also, check the cross-connecting piping to make certain that it is clean and free of obstruction.

It is impractical to blowdown the low water cutoff devices on a hot water boiler, since the entire water content of the system would become involved. Many hot water systems are fully closed and any loss of water will require makeup and additional feedwater treatment that might not otherwise be necessary. Since the boiler and system arrangement usually make it impractical to perform daily and monthly maintenance of the low water cutoff devices, it is essential to remove the operating mechanism from the bowl annually or more frequently, if possible, to check and clean float bowl, internal moving parts, and the bowl housing. Also check the cross- connecting piping to make certain that it is clean and free of obstruction.

⚠WARNING

Safe operation of your boiler demands periodic inspection and maintenance of all low water cutoff devices. If controls do not shut off the burner when the water level drops below the safe operating level, or if controls appear in poor physical condition, or become erratic in operation, they must be repaired or replaced at once. Failure to heed this warning could result in serious personal injury or death.

If test-n-check valves are installed on the float style low water cutoff devices, these controls can be tested by opening the blow down valve. The test-n-check valves restrict water flow when the blow down valve is open allowing water to drain from the control. The test-n-check valves permit testing of the control without draining the entire system therefore allowing regularly scheduled verification of float style low water cutoff.

Low Water Controls (Steam Boilers)

The need to periodically check water level controls and the waterside of the pressure vessel cannot be overemphasized. Most instances of major boiler damage are the result of operating with low water or the use of untreated (or incorrectly treated) water.

Always be sure of the boiler water level. The water column should be blown down routinely. Check samples of boiler water and condensate in accordance with procedures recommended by your water consultant. Refer to sections E and I in Chapter 3 for blowdown instructions and internal inspection procedures.

A typical water level control is mounted in the water column and has float actuated mercury switches. One switch is connected to the burner limit circuit and will stop the burner if a low water condition occurs. The other switch is connected to the feedwater circuit to energize a water pump or feeder valve to maintain water at the proper operating level.

Usually, the control is of the automatic reset type and will remake the limit circuit when the water level is restored. Some applications require that a control be equipped with a manual reset mechanism that must be manually reset before the burner can be restarted. This is usually accomplished with the use of a second or auxiliary control that has this feature.

Since low water cutoff devices are generally set by the original manufacturer, no attempt should be made to adjust these controls to alter the point of low water cutoff or point of pump cut-in or cut-out. If a low water device should become erratic in operation or if its setting changes from previous established levels, check for reasons and correct: Repair or replace as required.

These controls normally function for long periods of time, which may lead to laxity in testing on the assumption that normal operation will continue indefinitely.

The controls' operation may be checked by stopping the water supply to the boiler while the burner is operating at low fire. While under constant attendance, allow the water level to drop at a normal rate. Check for proper operation of the feedwater controller and the low water cutoffs.

⚠ CAUTION

If a control does not break the circuit to stop the burner at the proper point then shut down the burner immediately. Failure to do so may result in damage to the equipment.

Do not restart until all cross-connecting piping is checked for obstructions. Also check the float bowl. If these are clean, repair or replace the control. Repeat the above test to ensure proper operation prior to returning the boiler to service.

On a steam boiler, the head mechanism of the low water cutoff device(s) should be removed from the bowl at least once a month to check and clean the float ball, the internal moving parts, and the bowl or water column.

Remove the pipe plugs from the tees or crosses and make certain the cross- connecting piping is clean and free of obstructions. Controls must be mounted in a plumb position for proper performance. Determine that piping is vertically aligned after shipment and installation and throughout the life of the equipment.

A scheduled blowdown of the water controls on a steam boiler should be maintained.

Water Gauge Glass

A broken or discolored glass must be replaced at once. Periodic replacement should be a part of the maintenance program. Always use new gaskets when replacing a glass. Use a proper size rubber packing. Do not use “loose packing,” which could be forced below the glass and possibly plug the valve opening.

Close the valves when replacing the glass. Slip a packing nut, a packing washer, and packing ring onto each end of the glass. Insert one end of the glass into the upper gauge valve body far enough to allow the lower end to be dropped into the lower body. Slide the packing nuts onto each valve and tighten.

If the glass is replaced while the boiler is in service, open the blowdown and slowly bring the glass to operating temperature by cracking the gauge valves slightly. After glass is warmed up, close the blowdown valve and open the gauge valves completely.

Check trycocks and gauge cocks for freedom of operation and clean as required.

It is imperative that the gauge cocks are mounted in exact alignment. If they are not, the glass will be strained and may fail prematurely.

A blowdown cock is provided on the lower gauge glass fitting and a daily blowdown is recommended.

Electrical Controls

The operating controls should be inspected monthly. Examine the tightness of electrical connections and keep the controls clean. Remove any dust that accumulates on the interior of the controls using low pressure air that is free of moisture and oil. Take care not to damage the mechanism.

Examine any mercury tube switches for damage or cracks. Dark scum over the normally bright surface of the mercury indicates a damaged tube that may lead to erratic switching action. Make certain that controls are correctly leveled. Covers should remain on controls and panels at all times. Dust and dirt can cause excessive wear or overheating of the motor stator and the relay contacts, and affect operation of other controls. The power supply to the boiler must be protected with dual element fuses (fusetrons) or circuit breakers. Similar fuses should be used in branch circuits. Standard one-shot fuses are not recommended.

Flame Safeguard Control

This control requires minimal maintenance because the safety and logic sections are integral and inaccessible, with no accessible contacts. Regularly check to see that the retaining screws holding the chassis to the mounting base are secure, and that the amplifier and the program module are securely inserted.

It is recommended that a spare control be kept on hand and service be rotated between the active and the spare control (programmer).

Note: Be sure that the connecting contacts on the control and the base are not bent out of position.

⚠WARNING

When replacing a control, be sure to lock out the main power supply, since the control is “hot” even though the burner switch is off. Failure to heed this warning could result in serious personal injury or death.

Your spare control should be wrapped in plastic and stored in a dry atmosphere. During an extended shutdown (for example, a seasonal shutdown), the active control should be removed and stored in a dry atmosphere. Moisture can cause problems with control operation.

The flame detector lens should be cleaned as often as operating conditions demand. Use a soft cloth moistened with detergent to clean the lens.

A safety check procedure should be established to test the complete flame safeguard system at least once a month. Tests should verify safety shutdown and a safety lockout upon failure to ignite the main flame and upon loss of flame. Each of these conditions should be checked on a scheduled basis. Refer to the burner manual for information regarding tests of the flame safeguard system. Contact your local Cleaver- Brooks authorized representative for assistance, if required.

Checking Loss of Flame

With the burner in normal operation at the low fire rate, shut off the main burner fuel valve to interrupt the fuel supply and extinguish the main flame.

The relay must signal the loss of flame, resulting in the fuel valve(s) being deenergized. The control will lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will stop.

Turn the burner switch off. Reset the safety switch. Reestablish the main fuel supply.

F. Oil Burner Maintenance

Refer to the burner sections for specific information regarding operation and maintenance of the burner.

Oil strainers should be serviced frequently in order to maintain a free and full flow of fuel to the burner. Installation of a vacuum gauge in the burner supply line between the burner oil pump and the strainer is strongly recommended. Regular observation and recording of the gauge indication will assist in determining when the strainer needs servicing.

Strainer Servicing

The fuel oil strainer element must be removed and cleaned or replaced at regular intervals, or when a rising trend in the burner supply pump suction indicates blockage. When servicing the strainer, fuel supply and return line valves should be shut off. The strainer should be drained of oil and any sediment collected at the bottom of the canister. Remove the cover and withdraw the strainer element. Replaceable elements should be disposed of properly. Reusable elements may be cleaned by immersing them in solvent until attached deposits have been loosened, and then shaking them dry.

⚠WARNING

Use only safety type solvents such as Cleaver-Brooks "Safety Solvent" for cleaning strainers or other components. Work only in a well ventilated area. Do not use gasoline or other flammable liquids as a solvent. Do not dry the strainer elements with compressed air. Failure to heed this warning could result in serious personal Injury or death.

Reassemble the strainer, taking care to seal the canister properly to avoid air infiltration and resulting loss of suction. Open the fuel supply and the return line valves.

G. Gas Burner Maintenance

Refer to the burner sections for specific information regarding operation and maintenance of the burner. The motorized gas valve requires little maintenance, as the operating mechanism is immersed in oil and completely sealed. However, proper operation should be checked on a routine basis.

Keep the outer parts of the valve(s) clean, especially the stem between the operator and the valve. A nicked, scored, or otherwise damaged valve stem can cause leakage. Do not remove dust covers if installed.

The stem packing gland is the O-ring type. If oil is noticed around the operator base, or if leakage occurs, the valve must be repaired. If the actuator is sluggish or fails to operate, and the oil level is known to be correct, the operator portion should be replaced.

Solenoid Valves

Foreign matter between the valve seat and the seat disc will cause leakage. Valves are readily disassembled; however, care must be taken to see that internal parts are not damaged during removal and that reassembly is in the proper order.

