CLEAVER-BROOKS
Criterion Boilers
Model 4WG

Operation, Service, Maintenance and Parts Manual

100 to 800 HP

Steam and Hot Water

Fuel: Light Oil, Gas or Combination

Manual Part No. 750-212
2/05

CleaverBrooks®

SAFETY PRECAUTIONS AND ABBREVIATIONS

Safety Precautions

It is essential to read and understand the following safety precautions before attempting to operate the equipment. Failure to follow these precautions may result in damage to equipment, serious personal injury, or death. A complete understanding of this manual is required before attempting to start-up, operate or maintain the equipment. The equipment should be operated only by personnel who have a working knowledge and understanding of the equipment.
The following symbols are used throughout this manual:

⚠WARNING

This symbol indicates a potentially hazardous situation which, if not avoided, could result in serious personal injury, or death.

⚠ CAUTION

This symbol indicates a potentially hazardous situation which, if not avoided, could result in damage to the equipment.

Note: This symbol indicates information that is vital to the operation of this equipment.

Abbreviations

Following is an explanation of the abbreviations, acronyms, and symbols used in this manual.

AC	Alternating Current
AR	Automatic Reset
AC	Alternating Current
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
BHP	Boiler Horsepower
BTU	British Thermal Unit
°C	Degrees Celsius
CFH	Cubic Feet per Hour
Cu Ft	Cubic Feet
DC	Direct Current
°F	Degrees Fahrenheit
FM	Factory Mutual
FS	Flame Safeguard
ft	Feet
GPM	Gallons per Minute
Hd	Head
HT	Height
HTB	High Turndown Burner
HZ	Hertz
In H_2O	Inches of Water
IRI	Industrial Risk Insurance
Lb	Pound
LWCO	Low-Water Cut-Off
M	Million
MFD	Micro-Farad
MR	Manual Reset
NEC	National Electric Code
No.	Number
pH	Measure of the degree of acid or base of a solution
P/N	Part Number
PPM	Parts Per Million
PR	Program Relay
psi	Pounds Per Square Inch
SAE	Society of Automotive Engineers
scfh	Standard Cubic Feet per Hour
T	Temperature
TC	Temperature Control
TI	Temperature Gauge
UL	Underwriter's Laboratories
V	Volt
WC	Water Column
WSI	Watts Per Square Inch

Criterion Boilers
MODEL 4WG

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

Manual Part No. 750-212
Revised 2/05

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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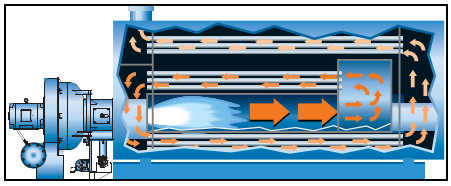

Figure 1-1 Criterion Boiler Cutaway, Wet-Back Design

A. General

Firetube boilers are available for low or high pressure steam, or for hot water applications. Firetube boilers are typically used for applications ranging from 15 to 1500 horsepower. A firetube boiler is a cylindrical vessel, with horizontal tubes passing through and connected to the front and rear tube sheets (see **Figure 1-1**). The Criterion boiler utilizes a Wet-Back design with a rear access way for cleaning and maintenance of the furnace and second pass tubes. The vessel contains the water and absorbs the energy generated from the flame. The front door and rear door provide the seal to contain the hot combustion gasses. Baffles designed into the doors serve to redirect the combustion gases through the various firetube passages. The flame originates in the furnace. As the combustion gasses travel down the furnace and through the various firetube channels, heat from the flame and combustion gasses is transferred to the water.

Figure 1-2 Criterion 4WG Firetube Boiler

Transferred energy develops into the required steam or hot water. The primary purpose of the boiler is to supply energy to the facility's operations — for heat, manufacturing process, laundry, kitchen, etc. The nature of the facility's operation will dictate whether a steam or hot water boiler should be used.

The general information in this manual applies directly to Cleaver-Brooks Criterion line of boilers in sizes ranging from 100 through 800 boiler horsepower for the following fuels:

Series 100	Light Oil (No. 2)
Series 200	Light Oil (No. 2) Or Gas
Series 700	Gas Only

Figure 1-3 Criterion 4WG Rear Access Way with Rear Door Open

Table 1-1. Criterion 4WG Boilers Specifications

Rated Capacity	100 through 800 HP
Operating Pressure	Steam 15 – 270 psig, Hot Water 30 – 125 psig
Fuel	Light Oil or Gas or Combination
Ignition	Automatic
Firing 100 – 800 hp	Full Modulation
Burner (Gas)	Non-premix, Orificed Type
Air Shutter	Rotary Damper (Electrically Modulated)
Steam Trim	ASME Code
Water Trim	ASME Code

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

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 in the Criterion series comply, when equipped with optional equipment, to Industrial Risk Insurers (IRI), Factory Mutual (FM), or other insuring underwriters requirements.

Figure 1-4 Criterion 4 Pass Wet-Back Design

B. The Boiler

The Criterion boiler is a packaged firetube boiler of welded steel construction and consists of a pressure vessel, burner, burner controls, burner accessories, refractory, and appropriate boiler trim.

The horsepower rating of the boiler is indicated by the numbers following the fuel series. Thus, 4WG 700-250 indicates a gas-fired 250 HP boiler.

The firetube construction provides some characteristics that differentiate it from other boiler types. Because of its vessel size, the firetube contains a large amount of water, allowing it to respond to load changes with minimum variation in steam pressure.

Firetube boilers are rated in boiler horsepower (BHP), which should not be confused with other horsepower measurements.

Figure 1-5 Access Way to Second Pass Turnaround Chamber

Figure 1-6 Front Baffle Between 3rd and 4th Gas Pass

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. The various tube sets and baffles allow the gas passes to travel through the boiler, (**Figure 1-6**) thereby transferring the energy into the waterside to generate steam or hot water.

Steam boilers are designed for low pressure or high pressure applications. Low pressure boilers are limited to 15 psig design, and are typically used for heating applications. High pressure boilers are typically used for process loads and can have a design pressure of 75 to 300 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.

Figure 1-7 Deaerator in Feedwater System

⚠ 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 or your local water treatment professional. Failure to follow these instructions could result in equipment damage.

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

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. Constant attention to water requirements will pay dividends in the form of longer life, less downtime, 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 2.

The operator should be familiar with Chapter 2 before attempting to place the unit into operation.

C. Construction

Steam boilers designed for operating at 15 psig and hot water boilers designed for 250°F at 125 psi or less are constructed in accordance with Section IV, Heating Boilers, of ASME Code.

Steam boilers designed for operating pressures exceeding 15 psig are constructed in accordance with Section I, Power Boilers, of the ASME Code. Hot water boilers designed for operating temperatures above 250°F or 125 psi are likewise built to Section I of the ASME Code.

Figure 1-8 ASME Welding on a Firetube Pressure Vessel

D. Steam Controls (All Fuels)

1. Operating Limit Pressure Control (**Figure 1-9**): 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.
2. High Limit Pressure Control (**Figure 1-9**): 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 normally equipped with a manual reset.
3. Modulating Pressure Control (**Figure 1-9**): 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 (**Figure 1-10**): Float-operated control responds to the water level in the boiler. It performs two distinct functions:

1. OPERATING LIMIT CONTROL
2. HIGH LIMIT CONTROL
3. MODULATING PRESSURE CONTROL

Figure 1-9 Pressure Controls

Figure 1-10 Water Column and Level Master Low Water Cut-Off

A. 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.

B. 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 (**Figure 1-10**): Houses the low-water cutoff and pump control and includes the gauge glass and gauge glass shutoff cocks.
6. Water Column Drain Valve (**Figure 1-10**): 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 (**Figure 1-10**): Provided to flush the gauge glass.
8. Vent Valve: (top of water column) Allows the boiler to be vented during filling, and facilitates routine boiler inspection as required by ASME Code.
9. Auxiliary Low Water Cutoff (**Figure 1-11**): Breaks the circuit to stop burner operation in the event boiler water drops below the primary low-water cutoff point. Manual reset type requires manual resetting in order to start the burner after a low-water condition.
10. Safety Valve(s) (**Figure 1-12**): Prevent pressure 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.

Figure 1-11 Auxiliary Low Water Cutoff

⚠ 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.

Figure 1-12 Safety Valves

E. Hot Water Controls (All Fuels)

1. Water Temperature Gauge (**Figure 1-13**): Indicates the boiler internal water pressure.
2. Operating Limit Temperature Control (**Figure 1-13**): 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.
3. High Limit Temperature Control (**Figure 1-13**): 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 normally is equipped with a manual reset.

Figure 1-13 Hot Water Temperature Controls

4. Low Water Cutoff (**Figure 1-14**) (Optional probe type): Breaks the circuit to stop burner operation if the water level in the boiler drops below the primary low-water cutoff point.

Figure 1-14 LWCO Probe Type

Safety Valve(s) (**Figure 1-15**): Relieves the boiler of pressure higher than the design pressure or a lower pressure, if designated. Relief valves and their discharge piping are to be installed to conform to ASME Code requirements.

⚠ 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.

Notes:

Chapter 2
Waterside Care and Requirements

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A. General

The operator should be familiar with this entire manual and related equipment Operation and Service manuals before attempting to place the unit into operation.

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 Cleaver-Brooks service and parts representative.

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

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. It is vital that care be taken in placing the pressure vessel into initial service. 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 the accumulations is described later in Chapter 2.

Boilers, as a part of a hot water system, require proper water circulation. The system must be operated as intended by its designer in order to avoid thermal shock or severe, possibly damaging, stresses from occurring to the pressure vessel.

Note: This manual only covers boilers using water. Glycol solutions have different operating requirements, circulation rates and temperatures, etc.

Figure 2-1. Water Column with Level Master

B. Water Requirements

1. Hot Water Boiler

Air Removal

The hot water outlet includes a dip tube (**Figure 2-2.**) which extends 2 to 3 inches into the boiler. The dip tube reduces the possibility of air, which may be trapped at the top of the shell, from entering into the system. Oxygen or air released in the boiler will collect or be trapped at the top of the boiler shell.

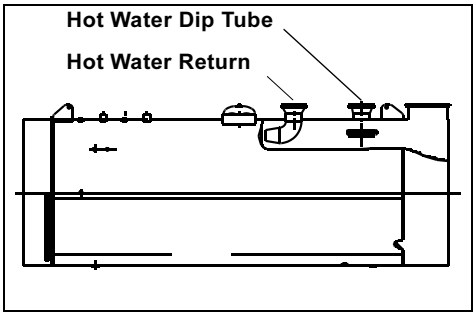


Figure 2-2. Dip Tube

The air vent tapping on the top center line of the boiler should be piped into the expansion or compression tank. Air trapped at the top of the boiler will find its way out of the boiler through the tapping.

Minimum Water Temperature — The minimum recommended boiler water temperature is 170°F. When water temperatures lower than 170°F are used, the combustion gases are reduced in temperature to a point where water vapor condenses, causing corrosion in the boiler and possible breeching.

Condensation is more severe on a unit that operates intermittently and which is greatly oversized for the actual load. Condensation can be minimized by maintaining boiler water temperatures above 170°F.

Rapid Replacement of Boiler Water — The system layout and controls should be arranged to prevent the possibility of pumping large quantities of cold water into a hot boiler, which will cause shock or thermal stresses. Water temperature in a boiler of 200°F or 240°F cannot be completely replaced with 80°F water in a few minutes time without causing thermal stress. The same fact applies to periods of normal operation, as well as during initial start-up.

Note: The circulating pumps should be interlocked with the burner so that the burner cannot operate unless the circulating pump is running in order to avoid damage to the equipment.

When individual zone circulating pumps are used, it is recommended that they be kept running — even though the heat users do not require hot water. The relief device or bypass valve will thus allow continuous circulation through the boiler and can help prevent rapid replacement of boiler water with cold zone water.

Continuous Flow Through the Boiler — The system should be piped and the controls arranged to allow water circulation through the boiler under all operating conditions. The operation of three-way valves and system controls should be checked to be sure that the boiler will not be bypassed. Constant circulation through the boiler eliminates the possibility of stratification within the unit and results in more even water temperatures to the system.

A rule of thumb of 3/4 to 1 gpm per boiler horsepower can be used to determine the minimum continuous flow rate through the boiler under all operating conditions. The operator should determine that a flow of water exists through the boiler before initial firing or refiring after boiler has been drained.

Water Circulation

Table 2-1 shows the maximum gpm circulation rate of boiler water in relation to full boiler output and system temperature drop.

Multiple Boiler Installations — When multiple boilers are used, care must be taken to ensure adequate or proportional flow through the boilers. Proportional flow can best be accomplished by use of balancing valves and gauges in the supply line from each boiler. If balancing valves or orifice plates are used, a significant pressure drop (e.g., 3 – 5 psi) must be taken across the balancing device to accomplish the purpose.

If care is not taken to ensure adequate or proportional flow through the boilers, wide variations in firing rates between the boilers can result.

In extreme cases, one boiler may be in the high-fire position while the other boiler or boilers may be at low-fire. The net result would be that the common header water temperature to the system would not be up to the desired point.

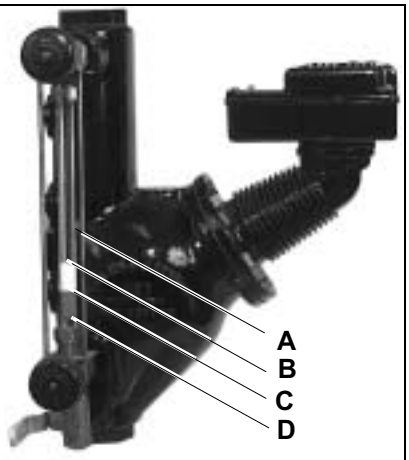
Pump Location — It is recommended that the system circulating pumps take suction from the outlet connection on the boiler, and that they discharge to the system load, in order to put the boiler and the expansion tank on the suction side of the pump. The suction side is preferred because it decreases air entry into the system and does not impose the system head on the boiler.

It is common practice to install a standby system circulating pump. The main circulating pumps are usually located adjacent to the boilers in the boiler room.

Pump Operation — Pumps are normally started and stopped by manual switches. It is also desirable to interlock the pump with the burner so that the burner cannot operate unless the circulating pump is running.

Pressure

The design of the system and usage requirements often dictate the pressure exerted upon the boiler. Some systems are pressurized with air, or with an inert gas such as nitrogen. Caution must be exercised to ensure that the proper relationship of pressure-to-temperature exists within the boiler so that all of the boiler's internal surfaces are fully wetted at all times. For this reason, the internal boiler pressure, as indicated on the water pressure gauge, must be held to the level shown in **Figure 2-3.**.



A. Normal level of water: feed pump turns off at this point. Fill pressure vessel initially to this height.
B. Pump turns on when water level reaches B. Distance between A-B is approximately 3/4".
C. Low water cut-off point burner will shut off if water level lowers to this point.
D. First visible point in gauge glass.

Figure 2-3. Water Level Gauge Glass

When initially firing a newly installed boiler, or when cutting an existing boiler into an operating system, the boiler or boilers to be cut into operation MUST be pressurized equal to the system and/or other boilers prior to opening the header valves.

It is advisable to have a thermometer installed in the return line to indicate return water temperature. Knowing the supply water temperature, the boiler system differential can be established. With knowledge of the pumping rate, the operator can easily detect any excessive load condition and take appropriate corrective action. (**Table 2-1**)

Special caution must be taken to guard against any condition, or combination of conditions, that might lead to the transfer of cold water to a hot boiler or hot water to a cold boiler. It cannot be overemphasized that rapid changes in temperature within the boiler can, and sometimes do, cause damage.

Table 2-1 Maximum Circulating Rate in Gallons per Hour for Hot Water Boilers

Boiler Size (BHP)	Boiler Output (1000) BTU/HR	System Temperature Drop – Degress °F									
		10	20	30	40	50	60	70	80	90	100
		Maximum Circulating Rate – GPM									
100	3,347	670	335	224	168	134	112	96	84	75	67
125	4,185	836	418	279	209	168	140	120	105	93	84
150	5,025	1,005	503	335	251	201	168	144	126	112	100
200	6,695	1,340	670	447	335	268	224	192	168	149	134
250	8,370	1,675	838	558	419	335	280	240	210	186	167
300	10,045	2,010	1,005	670	503	402	335	287	251	223	201
350	11,720	2,350	1,175	784	587	470	392	336	294	261	235
400	13,400	2,680	1,340	895	670	535	447	383	335	298	268
500	16,740	3,350	1,675	1,120	838	670	558	479	419	372	335
600	20,080	4,020	2,010	1,340	1,005	805	670	575	502	448	402
700	23,430	4,690	2,345	1,565	1,175	940	785	670	585	520	470
800	26,780	5,360	2,680	1,785	1,340	1,075	895	765	670	595	535

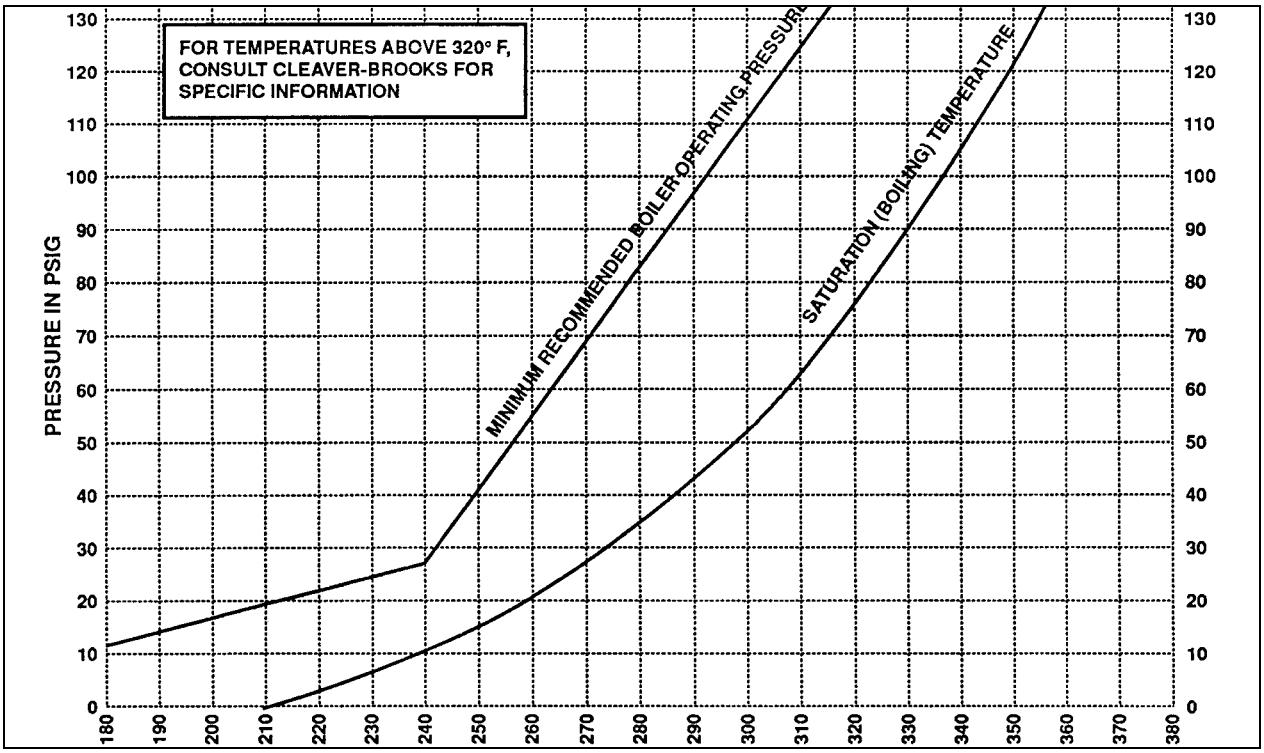


Figure 2-4. Internal Boiler Pressure

2. Steam Boiler

Feed Pump Operation

Figure 2-5. Low Water Cut Off

BEFORE turning on the pump motor, be certain that all valves in the water feed line are open to prevent possible damage to the feed pump mechanism. After opening the valves, momentarily energize the feed pump motor to establish correct pump rotation. With the correct rotation established, close the boiler feed pump entrance switch. The pump should shut down when the water level reaches the proper level .

Feedwater pumps must have adequate capacity to maintain required water level under all operating conditions. Check the feedwater pumps periodically and maintain as necessary to prevent unexpected breakdowns.

Note: Prior to operating the pump, carefully check the alignment of the flexible coupling, if one is used. A properly aligned coupling will last a long time and provide trouble-free mechanical operation.

Water Feeder Operation (Optional)

Water feeder operation is usually applicable to boilers operating at 15 psi steam or less. It is only necessary to open the water supply line valve and the water feeder discharge valve.

Note: In the event that water column isolation valves are provided or installed, it must be established that the valves are open and seated or locked in the open position. If the valves are installed, it is illegal to operate the boiler with closed or unsealed open valves.

C. Water Treatment

⚠ Warning

The isolation valves and the water column piping must be locked open during operation. Failure to do so may result in a low water condition. Failure to follow these instructions could result in serious personal injury or death.

Properly treated boiler feed water, coupled with good engineering and operating practices, leads to maximum effectiveness and long trouble-free life of pressure vessels, at the lowest operating cost. Contact your local Cleaver-Brooks authorized representative for information on how to prevent the presence of unwanted solids and corrosive gases.

Objectives of water treatment in general are:

1. Prevent hard scale deposits or soft sludge deposits, which reduce heat transfer and can lead to overheated metal and costly downtime and repairs.
2. Eliminate corrosive gases in the supply or boiler water.
3. Prevent intercrystalline cracking or caustic embrittlement of boiler metal.
4. Prevent carryover and foaming.

Accomplishment of the above objectives generally requires proper feedwater treatment before and after introduction of the water into the boiler. The selection of pre-treatment

processes depends upon the water source, its chemical characteristics, amount of makeup water needed, plant operating practices, etc. Treating methods include filtering, softening, de-mineralizing, deaerating, and preheating. After-treatment involves chemical treatment of the boiler water.Because of the variables involved, no single boiler compound can be considered a “cure-all” nor is it advisable to experiment with homemade treating methods. Sound recommendations and their employment should be augmented by a periodic analysis of the feedwater, boiler water, and condensate.

The internal or waterside surfaces of the pressure vessel should be inspected with enough frequency to determine the presence of any contamination, accumulations of foreign matter, or corrosion, and/or pitting. If any of these conditions are detected, contact your local Cleaver-Brooks authorized representative for advice on corrective action.

A properly sized water meter should be installed in the raw water make-up line in order to accurately determine the amount of raw water admitted to the boiler (steam or hot water) and to aid in maintaining proper waterside conditions.

D. Cleaning

1. Hot Water and Steam Piping

Steam and water piping systems connected to the boiler may contain oil, grease, or foreign matter. The impurities must be removed in order to prevent damage to pressure vessel heating surfaces. On a steam system, the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, attention must be given to the treatment of the raw water used as make-up so that an accumulation of unwanted materials or corrosion does not occur. For more information, contact your local Cleaver-Brooks authorized representative.