A low hum or buzzing will normally be audible when the solenoid coil is energized. If the valve emits a loud buzzing or a chattering noise, check for proper voltage. If voltage is correct, clean the plunger assembly and interior plunger tube thoroughly. Do not use any oil. Make sure that the plunger tube and solenoid are tight when assembled. Take care not to nick, dent, or damage the plunger tube.

Solenoid coils can be replaced without removing the valve from the line.

⚠WARNING

Be sure to disconnect the main power supply to the boiler in order to prevent the possibility of electrical shock, which could result in serious personal injury or death.

Check the coil position and make sure that any insulating washers or retaining springs are reinstalled in the proper order.

H. Refractory

The boiler is shipped with completely installed refractory. High temperature refractory lines the burner door and floor of the boiler. Front and rear walls, side casing panels, the roof section, the bottom drum and the drum vent are protected with high temperature insulation. Preventive maintenance through periodic inspection will keep the operator aware of the condition of the refractory and insulation and will guard against unexpected downtime for repairs.

I. Casing Seals

The most obvious indication of a problem is the appearance of discolored paint on the casing or soot and hot gases escaping at seal joints. It is important that at start-up any problems are noted and corrected before the boiler is put back into operation. The following are areas requiring inspection.

Burner Door

Inspect the area around the door and look for discolored paint or evidence of combustion gas leakage. If a problem is noted or the door is being opened for scheduled maintenance look for warped sealing surfaces and make sure that the insulation on the front wall around the door has not pushed away from the wall. Cracks may appear in the burner door refractory as a result of expansion and contraction from operation. If cracks are larger than 1/8” when the refractory is cooled, the cracks should be filled with a high temperature bonding air-dry mortar such as Cleaver- Brooks “Corline.”

⚠WARNING

Disconnect main power to the boiler and the pilot fuel supply to the burner before the burner door is opened. Electrical power and fuel supply must remain shut off at all times when the burner door is open. Failure to heed this warning could result in serious personal Injury or death.

Access to the boiler furnace area is gained through the burner door opening at the front of the boiler. Whenever the burner is opened, the gasket and gasket surfaces of the burner door should be inspected. A good seal between the burner door and the boiler is necessary to prevent leakage of combustion gases and loss of efficiency. Combustion gas leaks can cause hot spots with subsequent damage to the burner door and surrounding refractory. Damaged or hardened gaskets must be replaced before the burner is put back in operation.

If a new gasket is necessary, remove the old gasket and clean the gasket surface on the wall and burner door. A spray adhesive is used to hold the rope gasket in place around the burner opening. A high temperature silicone may be needed to seal under the rope gasket at the wall seams. The rope gasket should wrap around the opening at least two times.

Before the burner door is closed, inspect studs and clean threads if necessary with 1/2"-13 die. Apply a small amount of Cleaver-Brooks "Never-Seez" (p.n. 797-1814 or 797-1816) to the studs. Any nuts that are difficult to thread on studs should be replaced. Door fasteners should be run in and tightened evenly to avoid distorting the door or damaging the gasket. Start tightening at the top and proceed around the door, alternately tightening opposite fasteners until all are snug. After the boiler is back in operation, check for gas leaks around the door opening, and retighten the fasteners as required to provide a gas-tight seal.

Drum Seals

Inspect the areas around the drum seals and look for soot or hot gas leaks. If a problem is noted look for the source of the leak. Remove the old insulation and sealant from around the drum. Using a pumpable insulation material (p.n. 872-680), fill the void flush with the outside of the wall. Allow the area to set up and apply a thick bead of high temperature silicone around the drum and install the cover plates.

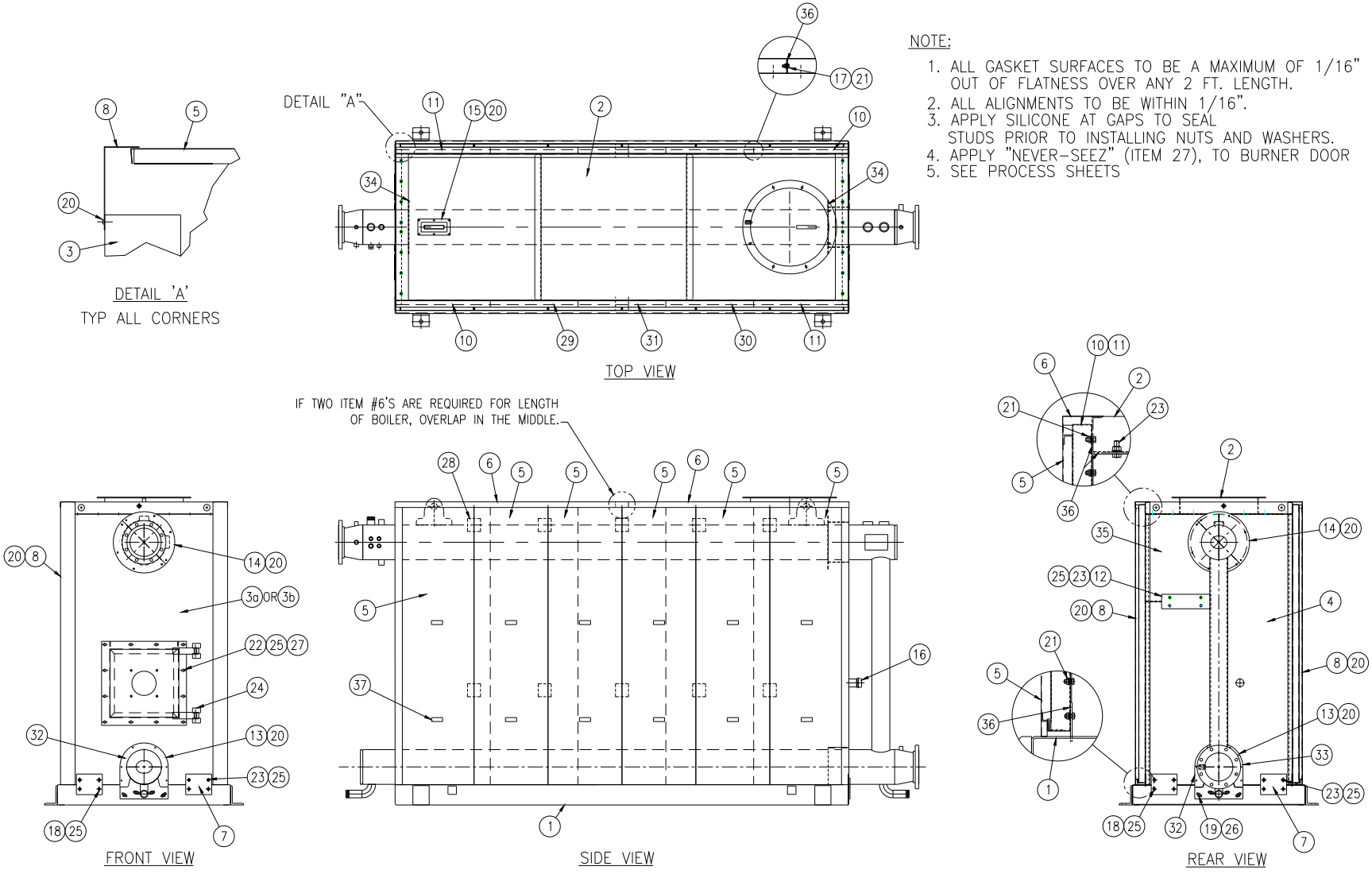
Sight Port

Inspect the area around the sight port for paint discoloration. A hot spot around the rear sight port is caused by either a poor seal between the sight port insulator and the wall, a cracked insulator or a flue gas leak at the sight port cap.

Check the threads of the cap and sight tube. If necessary, clean the threads and/or replace the cap. If the screws that hold the sight glass retainer in place are leaking tighten the screws or replace the cap.