On a hot water system, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult your local Cleaver-Brooks authorized representative for recommendations, cleaning compounds, and application procedures.

2. Pressure Vessel

The waterside of the pressure vessel must be kept clean from grease, sludge, and foreign material. Such deposits, if present, will shorten the life of the pressure vessel, will interfere with efficient operation and functioning of control of safety devices, and quite possibly cause unnecessary and expensive re-work, repairs, and downtime.

The installation and operating conditions that the boiler will be subjected to should be considered and cleaning of the

waterside of the pressure vessel should be provided during the course of initial start-up.

The pressure vessel and the steam and return lines or hot water piping represent, in effect, a closed system. Although the steam and return (condensate) lines or the hot water piping system may have been previously cleaned, it is possible that:

1. Cleaning has been inadequate.
2. Partial or total old system is involved.
3. Conditions may prevent adequate cleaning of piping.

The pressure vessel waterside should be inspected on a periodic basis. An inspection will reveal true internal conditions and serve as a check against conditions indicated by chemical analysis of the boiler water. Inspection should be made three months after initial starting and at regular 6-, 9-, or 12-month intervals thereafter. The frequency of further periodic inspections will depend upon the internal conditions found.

If any unwanted conditions are observed, contact your local Cleaver-Brooks authorized representative for recommendations.

Any sludge, mud or sediment found will need to be flushed out. If excessive mud or sludge is noticed during the blowdown the scheduling or frequency of blowdown may need to be revised. The need for periodic draining or washout will also be indicated.

Any oil or grease present on the heating surfaces should be removed promptly by a boil-out with an alkaline detergent solution.

Notice

Temperature of initial fill of water for hydrostatic tests, boil-out, or for normal operation should be as stated in the ASME Boiler Code.Boil-Out of New Unit

The internal surfaces of a newly installed boiler may have oil, grease or other protective coatings used in manufacturing. Such coatings must be removed because they lower the heat transfer rate and could cause over-heating of a tube. Before boiling out procedures may begin, the burner should be ready for firing. The operator must be familiar with the procedure outlined under burner operation.

Your local Cleaver-Brooks authorized representative will be able to recommend a cleaning or boil-out procedure. In the event such service is unavailable or is yet unscheduled, the following information may be of assistance.

There are several chemicals suitable for boil-out. 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.

The suggested general procedure for cleaning a boiler is as follows:

1. Have sufficient cleaning material on hand to complete the job.
2. When dissolving chemicals, the following procedure is suggested. Warm water should be put into a suitable container. Slowly introduce the dry chemical into the water, stirring it at all times until the chemical is completely dissolved. Add the chemical slowly and in small amounts to prevent excessive heat and turbulence.
3. An over-flow pipe should be attached to one of the top boiler openings and routed to a safe point of discharge. A relief or safety valve tapping is usually used.
4. Water relief valves and steam safety valves must be removed before adding the boil-out solution so that neither it nor the grease which it may carry will contaminate the valves. Use care in removing and reinstalling the valves.
5. All valves in the piping leading to or from the system must be closed to prevent the cleaning solution from getting into the system.
6. Fill the pressure vessel with clean water until the top of the tubes are covered. Add the cleaning solution and then fill to the top. The temperature of the water used in the initial fill should be at ambient temperature.
7. The boiler should then be fired intermittently at a low rate sufficient to hold solution just at the boiling point.

Warning

Use of a suitable face mask, goggles, rubber gloves, and protective garments is strongly recommended when handling or mixing caustic chemicals. Do not permit the dry material or the concentrated solution to come in contact with skin or clothing. Failure to follow these instructions could result in serious personal injury or death.

Boil the water for at least five hours. Do not produce steam pressure.

8. Allow a small amount of fresh water to enter the boiler to create a slight overflow that will carry off surface impurities.
9. Continue the boil and overflow process until the water clears. Shut the burner down.
10. Let the boiler cool to 120°F or less.
11. Remove handhole plates and wash the waterside surfaces thoroughly using a high pressure water stream.
12. Inspect the surfaces. If they are not clean, repeat the boil out.
13. After closing the handholes and reinstalling the safety or relief valves, fill the boiler and fire it until the water is heated to at least 180°F to drive off any dissolved gases, which might otherwise corrode the metal.

⚠ Warning

Be sure to drain the hot water to a safe point of discharge to avoid scalding. Failure to follow these instructions could result in serious personal injury or death.

The above procedure may be omitted in the case of a unit previously used or known to be internally clean. However, consideration must be given to the possibility of contaminating materials entering the boiler from the system.

E. Washing Out

1. Hot Water Boiler

In theory, a hot water system and boiler that has been initially cleaned, filled with raw water (and water treated), and with no make-up water added, will require no further cleaning or treatment. However, since the system (new or old) can allow entrance of air and unnoticed or undetected leakage of water, introductions of raw water make-up or air may lead to pitting, corrosion and formation of sludge, sediment, scale, etc., on the pressure vessel waterside.

If the operator is absolutely certain that the system is tight, then an annual waterside inspection may be sufficient. However, if there is any doubt, the pressure vessel waterside should be inspected no later than three months after initially placing the boiler into operation, and periodically thereafter as indicated by conditions observed during inspections.

2. Steam Boiler

No later than three months after initially placing the boiler into operation and starting service, and thereafter as conditions warrant, the pressure vessel should be drained after being properly cooled to near ambient temperature. Handhole covers should be removed and waterside surfaces

should be inspected for corrosion, pitting, or formation of deposits.

Flushing of Pressure Vessel Interior

Upon completion of the inspection, the pressure vessel interior should be flushed out, as required, with a high pressure hose. If deposits are not fully removed by flushing, a consultation may be required with your local Cleaver-Brooks authorized representative. In extreme cases, it may be necessary to resort to acid cleaning. Professional advice is recommended if acid cleaning is required.

The inspections will indicate the effectiveness of the feedwater treatment. The effectiveness of treatment, the water conditions, and the amount of fresh water make-up required are all factors to be considered in establishing frequency of future pressure vessel washouts. Contact your local Cleaver-Brooks authorized representative for more information.

F. Fireside Cleaning

Soot and non-combustibles are effective insulators, and, if allowed to accumulate, will reduce heat transfer to the water and increase fuel consumption. Soot and other deposits can be very moisture-absorbent, and may attract moisture to form corrosive acids that will deteriorate fireside metal.

Clean-out should be performed at regular and frequent intervals, depending upon load, type, and quality of fuel, internal boiler temperature, and combustion efficiency. A stack temperature thermometer (see **Figure 2-7**) can be used as a guide to clean-out intervals since an accumulation of soot deposits will raise the flue gas temperature.

Figure 2-6 Fireside Inspection and Cleaning (Wet-Back Boiler, Rear Door Open)

Tube cleaning is accomplished by opening the front and rear doors (see **Figure 8-2** and **Figure 2-6**). Tubes may be brushed from either end. All loose soot and accumulations should be removed. Any soot, or other deposits, should be removed from the furnace and tube sheets.

Refer to **Section J** for instructions on properly closing rear heads.

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

The fireside should be thoroughly cleaned prior to any extended lay-up of the boiler. Depending upon circumstances, a protective coating may be required. See **Section I**.

Figure 2-7 Stack Thermometer

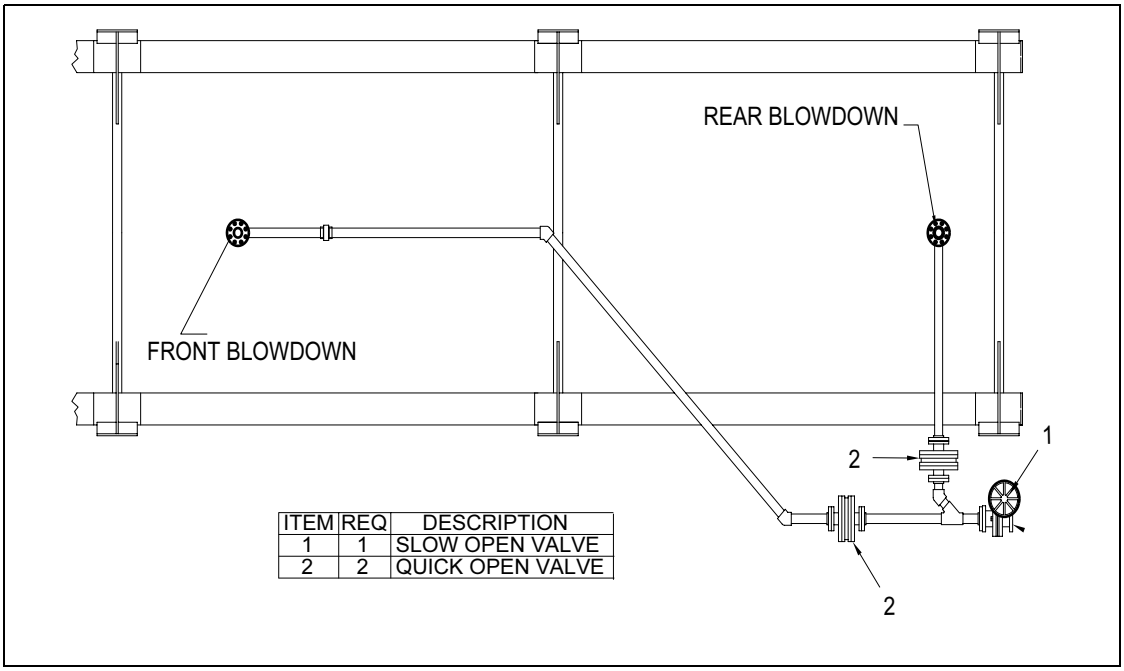


Figure 2-8. Bottom Blowdown Layout

Figure 2-9. Bottom Blowdown Valves

G. Blowdown Steam Boiler

Boiler water blowdown is the removal of some of the concentrated water from the pressure vessel and its replacement with feedwater so that the lowering of the concentration of solids in the boiler water occurs. Solids are brought in by the feedwater even though the water is treated prior to use through external processes that are designed to remove unwanted substances which contribute to scale and deposit formations. However, none of the processes can remove all substances. Regardless of their high efficiency, some solids will be present in the boiler feedwater.

Solids become less soluble in the high temperature of the boiler water and tend to accumulate on heating surfaces. Therefore blowdown and internal chemical treatment are required to prevent the solids from forming harmful scale and sludge.

Scale has a low heat transfer value and acts as an insulation barrier. Scale retards heat transfer, which not only results in lower operating efficiency, and consequently higher fuel consumption, but more importantly, can cause overheating of boiler metal. Over heating of boiler metal can result in tube failures or other pressure vessel metal damage and lead to boiler downtime and costly repairs.

Scale is caused primarily by calcium and magnesium salts, silica and oil. Any calcium and magnesium salts in the boiler water are generally precipitated by the use of sodium phosphate, along with organic materials, to maintain the precipitates or “sludge” in a fluid form. The solids such as sodium salts and suspended dirt do not readily form scale. But as the boiler water boils off as relatively pure steam, the remaining water is thickened with the solids. If the concentration is permitted to accumulate, foaming and priming will occur and the sludge can cause harmful deposits that bring about overheating of the metal.

The lowering or removal of the concentration requires the use of boiler water blowdown.

1. Types of Blowdown

There are two principal types of blowdown: intermittent manual blowdown, and continuous blowdown.

Intermittent Manual Blowdown

Manual or sludge blowdown is necessary for the operation of the boiler regardless of whether or not continuous blowdown is employed.

The blowdown tappings are located at the bottom or lowest part of the boiler in order to lower the dissolved solids in the pressure vessel water, and to remove a portion of the sludge that accumulates in the lower part of the vessel.

Equipment generally consists of a quick opening valve and a shut-off valve. The valves and necessary piping are not normally furnished with the boiler, but supplied by others. All piping must be to a safe point of discharge. Piping must be properly supported and free to expand.

Continuous Blowdown

Continuous blowdown is used in conjunction with a surface blow-off tapping and is the continuous removal of concentrated water.

The surface blow-off opening, when furnished, is on the top center line of the pressure vessel. It is provided with an internal collecting pipe terminating slightly below the working water level for the purpose of skimming surface sediment, oil or other impurities from the surface of the pressure vessel water.

A controlled-orifice valve is used to allow a continual, yet controlled, flow of concentrated water.

Periodic adjustments are made to the valve setting to increase or decrease the amount of blowdown in accordance with the test analysis.

The flow control valve and piping are generally provided by others. All piping must be to a safe point of discharge.

2. Frequency of Manual Blowdown

When continuous blowdown is utilized, manual blowdown is primarily used to remove suspended solids or sludge. The continuous blowdown removes sediment and oil from the surface of the water along with a prescribed amount of dissolved solids.

When surface or continuous blowdown is not utilized, manual blowdown is used to control the dissolved or suspended solids in addition to the sludge.

In practice, the valve(s) of the bottom blowdown are opened periodically in accordance with an operating schedule and/or chemical control tests. From the standpoint of control, economy and results, frequent short blows are preferred to infrequent lengthy blows. The length and frequency of the blowdown is particularly important when the suspended solids content of the water is high. With the use of frequent short blows, a more uniform concentration of the pressure vessel water is maintained.

In cases where the feedwater is exceptionally pure, or where there is a high percentage of return condensate, blowdown may be employed less frequently since less sludge accumulates in the pressure vessel. When dissolved and/or suspended solids approach or exceed predetermined limits, manual blowdown to lower the concentrations is required.

It is generally recommended that a steam boiler be blown down at least once in every eight-hour period, but frequency may vary depending upon water and operating conditions. The blowdown amounts and schedule should be recommended by your local Cleaver-Brooks authorized representative.

A hot water boiler does not normally include openings for surface blowdown and bottom blowdown since blowdowns are seldom practiced. The need remains to be alert to system water losses and corresponding amount of raw water make-up. A water meter is recommended for water make-up lines.

3. Manual Blowdown Procedure

Blowdown is most effective at a point in time when the generation of steam is at the lowest rate and feedwater input is also low, thus providing a minimum dilution of the boiler water with low concentration feedwater.

Be sure the blow-off piping and tank, if used, are in proper operating condition. Discharge vents should be clear of obstruction, and the waste should be piped to a point of safe discharge.

Most blow-off lines are provided with two valves, generally a quick opening valve nearest the boiler and a slow opening globe type valve downstream. Valves will vary depending upon pressure involved and make or manufacturer. If seatless valves are installed, follow the manufacturer's recommendations.

If a quick opening valve and globe type of slow opening valve are in combination, the former is normally opened first and closed last with blowdown accomplished with the globe or slow opening valve.

When opening the second or downstream valve, crack it slightly to allow the lines to warm, then continue opening slowly

Figure 2-10. Blowing Down the Water Column

⚠ Caution

Do not pump the lever action valve open and closed, as water hammer is apt to break the valve bodies or pipe fittings. Failure to follow these instructions could cause damage to the equipment.

Figure 2-11. Vent Valve on Water Column

The length of each blow should be determined by actual water analysis. Lowering the water in the gauge glass approximately 1/2" is often acceptable as a guide to adequate blow. However, lowering the water 1/2" should not be interpreted as a rule since water analysis procedures should prevail. If the glass cannot be viewed by the party operating the valve, another operator should watch the glass and direct the valve operator.

Close the downstream (slow opening) valve first and as fast as possible. Then close the valve next to the boiler. Slightly crack the downstream valve and then close it tightly. Under no circumstances should a blow-off valve be left open and the operator should never leave until the blowdown operation is completed and the valves are closed.

H. Periodic Inspection

Insurance regulations or local laws will require a periodic inspection of the pressure vessel by an authorized inspector. Sufficient notice is generally given to permit removal of the boiler from service and preparation for inspection.

⚠ Warning

To avoid the hazard of electrical shock, we recommend the use of a low voltage flashlight during an internal inspection. Preferably, inspectors should work in pairs. Failure to follow these instructions could result in serious personal injury or death.

When shutting down the boiler, the load should be reduced gradually and the pressure vessel cooled at a rate that avoids damaging temperature differential that can cause harmful stresses. Vessels should not normally be drained until all pressure is relieved — again to prevent uneven contraction and temperature differentials that can cause expanded tubes to leak. Draining the unit too quickly may cause the baking of deposits that may be present on the heating surfaces. Some heat, however, may be desirable to dry out the interior of the boiler.

If the internal inspection is being made at the request of an authorized inspector, it is well to ask the inspector to observe the conditions prior to cleaning or flushing of waterside surfaces.

Be certain that a supply of manhole and handhole gaskets is available, along with any other gaskets or items needed to place the unit back into operation after inspection.

Have available information on the boiler design, dimensions, generating capacity, operating pressure or temperature, time in service, defects found previously, and any repairs or modifications. Also have available for reference records of previous inspections.

Be prepared to perform any testing required by the inspector including a hydrostatic test.

After proper cooling and draining of the vessel, flush out the waterside with a high pressure water hose. Remove any scale or deposits from the waterside surfaces and check for internal or external corrosion and leakage.

The fireside surface should also be thoroughly cleaned so that metal surfaces, welds, joints, tube ends, fittings and any previous repairs can be readily checked.

Be sure that steam valves, and valves to expansion tank (hot water), feedwater valves, blow-off valves, all fuel valves, valves to expansion tank, and electrical switches are shut off prior to opening handholes, manhole and front or rear doors. Adequately vent the pressure vessel prior to entry.

Clean out the low-water cutoff piping, the water level controls and cross-connecting pipes. Replace the water gauge glass and clean out the water cocks. Also check and clean the drain and the blowdown valves and piping.

Check all water and steam piping and valves for leaks, wear, corrosion, and other damage. Replace or repair as required.

I. Preparation for Extended Lay-Up

Many boilers used for heating or seasonal loads or for standby service may have extended periods of non-use. Special attention must be given to idle boilers so that neither waterside nor fireside surfaces are allowed to deteriorate from corrosion.

Too many conditions exist to lay down definite rules. There are two methods of storage: wet or dry. Your local Cleaver-Brooks authorized representative can recommend the better method depending upon circumstances in the particular installation.

Whichever method is used, common sense dictates a periodic recheck of fireside and waterside conditions during lay-up to allow variations from the above methods for special area or jobsite conditions.

Swing open the boiler head at the stack end of the unit to prevent flow of warm, moist air through the boiler tubes.

Although pollution control regulations may continue to limit the permissible sulphur content of fuel oils, care must be taken to avoid corrosion problems that sulphur can cause, especially in a boiler that is seasonally shutdown. Dormant periods, and even frequent shutdowns, expose the fireside surfaces to condensation below the dew point during cooling. Moisture and any sulphur residue can form an acid solution. Under certain conditions, and especially in areas with high humidity, the corrosive effect of the acid will be serious enough to eat through or severely damage boiler

tubes or other metal heating surfaces during the time that a boiler is out of service.

The condition does not generally occur during normal firing operation, because the high temperature of operation vaporizes any condensation. However, proper boiler operation must be maintained, especially with a hot water boiler, to prevent the flue gases from falling below the dew point.

At the start of lay-up, thoroughly clean the fireside by removing any soot or other products of combustion from the tubes, tube sheets and other fireside surfaces. Brushing will generally suffice. Sweep away or vacuum any accumulation. The fireside surfaces may be flushed with water. However, all moisture must be eliminated after flushing and the surface dried by blowing air or applying some form of heat. It is good practice to protect the cleaned surfaces by coating them with an anti-corrosive material to prevent rust.

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

Dry storage is generally employed when the boiler will be out of service for a significant period of time, or where freezing temperatures may exist. In the dry storage method the boiler must be thoroughly dried because any moisture would cause corrosion. Both fireside and waterside surfaces must be cleaned of all scale, deposits, soot, etc. Steps must be taken to eliminate moisture by placing moisture-absorbing materials such as quick lime (at 2 pounds for 3 cubic feet of volume) or silica gel (at 5 pounds for 30 cubic feet of volume) on trays inside the vessel. Fireside surfaces may be coated with an anticorrosive material, or grease or tar paint. Refractories should be brushed clean and wash-coated. All openings to the pressure vessel, such as manhole and handholes, should be shut tightly. Feedwater and steam valves should be closed. Damper and vents should be closed to prevent air from reaching fireside surfaces. Periodic inspection should be made and absorption materials renewed.

Wet storage is generally used for a boiler held in standby condition or in cases where dry storage is not practical. The possibility of freezing temperatures must be considered. Care must again be taken to protect metal surfaces. Variables preclude definite recommendations. However, it is suggested that the pressure vessel be drained, thoroughly cleaned internally, and re-filled 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. Additional chemicals may be suggested by your local Cleaver-Brooks authorized representative to minimize corrosion. Internal

water pressure should be maintained at greater than atmospheric pressure. Nitrogen is often used to pressurize the vessel. Fireside surfaces must be thoroughly cleaned and refractory should be wash-coated.

J. Opening And Closing Doors

1. Opening Front or Rear Door

Before opening the doors, tighten the nut on the davit arm to create slight tension (See **Figure 2-12**.) This will prevent sagging and facilitate opening of the door. After opening either door, check the gaskets and seating surfaces. Replace the door gaskets if they are hard or brittle. Clean the sealing surfaces of the door and tube sheet.

Figure 2-12 Tighten Davit Nut

2. Rear Access Plug

Access to the first to second gas pass turn around area is accomplished through the removal of the rear plug. The access plug weighs approximately 120 pounds. Two people make the handling of the access plug easier. When resealing the access plug area, be sure the sealing area is clean and free of old gasket material and rust. Secure 2" blanket insulation to the inside of the plug with a 2" overlap around the circumference of the plug refractory. Attach one wrap of 1" rope to the inner access sealing area an two wraps of 1/2” rope to the outside area. Insert the plug and tighten evenly (see **Figure 2-14**).

Figure 2-13 Removing Rear Access Plug

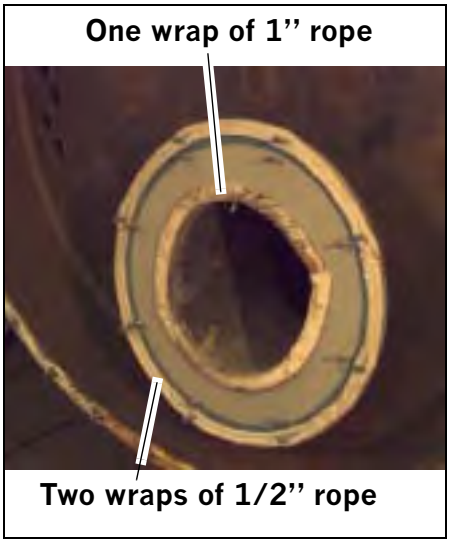


Figure 2-14 Rope Gasket on Rear Access Way

Figure 2-15 Replacement Of Rear Access Plug

Figure 2-16 Rear Door Open

⚠ Caution

The rear access plug is made up of cast in place refractory. When removing, two boiler technicians should be on hand to assist with removal.

3. Closing and Sealing Doors

Swing the door to the closed position and run all retaining bolts in until snug. Tighten the bolts uniformly, starting at the top center and alternating between the top and bottom bolts until both are tight. Do not over-tighten. Tighten alternate bolts until all are secure and the door is gas tight.

Notice

When closing the rear door, inspect the threads on all studs and where necessary use the correct sized die to clean the threads. Damaged stud threads can strip the brass nuts.

After closing the door, loosen the nut on the davit arm stud to release tension on the davit arm. Failure to do so may result in damage to the boiler due to thermal stresses during boiler operation.

After the boiler is back in operation, re-tighten the door bolts to compensate for compression of the gasket or movement of the door.

Figure 2-17 Replace Gasket

Chapter 3

Sequence of Operation

A. General

Chapter 3 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 (WD) prepared by Cleaver-Brooks for your specific installation.

Abbreviations for the various electrical components are listed in Table 3-1. The sequences outlined in Chapter 3 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:

1. Boiler water is up to the correct level, closing the low-water cutoff switch.
2. The low-water light (panel) is off.
3. 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.
4. All applicable limits are correct for burner operation.
5. The load demand light glows (fuel pressure, temperature).
6. Reset manual reset (water, fuel pressure, operating limits).

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

1. Blower motor starter
2. Air compressor motor starter (if provided)
3. Oil pump motor starter (if provided)

The sequences do not attempt to correlate the action of the fuel supply system or feedwater system except for the interlock controls that directly relate to the action of the program relay. Chapter 4 and Chapter 5 contain set-up and operating instructions for the “F” Series ProFire burner. Chapter 6 and Chapter 7 contain set-up and operation instructions for the “D” Series ProFire burner.

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 over travel interlock circuit
- Main gas valve auxiliary switch (MGVAS)

Blower Motor Starter Circuit

- Blower motor starter (BMS)
- Air compressor motor starter (ACMS) (if provided)

Running Interlock Circuit

- Blower motor starter interlock (BMSI)
- Combustion air proving switch (CAPS)
- Atomizing air proving switch (AAPS) (if provided)

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

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

High Fire Proving Circuit

- High fire switch (HFS)

Running Interlock and Limit Circuit

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

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**.

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.

1. 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. When firing oil, the air compressor motor starter (ACMS) (if provided) is also powered.

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 all 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.

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.

2. Ignition Cycle

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

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.

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/or 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.

3. 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.

Note: Normal operation of the burner should be with the 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.

4. Burner Shutdown — 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:

1. 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.

2. The blower motor start circuit is deenergized at the end of the post purge cycle and the shutdown cycle is complete.
3. 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 pre-purge period or any time the burner switch is open.

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. The pilot flame will be extinguished 10 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 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 Troubleshooting section in Chapter 8 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 3-1. 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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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
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	

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
FPS	Feed Pump Switch
FRI	Firing Rate Interface
FRP	Firing Rate Potentiometer (O_2 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
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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
LFTC	Low Fire Temperature Control

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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
(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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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	O_2 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
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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)

Notes:

Chapter 4

Starting and Operating Instructions Profire H Series

Milwaukee, Wisconsin

www.cleaver-brooks.com

A. GENERAL PREPARATION FOR INITIAL STARTUP

Notice

If the boiler is not equipped with a ProFire burner. Please refer to the specific Operation and Maintenance manual for the burner supplied.

Instructions in Chapter 4 are all based upon installation being complete and all electrical, fuel, water and vent stack connections are made.

The operator should be familiar with the burner, boiler, and all controls and components. To quickly locate and identify the various controls and components mentioned in the following paragraphs, refer to the illustrations and the contents of Chapters 1, 2 and 3. Instructions for adjusting major components are given in Section C this should be reviewed prior to firing. The wiring diagram should also have been studied, along with the firing sequence outlined in Chapter 3.

⚠ Warning

It is recommended that the starting instructions be read completely until they are thoroughly understood, before attempting to operate the boiler, rather than performing each operation as it is read for the first time. Failure to follow these instructions could result in serious personal injury or death.

Verify supply of fuel and proper voltage. Check for blown fuses, open circuit breakers, dropped out overloads, etc. Check reset of all starters and controls having manual reset features. Check the lockout switch on the programmer and reset if necessary.

⚠ Warning

Prior to firing a boiler, be sure that discharge piping from safety valves or relief valves, and discharge piping from all blowdown and drain valves, is piped to a SAFE point of discharge, so that emission of hot water or steam cannot possibly cause injury. Failure to follow these instructions could result in serious personal injury or death.

The boiler should be filled with water to the proper operating level using water of ambient temperature. Be sure that treated feedwater is available and used. In heating applications, the entire system should be filled and vented. Refer to Chapter 2 for water requirements. On a steam boiler, open the vent valve to vent air displaced during filling. Leave the vent valve open until the escape of steam is noted after the burner is operating.

Check all linkage for full and free movement of the damper and metering valves and cams. The check can be done by loosening the linkage at the damper motor connecting arm and manipulating the linkage by hand.

Check for rotation of all motors by momentarily closing the motor starter or relay. The blower impeller rotation is counter-clockwise for the ProFire, when viewed from the motor side of the burner (see **Figure 4-1**).

Notice

All work on the burner should be performed by qualified persons knowledgeable in safe practices and applicable codes. Wiring should be in accordance with the National Electrical Code (NEC).

1. Fuel Supply

Before initial startup, verify that all fuel connections are tight. Fuel supply lines should be securely connected, correctly supported, and leak tested.

The gas train for gas-fired, or combination gas/oil, burners is provided with the overall boiler package. Configuration of the appropriate gas train is based on minimum requirements established by Underwriter's Laboratories / Canadian Underwriter's Laboratories (UL/cUL) and the responsible insurance carrier if applicable.

The pilot gas train is supplied with the burner, and is factory-installed.

Figure 4-1 Motor and Fan Rotation

Fuel oil piping for oil-fired systems: In this circuit, an oil supply line from the oil tank is connected to the inlet port of the oil pump, and an oil return line from the pump circulates excess oil from the pump back to the oil supply tank.

Cleaver-Brooks 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.

⚠ Caution

Oil circulation back to the tank is required at all times. Do not start the burner with closed stop valves in the return lines or serious damage will occur

2. Control Settings

Inspect the operating limit control for proper setting.

- The pressure control of a steam boiler should be set slightly above the highest desired steam pressure, but at least 10% lower than the setting of the safety valve.

Inspect the high limit control for proper setting.

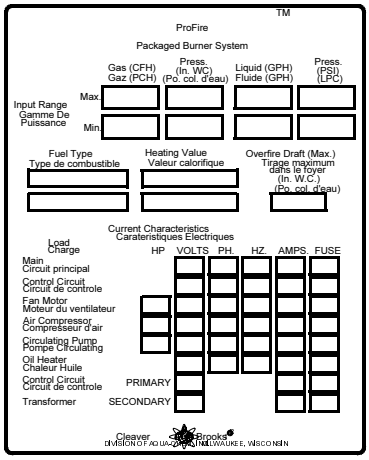


Figure 4-2 Data Plate

Warning

Shut off and lock out all electrical power to the burner before performing any service or maintenance that requires removal of electrical equipment covers or component parts. Failure to follow these instructions could result in serious personal injury or death.

Before burner startup, the two oil solenoid valves are in the closed (de-energized) position and the oil metering valve is in its most open position. Under this condition (with the pump operating), oil cannot flow to the oil burner nozzle, but circulates through the by-pass tubing, oil metering valve, and back to the inlet of the pump. When the flame safeguard control calls for the main flame, the two oil solenoid valves are electrically energized. After opening, oil flows through the nozzle at the low-fire flow rate.

When high-fire operation is required, the modulating motor, by way of the valve linkage, rotates the oil metering valve to its least-open position. This reduces the flow rate of oil through the by-pass circuit, which increases the oil flow to the burner nozzle.

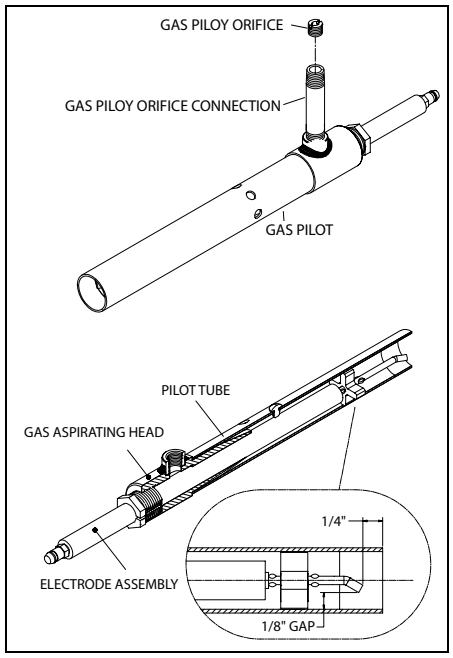


Figure 4-3 Gas Pilot

Warning

Shut off and lock out all electrical power to the burner before performing any service or maintenance that requires removal of electrical equipment covers or component parts. Failure to follow these instructions could result in serious personal injury or death.

Verify that all electrical power supplies and branch circuit wiring are sized in accordance with the electrical loads shown on the specification plate on the side of the burner control cabinet (**Figure 4-2**). Check system interlocks, control interfaces, and any additional remote controls against the system schematic and wiring diagram. Refer to the Cleaver-Brooks wiring diagram supplied with the burner for specific requirements. Verify that all supply wiring terminations are tight.

3. Linkage Connections

Inspect all linkages for damage and/or loosening during shipment. All fasteners must be secure for safe operation. All connections must be correctly positioned and tightened. Apply a lock-tight type compound to any fasteners after adjustment.

B. STARTUP PROCEDURES

PRESTART TASKS AND CHECKLIST - ALL FUELS

Before proceeding with system startup and adjustment, be sure that overall installation is complete. Review the boiler operating and installation manual set carefully to verify that the boiler is properly set up for operation. Check that all shipped-loose items (those items not installed when shipped) have been correctly installed. Verify the supply of fuel. Check to make sure the burner is wired as shown on the wiring diagram. Ensure that all control wiring terminals are tight.

Complete the following checklist in preparation for system startup:

- Confirm that the fuel and electrical connections have been completed in accordance with the applicable codes and insurance requirements (if necessary), and that connections comply with the piping schematic and wiring diagram.
- Check the combustion air fan motor for correct rotational direction.
- Check that the boiler is filled with water to the proper level, and that all circulating pumps (hot water units) are correctly installed and operational.
- Verify that there is proper gas pressure at the gas train, if this is a gas or combination burner. See the burner specification plate (Figure 4-2) for minimum and maximum natural gas pressure requirements.
- For oil burners confirm that the oil tank is adequately filled with the correct grade of fuel oil, and that any isolation valves in the supply and return lines are open.
- Check that the flame safeguard has been properly installed inside the control panel.
- Provide the following test equipment on site:

1. Combustion analyzer for O_2.
2. U-tube manometer, or pressure gauge, to measure gas pressures (main and pilot).
3. Inclined manometer to measure draft pressures.
4. Smoke spot tester for oil fired units. CO analyzer for gas fired burners.
5. Voltmeter.
6. Thermometers and thermocouples.

AIR AND FUEL CONTROLS (DESCRIPTION)

The combustion system air and fuel controls have been factory adjusted, and the unit has been test fired before it was shipped. Regardless of preliminary adjustment and operation, it is necessary to readjust the controls for local conditions:

- The fuel flow controls must be adjusted to establish the rated heat input over the full range of firing-rate modulation.
- The air controls need to be adjusted, relative to the established fuel flow rates, to provide the correct amount of air for complete, efficient combustion.

Fuel and air adjustments are similar on all ProFire burners, whether gas-fired, oil-fired, or combination gas/oil fired. The following topics describe air and fuel flow rate adjustments,

⚠ Warning

Attempting initial burner startup with insufficient knowledge of the equipment and startup procedures can result in serious damage to the equipment. The operator must be totally familiar with the entire startup and adjustment process before attempting to operate the burner. Failure to follow these instructions can result in serious personal injury or death

and the combustion set-point objectives for optimum combustion performance:

1. Air Flow Adjustments

The Profire burner includes a unique rotary air damper design with cam fuel trim. Fuel and air adjustments are similar on all Profire burners, whether gas-fired, oil-fired, or combination gas/oil fired. The following Chapters describe air and fuel flow rate adjustments, as well as the combustion set-point objectives for optimum combustion performance.

The modulating air damper regulates the flow of combustion air to the burner at flow rates corresponding to the maximum and minimum fuel input to the burner. The air damper and fuel valves are connected via linkages to a common modulating motor, or actuator. The travel, or stroke, of the rotary air damper should be checked to verify proper operation prior to any fuel adjustments. **Figure 4-5** shows the recommended linkage settings at the low fire start positions for each model burner.

Figure 4-4 Rotary air damper linkage at low fire position

Check the linkages to confirm they are securely fastened and ready for operation (see **Figure 4-6**). As mentioned previously, the linkages have been factory set and tested, although they may require minor adjustment after shipment. On combination gas-oil burners, the fuel selector switch should initially be set to the "GAS" position.

With the manual gas shut-off valve closed, start the burner so it will pre-purge. When the high fire switch is closed, switch the flame safety control to "CHECK" or "TEST". At this point, the air damper position at high fire can be checked.

First make sure that the damper is not making contact with the damper stop, located inside the air damper box. If it is, carefully loosen the set screws of the damper arm while holding the damper shaft steady (see **Figure 4-6**), then rotate the damper off the stop approximately 5 degrees. Retighten the damper arm set screws.

The damper shaft slot should be in a near vertical position. The air damper can now be stroked for full modulation. Switch the flame safety control back to "RUN". The modulating motor should drive to the low fire position. Observe the air damper travel and adjust the linkage rod clamp if the air damper does not travel to the desired position (5 to 25 degrees open) at low fire -- depending on the burner model, fuel, and turndown -- to a full open position at high fire. If necessary, repeat until air damper strokes properly.

2. Combustion Settings

Fuel and air flow rates are individually adjusted at low fire, at high fire, and at each intermediate cam screw position 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. Adjustments may be required to meet certain environmental emissions criteria, such as NOx or CO. Combustion adjustments also vary with specific system applications.

Notice

The low fire position will be fine-tuned during combustion start-up.

Turndown capability for oil is typically less than that for natural gas. Therefore, on combination fueled burners, gas turndown performance may be restricted (or determined) by the excess air levels set initially for oil combustion.

Two key components residing in flue gas are used to optimize combustion efficiency; excess air and unburned fuel. The system should be adjusted to the minimum excess air quantity that provides low levels of unburned fuel with sufficient remaining oxygen to cope with normal atmospheric and fuel related changes. Unburned fuel is measured as carbon monoxide (CO) when burning natural gas, and smoke spots when burning oil.

ProFire burners are capable of operating at CO levels of less than 50 ppm at all firing rates when firing natural gas. The burner should be set-up and maintained to yield smoke spot levels less than a #2 spot (ASTM D2156 Shell-Bacharach Scale) to minimize soot build-up in the boiler when firing #2 oil.

C. BURNER ADJUSTMENTS, SINGLE FUEL NATURAL GAS

Note: The operator must consider and allow for normal variations in air and fuel, which would reduce the range of excessive oxygen in the flue gas accordingly.

LINKAGE SETTINGS		Fuel	Oil Only	Gas Only	Gas/Oil combination
ITEM	DESCRIPTION (lengths in inches)	INPUT (MMBH)	6.3	6.3	6.3
A	Main Shaft Air Damper Arm Length		4	4	4
B	Air Damper Arm Length		4	4	4
C	Main Shaft Air Damper Arm Angle (deg)		-100	-100	-100
D	Air Damper Arm Angle (degrees)		-130	-130	-130
E	Oil Controller Arm Length		2		2
F	Oil Cam Follower Position (Hole # From Pivot)		6		6
G	Oil Controller Arm Angle (degrees)		-85		-85
	Oil Controller Low Fire Position		#5		#5
	Oil Controller High Fire Position		#1.75		#1.75
H	Gas Valve Arm Length			1.75	1.75
J	Gas Cam Follower Position (Hole # From Pivot)			7	7
K	Gas Valve Arm Angle (degrees)			-150	-150

Settings at the Low Fire/Lightoff position of the respective fuel.
View perspective is from the rear of the burner. Top dead center is 0°.
Clockwise is considered the positive direction.

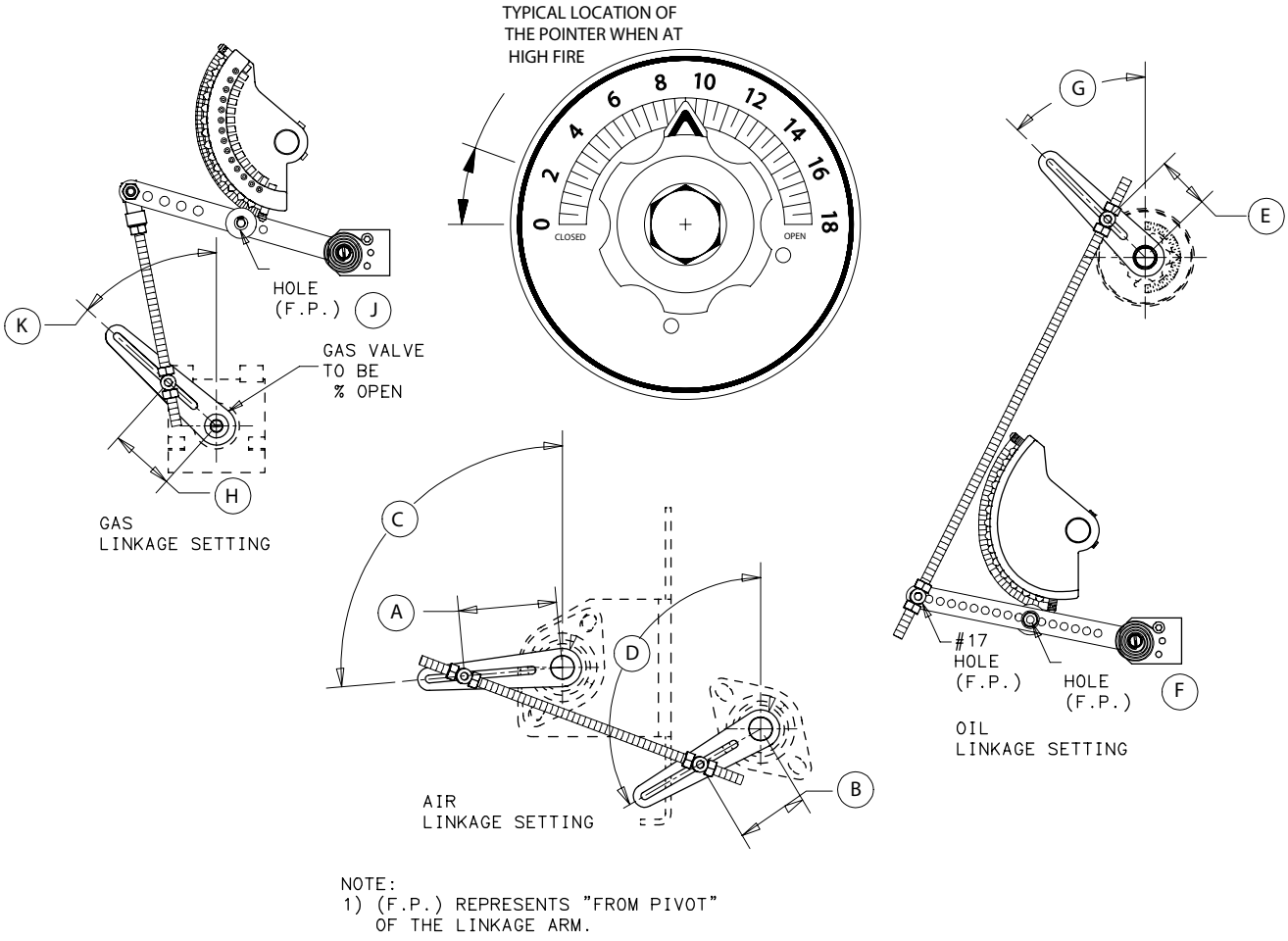


Figure 4-5 Initial Settings

Note: This Chapter provides detailed procedures for setup and adjustment of a gas-fired combustion system. Similar discussions are also presented in this chapter for startup and adjustment of oil-fired and combination-fueled gas or oil systems.

These procedures assume that the pre-startup tasks, checklists, and adjustments have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment, should be available on site and installed.

CONTROLS SETUP. Complete the following burner system control setup steps before beginning the natural gas startup procedure:

1. Check the linkages to confirm they are securely fastened and ready for operation (**Figure 4-5**)
2. Set the burner switch in the "OFF" position.
3. Place the Manual/Auto mode switch to the "MANUAL" position.
4. Adjust the manual flame control to the "CLOSED" (or low fire) position.
5. Verify that the gas valve cam trim and linkage assembly is close to the settings listed in **Figure 4-5**. Check that the cam follower, linkage and gas valve arm are in the proper positions and properly tightened. The slot in the gas valve shaft should be 5 to 10% open at the low fire position.

STARTUP. Proceed with startup of the natural gas-fired system as follows:

1. Close the downstream manual shut-off valve of the burner gas train.
2. Turn on electrical power for the burner, boiler, and related components.
3. Place the upstream manual gas valve in the on position, allowing natural gas to enter the gas train. (furthest from the burner). Reset Low Gas Pressure Switch (if applicable).
4. Verify that the gas metering valve is nearly closed.
5. Turn the burner switch on. This will start the combustion air fan motor and initiate the pre-purge sequence. Observe the travel of the gas valve. The valve should be nearly full open at the high fire position. If necessary, adjust the gas valve linkage rod clamp setting.
6. When the prepurge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.
7. When the pilot is established, the flame safeguard will energize the main gas valve (this is accompanied by fuel valve activity and illumination of the FUEL VALVE light). The main gas valve should be visually checked by

Warning

Attempting initial burner startup with insufficient knowledge of the equipment and startup procedures can result in serious damage to the equipment. The operator must be totally familiar with the entire startup and adjustment process before attempting to operate the burner. Failure to follow these instructions can result in serious personal injury or death

Notice

The linkages have been factory-set and tested, although they may require fine adjustment for the specific application. If the linkage is not in place, or if the setting has been lost, install the linkage in accordance with Figure 5-9.

Notice

For initial boiler startup, the downstream manual gas shutoff valve should be in the closed position to ensure proper operation of the automatic gas valves. This valve can then be slowly opened when the pilot is established and proven.

observing the stem move from the CLOSED to the OPEN position. Slowly open the manual shut-off valve.

8. After the main flame has been established, the gas manifold pressure entering the burner should be measured using the pressure tap between the butterfly valve and the firing tube. This measurement should be compared to the Min. Gas Pressure value on the burner data plate. Obtain a stable operating point by adjusting the low fire cam screw to the recommended low fire pressure setting. (This low fire setting for startup is not critical; it is merely an acceptable starting point to begin the high fire fuel adjustment.)