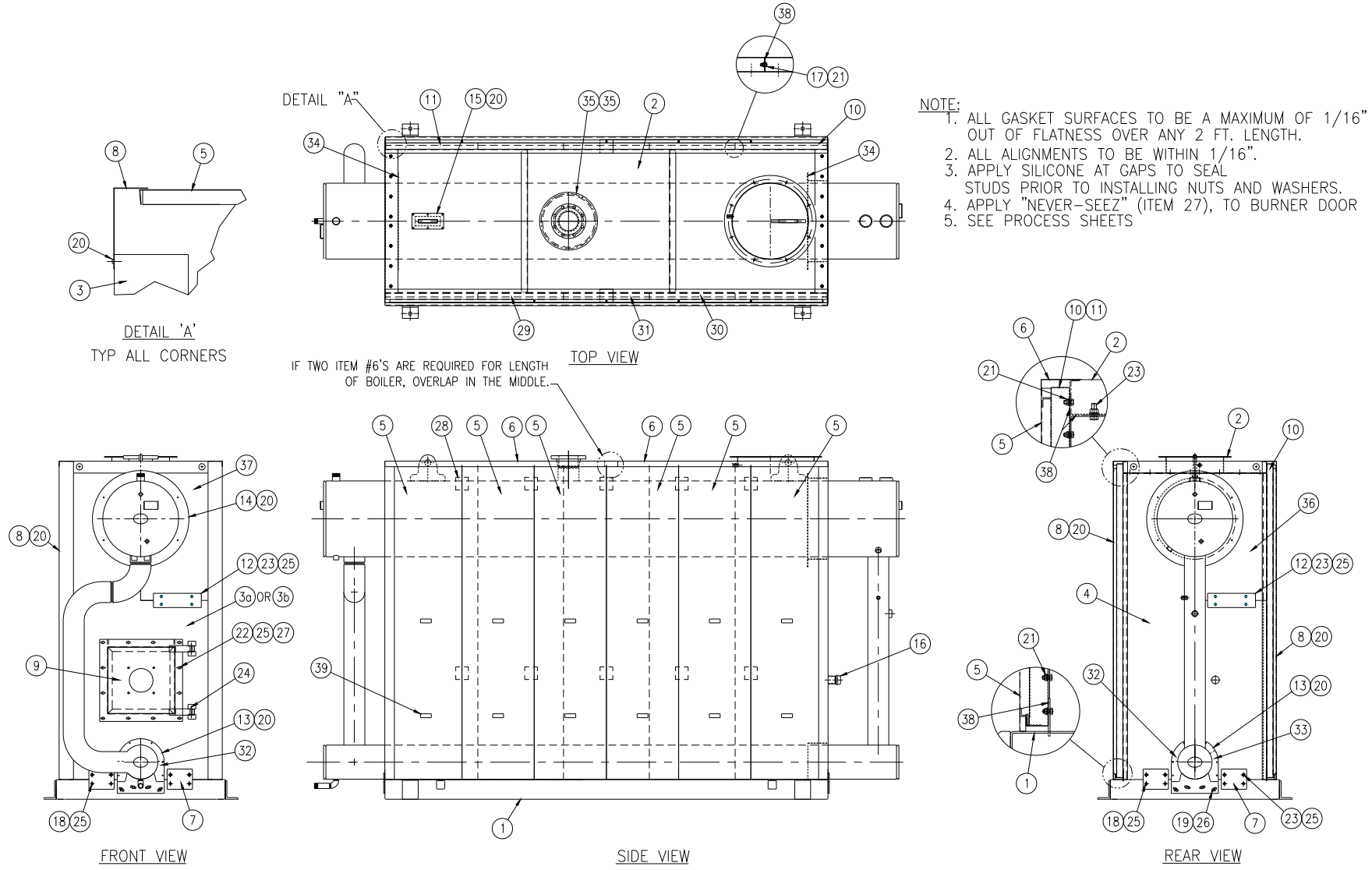
CHAPTER 8
PARTS

Figure: 8-1 Typical Hot Water Flextube Casing



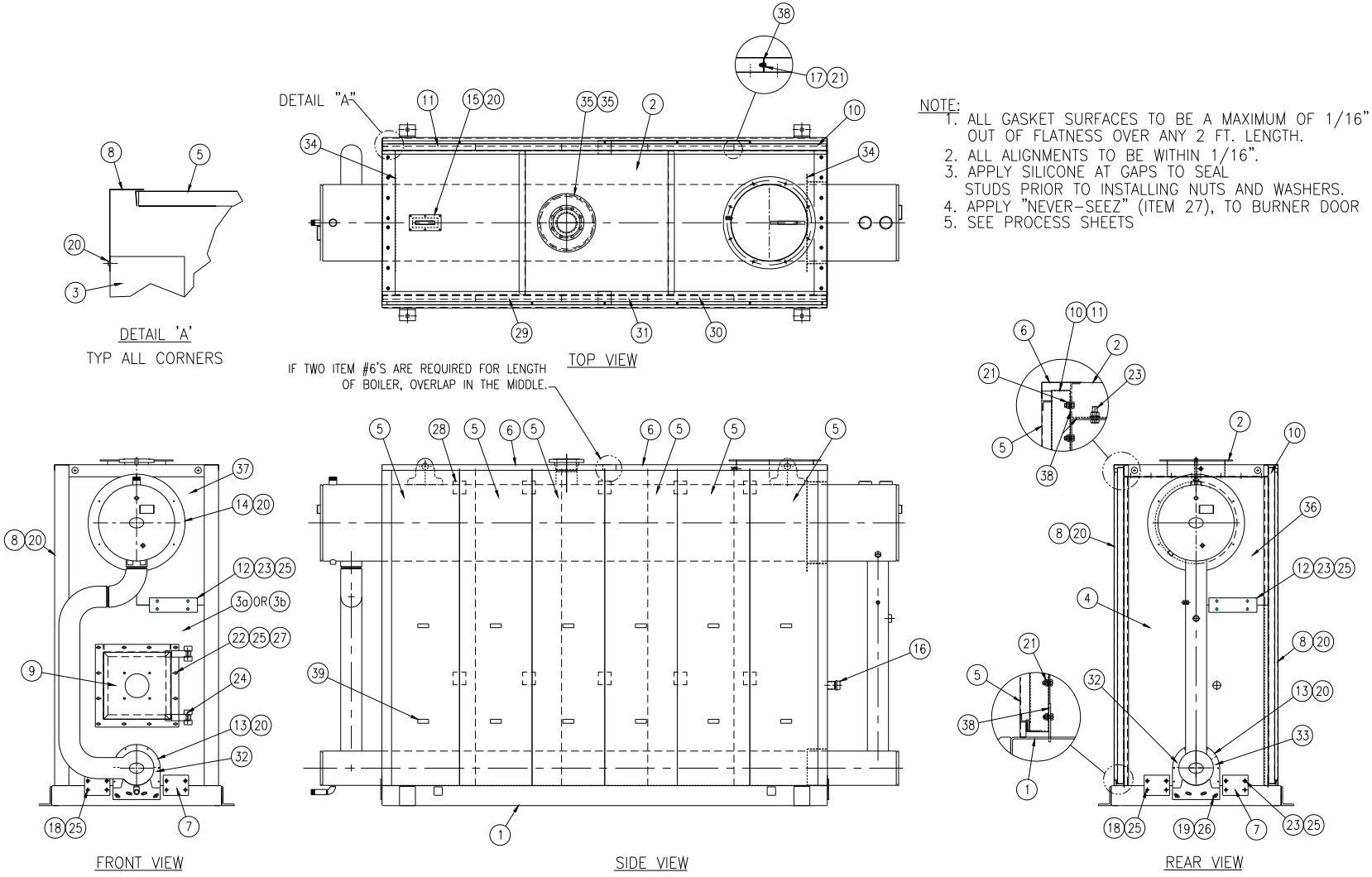
Part List, Hot Water		250		350		500		800		1100	
ITEM	DESCRIPTION	PART #	REQ	PART #	REQ	PART #	REQ	PART #	REQ	PART #	REQ
1.	Base	315-1124	1	315-1169	1	315-1180	1	315-1194	1	315-1203	1
2.	Roof	315-1127	1	315-1167	1	315-1178	1	315-1192	1	315-1202	1
3.a	Front wall, w/o Hinge	315-1262	1	315-1265	1	n/a		n/a		n/a	
3.b	Front wall w Hinge	315-1128	1	315-1166	1	315-1177	1	315-1191	1	315-1201	1
4.	Rear wall-large piece	315-1129	1	315-1165	1	315-1176	1	315-1190	1	315-1190	1
5.	Outer casing panel	315-1130	6	315-1164	6	315-1175	8	315-1189	10	315-1198	12
6.	Outer casing strips-top	315-1131	2	315-1163	2	315-1174	2	315-1188	2	315-1197	4
7.	Plate, base to wall	315-1132	4	315-1132	4	315-1132	4	315-1132	4	315-1132	4
8.	Outer casing strips corner strip	315-1133	4	315-1162	4	315-1173	4	315-1187	4	315-1187	4
9.	Burner plate	Note 5	1	Note 5	1	Note 5	1	Note 5	1	Note 5	1
10.	Inner side panel Left Hand	315-1135	2	315-1161	2	315-1172	2	315-1186	2	315-1196	2
11.	Inner side panel Right Hand	315-1136	2	315-1160	2	315-1171	2	315-1185	2	315-1195	2
12.	Mounting Plate	315-1143	1	315-1143	1	315-1143	1	315-1143	1	315-1143	1
13.	Plate, Collar, Lower Outer	315-694	2	315-694	2	315-695	2	315-695	2	315-695	2
14.	Plate, Collar, Upper Outer	315-1159	2	315-1159	2	315-1183	2	315-1183	4	315-1210	2
15.	Plate, Cover, Lug, Lifting	315-1100	1	315-1100	1	315-1100	1	315-1099	1	315-1099	1
16.	Cap, sight	550-42	1	550-42	1	550-42	1	550-42	1	550-42	1
17.	Capscrew, hex hd. 3/8”-16x 3/4”lg	868-1506	26	868-1506	28	868-1506	60	868-1506	96	868-1506	128
18.	Capscrew, hex hd. 1/2”-13x 1-1/2”lg	868-102	8	868-102	8	868-102	8	868-102	8	868-102	8
19.	Capscrew, hex hd. 5/8”-11x 1-1/2”lg	868-188	8	868-188	8	868-188	8	868-188	8	868-188	8
20.	Screw, self tapping, ¼” x 1”lg	841-423	50	841-423	50	841-423	50	841-423	50	841-423	54
21.	Locknut, hex hd., 3/8”	869-510	118	869-510	124	869-510	180	869-510	232	869-510	284
22.	Nut, hex hd., ½” brass	869-27	12	869-27	12	869-27	12	869-27	12	869-27	12
23.	Nut, hex hd., ½”	869-144	24	869-144	24	869-144	24	869-144	28	869-144	28
24.	Capscrew, Hex hd ¾”-10 x 6” LG	868-600	2	868-600	2	868-600	2	868-600	2	868-600	2
25.	Washer, flat, ½”	952-286	44	952-286	44	952-286	44	952-286	48	952-286	48
26.	Washer, flat, 5/8”	952-321	8	952-321	8	952-321	8	952-321	8	952-321	8
27.	Never-Seez	797-1816	1	797-1816	1	797-1816	1	797-1816	1	797-1816	1
28.	Inner Casing Spacer Block	315-1336	8	315-1336	8	315-1336	12	315-1336	16	315-1336	20
29.	Inner Side Panel Mid Left	n/a		n/a		n/a		315-1294	2	315-1294	2
30.	Inner Side Panel Mid Right	n/a		n/a		n/a		315-1208	2	315-1208	2
31.	Inner Side Panel Mid	n/a		n/a		315-1206	2	n/a		315-1209	2
32.	Retaining Plates, Lower, Inner, Small	315-1178	3	315-1178	3	315-1280	3	315-1280	3	315-1280	3
33.	Retaining Plates, Lower, Inner, Large	315-1158	1	315-1158	1	315-1182	1	315-1182	1	315-1182	1
34.	Plate, collar, upper, inner	315-1204	2	315-1204	2	315-1207	2	n/a		315-1183	2
35.	Assembly, rear wall corner piece	315-1140	1	315-1279	1	315-1281	1	315-1282	1	315-1282	1
36.	Gasket, Expanded PTFE 3/8” x 3/16”	32-2560	70 ft	32-2560	75 ft	32-2560	99 ft	32-2560	127ft	32-2560	149ft
37.	Handle, Flush Mount, Snap In	865-68	12	865-68	12	865-68	16	865-68	16	865-68	24