Figure 4-6 Linkage Adjustment

Notice

If the gas manifold pressure at low fire is significantly greater than the specified minimum, fine tuning of the low fire air damper setting is necessary to obtain proper turndown. First, reduce the gas manifold pressure to the specified minimum by adjusting the length of the gas valve cam link. Next, loosen the jam nuts on the air damper link, carefully close the damper to match the desired excess air level, and retighten the jam nuts. (This will have a very minimal effect on the high fire excess air.) Recheck the gas input rate or manifold pressure to verify minimum input.

9. After a few seconds, the oxygen (O2) analyzer should have an accurate reading of the O2 level in the flue gas. Normally, O2 is set between 4 and 6% at low fire, depending on the application and burner size. Adjust the low fire cam screw as needed to obtain a reasonable excess air level.
10. 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. While increasing the input, observe that the 0_2 levels remain within the safe firing range. Adjust the gas 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).
11. Measure the gas manifold pressure at the high fire position. Adjust the high fire gas input with the pressure regulator to match the specified Max. Gas Pressure on the burner data plate. This value should correspond to the maximum rated fuel input to the burner

If a dedicated gas meter is available, the following formula may be used to check fuel flow. Conduct this measurement while operating at a constant rate.

Where:

HHV = The higher heating value of natural gas (1000 Btu/ ft^3). Contact your local gas company for an exact measurement.

P_{atm} = Atmospheric pressure in inches of mercury.

P_{gas} = Gas pressure ahead of the volumetric flow meter in inches of mercury.

T_{gas} = Gas temperature at the volumetric flow meter in °F.

Notice

Some meters may require 6.0 IN. H_20 correction to Pgas. Consult meter calibration data.

RATE = Natural gas rate taken with the volumetric flow meter in ft^3/second.

S = Seconds.

Gas Input = (HHV x Patm + Pgas) x T_{gas}+460 x 3600 s/hr x RATE ft3 = Btu/hr

12. Fine-tune the high fire input with the corresponding high fire cam screw to obtain the desired excess air level. Normally, the O2 level is set between 3.5 and 5% at high fire, depending on the application and burner size.
13. Modulate the burner with the manual flame control to the next lower cam screw position. Measure the O2 level and adjust the cam screw accordingly. Continue this procedure until the low fire cam screw is reached.
14. Check the gas manifold pressure (gas input rate as well if meter is available) against the burner data plate minimum settings. Adjust low fire cam screw accordingly.
15. Modulate the burner from low to high fire and back to low fire. Verify that combustion is stable and that the air damper and fuel valve are stroked properly and all linkages are tight.
16. When combustion tuning has been completed, install the brass cam locking set screws and tighten with sufficient torque to prevent unwanted changes of the cam screw settings during operation.

Warning

Do not tune the burner to a lower firing rate than the specified minimum values on the burner data plate. Input rates below the recommended minimum value can result in poor combustion and/or damage to burner firing tube components. Failure to follow these guidelines can result in unsafe operation of the burner leading to serious personal injury or death.

D. BURNER ADJUSTMENTS, SINGLE FUEL, OIL-FIRED (RETURN FLOW PRESSURE ATOMIZATION)

This Chapter of the manual presents detailed procedures for initial startup of an oil-fired combustion system.

Note: The operator must consider and allow for normal variations in air and fuel, which would reduce the range of excessive oxygen in the flue gas accordingly.

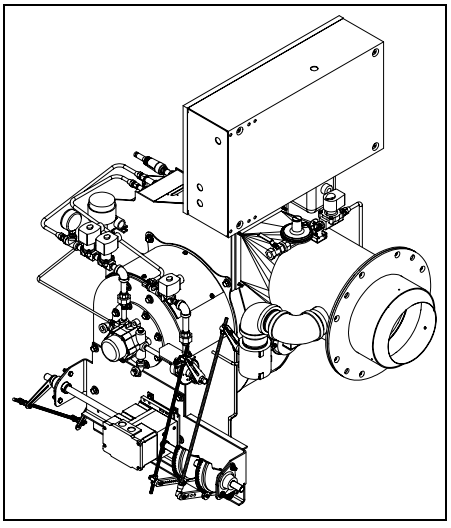


Figure 4-7 Combination Profire Burner

This burner is designed to burn only those fuels shown on the burner data plate. Burning fuels not specified on the data plate could cause damage to the equipment.

The following procedures assume that the pre-startup tasks, checklists, and adjustments have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment should be available on site.

Attempting initial burner startup with insufficient knowledge of the equipment and startup procedures can result in serious damage to the equipment. The operator must be totally familiar with the entire startup and adjustment process before attempting to operate the burner. failure to

follow these instructions could result in serious personal injury or death

CONTROLS SETUP. Complete the following combination system control setup steps before beginning the oil-fired burner startup procedure:

1. Check the linkages to confirm that they are securely fastened and ready for operation (see **Figure 4-5**).
2. Place the burner switch to the OFF position.
3. Place the Manual/Auto mode switch to the MANUAL position.
4. Place the manual flame control potentiometer to the CLOSED (low-fire) position.
5. Verify that the oil metering valve, cam trim, and linkage assembly is close to the settings listed in **Figure 4-5**. Check that the cam follower, linkage, oil metering valve arm and indicator are in the correct low fire positions and properly tightened. Two oil pressure gauges should be installed in the oil piping: the burner oil nozzle supply pressure is measured downstream of the oil safety shut-off valves while the nozzle return pressure is measured between the nozzle and the oil metering valve.
6. Open the manual shut-off valve of the gas pilot.

The linkages have been factory-set and tested, although they may require fine adjustment for the specific application. If the linkage is not in place, or if the setting has been lost, install the linkage in accordance with Figure 4-5.

When a gas pilot is used, open the valve in the gas pilot line.

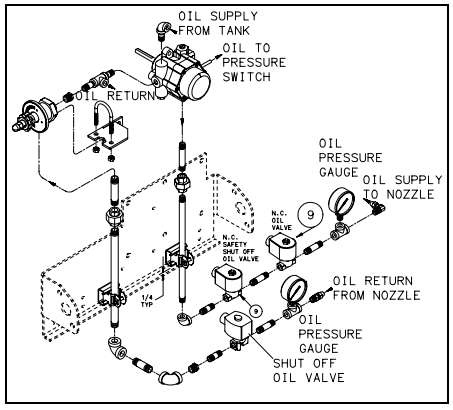


Figure 4-8 Oil Piping

STARTUP. Proceed with initial startup of the oil-fired system as follows:

1. Turn on the electrical power for the burner, boiler, and related components.
2. Verify that the oil-metering valve is at the low fire start position.

Note: Opening the oil metering valve reduces oil flow to the burner.

3. Turn the burner switch on. This will start the blower motor and initiate the prepurge sequence. Observe the travel of the oil-metering valve. The valve should be nearly closed at the high fire position (see **Figure 4-5**). Check the specified high fire oil metering valve position in **Figure 4-5**. If necessary, adjust the oil valve linkage rod clamp setting.
4. When the prepurge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.

5. After the main flame has been established, the oil pressures entering and returning from the burner nozzle should be measured. On return flow pressure atomized oil systems, the supply pressure should remain relatively constant from low fire to high fire, normally between 270 and 300 psi. (The oil pump is factory set at 300 psi. If necessary, oil pump supply pressure can be adjusted with the pump's internal pressure regulating screw.)
6. The low fire return pressure should match the Min. Oil Pressure specified on the burner data plate (between 40 - 100 psi). For fine-tuning, change the oil metering valve position by adjusting the low fire cam screw. If the pressure is significantly off, adjust the length of the oil cam linkage rod to correct the low fire position of oil metering valve. Adequate excess air should also be verified with an oxygen analyzer. Normally, O2 is set between 4 and 6% at low fire, depending on the application and burner size.
7. Operate at low fire until it is thoroughly warmed. Then, one cam screw at a time, modulate to high fire with the manual flame control. This will cause the oil metering valve to close, resulting in an increase in the return line oil pressure. Check the excess air in the flue gas while modulating to high fire (maintain O2 levels between 4 - 6%). Make cam screw adjustments as needed to maintain adequate excess air.
8. Verify that the high fire supply pressure stays between 280 to 300 psi. (The oil pump is factory set at 300 psi. If necessary, oil pump supply pressure can be adjusted with the pump's internal pressure regulating screw.)
9. Set the high fire oil return pressure to match the specified burner data plate Max. Oil Pressure setting (usually in the range of 160 - 220 psi) by adjusting the corresponding cam screw to open or close the oil-metering valve, as necessary.
10. Check the high fire excess air level. Normally, the O2 level is set between 3.5 and 5% at high fire, depending on the application and burner size
11. Modulate the burner with the manual flame control to the next lower cam screw position. Measure the O2 level at intermediate screw positions and adjust each cam screw to maintain between 3.5 to 5%. Continue this procedure until the low fire cam screw is reached.
12. Verify that the low fire return oil pressure is at the burner data plate specified minimum pressure. Excess air level should be set between 4 to 6% O2. Fine tune by adjusting the low fire cam screw accordingly.
13. Following combustion setup, tighten all linkages. Check for smooth light off by cycling the burner through the pre-purge sequence again. During pre-purge, verify that all linkages, dampers and valves operate smoothly without interference or binding. Verify that the pilot flame is sufficient and the burner lights off smoothly.

Notice

If the pilot is established, the flame safeguard will energize the two oil solenoid valves (this is accompanied by a click from the solenoid valves and illumination of the FUEL VALVE light) and the oil burner should ignite on low-fire.

Notice

If the excess air significantly deviates from the recommended O2 level after making the proper low fire oil valve adjustment, fine tuning of the low fire air damper setting is necessary to obtain proper turndown. Loosen the jam nuts on the air damper link, carefully adjust the damper to match the desired excess air level, and retighten the jam nuts. (This will have a very minimal effect on the high fire excess air.) Recheck the low fire oil return pressure to verify minimum input.

Notice

Burner input can be verified with the use of oil meters in the supply and return lines from the burner nozzle. The flow rate measured in the return line must be subtracted from the flow rate measured in the supply line. Following start-up, it is strongly recommended that the flow meters be removed from the system.

14. Modulate and recheck combustion air at different firing rate positions. Smoke spot measurements should be less than a No. 2 (Bacharach).
15. When combustion tuning has been completed, install the brass cam locking set screws and tighten with sufficient torque to prevent unwanted changes of the cam screw settings during operation.

E. ATOMIZING AIR

This Chapter of the manual presents detailed procedures for start-up on oil fired air atomizing system. Burners are available with a burner mounted oil pump or remote oil pump. (Refer to **Figure 4-9** and **Figure 4-10**)

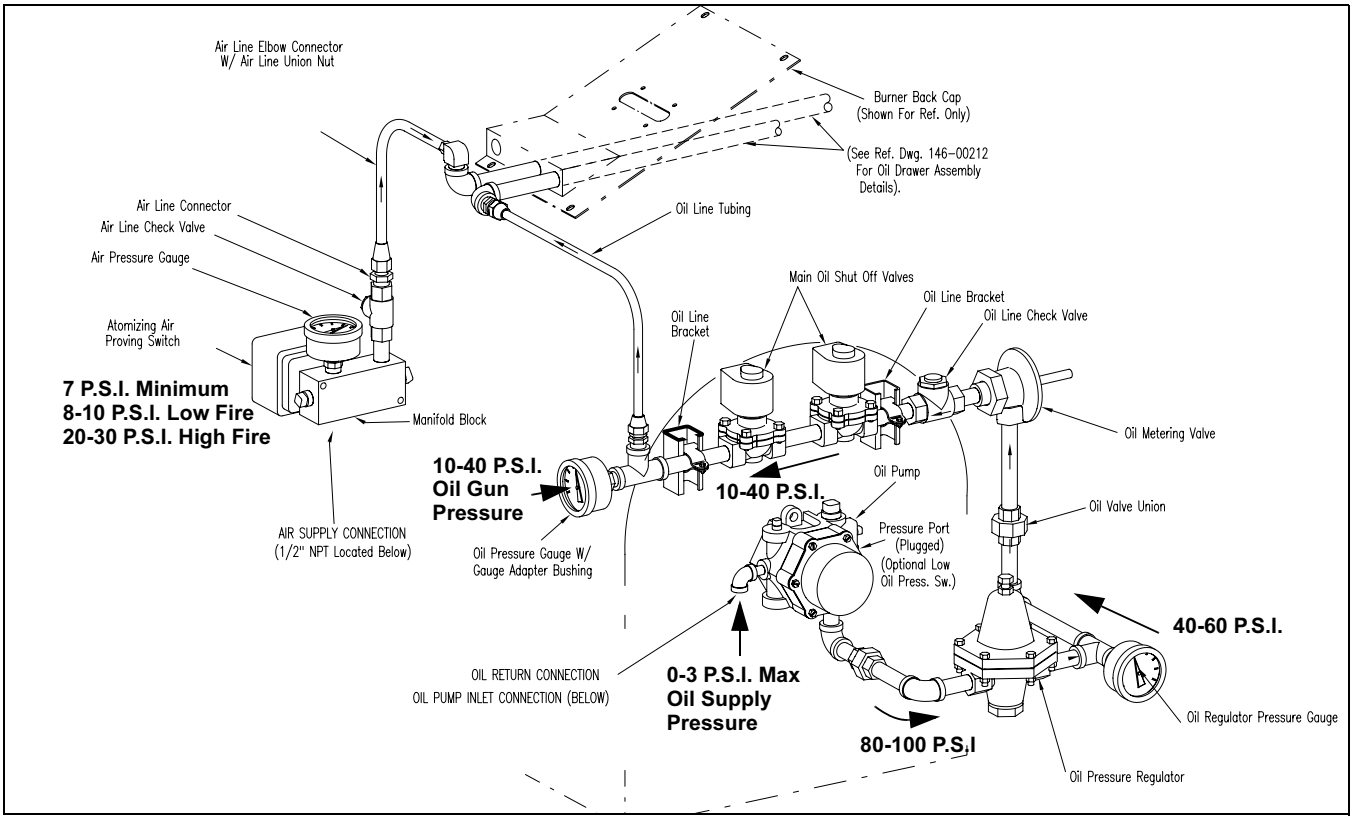


Figure 4-9 Light Oil Piping, Direct Drive

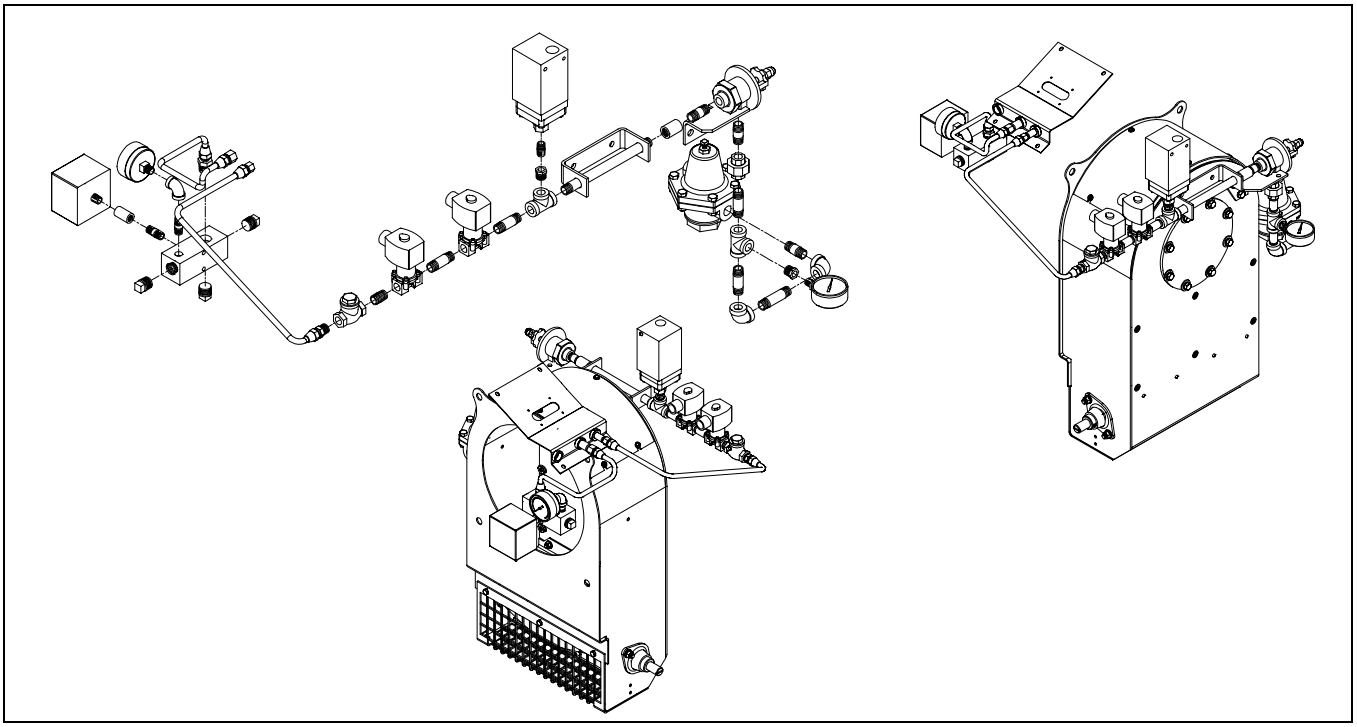


Figure 4-10 Typical Arrangement for Remote Oil Pump with Air Atomization

1. The supply and pressure of the atomizing air on an oil-fired burner should be checked. Before starting, inspect the oil pump lube oil level. Add oil if necessary to bring the level to the mid-point or slightly higher of the sight glass. Use SAE 20 detergent oil.

2. To verify air flow and pressure, place the burner Run/test Switch on the program relay to the test position. If the burner is a combination fuel burner, be sure that the gas/oil selector switch is set to "oil." Turn the Burner Switch on. The burner will cycle to the low fire pre-purge position and stop there. Observe the reading on the air pressure gauge (**Figure 4-9**). With no oil flow, the pressure should be a minimum of 7 psi.

   If there is no pressure, determine the cause and correct it before proceeding. Check for obstructions in the air inlet line, incorrect rotation, or a loose oil nozzle or other leaks. If the pressure is much higher without any oil flow, check for obstruction in the discharge line or at the oil nozzle. If there is no obstruction, restrict the air flow by adjusting the air intake valve screw.
   The air pressure will increase when an oil flow exists. At low firing rate, the air pressure may rise to 8 psi or more.

Note: Abnormally high pressure indicated on the nozzle air pressure gauge is an indication that the burner nozzle has become clogged. In the event of clogging, check the nozzle and clean as necessary.

⚠ Caution

The air pressure should not exceed 30 psi at high fire. Greater air pressure causes excessive wear of the air pump, increases lube oil usage, and can overload the motor, thus causing damage to the equipment.

After air flow has been verified, turn the burner switch off and return the run/test switch to the run position.

3. Prior to initial firing, oil flow and pressure should be established and verified. Atomizing air pressure should also be established as outlined above.

If the burner is a combination fuel model, be certain that the **Main Gas Shutoff Cock** is closed and set the **Gas/oil Selector Switch** to "oil."

Oil Flow - Open all valves in the oil suction and oil return lines.

If the oil supply tank is located above the level of the pump and flow to the pump is by gravity, then it will usually be necessary to vent the suction line to allow oil to fill the line. Venting the suction line can generally be accomplished by cracking a union fitting, or by opening the cap of the oil strainer using care to prevent spillage of oil. Tighten the fitting or the cap as soon as oil flow appears.

If the oil supply tank is below the level of the oil pump, it is MANDATORY that the suction line to the pump be completely filled with oil prior to starting the pump to avoid the possibility of damage to the pump gears. Non-lubricating fluids such as kerosene should not be used for priming.

Prior to priming the suction line and the initial start, check to make certain that all plugs, connections, etc., have been securely tightened to prevent leaks.

A standard equipped boiler has a selector switch incorporated in the oil pump motor starter. Momentarily energize the starter to check for proper pump rotation. With the rotation verified, operate the pump to determine that oil circulation exists. Observe the regulated oil pressure gauge for indication that flow is established. If no pressure shows on the gauge 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. If oil flow is not readily established, avoid prolonged operation of the pump to minimize risk of damage to internal parts of the pump. **If oil flow is not established after a second or third priming attempt, a full investigation is required to determine the cause.**

A vacuum (or a compound pressure-vacuum) gauge should be installed at the suction port of the pump and its reading observed and recorded for future guidance. If a vacuum condition exists, the reading will reveal the tightness of the system. It is advisable to maintain the vacuum reading at less than 10" Hg. A vacuum in excess of 10" Hg. may allow oil to vaporize, causing cavitation, loss of prime, and unstable firing condition.

4. **Oil Pressure** - For burner mounted oil pumps supply pressure is 3 to 5 psi at the inlet of the oil pump.
   For remote oil pump systems oil supply pressure is 75 to 50 psi at inlet of pressure regulator.

   The pressure regulator needs to be adjusted to obtain approximately 21 psi. on the nozzle line pressure gauge at maximum firing rate.

When oil is supplied from a pressurized loop to a multiple boiler installation, the relief valve in the loop should be properly adjusted to provide this reading. In this circumstance, the relief valve at the terminal block should be adjusted to the point when it will be inoperative (or removed and openings plugged). To render inoperative, turn the adjusting screw in as far as possible.

Atomizing air pressure will vary from 8 psi on low fire to 20 psi on high fire. The pressure gauge will indicate a higher reading when the flame is present and will increase as the firing rate increases. After the burner is firing and when the air pump is running, final adjustment can be made at the air compressor.

O2 readings shall be approximately 6% at low fire and 4% at high fire.

F. BURNER ADJUSTMENTS, COMBINATION GAS AND OIL

Note: The operator must consider and allow for normal variations in air and fuel, which would reduce the range of excessive oxygen in the flue gas accordingly.

This Chapter of the manual presents procedures to be followed for initial startup of a combination ProFire burner.

These procedures assume that the pre-startup tasks, checklists, and adjustments have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment should be available on site.

⚠ Caution

This burner is designed to burn only those fuels shown on the burner data plate. Burning fuels not specified on the data plate could cause damage to the equipment.

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. After being completely adjusted for oil combustion, the burner is re-started and adjusted using natural gas as fuel. Combustion adjustment of the combination burner for natural gas involves balancing the input gas rates only against the existing flow of combustion air, as established initially for oil-firing. Do not readjust the air damper setting when tuning the combination burner for combustion of natural gas.

⚠ Warning

Attempting initial burner startup with insufficient knowledge of the equipment and startup procedures can result in serious damage. The operator must be totally familiar with the entire startup and adjustment process before attempting to operate the burner.

CONTROLS SETUP. Complete the following system control setup steps before beginning the combination burner startup procedure:

1. Check the linkages to confirm that they are securely fastened and ready for operation.

NOTE: The linkages have been factory-set and tested, although they may require fine tuning for the specific application. If the linkage is not in place, or if the setting has been lost, install the linkage in accordance with **Figure 4-5**.