Figure: 8-2 Typical Low Pressure Steam Flextube Casing



Part List, LP Steam		250		350		500		800		1100	
ITEM	DESCRIPTION	PART #	REQ	PART #	REQ	PART #	REQ	PART NO.	REQ	PART #	REQ
1.	Base	315-1124	1	315-1169	1	315-1180	1	315-1194	1	315-1203	1
2.	Roof	315-1215	1	315-1230	1	315-1239	1	315-1250	1	315-1260	1
3.a	Front wall, w/o Hinge	315-1263	1	315-1264	1	n/a		n/a		n/a	
3.b	Front wall w Hinge	315-1216	1	315-1229	1	315-1138	1	315-1249	1	315-1249	1
4.	Rear wall-large piece	315-1217	1	315-1228	1	315-1237	1	315-1248	1	315-1248	1
5.	Outer casing panel	315-1218	6	315-1227	6	315-1236	8	315-1247	10	315-1257	12
6.	Outer casing strips-top	315-1131	2	315-1163	2	315-1174	2	315-1188	2	315-1197	4
7.	Plate, base to wall	315-1132	4	315-1132	4	315-1132	4	315-1132	4	315-1132	4
8.	Outer casing strips corner strip	315-1219	4	315-1226	4	315-1235	4	315-1246	4	315-1246	4
9.	Burner plate	Note 5	1	Note 5	1	Note 5	1	Note 5	1	Note 5	1
10.	Inner side panel Left Hand	315-1220	2	315-1225	2	315-1234	2	315-1245	2	315-1256	2
11.	Inner side panel Right Hand	315-1221	2	315-1224	2	315-1233	2	315-1244	2	315-1255	2
12.	Mounting Plate	315-1143	1	315-1143	2	315-1143	2	315-1143	2	315-1143	2
13.	Plate, Collar, Lower Outer	315-694	2	315-694	2	315-695	2	315-695	2	315-695	2
14.	Plate, Collar, Upper Outer	315-1222	2	315-1222	2	315-1222	2	315-1243	2	315-1243	2
15.	Plate, Cover, Lug, Lifting	315-1100	1	315-1100	1	315-1100	1	315-1099	1	315-1099	1
16.	Cap, sight	550-42	1	550-42	1	550-42	1	550-42	1	550-42	1
17.	Capscrew, hex hd. 3/8”-16x 3/4”lg	868-1506	28	868-1506	30	868-1506	64	868-1506	108	868-1506	144
18.	Capscrew, hex hd. 1/2”-13x 1-1/2”lg	868-102	8	868-102	8	868-102	8	868-102	8	868-102	8
19.	Capscrew, hex hd. 5/8”-11x 1-1/2”lg	868-188	8	868-188	8	868-188	8	868-188	8	868-188	8
20.	Screw, self tapping, ¼” x 1”lg	841-423	56	841-423	56	841-423	56	841-423	56	841-423	60
21.	Locknut, hex hd., 3/8”	869-510	128	869-510	130	869-510	188	869-510	252	869-510	308
22.	Nut, hex hd., ½” brass	869-27	12	869-27	12	869-27	12	869-27	12	869-27	12
23.	Nut, hex hd., ½”	869-144	28	869-144	28	869-144	28	869-144	32	869-144	32
24.	Capscrew, Hex hd ¾”-10 x 6” LG	868-600	2	868-600	2	868-600	2	868-600	2	868-600	2
25.	Washer, flat, ½”	952-286	48	952-286	48	952-286	48	952-286	52	952-286	52
26.	Washer, flat, 5/8”	952-321	8	952-321	8	952-321	8	952-321	8	952-321	8
27.	Never-Seez	797-1816	1	797-1816	1	797-1816	1	797-1816	1	797-1816	1
28.	Inner Casing Spacer Block	315-1336	8	315-1336	8	315-1336	12	315-1336	16	315-1336	20
29.	Inner Side Panel Mid Left	n/a		n/a		n/a		315-1295	2	315-1295	2
30.	Inner Side Panel Mid Right	n/a		n/a		n/a		315-1253	2	315-1253	2
31.	Inner Side Panel Mid	n/a		n/a		315-1242	2	n/a		315-1261	2
32.	Retaining Plates, Lower, Inner, Small	315-1278	3	315-1278	3	315-1280	3	315-1280	3	315-1280	3
33.	Retaining Plates, Lower, Inner, Large	315-1158	1	315-1158	1	315-1282	1	315-1182	1	315-1182	1
34.	Plate, collar, upper, inner	315-1223	2	315-1223	2	315-1223	2	351-1254	1	315-1254	2
35.	Ring Seal, Outlet Steam #15	315-219	1	315-220	1	315-221	1	315-1057	1	315-1058	1
36.	Assembly, rear wall corner piece	315-1286	1	315-1287	1	315-1289	1	315-1291	1	315-1291	1
37.	Assembly, front wall corner piece	315-1285	1	315-1288	1	315-1290	1	315-1292	1	315-1292	1
38.	Gasket, Expanded PTFE 3/8” x 3/16”	32-2560	79 ft	32-2560	86 ft	32-2560	110 ft	32-2560	144ft	32-2560	168ft
39.	Handle, Flush Mount, Snap In	865-68	12	865-68	12	865-68	16	865-68	20	865-68	24

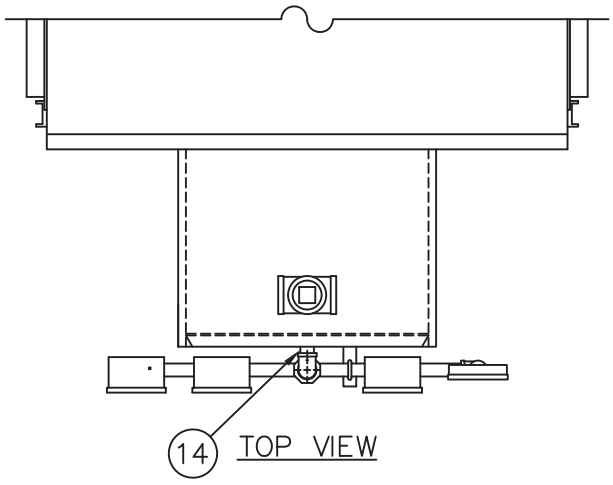
Figure: 8-3 Typical High Pressure Steam Flextube Casing