2. Place the burner switch in the OFF position.
3. Place the Modulating Mode switch in the MANUAL position.
4. Place the manual flame potentiometer in the CLOSE (low-fire) position.
5. Verify that the oil metering valve, gas valve, cam trim and associated linkage assemblies are close to the settings listed in **Figure 4-5**. Check that the cam followers, linkages, valve arms and indicators are in the correct low fire positions and properly tightened. Two oil pressure gauges should be installed in the oil piping: the burner oil nozzle supply pressure is measured downstream of the oil safety shut-off valves while the nozzle return pressure is measured between the nozzle and the oil metering valve. The slot in the gas valve shaft should be 5 to 10% open at the low fire position.
6. Open the manual shut-off valve of the gas pilot.

STARTUP. Proceed with initial startup using oil as follows:

1. Position the fuel selector switch to "OIL".
2. Proceed with startup and combustion adjustments using the same procedures defined for oil-fired burners.
3. After the system has been completely adjusted for oil-firing, place the burner switch to the off position, and position the fuel selector switch to GAS.
4. Place the Manual/Auto mode switch to the MANUAL position.
5. Place the manual flame control potentiometer to the CLOSE (low-fire) position.
6. Close the downstream manual shutoff valve on the burner gas train (closest to the burner).
7. Admit natural gas to the gas train.
8. Verify that the butterfly valve is in a position that is nearly closed.
9. Proceed with startup and combustion adjustment procedures as described for gas-fired burners. Only adjustments to the gas valve linkage settings should be undertaken at this point. No adjustments should be made to the air damper linkage settings. Changes to the air damper settings could adversely effect oil combustion tuning.
10. When combustion tuning has been completed on both fuels, install the brass cam locking set screws and tighten with sufficient torque to prevent unwanted changes of the cam screw settings during operation.

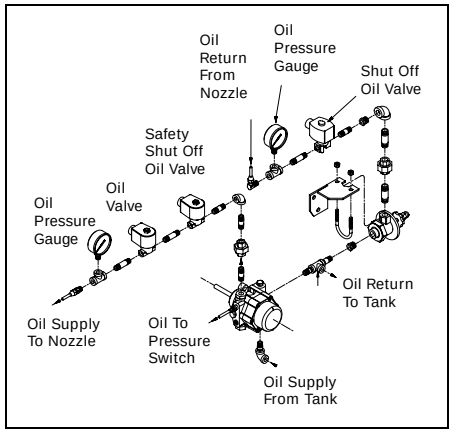


Figure 4-11 Oil Loop

Turn the burner switch on. This will start the blower motor and initiate the prepurge sequence.

When the prepurge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.

When the pilot is established, the flame safeguard will energize the main gas valve (this is accompanied by fuel valve activity and illumination of the FUEL VALVE light). The main gas valve should be visually checked by observing the stem move from the CLOSED to the OPEN position.

NOTE: **The downstream manual gas shutoff valve should be in the closed position, for initial boiler startup, to ensure proper operation of the automatic gas valves. This valve can then be slowly opened when the pilot is established and proven.**

After the main flame has been established, the gas pressure entering the burner should be read (using the pressure tap between the butterfly valve and the blast tube) to determine an initial estimate of the gas input rate. By doing so, and referring to the Burner Data Plate, an approximation of the burner input can be assessed. Obtain a stable operating point by adjusting the butterfly valve to the pressure indicated on the Burner Data Plate and select the temporary firing rate. This rate for startup is not critical, but merely an

Table 4-1: Recommended Stack Gas Concentration at Various Rated (Natural Gas)

Size 4		
Input (MMBtu/ Hr)	Minimum O2 (%)	Maximum O2 (%)
8.4	2.5	5.0
10.5	2.5	5.0
12.6	2.5	4.5
14.7	2.5	3.5

acceptable starting point to begin the high fire adjustment procedures.

After a few seconds, the O_2 analyzer should have an accurate reading of the O_2 present in the flue gas. Table 4-1 provides a representation of the acceptable O_2 range for the gas burner. Normally, the O_2 levels are set between 3 and 5 percent at low fire, depending on the application and burner size (see the burner specification plate for the minimum firing rate).

Operate the boiler at low fire until it is thoroughly warmed. Then increase the fuel input to the boiler by turning the manual flame potentiometer towards open in small increments. This will cause the butterfly valve to open farther, allowing more gas into the burner. While increasing the input, observe that the O_2 levels remain within the range shown in Table 4-1. Adjust the gas 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).

Adjust the high fire gas input to match the maximum rating. At high fire, the butterfly valve should be near the full open position (readjust linkage if required). Adjust the gas pressure to obtain the correct fuel input. (Maximum pressure specified on the burner specification plate.)

If a dedicated gas meter is available, the following formula may be used to check fuel flow. Conduct this measurement while operating at a constant rate.

NOTE: Some meters may require 6.0 IN. H_20 correction to Pgas. Consult meter calibration data.

Where:

HHV = The higher heating value of natural gas (1000 Btu/ ft^3). Contact your local gas company for an exact measurement.

P_{atm} = Atmospheric pressure in inches of mercury.

P_{gas} = Gas pressure ahead of the volumetric flow meter in inches of mercury.

T_{gas} = Gas temperature at the volumetric flow meter in °F.

RATE = Natural gas rate taken with the volumetric flow meter in ft^3/second

S = Seconds.

Gas Input = (HHV x Patm + Pgas) x T_{gas}+460 x 3600 s/hr x RATE ft3 = Btu/hr

NOTE: **It is unnecessary to readjust the position of the high-fire or low-fire shutters after having been set for oil firing.**

Modulate the burner to low fire. The butterfly valve should be adjusted to provide the correct fuel pressure at the low-fire position in accordance with the burner data plate minimum gas-pressure rating.

FUEL FLOW ADJUSTMENTS. Fuel flow rates are adjusted to provide the design-rated heat inputs into the burner at both high-fire (maximum rate) and low-fire (minimum rate) operating conditions. The maximum and minimum fuel input flow rates for the burner are identified on the data plate. Natural gas flow rates are specified in cfh (cubic feet per hour), and fuel oil flow rates are specified in gph (gallons per hour).

Fuel flow rate adjustment for both natural gas and oil is accomplished by regulating the fuel pressure against a fixed diameter orifice (nozzle). The methods for accomplishing the pressure regulation, however, are different for natural gas and oil.

The method for regulating the natural gas flow rate (manifold pressure) is as follows:

Maximum flow rate is established by operating the burner at high-fire with the butterfly valve fully open, then adjusting the manifold pressure to the maximum as specified on the data plate. Maximum manifold pressure is obtained by adjusting the main gas pressure regulator on the gas train while operating the burner at high-fire.

Gas flow modulation for turndown is accomplished by throttling the flow rate with the butterfly valve. The flow restriction of the partially closed butterfly valve reduces the flow of gas through the burner nozzle. The butterfly valve throttling position is controlled by linkage from the main air shutter shaft, which is operated by the modulating motor.

With the modulating motor positioned for low-fire operation, the butterfly valve linkage is adjusted to provide the minimum pressure in the nozzle manifold, as specified on the burner data plate.

The method for regulating the fuel-oil flow rate (nozzle pressure) is as follows:

Maximum flow rate is established by operating the burner at high-fire with the oil metering valve in a nearly closed position with the modulating motor set at the high-fire position. In this position, the flow of fuel oil through the oil by-pass is minimal, resulting in nearly maximum flow pressure from the pump. High-fire oil flow adjustment is accomplished by adjusting the linkage to the oil metering valve so that the burner nozzle pressure equals the maximum oil pressure specification on the burner data plate.

Oil pressure modulation for turndown to low-fire operation is accomplished by increasing the flow rate of oil through the

oil by-pass loop, which reduces pressure in the burner nozzle. This is accomplished by setting the modulating motor to the low-fire position, which causes the oil metering valve to open. While in this position, the oil metering valve linkage can be adjusted so that the burner nozzle pressure equals the minimum oil pressure specification on the burner specification plate.

G. STARTUP, OPERATING AND SHUTDOWN - ALL FUELS

⚠ Warning

Do not re-light the pilot or attempt to start the main burner, either oil or gas, if the combustion chamber is hot and/or if gas or oil vapor combustion gases are present in the furnace or flue passages. Failure to follow these instructions could result in serious personal injury or death.

⚠ Warning

The burner and control system is designed to provide a "pre-purge" period of fan operation prior to establishing ignition spark and pilot flame. Do not attempt to alter the system or take any action that might circumvent the "pre-purge" feature. Failure to follow these instructions could result in serious personal injury or death.

Depending upon the fuel being burned, the applicable previous Chapters in Chapter 4 should be reviewed for preliminary instructions.

The fuel selector switch should be, accordingly, set to either oil or gas.

Set the manual-automatic switch to "manual" and turn the manual flame control to "close."

Turn burner switch to "ON." The load demand light should glow. The low-water level light should remain out, indicating a safe water level in the boiler. The programmer is now sequencing. See Chapter 3 for sequence details.

On an initial starting attempt, several efforts might be required to accomplish "bleeding" of fuel lines, main or pilot. If ignition does not then occur, do not repeat unsuccessful attempts without rechecking the burner and pilot adjustment.

On ignition failure, the flame failure light will glow and the blower will purge the boiler of unburned fuel vapors before stopping. After ignition failure, wait a few moments before re-setting the lockout switch.

After main flame ignition, the burner should be set on manual control at its low fire setting (that is, with manual flame control at "close") until the boiler is properly warmed. In the case of a steam boiler, CLOSE THE VENT VALVE when the steam begins to appear.

A hot water boiler must have a continuous flow of system water through the vessel during the warm-up period. The entire water content of the system and boiler must be warmed prior to increasing fuel input.

If the flame at low fire provides insufficient heat to reach normal operating pressure or temperature after 30 minutes, gradually increase the firing rate by turning the manual flame control in one point increments. Operate at the increased fuel input rate for a period of time until an increase is noted in pressure or temperature.

After the boiler is thoroughly warmed, turn the manual flame control to high fire. At this point a combustion analysis should be made, with instruments, and fuel flow regulated as required. After making the high-fire adjustment, manually

decrease the firing rate to analyze combustion gases, and adjust as required.

To properly perform the testing and adjusting, it is necessary that the burner be allowed to fire at a maximum rate long enough to achieve desired results.

Operating - Normal operation of the burner should be with the 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. The hot flame to cool air cycling subjects the pressure vessel metal and refractory to undesirables conditions.

With the switch set at "auto," the burner will operate on a modulating basis according to the load demand.

The burner will continue to operate with modulated firing until the operating limit pressure or temperature is reached, unless:

The burner is manually turned "off."

A low-water condition is detected by low-water level control.

The electrical or fuel supply is interrupted.

The combustion air pressure drops below minimum level.

There can be other reasons for shutdown such as motor overload, flame outages, tripped circuit breakers, blown fuses, or through other interlock devices in the circuitry.

When the burner is shut down normally, by either the operating limit control or by manually switching the burner off, the load demand light no longer glows.

Shutdown through conditions causing safety or interlock controls to open will actuate the flame failure light (and alarm if so equipped) and the load demand light will remain lit. The cause of this type of shutdown will have to be located, investigated, and corrected before operation can be resumed. Refer to the troubleshooting section in Chapter 5.

Shutdown - When the operating limit control setting is reached to open the circuit or if the burner switch is turned "off," the following sequence occurs.

The fuel valve is deenergized and the flame is extinguished. The timer begins operation and the blower motor continues running to force air through the furnace in the post-purge period.

At the end of the programmed post-purge period, the blower motor is turned off. The timer has returned to its original starting position and stops. The unit is ready to re-start.

⚠ Warning

It is advisable to check for tight shut-off of fuel valves. Despite precautions and strainers, foreign material in either new or renovated fuel lines may lodge under a valve seat and prevent tight closure. The situation is especially true in new installations. Promptly correct any conditions causing leakage. Failure to follow these instructions could result in serious personal injury or death.

H. CONTROL OPERATIONAL TEST AND CHECKS

Proper operation of the various controls should be verified and tested when the boiler is initially placed into service, or whenever a control is replaced. Periodic checks should be made thereafter in accordance with a planned maintenance program.

The operating limit control may be checked by allowing steam pressure to increase until the burner shuts down. Depending upon the load, it may be necessary to manually increase the firing rate to raise steam pressure to the burner shut off point. If the load is heavy, the header valve can be closed or throttled until the pressure increases. Observe the steam gauge to check the cut off pressure as the operating limit control shuts the burner down. Slowly open the header valve to release steam pressure and check the cut-in setting as the burner restarts. Check the modulating control for the desired operating pressure range.

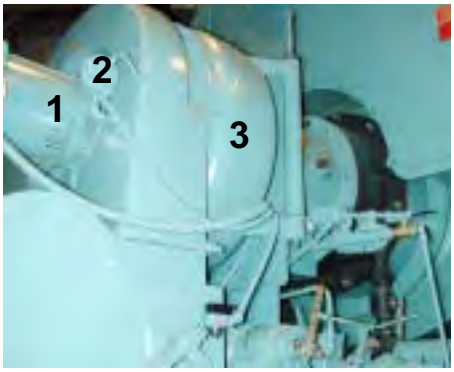
The water temperature on a hot water boiler that may be operating at less than full load may be raised by manually increasing the firing rate until the burner shuts down through the action of the operating limit control. Observe the thermometer to verify the desired settings at the point of cut-out and again when the burner restarts. Return the manual automatic switch to “automatic” and check the modulating control for the desired temperature range.

Check the proper operation and setting of the low-water cutoff and the auxiliary low water cutoff (and pump operating control, if used).

Proper operation of the flame failure device should be checked at startup and at least once a week thereafter. Check the program relay’s annunciation for any system failure. Observe the promptness of ignition of the pilot flame and the main flame.

Chapter 5
Profire D Series Burner

Table of Contents



1. BLOWER MOTOR
2. COMBUSTION AIR PROVING SWITCH
3. BLOWER HOUSING

Figure 5-1 Mounted D Series Burner

Figure 5-2 Burner Control Panel

A. DESCRIPTION

The Cleaver-Brooks ProFire D Series oil burners are of the low pressure, air atomizing (nozzle) type. Gas burners are of the peripheral mix type. All burners feature ignition by spark-ignited gas pilot flame. With either fuel, the burner operates with full modulation. A switch permits changeover from automatic fully modulated firing to manually set firing at any desired rate between minimum and maximum. Additional safeguards assure that the burner always returns to minimum firing position for ignition. See **Figure 5-1**.

The ProFire D Series burners are designed for automatic, unattended operation except for periodic inspection and maintenance. After selecting the proper overload settings for the starter, the rest of the control panel components require little attention except for occasional cleaning.

B. OPERATING CONTROLS / CONTROL PANEL

(See Figure 5-2)

The control panel contains a flame safeguard programming control, motor starters, relays, time delays and terminal strips mounted internally on a panel subbase. Lights, switches, potentiometers, a control circuit breaker and flame safeguard displays are mounted externally on the panel as indicated below.

1. **ON-OFF BURNER SWITCH** - (for gas or oil only)
2. **FUEL SELECTOR SWITCH** - Gas-Off-Oil

(for combination gas-oil burners only)

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.

Manual Position: Selects 135 ohm potentiometer for manual modulating control.

5. **MANUAL MODULATING CONTROL 135 ohm**

Increases or decreases the burner firing rate manually.

6. **SIGNAL LAMPS**.

   A. POWER ON (white) illuminates when the control circuit is energized (powered).

   B. IGNITION (amber) illuminates when the ignition transformer is powered, and gas pilot valve is energized (opened).

   C. MAIN FUEL (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.

C. FLAME SAFETY CONTROLS (see Figure 5-3)

The flame safeguard programmer incorporates a flame sensing cell (scanner) to shut down the burner in the event of pilot flame or main flame failure. Other safety controls shut down the burner based on sequence of operation as shown in the manufacturers flame safeguard manual.

⚠ Warning

Read the flame safety manual and fully understand its contents before attempting to operate this equipment. Serious personal injury or death may result

Figure 5-3 Flame Safety Inside Burner Control Panel

D. COMBUSTION AIR HANDLING SYSTEM

The combustion air handling system consists of three major components: (See **Figure 5-4**)

1). DAMPER ASSEMBLY. A rotary damper regulates the combustion air volume and is positioned by a modulating motor. The damper is normally ALMOST CLOSED in the low fire position and opens as the burner drives toward a high fire position.

2). MOTOR DRIVEN IMPELLER. The diameter of the impeller determines available air pressure and the width determines air capacity in cubic feet per minute. Alternate motor-impeller combinations are available for 50 cycle or 60 cycle power.

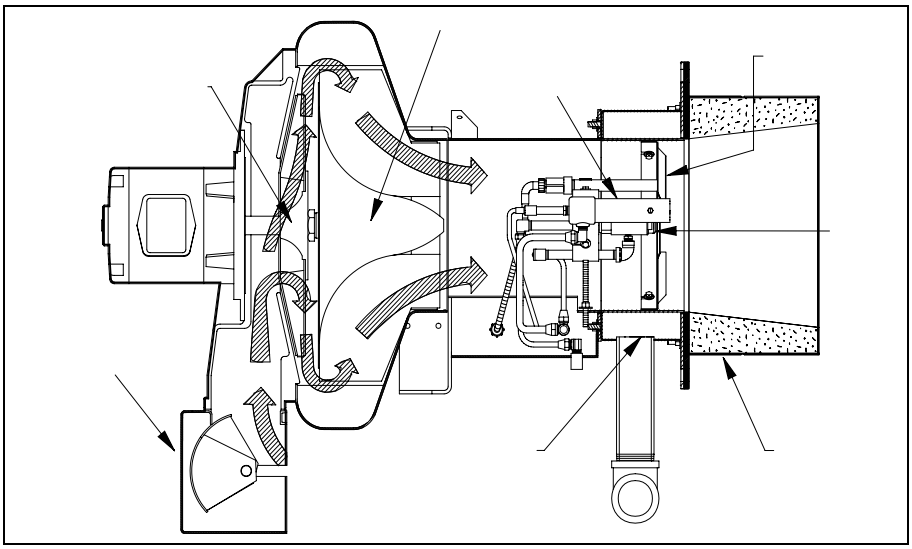


Figure 5-4 Combustion Air Handling System

3). STATOR CONE. The stator cone in the air housing transforms the rotating air velocity pressure to static pressure prior to air entry into the blast tube.