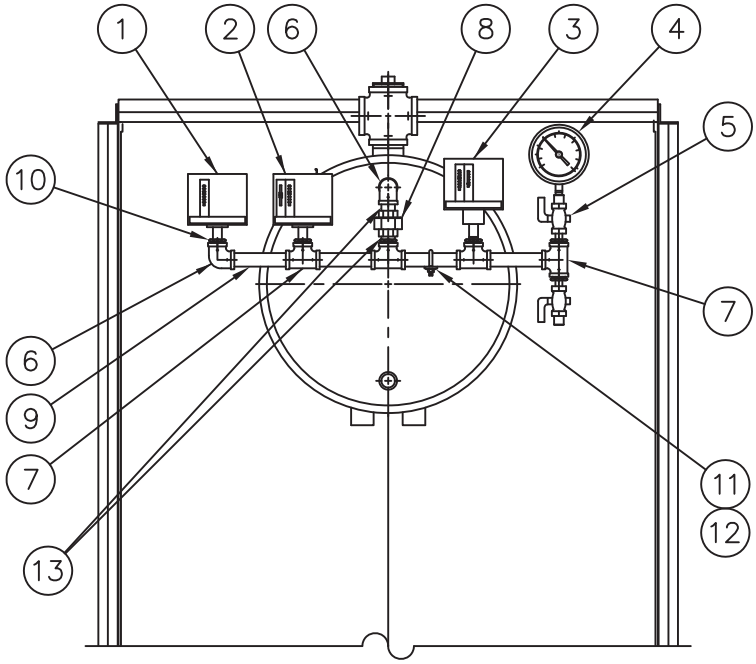
Parts List, HP Steam		250		350		500		800		1100	
ITEM	DESCRIPTION	PART #	REQ	PART #	REQ	PART #	REQ	PART #	REQ	PART #	REQ
1.	Base	315-1124	1	315-1169	1	315-1180	1	315-1194	1	315-1203	1
2.	Roof	315-1215	1	315-1230	1	315-1239	1	315-1250	1	315-1260	1
3.a	Front wall w/o Hinge	315-1263	1	315-1264	1	n/a		n/a		n/a	
3.b	Front wall w Hinge	315-1216	1	315-1229	1	315-1238	1	315-1249	1	315-1249	1
4.	Rear wall-large piece	315-1217	1	315-1228	1	315-1237	1	315-1248	1	315-1248	1
5.	Outer casing panel	315-1218	6	315-1227	6	315-1236	8	315-1247	10	315-1257	12
6.	Outer casing strips-top	315-1131	2	315-1163	2	315-1174	2	315-1188	2	315-1197	4
7.	Plate, base to wall	315-1132	4	315-1132	4	315-1132	4	315-1132	4	315-1132	4
8.	Outer casing strips corner strip	315-1219	4	315-1226	4	315-1235	4	315-1246	4	315-1246	4
9.	Burner plate	Note 5	1	Note 5	1	Note 5	1	Note 5	1	Note 5	1
10.	Inner side panel Left Hand	315-1220	2	315-1225	2	315-1234	2	315-1245	2	315-1256	2
11.	Inner side panel Right Hand	315-1221	2	315-1224	2	315-1233	2	315-1244	2	315-1255	2
12.	Mounting Plate	315-1143	2	315-1143	2	315-1143	2	315-1143	2	315-1143	2
13.	Plate, Collar, Lower Outer	315-694	2	315-694	2	315-695	2	315-695	2	315-695	2
14.	Plate, Collar, Upper Outer	315-1222	2	315-1222	2	315-1222	2	315-1243	2	315-1243	2
15.	Plate, Cover, Lug, Lifting	315-1100	1	315-1100	1	315-1100	1	315-1099	1	315-1099	1
16.	Cap, sight	550-42	1	550-42	1	550-42	1	550-42	1	550-42	1
17.	Capscrew, hex hd. 3/8”-16x 3/4”lg	868-1506	28	868-1506	30	868-1506	64	868-1506	108	868-1506	144
18.	Capscrew, hex hd. 1/2”-13x 1-1/2”lg	868-102	8	868-102	8	868-102	8	868-102	8	868-102	8
19.	Capscrew, hex hd. 5/8”-11x 1-1/2”lg	868-188	8	868-188	8	868-188	8	868-188	8	868-188	8
20.	Screw, self tapping, ¼” x 1”lg	841-423	50	841-423	56	841-423	56	841-423	56	841-423	60
21.	Locknut, hex hd., 3/8”	869-510	118	869-510	130	869-510	188	869-510	252	869-510	308
22.	Nut, hex hd., ½” brass	869-27	12	869-27	12	869-27	12	869-27	12	869-27	12
23.	Nut, hex hd., ½”	869-144	24	869-144	28	869-144	28	869-144	32	869-144	32
24.	Capscrew, Hex hd ¾”-10 x 6” LG	868-600	2	868-600	2	868-600	2	868-600	2	868-600	2
25.	Washer, flat, ½”	952-286	44	952-286	48	952-286	48	952-286	52	952-286	52
26.	Washer, flat, 5/8”	952-321	8	952-321	8	952-321	8	952-321	8	952-321	8
27.	Never-Seez	797-1816	1	797-1816	1	797-1816	1	797-1816	1	797-1816	1
28.	Inner Casing Spacer Block	315-1336	8	315-1336	8	315-1336	12	315-1336	16	315-1336	20
29.	Inner Side Panel Mid Left	n/a	2	n/a		n/a		315-1295	2	315-1295	2
30.	Inner Side Panel Mid Right	n/a	2	n/a		n/a		315-1253	2	315-1253	2
31.	Inner Side Panel Mid	n/a	2	n/a		315-1242	2	n/a		315-1261	2
32.	Retaining Plates, Lower, Inner, Small	315-1178	3	315-1278	3	315-1280	3	315-1280	3	315-1280	3
33.	Retaining Plates, Lower, Inner, Large	315-1158	1	315-1158	1	315-1282	1	315-1182	1	315-1182	1
34.	Plate, collar, upper, inner	315-1223	2	315-1223	2	315-1223	2	315-1254	1	315-1254	2
35.	Ring Seal, Outlet Steam #150	315-517	1	315-518	1	315-519	1	315-550	1	315-221	1
36.	Assembly, rear wall corner piece	315-1286	1	315-1287	1	315-1289	1	315-1291	1	315-1291	1
37.	Assembly, front wall corner piece	315-1285	1	315-1288	1	315-1290	1	315-1292	1	315-1292	1
38.	Gasket, Expanded PTFE 3/8” x 3/16”	32-2560	79 ft	32-2560	86 ft	32-2560	110 ft	32-2560	114ft	32-2560	168ft
39.	Handle, Flush Mount, Snap In	865-68	12	865-68	12	865-68	16	865-68	16	865-68	16

Steam Pressure Controls

ITEM	QTY	PART NO. 15# STEAM	PART NO. 150# STEAM	DESCRIPTION
1	1	817–04095	817–04093	CONTROL,PRESSURE,OPERATING AUTO RESET
2	1	817–04094	817–04092	CONTROL, PRESSURE,HIGH LIMIT MANUAL RESET
3	1	817–00251	817–00204	CONTROL, PRESSURE, MODULATING
4	1	850–00243	850–00122	GAUGE, PRESSURE
5	2	941–00055		VALVE, BALL
6	2	859–00081		ELBOW, FEMALE
7	4	859–00025		TEE, 3/4" NPT
8	1	858–00165		UNION, FEMALE, 3/4" NPT
9	4	857–00683		NIPPLE, PIPE
10	6	847–00422		BUSHING, REDUCING
11	1	008–03183		BRACKET, PRESSURETROLS
12	1	993–08928		U–BOLT
13	2	857–00708		NIPPLE, CLOSE
14	1	857–00658		NIPPLE, PIPE



TOP VIEW

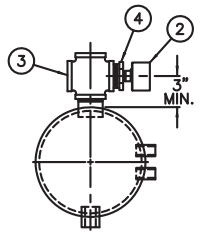


FRONT VIEW

Water Level Controls

ITEM	REQ.	PART NO.	DESCRIPTION
1	1	817–2349	LOW WATER CUTOFF, MCM&M 750–T–120, AR
	1	817–2305	LOW WATER CUTOFF, MCM&M 750–MT–120, MR
2	1	817–2351	PROBE, REMOTE, MCM&M RS–1–LP
3	1	859–267	CROSS, 2"
4	1	847–440	BUSHING, REDUCING, 2" X 3/4"

MAXIMUM DESIGN PRESSURE – 160 P.S.I. H.W.

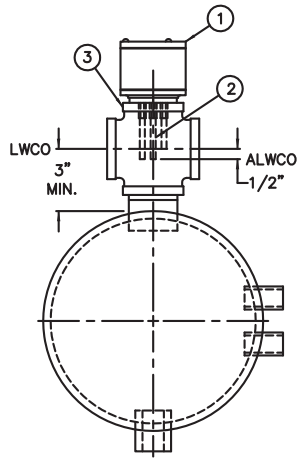


NOTES:

1.) DO NOT ATTACH ANY ROD FOR PROBE LENGTH TO ITEM #2.
2.) INSURE MINIMUM CLEARANCE OF 1/4" BETWEEN PROBE END AND PIPING.

ITEM	REQ.	PART NO.	DESCRIPTION
1	1	817–740	CONTROL, LIQUID LEVEL, WARRICK 3E2B
	1	817–1020	CONTROL, LIQUID LEVEL, WARRICK 3E3B
2	3	67–536	1/4" BRASS ROD X 4 1/8" LG.
3	1	859–267	CROSS, 2"

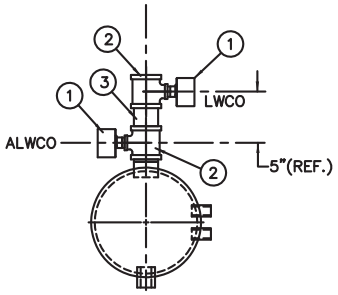
MAXIMUM DESIGN PRESSURE – 250 P.S.I. H.W.



SCALE: 2X

ITEM	REQ.	PART NO.	DESCRIPTION
1	2	817–2351	PROBE, REMOTE, MCM&M RS–1–LP
2	2	847–311	REDUCING TEE, 2" NPT X 3/4" NPT.
3	1	857–298	NIPPLE, 2" NPT X 3" LG. SCH. 80

MAXIMUM DESIGN PRESSURE – 160 P.S.I. H.W.

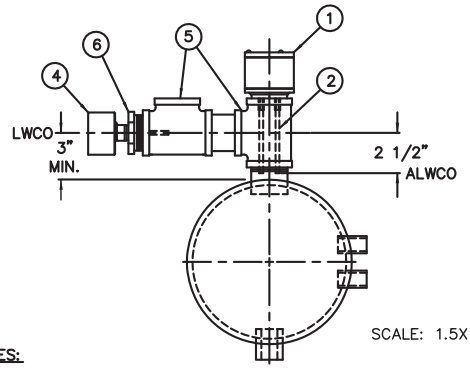


NOTES:

1.) DO NOT ATTACH ANY ROD FOR PROBE LENGTH TO ITEM #1.
2.) INSURE MINIMUM CLEARANCE OF 1/4" BETWEEN PROBE END AND PIPING.

ITEM	REQ.	PART NO.	DESCRIPTION
1	1	817–740	CONTROL, LIQUID LEVEL, WARRICK 3E2B
2	2	67–536	1/4" BRASS ROD X 4 1/8" LG.
3	1	817–2349	LOW WATER CUTOFF, MCM&M 750–T–120, AR
	1	817–2305	LOW WATER CUTOFF, MCM&M 750–MT–120, MR
4	1	817–2351	PROBE, REMOTE, MCM&M RS–1–LP
5	2	859–28	TEE, 2"
6	1	847–440	BUSHING, REDUCING, 2" X 3/4"

MAXIMUM DESIGN PRESSURE – 160 P.S.I. H.W.



SCALE: 1.5X

NOTES:

1.) DO NOT ATTACH ANY ROD FOR PROBE LENGTH TO ITEM #1.
2.) INSURE MINIMUM CLEARANCE OF 1/4" BETWEEN PROBE END AND PIPING.

Water Level Controls continued

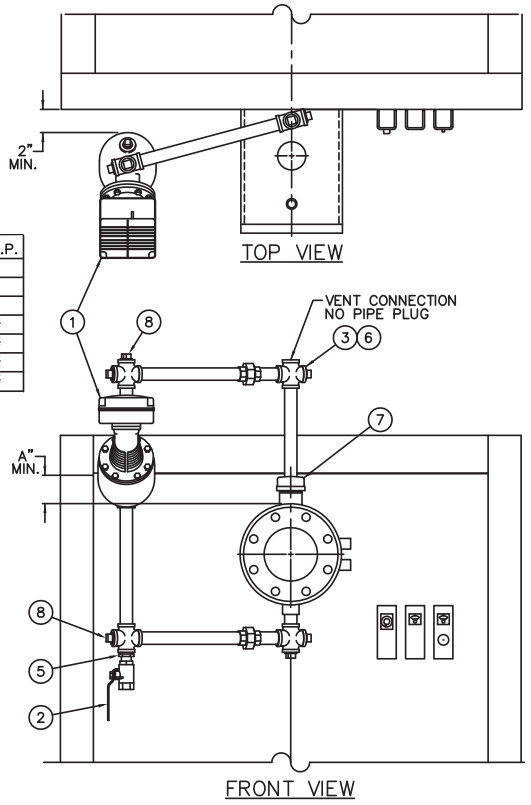
ITEM	PART NO.	DESCRIPTION	MAX. D.P.
1	817–746	McDONNELL & MILLER 63B LWCO CONTROL	50#
	817–777	McDONNELL & MILLER 64B LWCO CONTROL	50#
	817–2408	McDONNELL & MILLER 150S LWCO CONTROL	150#
	SEE NOTE 2	MAGNETROL B24 LIQUID LEVEL CONTROL	250#
	SEE NOTE 2	MAGNETROL B29 LIQUID LEVEL CONTROL	250#
	SEE NOTE 2	MAGNETROL B73 LIQUID LEVEL CONTROL	250#
	817–163	MAGNETROL W25 LIQUID LEVEL CONTROL	250#
2	941–1790	VALVE, BALL, 3/4"	
3	859–264	CROSS, 1"	
4	858–166	UNION, FEMALE, 1"	
5	847–426	BUSHING, REDUCING, 1" TO 3/4"	
6	858–93	PLUG, 1"	
7	858–66	CAP, PIPE, 2"	
8	941–2223	McD–M TEST–N–CHECK VALVES #TC–4 CONSIST OF VALVES #317350 & #317353	

DIM. "A"	LWCO & ALWCO CONFIGURATIONS
3"	SINGLE FLOAT STYLE LWCO
3 1/2"	FLOAT STYLE LWCO & PROBE ALWCO
2 1/2"	PROBE STYLE LWCO & FLOAT STYLE ALWCO

NOTES:

1.) USE 1" MIN. PIPE SIZE & PLUG ALL UNUSED CROSS OPENINGS.

2.) FOR PART NO., SEE PROCESS SHEET.



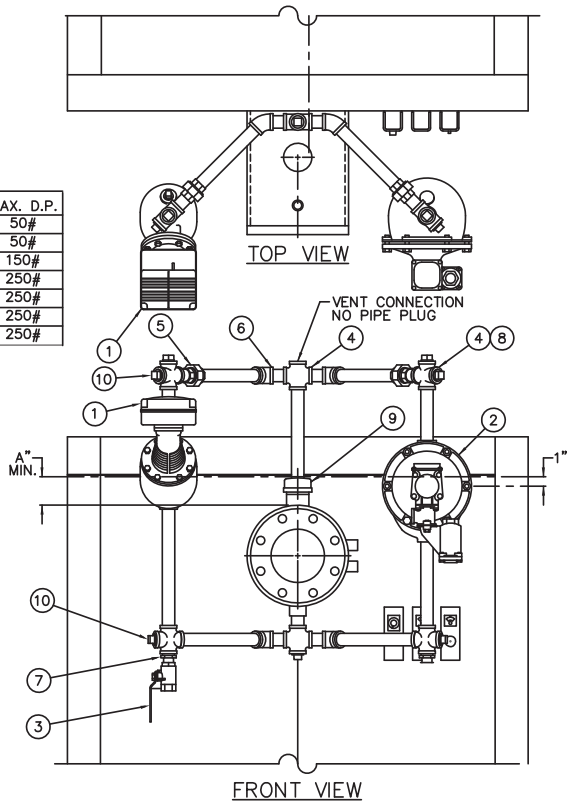
ITEM	PART NO.	DESCRIPTION	MAX. D.P.
1	817–746	McDONNELL & MILLER 63B LWCO CONTROL	50#
	817–777	McDONNELL & MILLER 64B LWCO CONTROL	50#
	817–2408	McDONNELL & MILLER 150S LWCO CONTROL	150#
	SEE NOTE #2	MAGNETROL B24 LIQUID LEVEL CONTROL	250#
	SEE NOTE #2	MAGNETROL B29 LIQUID LEVEL CONTROL	250#
	SEE NOTE #2	MAGNETROL B73 LIQUID LEVEL CONTROL	250#
	817–163	MAGNETROL W25 LIQUID LEVEL CONTROL	250#
2	817–453	McDONNEL & MILLER 53B WATER FEEDER	
3	941–1790	VALVE, BALL, 3/4"	
4	859–264	CROSS, 1"	
5	858–166	UNION, FEMALE, 1"	
6	859–96	ELBOW, 45', 1"	
7	847–426	BUSHING, REDUCING, 1" TO 3/4"	
8	858–93	PLUG, 1"	
9	858–66	CAP, PIPE, 2"	
10	941–2223	McD–M TEST–N–CHECK VALVES #TC–4 CONSIST OF VALVES #317350 & #317353	

DIM. "A"	LWCO & ALWCO CONFIGURATIONS
3"	SINGLE FLOAT STYLE LWCO
3 1/2"	FLOAT STYLE LWCO & PROBE ALWCO
2 1/2"	PROBE STYLE LWCO & FLOAT STYLE ALWCO

NOTES:

1.) USE 1" MIN. PIPE SIZE & PLUG ALL UNUSED CROSS OPENINGS.