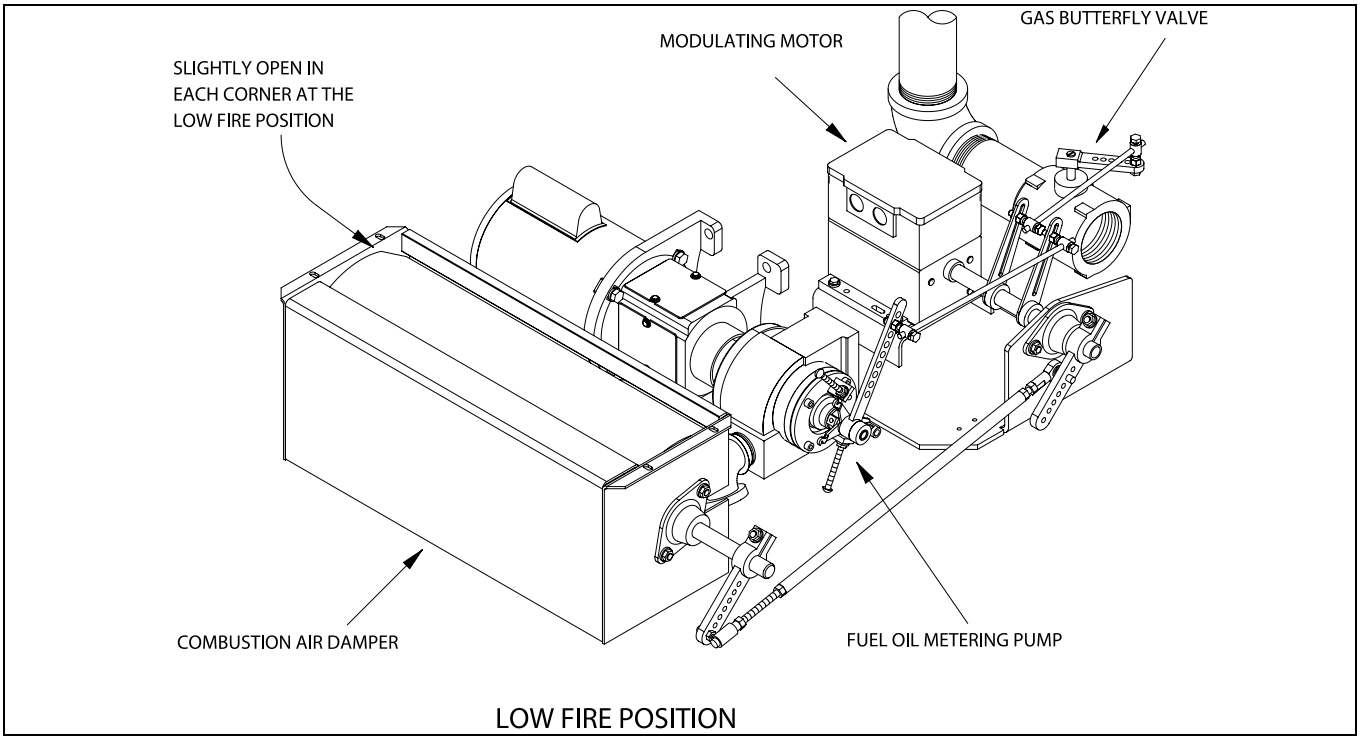


Figure 5-5 Low Fire Position

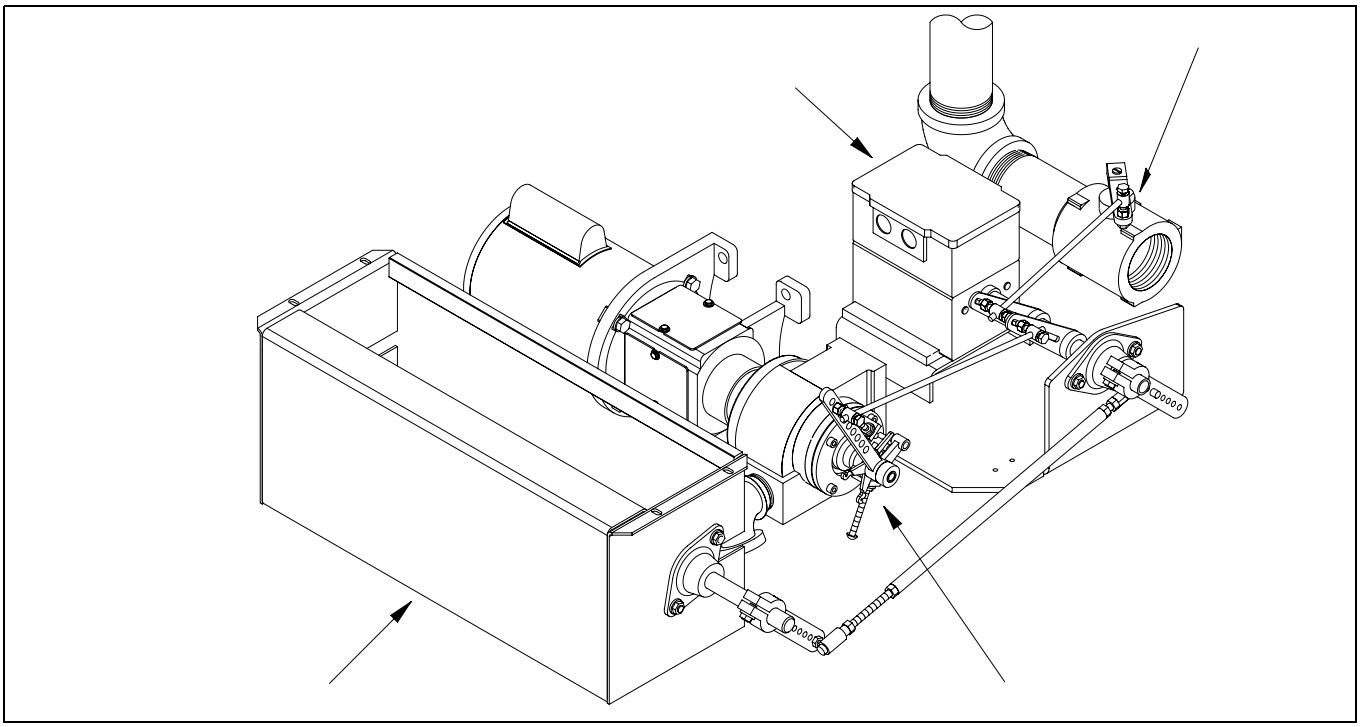


Figure 5-6 High Fire Position

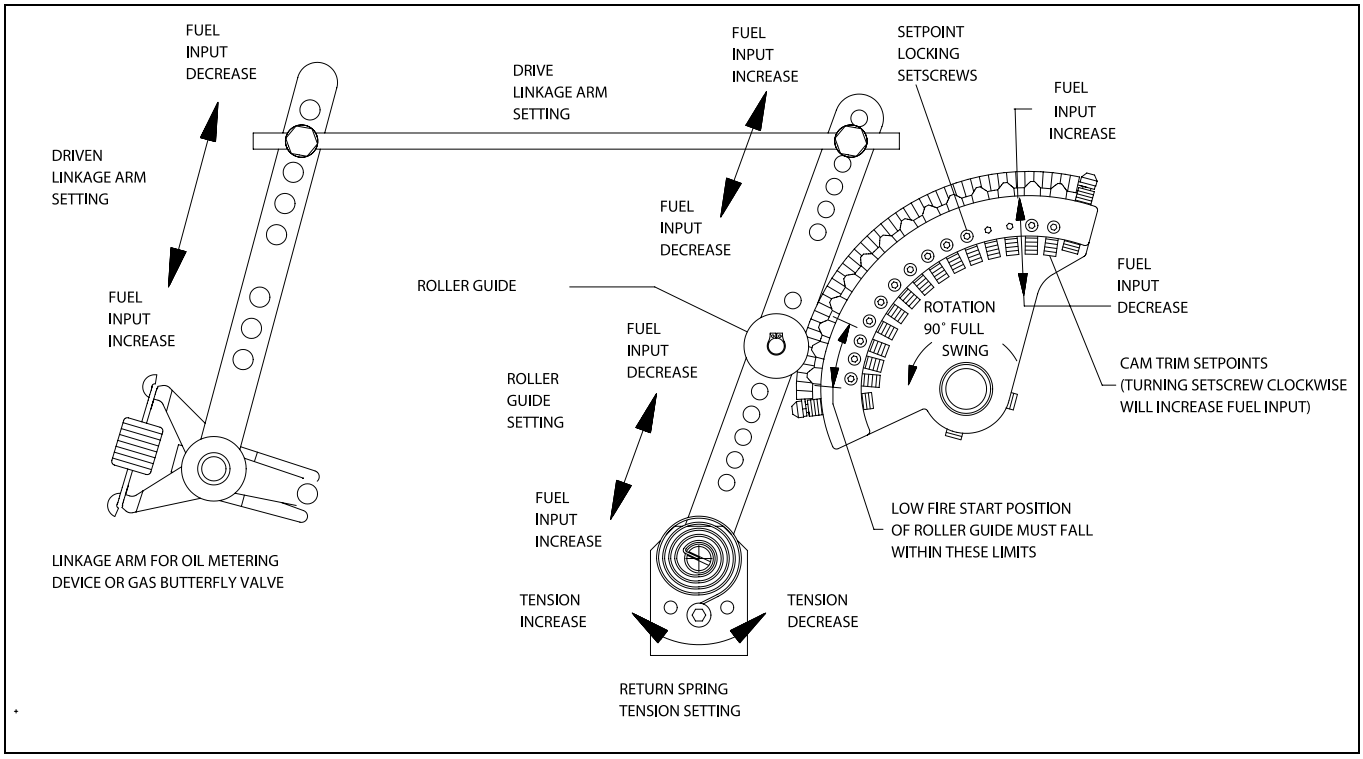


Figure 5-7 Cam Trim Adjustment

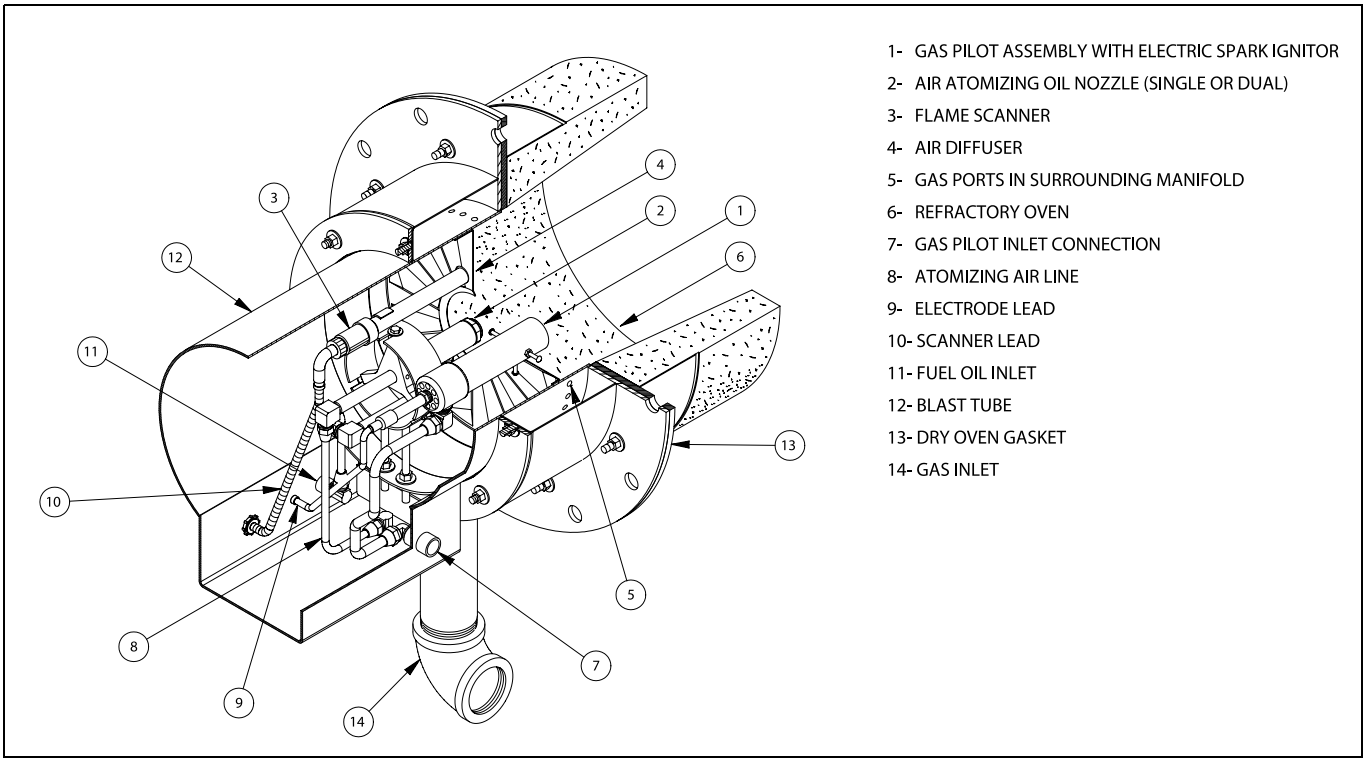


Figure 5-8 Firing Head Assembly

E. FIRING RATE CONTROLS

Regardless of the fuel used, burner input is fully modulated between low fire and high fire on boiler demand see **Figure 5-5** and **Figure 5-6**. Firing rate is controlled by the potentiometer-regulated modulating motor. Combustion air control damper, oil metering pump and/or gas volume butterfly valve are through variable rate rod and lever linkages. The modulating motor rotates 90 degrees from low to high position. Flow rate through each component is adjusted by positioning the control rods on the levers and the angular position of levers on shafts see **Figure 5-7** Lever on the modulating motor shafts actuate the high fire position proving switch.

Figure 5-9 Mod Motor and Linkage

F. FIRING HEAD

Access to the firing head is provided by swinging open the impeller housing see **Figure 5-8**. First, disconnect the damper linkage, release the housing latch, see **Figure 5-10** and swing the housing to open position. An internal gas pilot is standard on all burners. Pilot gas pressure is adjusted at the pilot pressure regulator.

Figure 5-10 Housing Swing Latch

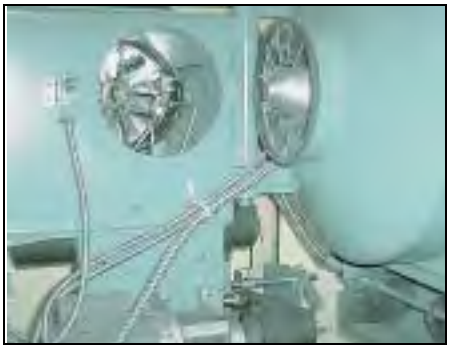


Figure 5-11 Burner Swung Out for Service

G. OIL SYSTEM AIR ATOMIZING

The ProFire D Series burners use compressed air for atomization. Atomizing air is independent of combustion air. Either of two air/oil systems are used, depending on burner size and fuel. One system uses an integral air compressor/oil metering unit mounted on the burner and is driven by a separate motor. The other system is supplied with a separate compressor module for mounting near the burner.

3-WAY SOLENOID VALVE.

Metered oil enters the common port of the 3-way solenoid valve. During shutdown, pre and post purge the valve is de-energized (N.C. port closed) and all metered fuel oil returns to the storage tank. When the valve is energized, metered oil is directed to the nozzle through the N.C. port.

NOZZLE ASSEMBLY.

The nozzle assembly consists of four main parts: body, compression spring, swirlier, and tip. The swirlier is held against the nozzle tip by the compression spring. The nozzle body has inlet ports for air and oil lines. Metered fuel oil enters the nozzle body and flows through a tube to the swirlier. Oil is forced from the core of the swirlier to the side ports where it meets with the atomizing air see **Figure 5-12**

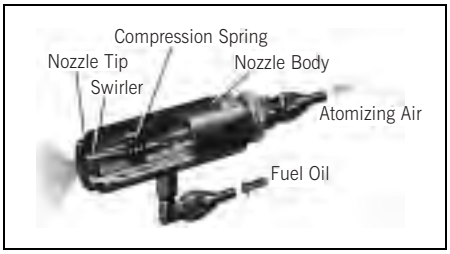


Figure 5-12 Oil Nozzle Cutaway

Atomizing air enters and passes through the nozzle body to grooves in the swirlier, where it mixes with fuel oil. Air/oil passes through grooves and out of the nozzle orifice in a cone of atomized oil. Proper velocity and angle of the fine spray ensures good mixing with the combustion air, providing quiet starts and excellent combustion efficiency.

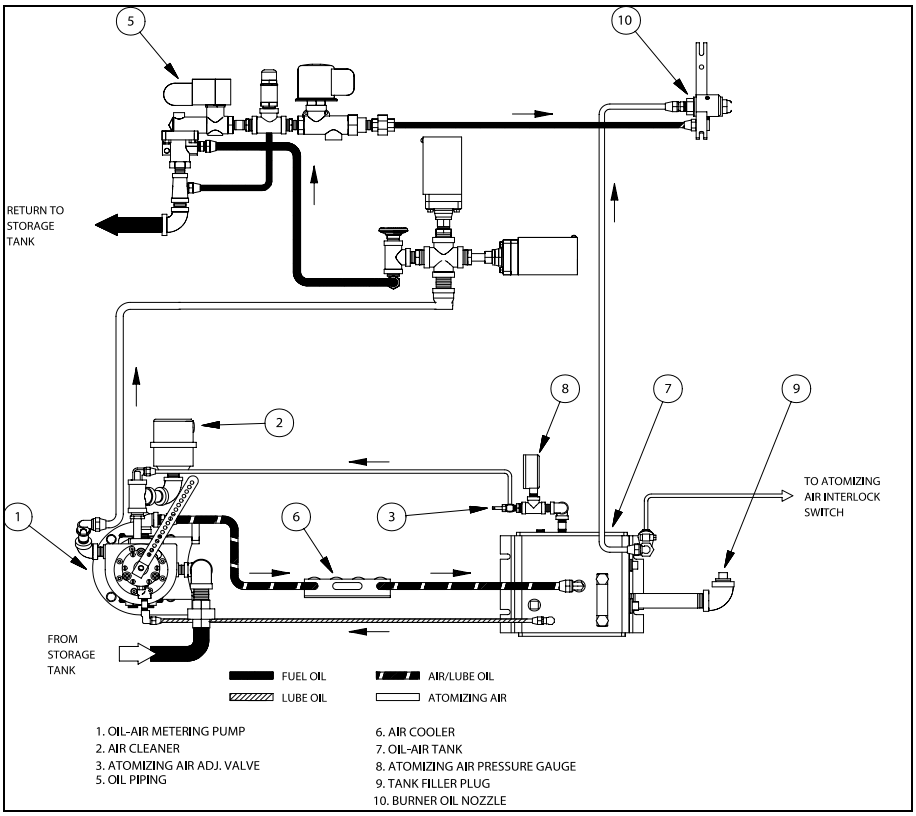


Figure 5-13 Integral Compressor Oil-Air Metering System

During pre and post purge, the nozzle tip is purged with air. This prevents afterdrip or baked-on residue.

OIL STRAINER.

Prevents foreign matter from entering the burner oil system.

ATOMIZING AIR PROVING SWITCH.

Pressure actuated switch contacts close when sufficient atomizing air pressure is present. The oil valve will not open unless switch contacts are closed.

AIR/LUBE OIL TANK.

Burner mounted tank stores compressed air for oil atomization and oil for compressor lubrication. Contains wire mesh filter to separate lube oil from compressed air.

INTEGRAL AIR/OIL UNIT.

Model designation DL, DLG, DM, DMG No. 2 oil with air atomization (model D42 to 145). These models utilize an integral air compressor/ oil metering unit which is separately driven at 1725 rpm and mounted on the burner. See **Figure 5-13**

AIR COMPRESSOR.

Air is drawn into the vane-type, rotary compressor section of the air/ oil unit through an air cleaner (see **Figure 5-14**). The compressed air flows to an air-lube oil tank which serves the multiple purpose of lube oil mist recovery, lube oil sump and air storage. The compressor is cooled and lubricated continuously by oil under pressure from the bottom of the tank. Oil vapor is extracted from the compressor air, by a mist eliminator in the upper section of the tank. Atomizing air flows to the nozzle at a constant volume, but air pressure increases as the firing rate increases. Atomizing air is regulated by an adjusting valve in the return air line on integral metering units or in the air inlet on air compressor module burners.

SEPARATE COMPRESSOR MODULE.

All models DE, DEG, (also DL, DMG, DM, DMG 175-420) burners have, a burner mounted oil metering unit and a separate compressor module. The system functions as follows

AIR COMPRESSOR MODULE.

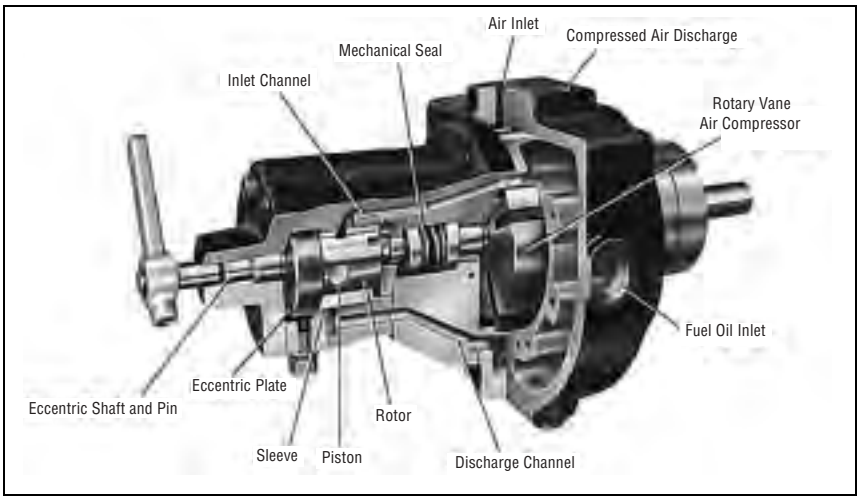


Figure 5-14 Air Compressor Cutaway

Air is supplied by a positive displacement rotary vane compressor. This provides a constant volume of atomizing air regardless of pressure. The compressor module includes motor, air-oil reservoir tank, air filter and lube oil cooling coil. Air enters the compressor through the filter. The air flows from the compressor into the air-oil separating and reservoir tank. Filtering material and baffles separate

the lube oil from the compressed air. The tank air pressure forces lubricating oil from the tank to the compressor to lubricate bearings and vanes. A sight glass indicates the level of lubricating oil in the air/oil reservoir. Lubricating oil must be visible in the gauge glass at all times. Air compression heat is absorbed in part by the flow of lube oil, creating a hot oil mist. The air/oil mist is cooled by a coil assembly. Lube oil is also cooled before entering the compressor.

OIL METERING.

Fuel oil under nominal pressure in the circulating loop, flows to the adjustable positive displacement,(volumetric metering unit. Oil metering is accomplished by changing the piston stroke by means of an eccentric shaft and pin assembly. The pistons reciprocate in a rotor assembly, turning in a hardened steel sleeve having oil inlet and discharge slots. During each revolution the pistons go through the following cycle:

1. Inlet Cycle. The piston is at the bottom dead center position. At this position the cavity between the top of the piston and the outside diameter of the rotor fills with oil

.

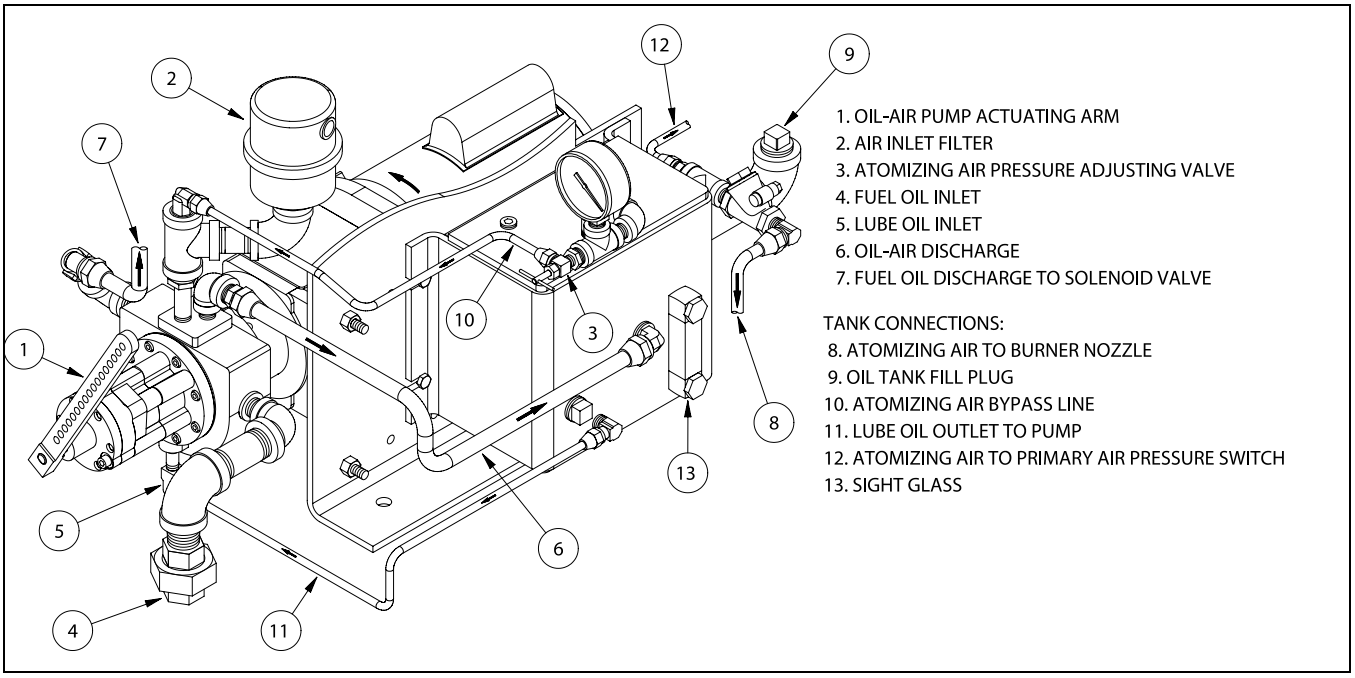


Figure 5-15 Oil Metering Pump and Tank Assembly, Integral Compressor

Discharge Cycle. (180° from inlet cycle.) The piston is at the top dead center position. At this position the oil is forced out of the discharge port to the nozzle. The piston stroke length is determined by the position of the eccentric shaft and plate. The piston adjustment plate is positioned by an adjustable eccentric shaft. The eccentric shaft is positioned by the modulator through adjustable linkage. Counterclockwise rotation of the eccentric shaft increases the piston stroke (more oil delivered to nozzle); clockwise rotation decreases the amount of oil delivered. When the eccentric shaft is stationary, at any position, the stroke of the pistons remains constant delivering a constant volume of oil regardless of viscosity.