2.) FOR PART NO., SEE PROCESS SHEET.

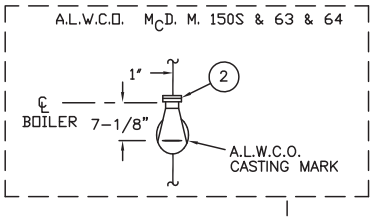


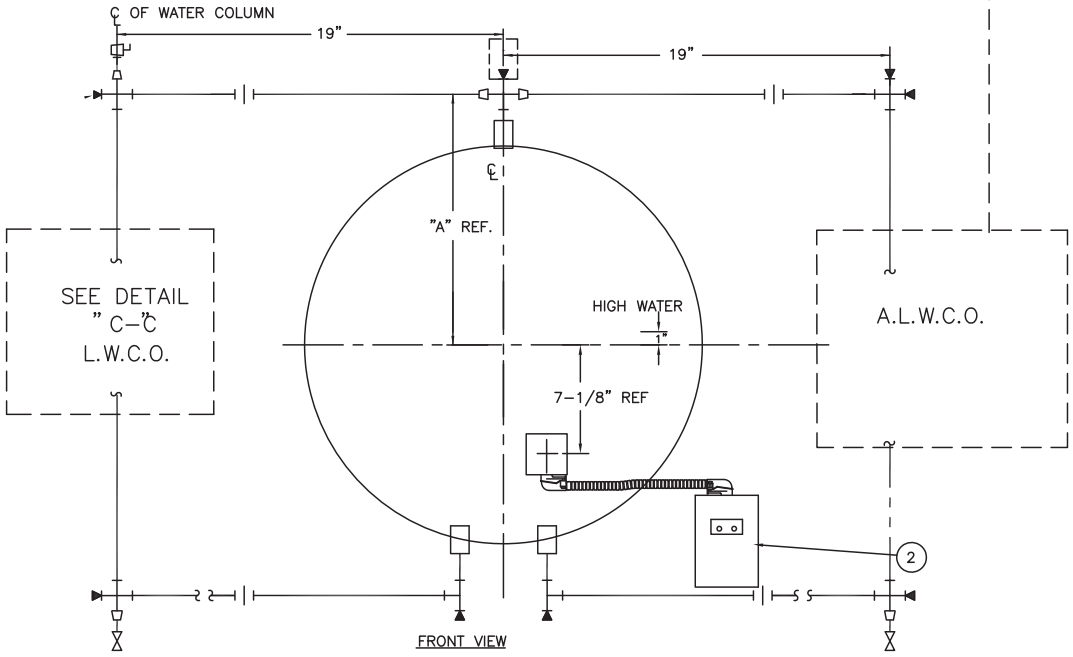
Water Column, Main and Aux. - 15# Steam

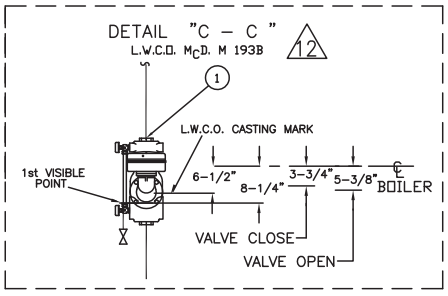
ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	100–271	LOW WATER CUT–OFF W/PUMP CONTROL (CB271)	STANDARD
	1	------	----------	------
	1	817–371	LOW WATER CUT–OFF W/FEEDER (McDM 247–2)	OPTIONAL
	1	81\ –7307	LOW WATER CUT–OFF (McDM 193B)	OPTIONAL SEE NOTE No 3
2	1	817–2305	McDM #750–MR CONTROL BOX	STANDARD
	1	817–2351	PROBE FOR McDM #750	
	1	817–740	AUX. LOW WATER CUT–OFF (WARRICK E2) **	OPTIONAL
	2	067–868	PROBES FOR WARRICK (TRIM PER "B" DIM.)	
	1	817–1020	AUX. LWCO (WARRICK E3 W/HIGH ALARM) **	OPTIONAL
	3	067–868	PROBES FOR WARRICK (TRIM 2 PER "B", 1 PER "C")	
	1	817–312	AUX. LOW WATER CUT–OFF (McDM 63–BM)	OPTIONAL
	1	817–777	AUX. LOW WATER CUT–OFF (McDM 64–B) *	OPTIONAL
	1	817–2407	AUX. LOW WATER CUT–OFF (McDM 150S–BM)	OPTIONAL

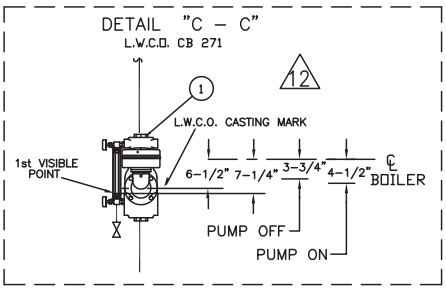
* NOTE: WHEN USING McD–M 64, WIRE AS MANUAL RESET THROUGH FLAME SAFEGAURD.
** NOTE: ADD APPROPRIATE WARRICK RELAYS TO BURNER CONTROL PANEL.

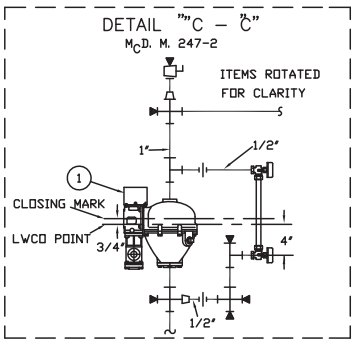
SIZE	"A"	A.L.W.C.O. PROBE LENGTHS "B"	H.W. PROBE LENGTHS "C"
250	13–3/4"	22–3/8"	14–1/4"
350	13–3/4"	22–3/8"	14–1/4"
500	13–3/4"	22–3/8"	14–1/4"
800	15–3/4"	24–3/8"	16–1/4"
1100	15–3/4"	24–3/8"	16–1/4"







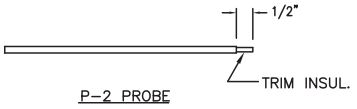




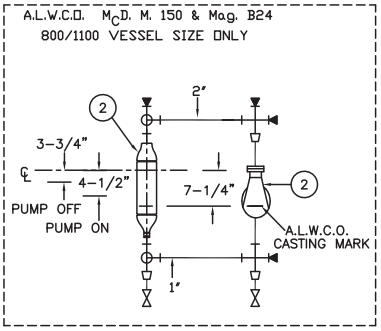
Water Column, Main and Aux. - 150# Steam

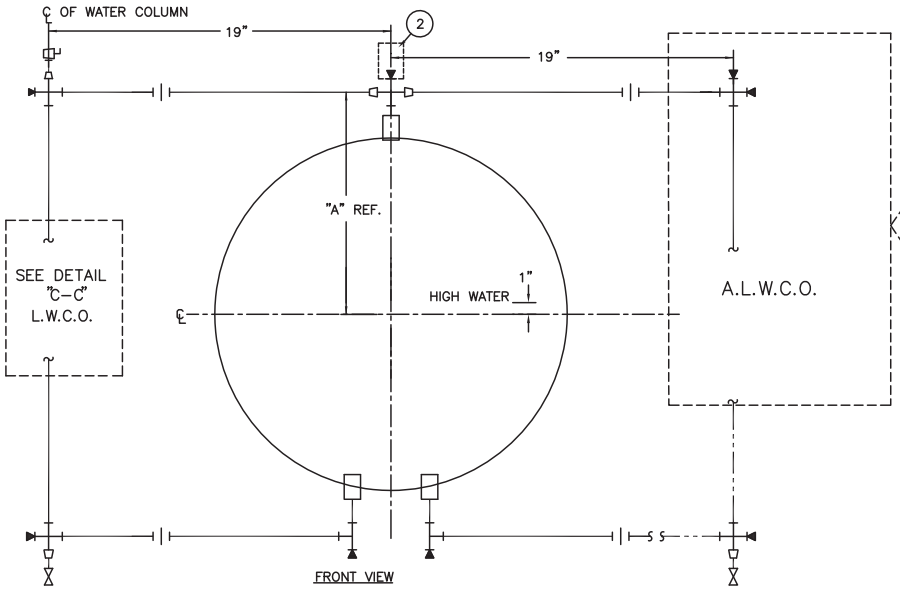
ITEM	QTY	PART NO.	DESCRIPTION	USED ON VESSEL SIZE
1	1	817-2411	LOW WATER CUT-OFF W/PUMP CONTROL(McDM 157S-RD-MD)	250/350/500
	1	817-2406	LOW WATER CUT-OFF (McDM 157S-R)	800/1100
	1	------	----------	------
	1	817-621	LOW WATER CUT-OFF (McDM 193B)	OPTIONAL SEE NOTE No 3
	1	817-163	LOW WATER CUT-OFF W/PUMP CONTROL (Mag. W25)	OPTIONAL
2	1	817-2305	McDM #750-MR CONTROL BOX - A.L.W.C.O.	250/350/500
	1	817-2306	McDM SENSOR HEAD, RS-1-BR-1	
	1	817-2307	PROBE FOR McDM ,P-2-SS(TRIM PER DETAIL & "B" LGTH)	
	1	817-2305	McDM #750-MR CONTROL BOX - A.L.W.C.O.	800/1100
	1	817-2307	PROBE FOR McDM ,P-2-SS(TRIM PER DETAIL & "B" LGTH)	
	1	817-2397	McDM CONTROL BOX, PCH-G-M-3 - PUMP CONTROL	
	1	817-2387	McDM SENSOR HEAD, RS-3-BR-1	
	1	817-2388	PROBE FOR McDM ,P-2-SS(TRIM PER DETAIL & "C" LGTH)	
	1	817-2388	PROBE FOR McDM ,P-2-SS(TRIM PER DETAIL & "D" LGTH)	
	1	100-A-402	BODY,ALWCO FLEXTUBE 800, 150#	
	1	817-740	AUX. LOW WATER CUT-OFF (WARRICK E2) *	OPTIONAL
	2	067-868	PROBES FOR WARRICK (TRIM PER "B" DIM.)	OPTIONAL
	1	817-1020	AUX. LWCO (WARRICK E3 W/HIGH ALARM) *	OPTIONAL
	3	067-868	PROBES FOR WARRICK (TRIM 2 PER "B", 1 PER "E")	OPTIONAL
	1	817-97	AUX. LOW WATER CUT-OFF (McDM 150S-M)	OPTIONAL
	1	817-93	AUX. LOW WATER CUT-OFF (MAG. B24)	OPTIONAL