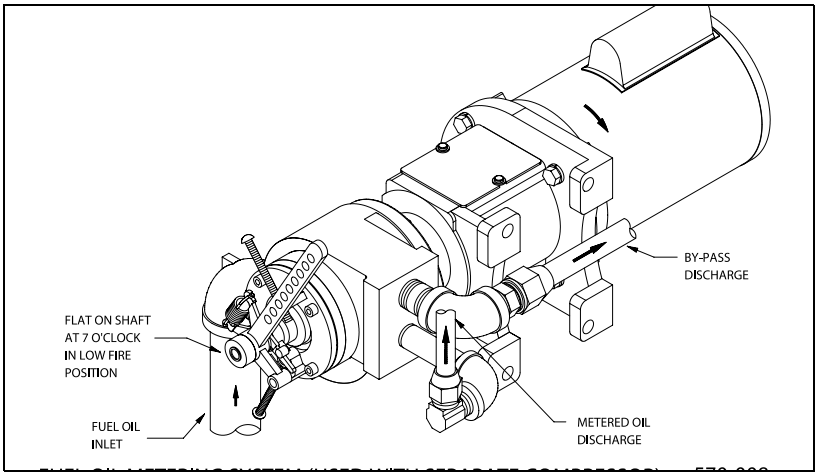


Figure 5-16 Separate Fuel Oil Metering Pump

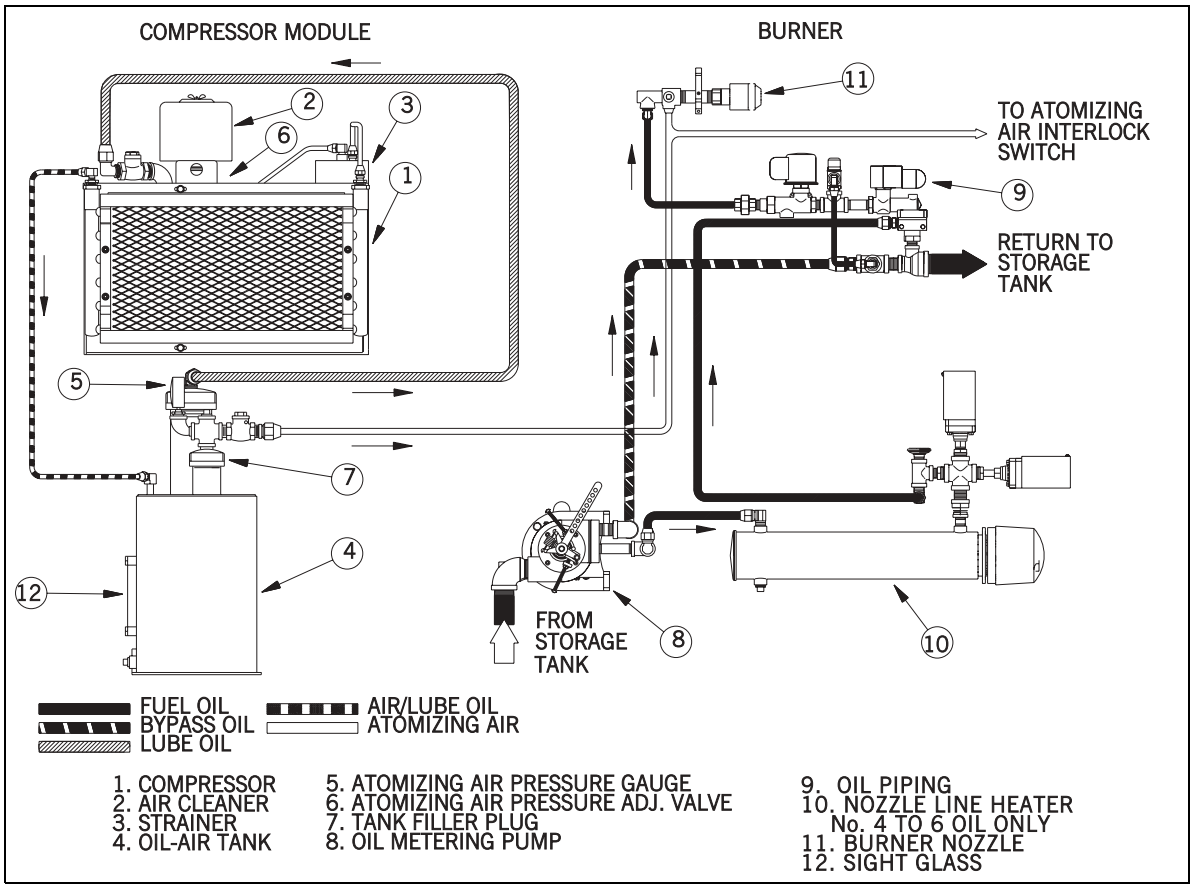


Figure 5-17 Separate Compressor - Air Metering System

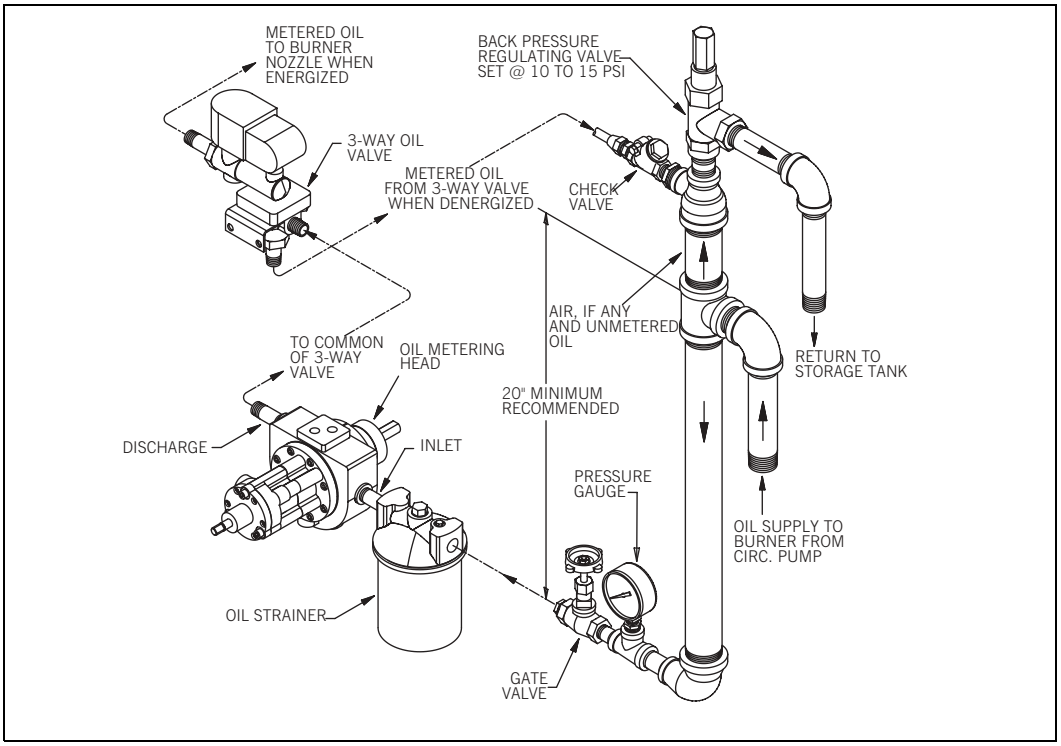


Figure 5-18 Typical Oil Supply Loop

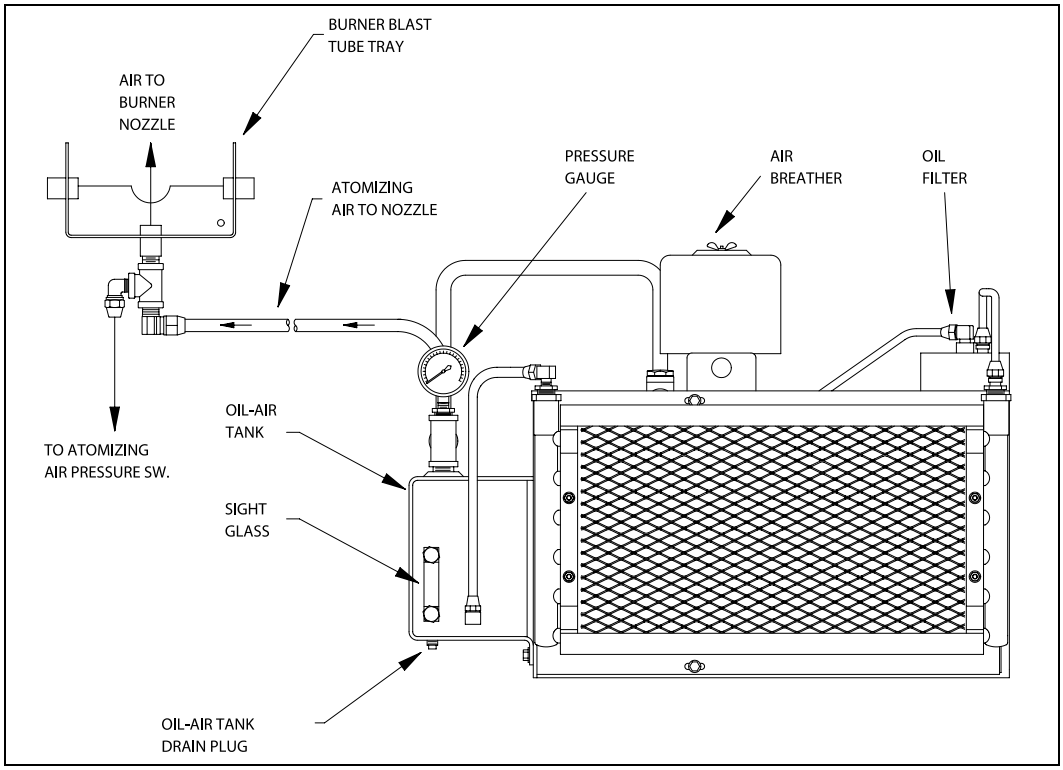


Figure 5-19 Separate Compressor Module

OPERATION

Fuel is delivered to the positive displacement metering pump at 10 to 15 psi. Metered oil is delivered to the common port of a 3-way solenoid valve for transfer to the burner nozzle through the normally closed port or back to the storage tank through the normally open port. During pre - and post purge, metered oil is returned to the tank. During normal firing, all metered oil is delivered to the nozzle. Heavy oil burners have a supplementary nozzle line heater between the metering pump and the 3-way valve. For the description of typical fuel oil piping installations, see **Figure 5-18**. Air enters a rotary vane compressor through an air cleaner where it is compressed to atomizing pressure. Air flows from the compressor to an air oil tank which serves the multiple purpose of dampening air pulsation, lube oil mist recovery, lube oil and atomizing air storage. The compressor rotor is cooled and lubricated continuously by oil under pressure from the air oil tank. Oil vapor is extracted by a mist eliminator in the upper section of the tank. Atomizing air from the upper tank section is delivered to the nozzle at a constant volume. Air pressure increases as the burner firing rate increases. Atomizing pressure may be adjusted by the needle valve located on the air-oil pump. The valve allows air to be bled from the tank to the compressor inlet. Delivery rate of the fuel oil metering pump is controlled by the modulating motor through adjustable linkage.

H. GAS SYSTEM

Gas is introduced into the combustion zone from a circular manifold through multiple ports in the blast tube. 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 an adjustable linkage from the modulating motor. Depending upon specific requirements, one or two safety shutoff, motorized main gas 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 may consist of some, or all, of the following items. A typical gas train is shown in **Figure 5-20**.

GAS VOLUME VALVE.

The butterfly type valve is positioned by linkage from the modulating motor and controls the rate of flow of gas.

MAIN GAS VALVES.

Electrically operated safety shutoff valve(s) that open to admit gas to the burner. Standard UL. burners include:

-Models: D42; One motorized gas valve and one solenoid valve

-Models: D54-105; One motorized gas valve with closure interlock and one solenoid valve.

-Models: D145-420; One motorized gas valve with /closure interlock and one standard motorized valve.

MAIN GAS REGULATOR

Regulates gas train pressure to specified pressure required at inlet to gas train. Input is set by main gas pressure regulator adjustment.

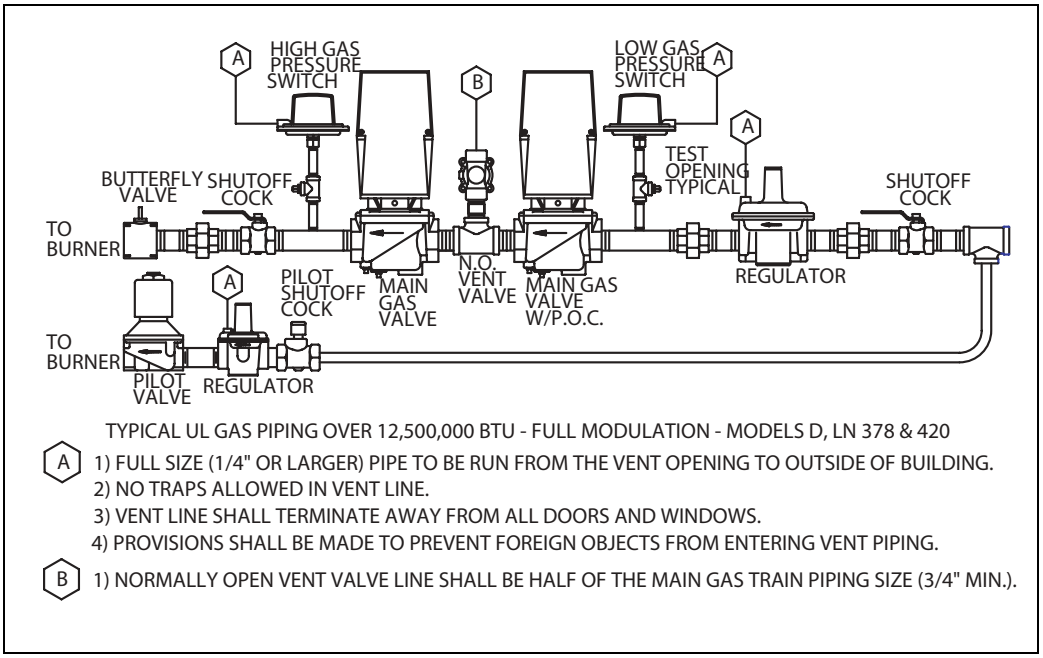


Figure 5-20 Typical UL Gas Train Over 12.5 MMBtu, Full Modulation

MAIN GAS COCKS

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.

A pressure actuated switch that remains closed when gas pressure is below a preselected setting. Should the pressure rise above the setting, the switch contacts will open causing main gas valve(s) to close. This switch requires manual reset after being tripped.

LOW GAS PRESSURE SWITCH.

A pressure actuated switch that remains closed when gas pressure is above a preselected 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.

Figure 5-21 Pilot Gas Train

Figure 5-23. ProFire D Series Burner

PILOT GAS TRAIN, GAS PILOT VALVE (see Figure 5-21).

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 SHUT-OFF COCK.

For manually closing the pilot gas supply.

I. OPERATION

PREPARATIONS FOR STARTING

When the installation is complete and all electrical, fuel, water and vent stack connections are made, make certain said connections are tight. The operator should become familiar with the burner, boiler controls and components. To identify controls and components refer to contents of Chapter 1. The wiring diagram should also be studied along with the operating sequence of burner programmer.

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

1. BOILER.

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

2. BURNER.

Check the electrical power supply to the burner in accordance with the nameplate voltage on all motors and the control circuit. Check the direction or rotation of the motors. Open the housing to check the electrode setting. Check the gas pilot pressure at the pilot gas regulator. Normal setting is 3" to 6" W.C.

For protection in shipment, the flame safeguard control chassis is shipped unmounted. Check all screw connections before attaching flame safeguard chassis to base. 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 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 level and manipulating by hand.

Check the air shutter and adjust low fire setting.

3. FIRING PREPARATIONS FOR OIL BURNERS

Prior to initial firing, oil flow pressure and temperature should be verified. Inspect the compressor lube oil sump level. Add oil to bring the oil level to the midpoint or slightly higher in the reservoir sight glass.

Make certain that the drive belts or couplings are aligned and properly adjusted. To verify air flow and pressure, momentarily flip the switch "ON" and immediately turn OFF. The programmer will continue through its cycle, however, without ignition or energizing the fuel valves. Observe the air pressure gauge. With compressor running and no oil flow, the pressure should be approximately 10 psi.

If the burner is a dual fuel model, make certain that the main gas shut off cock is closed and the fuel selector switch set to OIL.

4. LIGHT OIL

Open all valves in the oil suction and return line. The burner oil metering units are not capable of creating suction. Fuel oil must be supplied to the metering unit at a nominal 10 to 15 psi pressure by a circulating supply pump.

5. FIRING PREPARATIONS FOR 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 start-up it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through pre-purge and pilot sequences.

Check for leaks and determine there is adequate gas pressure available at the burner for operating at full capacity. Check with the local utility if necessary. Check gas pressure at the pilot and the main burner. Close the manual gas valve.

Figure 5-24 Gas Train Linkage

ELECTRICAL INTERFERENCE TEST

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

1. GAS FIRED

Close the pilot and the 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 (i.e. be energized).

Upon completion of successful test, proceed with start-up procedures.

2. OIL FIRED

Disconnect the electrical power to the burner.

Disconnect the electric oil safety shutoff valve.

Reconnect electric power to the burner. 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 start-up procedures.

J. GAS SYSTEM

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 Namplate 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.

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).

GAS PILOT FLAME ADJUSTMENT

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 3" to 6" WC 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 start-up and during planned maintenance, test the pilot flame signal, pilot turndown, and safety switch lockout.

MAIN GAS PRESSURE REGULATOR

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. Refer to manufacturers literature for regulator adjustment.

Figure 5-25 Main Gas Regulator

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 adjusting screw until 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.

Figure 5-26 Typical Gas Train

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 manufacturers 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. See Section B of this chapter for additional information.

SECONDARY VALVE ADJUSTMENT
GAS MODELS D 378 AND 420

The secondary valve feeds gas to the inner spuds. A slot in the valve stem in relationship to the shut/open scale on the valve indicates the blade position. In the LOW FIRE starting position the stem slot should

be positioned at the left hand 1/4 mark and travel in a counterclockwise direction to the MID FIRE shut position. Continuing in a counterclockwise direction the stem slot should stop at the right hand 1/4 mark. This is the HIGH FIRE position. Both low and high fire positions are approximate. Adjustments to the valve should be made on the secondary valve linkage arm. To increase the travel move the linkage arm closer to the pivot point. To decrease the travel move the linkage arm away from the pivot point. The primary valve which feeds the outer spuds should be adjusted as normal.

K. OIL SYSTEM

OIL METERING SYSTEM

Fuel oil supply to the integral metering unit must be 10-15 psi and up to 20 psi on separate metering units. The oil spray should ignite as soon as the oil solenoid valve opens. If the oil spray fails to ignite, move the metering unit adjustment lever a few degrees counterclockwise. This increases the amount of oil at low fire and makes ignition easier; it will also increase the oil on high fire, so this must be checked later. Once adjusted, the pump should operate with a minimum amount of adjustment. If a burner failure is caused by the oil metering pump, check the following:

1.See that the oil tanks are not empty.

2.That all oil valves between the burner and the tank are

open.

3.That the suction line is not airbound.

4.That the low-fire setting has not been disturbed.

5.That there is pressure at the integral metering unit but not to exceed 15 psi (20 psi on separate metering unit).

6.That the pump turns freely.

7.Check for a clogged strainer at the suction side of the circulating pump.

8.Check for a dirty burner strainer.

9.Check for a plugged or carboned nozzle. This will show up as excessive primary air pressure.

10. That the oil by-pass valve is not by-passing the metered fuel oil.

Internal wear of the pump may take place due to the presence of dirt in the oil and in time this will result in excessive clearances which reduces the pump capacity.

If oil metering pump fails to deliver capacity or meters erratically, replace the oil and air pump as a unit and return the old pump for repair or exchange (where allowed).

ATOMIZING AIR PRESSURE.

Atomizing air in the air/oil tank is regulated by adjusting valve in the return air line on integral metering units or in the air inlet on air compressor module burners. The air pressure is indicated by the pressure gauge at the air/oil tank.

A minimum of 10 psi air pressure in low fire is suggested. As the firing rate increases, the air pressure also increases. Air pressure will be less with light oils. If any change in atomizing air pressure is made, check ignition several times for reliable light off. Adjustments should be set to obtain reliable ignition with best low and high fire combustion results.

If the required atomizing air pressure cannot be maintained, a lack of lubricating oil may be the cause or the intake filter may be dirty.

ATOMIZING AIR PROVING SWITCH.
The knurled nut between the switch and bellows is turned in to raise pressure setting. The minimum amount of atomizing air is during pre- and post-purge. During pre-purge, adjust switch until it breaks the circuit. Readjust switch above this circuit break point to actuate under a condition of minimum pressure, but not so close as to cause nuisance shutdowns. Air pressure against the Bourdon tube actuates two single pole, single throw mercury switches, which when made completes a circuit, proving the presence of atomizing air. Since the pressure of the atomizing air is at minimum when no fuel is present at the nozzle, adjustment of the switch should be made while the unit is purging, but not firing.

LOW OIL PRESSURE SWITCH
The low oil pressure switch is adjusted at the minimum setting of 4 psi. Turning the knob clockwise will increase pressure, counter clockwise will decrease pressure.

HIGH OIL TEMPERATURE SWITCH
The temperature switch is set slightly below the maximum of 260F. To adjust, remove cover and turn the screw located on top. Clockwise will increase temperature, counter clockwise will decrease temperature.

NOZZLE LINE HEATER
1. Remove the cover which encloses the thermostat and interlock switch. The pointer controls the thermostat setting. The knurled knob controls the cold oil interlock switch.

2. The thermostat pointer should be set at position 6 and then raised or lowered as required. Higher numbers indicate higher temperatures. Let unit run before making further adjustments. The thermostat governing the nozzle line heater element is set lower than the thermostat governing the oil heater in the circulating loop.

3. The cold oil interlock switch is controlled by the small brass knurled knob under the pointer. This is set to prevent the burner from starting until proper oil temperature is attained. Set below the oil thermostat setting. If the cold oil interlock is set higher than the oil temperature, the burner will not run.

4. Replace cover.

START-UP 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:

a. The operating and high limit control (temperature or pressure) are below their cutoff setting;

b. All power supply switches are closed;

c. Power is present at the control panel.

Refer to the manufacturers literature on programming controls 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. (Power On) light.
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.
5. Place the gas /oil selector switch in position for desired fuel. With all limit and operating controls calling for heat, the burner will follow the Flame Safeguard Sequence below.
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 open the manual leak test valve.

Time in seconds	External Operation
0	Provided the fuel valve is proven closed the burner motor and flame safeguard timer will start
7	Air flow must be proven before ignition, or the flame safeguard will lockout. If the interlock circuit opens during a firing period, the burner will shutoff and the flame safeguard will lockout.
60	Firing on gas and providing the air flow and low fire have been proven, the pilot ignition transformer and ignition lamp are energized and the gas pilot valve opens to ignite the pilot.
70	Firing on oil, providing air flow and pilot have been proven, the main fuel lamp lights. When on gas or oil, the main valve opens to ignite the burner at low fire.
80	The pilot ignition transformer is de-energized, and the main safety shut off pilot valve closes, scanner proves main flame only. If the low/auto. switch is in the auto position, the following will occur: On gas, the butterfly valve and the burner air louvre moves to "low fire" position. On oil, the metering pump and the burner air louvre moves to "low fire" position.
100	"Normal run" position. Burner continues.