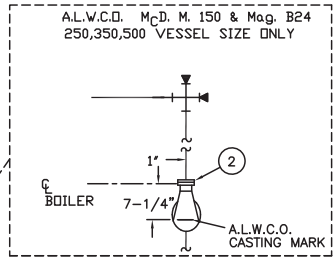
* - ADD APPROPRIATE WARRICK RELAYS TO BURNER CONTROL PANEL.

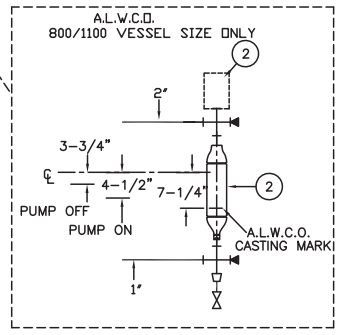


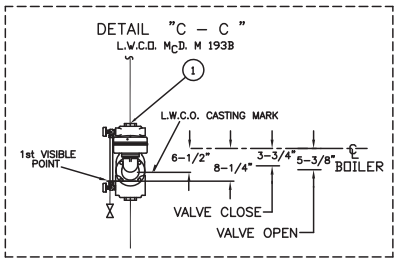
P-2 PROBE

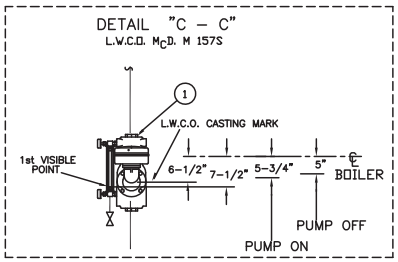


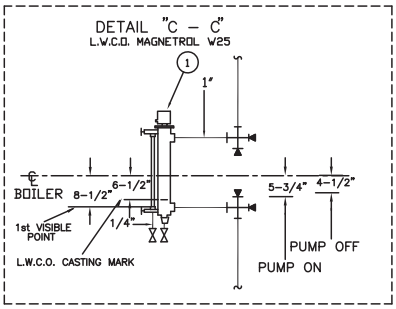












		PROBE LENGTHS			
SIZE	"A"	A.L.W.C.O. "B"	PUMP ON "C"	PUMP OFF "D"	H.W. "E"
250	13-3/4"	22-1/2"	-	-	14-1/4"
350	13-3/4"	22-1/2"	-	-	14-1/4"
500	13-3/4"	22-1/2"	-	-	14-1/4"
800	15-3/4"	24-1/2"	21-3/4"	21"	16-1/4"
1100	15-3/4"	24-1/2"	-	-	16-1/4"

Safety Valves

Boiler Size	Min. Relieving Cap. (lbs/hr)		H. P. STEAM							
			15 PSI	30 PSI	45 PSI	60 PSI	75 PSI	100 PSI	125 PSI	150 PSI
150-250	2125	Inlet (in") Outlet (in") P/N (940-)	2 @ 1.5 2 5332	2 2.5 5524	1.5 2 5338	1.5 2 5341	1.25 1.5 5391	1.25 1.5 5396	1 1.25 5068	1 1.25 5453
300-350	2975	Inlet (in") Outlet (in") P/N (940-)	2 @ 2 2.5 5521	2 @ 1.5 2 5335	2 2.5 5527	1.5 2 5341	1.5 2 5344	1.5 2 5349	1.25 1.5 5065	1.25 1.5 5405
400-600	5100	Inlet (in") Outlet (in") P/N (940-)		2 @ 2 2.5 5524	2 @ 2 2.5 5527	2 @ 1.5 2 5341	2 @ 1.5 2 5344	2 @ 1.25 1.5 5396	2 @ 1.25 1.5 5065	2 @ 1 1.25 5453
700-900	7650	Inlet (in") Outlet (in") P/N (940-)			2 @ 2 2.5 5527	2 @ 2 2.5 5530	2 @ 2 2.5 5533	2 @ 1.5 2 5349	2 @ 1.5 2 5074	2 @ 1.25 1.5 5405
1000-1200	10200	Inlet (in") Outlet (in") P/N (940-)					2 @ 2 2.5 5533	2 @ 2 2.5 5538	2 @ 1.5 2 5074	2 @ 1.5 2 5358

Boiler Size	Min. Relieving Cap. (lbs/hr)		LP ST
			15 PSI
150-250	3073	Inlet (in") Outlet (in") P/N (940-)	2 2 5297
300-350	3798	Inlet (in") Outlet (in") P/N (940-)	2.5 2.5 5632
400-600	5450	Inlet (in") Outlet (in") P/N (940-)	3 3 5298
700-900	7958	Inlet (in") Outlet (in") P/N (940-)	2 @ 2.5 2.5 5632
1000-1200	9749	Inlet (in") Outlet (in") P/N (940-)	2 @ 3 3 5298

Boiler Size	Min. Relieving Cap. (MBH)		Hot Water							
			30 PSI	50 PSI	60 PSI	75 PSI	100 PSI	125 PSI	150 PSI	160 PSI
150-250	2946	Inlet (in") Outlet (in") P/N (940-)	1.5 2 5143	1.25 1.5 5147	1.25 1.5 5818	1 1.25 6015	1 1.25 5806	.75 1 5150	.75 1 5153	.75 1 5155
300-350	3656	Inlet (in") Outlet (in") P/N (940-)	1.5 2 5143	1.25 1.5 5147	1.25 1.5 5818	1.25 1.5 6016	1 1.25 5806	1 1.25 5151	1 1.25 5154	.75 1 5155
400-600	5360	Inlet (in") Outlet (in") P/N (940-)	2 2.5 5144	1.5 2 5148	1.5 2 5766	1.5 2 5705	1.25 1.5 6017	1.25 1.5 5152	1 1.25 5154	1 1.25 5320
700-900	7729	Inlet (in") Outlet (in") P/N (940-)	2 @ 2 2.5 5144	2 2.5 5149	2 2.5 6018	2 2.5 6019	1.5 2 5704	1.25 1.5 5152	1.25 1.5 5327	1.25 1.5 5200
1000-1100	9360	Inlet (in") Outlet (in") P/N (940-)	2 @ 2 2.5 5144	2 @ 1.5 2 5148	2 2.5 6018	2 2.5 6019	1.5 2 5704	1.5 2 5324	1.25 1.5 5327	1.25 1.5 5200
1200	9600	Inlet (in") Outlet (in") P/N (940-)	2 @ 2 2.5 5144	2 @ 1.5 2 5148	2 2.5 6018	2 2.5 6019	1.5 2 5704	1.5 2 5324	1.25 1.5 5327	1.25 1.5 5200

Boiler Size	Min. Relieving Cap. (#/hr)		High Temperature Hot Water (KUNKLE # 927-SERIES ONLY)									
			30 PSI	50 PSI	60 PSI	65 PSI	75 PSI	100 PSI	125 PSI	150 PSI	160 PSI	200 PSI
150-250	2,947	Inlet (in") Outlet (in") P/N									1.25 2	
300-350		Inlet (in") Outlet (in") P/N										
400-600		Inlet (in") Outlet (in") P/N										
700-900	7,729	Inlet (in") Outlet (in") P/N (940-)							2 @1.5 2.5 6674			
1000-1100		Inlet (in") Outlet (in") P/N										
1200	9,600	Inlet (in") Outlet (in") P/N (940-)				2 @2.0 3.0 7057						1 @2.0 3.0 7136

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