AUTOMATIC SHUTDOWN

Limit or operating controls open:

100	Fuel valves close. Main fuel lamp goes off. Flame safeguard timer starts
115	Flame safeguard timer and burner motor stop. Burner is ready for start up on the next call for heat

L. MANUAL SHUTDOWN

1. Turn gas/oil selector switch off. Burner shuts down in Automatic Shutdown as above.
2. When burner motor stops, close all manual valves

M.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.

Chapter 6

Profire D Series Burner Maintenance

Milwaukee, Wisconsin

www.cleaver-brooks.com

A. MAINTENANCE

⚠ 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.

⚠ Caution

IT IS IMPORTANT THAT YOU PROVIDE SUPPORT FOR THE HOUSING WHEN IN THE OPEN POSITION TO PREVENT DAMAGE TO THE HINGES AND SUBSEQUENT COMPONENTS.

B. GENERAL

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

Electrical and mechanical devices require systematic and periodic inspection and maintenance. Any “automatic” features do not relieve the operator from responsibility, but rather free 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.

C. 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 manufacturers bulletin. Never use abrasive materials. The manufacturers 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 lock out 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.

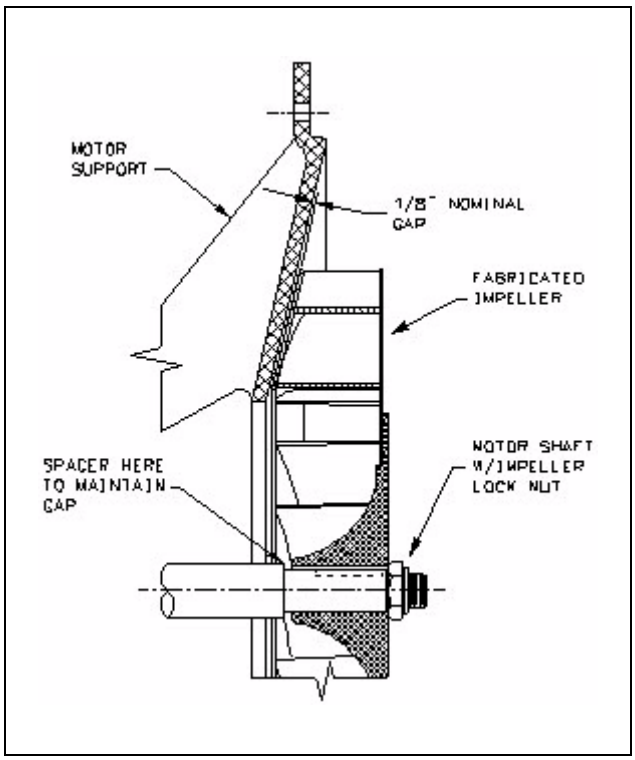


Figure 6-1 Impeller Cutaway

IMPELLER AND STATOR CONE

Refer to **Figure 6-1**.

Proper clearance between the impeller and the inlet housing and between the impeller and stator cone is not critical and is set at 1/8" nominal When installing or removing the impeller it is mandatory to use a impact wrench. **UNDER NO CIRCUMSTANCES SHOULD YOU USE ANYTHING OTHER THAN AN IMPACT WRENCH.** Inserting a bar through the impeller blade and using it as a lever will only damage the blade and also void the 5 year impeller warranty. If the impeller is changed to a different width, the stator cone position may require adjustment. This is provided for by means of slotted mounting holes in the blast tube. Loosen the three screws to reposition the cone. If a wide impeller is used to replace a narrower one, it may be necessary to trim the vanes for additional clearance.

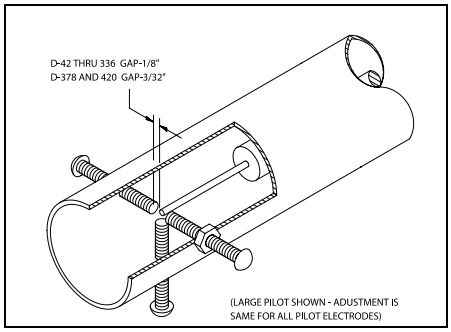


Figure 6-2 Gas Pilot Electrode

D. FIRING HEAD INSPECTION

Refer to **Figure 6-2** Disconnect the damper linkage, release the impeller housing latch and swing the housing open for access to the firing head. Inspect the flame scanner lens to be sure it is clean and the support tube is in proper position to sight the flame through the hole in the diffuser. 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 depending on the grade of oil burned and the cleanliness of the environment.

E. PILOT AND IGNITION ELECTRODE

The ignition transformer requires little attention other than making sure the ignition wire is firmly attached to the transformer and the electrode. Be sure the wire insulation is in good condition and not grounded. Failure to keep the ignition electrode clean and properly set can cause faulty operation. Refer to **Figure 6-2** for electrode gap setting and position (1/8" for D42 to 336 and 3/32" for D378-420). The pilot assembly is supported by a socket in the diffuser and gas inlet tube. No adjustment is required except proper positioning of the electrode wire.

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.

F. OIL NOZZLE.

Successful burner operation requires use of the proper style nozzle tip and keeping the orifice clean. Standard nozzle tips furnished on the burners are of a special emulsifying type which delivers a spray of extreme fineness and at an angle which insures proper mixing with the air stream. Unsatisfactory performance and loss of efficiency can result from the use of nonstandard nozzle tips. If the burner flame becomes stringy or lazy, it is possible that the nozzle spring is not properly in place or the nozzle is clogged. Refer to **Figure 6-3**. This problem is usually indicated by an abnormally high reading on the atomizing air pressure gauge on the air-oil tank. To remove the nozzle, disconnect the oil and air tubes to the nozzle assembly. Loosen the three 1/4" screws holding the nozzle spider bracket to the support ring. Withdraw the nozzle and bracket assembly.

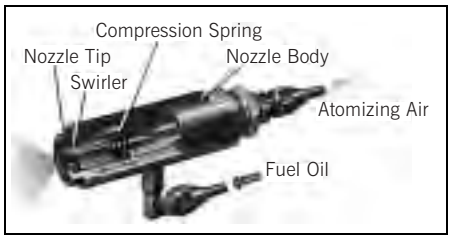


Figure 6-3 Oil Nozzle Cutaway

To clean the nozzle tip and swirlier, unscrew the tip from the nozzle body. Use care not to distort the tube. Hold the nozzle body in a vise or use two wrenches, one on the body and one on the tip. Disassemble the nozzle tip. Carefully clean all parts in solvent and reassemble the nozzle. To insure proper atomizing, the tip must be screwed in tightly with the swirlier seating spring pressing the swirlier tight against the nozzle tip. Turn the swirlier 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 as shown in **Figure 6-5**

⚠Caution

DO NOT attempt to use wire or a sharp metal tool to clean the nozzle orifice as this will distort the fine orifice and ruin the nozzle. Use a sharp pointed piece of soft wood.

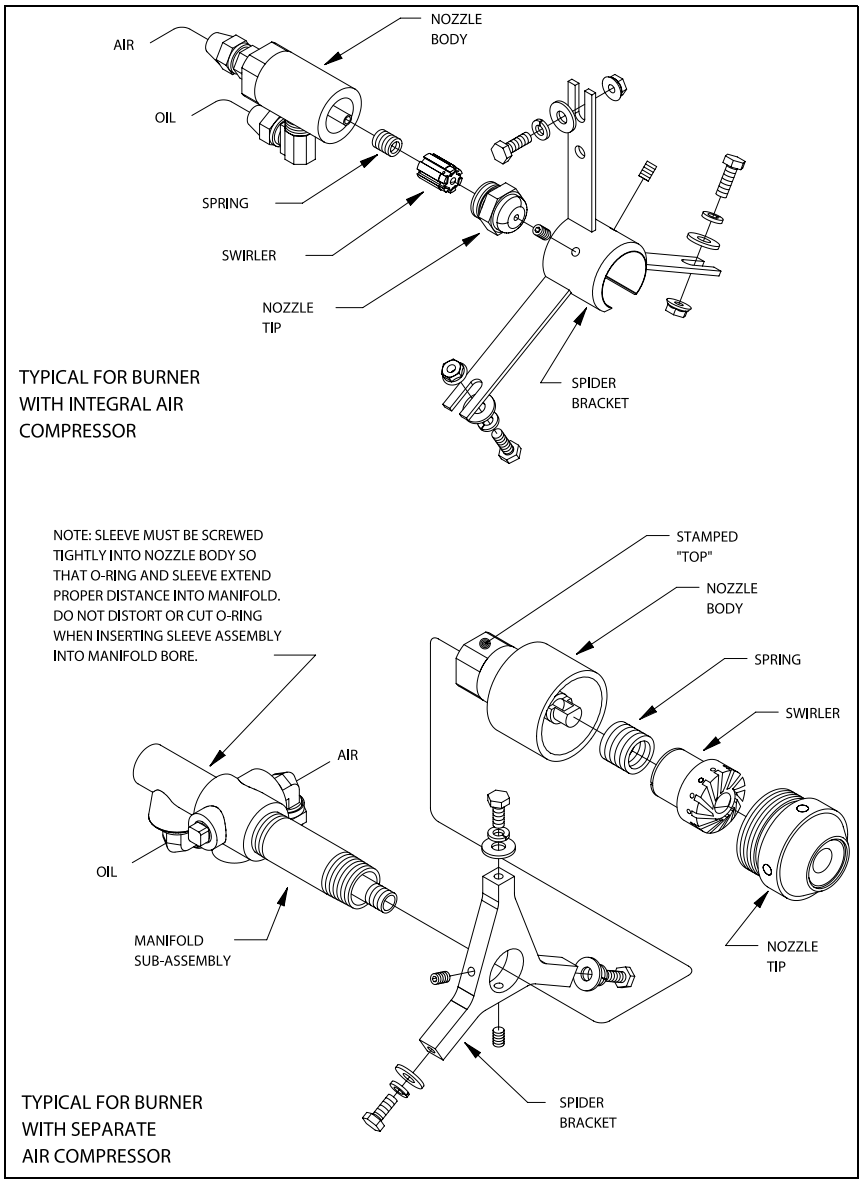


Figure 6-4 Oil Nozzle Assemblies

G. 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. First remove the electrode and scanner leads, the gas pilot assembly, air and oil tubes and the nozzle support assembly, before you attempt to remove the diffuser. 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. Remove the three screws holding the diffuser to the blast tube and slowly pull the diffuser along the blast tube towards the firing head. Keep the diffuser as parallel as possible. If it should became stuck or tight do not apply any tool which would distort the shape or blade configuration. A small wooden block tapped gently against the diffusers outer edge will help expedite its removal. Clean all carbon from the diffuser vanes and reinstall in reverse order of disassembly aligning the diffuser with the scribed marks. Do not attempt to drive the diffuser back along the blast tube with anything other than a small block of wood tapped against the diffuser's outer edge. When reinstalling, be sure the diffuser is centered with the proper distance as shown in **Figure 6-5**.

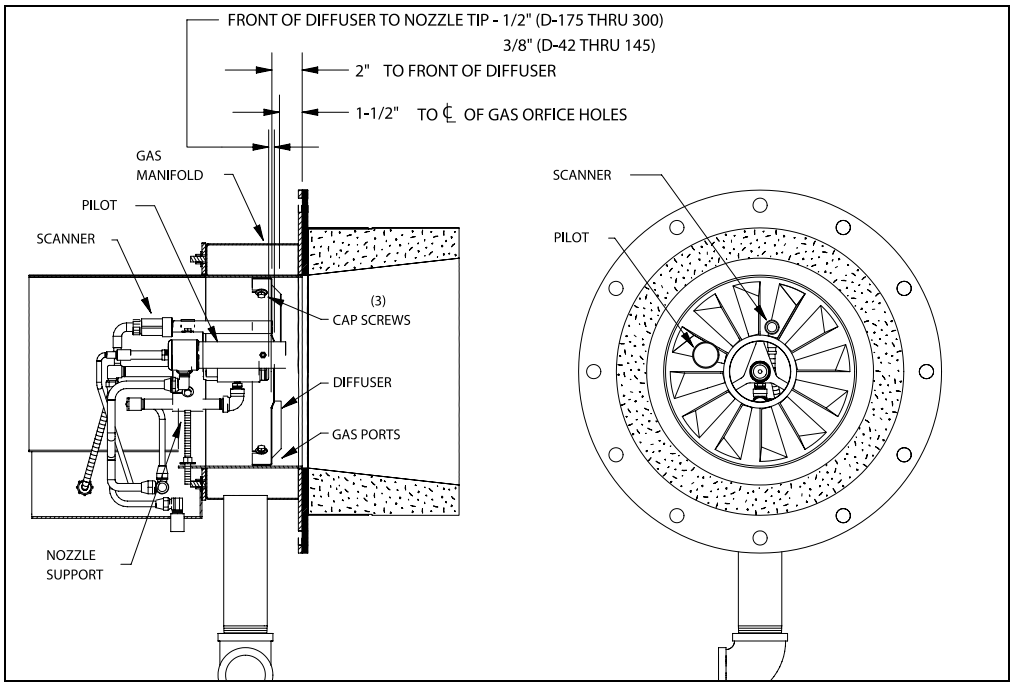


Figure 6-5 Firing Head Assembly

H. FIRING RATE CONTROLS

Check all rods and linkages. Make sure all connections are tight. Adjust if necessary. Perform a combustion test and adjustments, and readjust burner if necessary. Firing rate adjustments are made at the modulating motor linkages to the combustion air inlet damper, air-oil metering pump and main gas butterfly valve. Settings are determined by the operating length of the levers and the angular position on the shafts. Increasing the lever lengths on damper, pump or valve decreases the flow rate. Driving and driven levers are approximately parallel, but the angles can be adjusted to vary the rate of change. The most rapid rod travel occur when the lever is perpendicular to the rod. The closer the rod comes to being parallel with the lever, the slower the rod moves. ALWAYS allow the burner to return to low fire position before adjusting high or intermediate settings. DO NOT alter low fire settings. Normally, the air control damper will be almost closed in low fire position. For best pilot operation, the damper should be set as low as possible. Excessive opening in low fire can cause pilot ignition problems. Air to the pilot is supplied under

pressure to compensate for variations in furnace pressure, but the damper must be in low fire position for reliable ignition .

⚠ Warning

Keep fingers away from the air damper. The damper is actuated with sufficient force to cause injury. Failure to follow this warning could result in severe bodily injury.

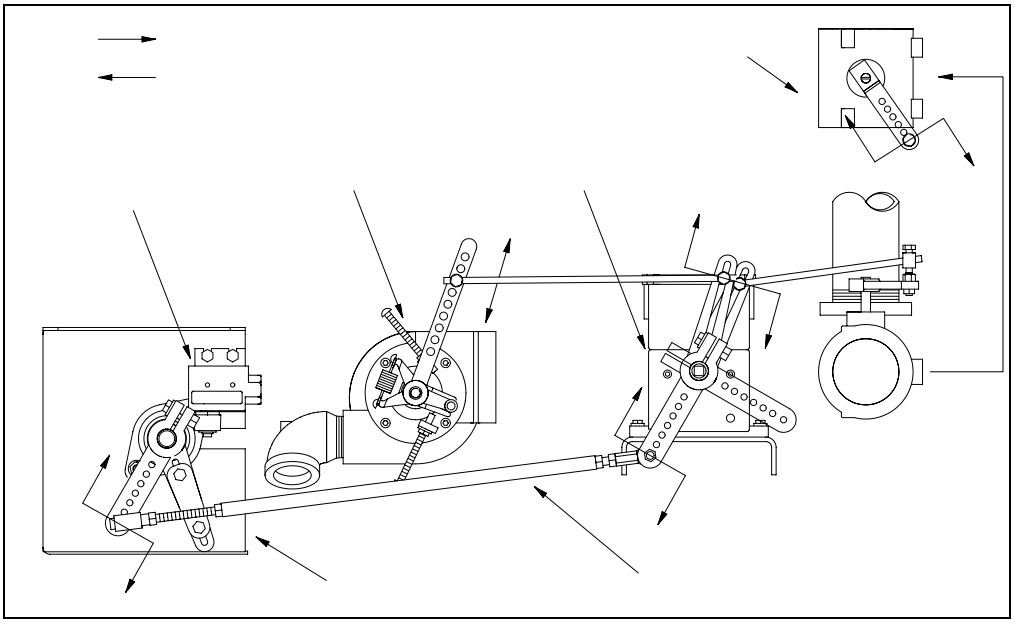


Figure 6-6 Firing Rate Controls

J. BURNER MOUNTING INSPECTION

The seal between the burner flange and furnace front plate must not permit combustion gases to escape. Periodic inspection is important. Replace gasket if necessary. Inspect burner head for signs of discoloration. A change in the head color paint, might indicate gas leakage between the dry oven and the boiler refractory.

K. FUEL OIL SYSTEM / FUEL OIL CIRCULATING PUMP

Failure of the circulating pump to deliver sufficient oil may be due to one of the following reasons:

1. Insufficient fuel oil in the storage tank.
2. Suction line or check valve clogged.
3. Air leaks or air traps in the suction line. If the line has a high point at which an air trap can occur, the line must be changed.
4. Oil strainer clogged (line strainer or burner strainer).
5. Suction line piping too small Pump rotating in wrong direction

6. Three phase pump motor operating on single phase because of fuse failure.
7. Low voltage applied to pump motor.

Notice

Heavy fuel oil sometimes will not leak out through a suction line joint when the burner is idle, but the same joint may allow air leakage inward when a vacuum is created in the line by pump action. The cause of a pulsating burner fire can often be traced directly to air leakage in the oil suction line. Always be sure suction line joints are absolutely air tight.

AIR-OIL METERING PUMP

Both the integral air-oil metering pump for light oil and the heavy oil metering pump, are precisely fitted units employing a seal on the shaft to prevent oil leakage. Internal wear can take place due to dirt in the oil and may in time result in excessive clearances, reducing pump capacity. Once adjusted, the pump will continue to operate with a minimum of readjustment. If burner failure appears to be caused by the metering pump, check the following:

1. See that the oil is at sufficient level in both fuel oil tank and air-oil tank on burner.
2. Make sure all valves between the fuel oil tank and the burner are open.
3. Be sure the oil suction line is not air bound and check the suction line strainer.
4. Check the low fire setting of the metering pump to be sure it has not been disturbed.
5. Make sure the pump turns freely.
6. Inspect the burner oil nozzle for clogging.

Whenever an oil metering pump fails to deliver full capacity or pressure, order a replacement pump at once and return the old pump for repair or exchange (where allowed).

PRIMARY AIR PUMP OR COMPRESSOR

The air compressor itself requires little maintenance, however its life is dependent upon sufficient clean, cool lubricating oil. The oil level in the air-oil tank must be checked regularly. Lack of oil will damage the compressor. Disassembly or field repairs to the air compressor are not recommended. Check the air-oil tank sight glass for proper oil level. The level should be kept at midpoint up the glass. The compressor rotor must turn freely. All tube connections must be air tight.

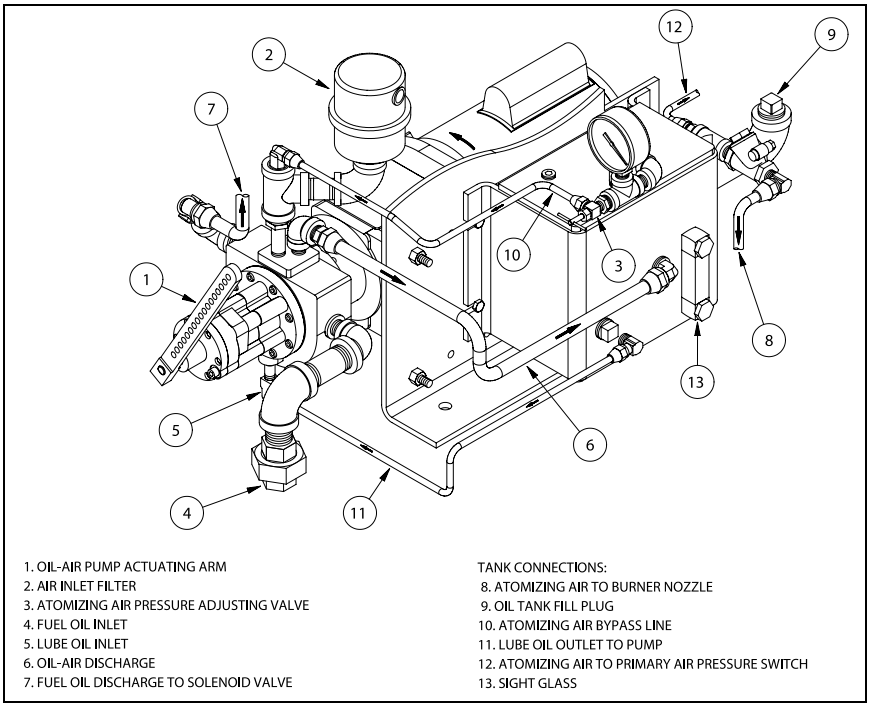


Figure 6-7 Integral Oil Air Metering System and Tank

AIR CLEANER.

Never operate the compressor without the air cleaner in place. The cleaner should be cleaned at regular intervals. The correct oil level must be maintained in the air cleaner. Use the same oil used for air compressor lubrication.

OIL-AIR TANK

Check the lube oil level in the oil -air tank. Inspect oil level regularly as loss of oil will damage the compressor. Change oil every 2000 hours of operation. The oil-air tank should be drained once a year and thoroughly flushed. Remove the mist eliminator pads from the upper section of the tank, wash thoroughly in kerosene and dry. Refill with **non detergent** SAE30 oil to a level midway up the sight glass. For normal environment use SAE30 oil. For a 32 degree F. and below environment use SAE10 oil.

OIL LEVEL SIGHT GAUGE.

The oil level sight gauge can be cleaned by removing it from the air-oil tank and soaking it in a detergent solution. If cleaning the gauge proves unsatisfactory, replace it. Compressor Inlet Oil Strainer (Lube Oil Strainer). The lube oil strainer prevents foreign materials from entering the compressor. The strainer screen must be cleaned at regular intervals.

The screen is easily removed for cleaning by unscrewing the bottom plug. Immerse in solvent and thoroughly clean.

Maintenance consists primarily of removing the heating element from the manifold and scraping any accumulation of carbonized oil or sludge deposits from the heat exchange surfaces.

Before breaking electrical connections to the heating elements, mark all wires and terminals to assure correct replacement of wires.

Periodic cleaning is necessary to prevent over heating or burn out of the elements. If operation of the heater becomes sluggish, examine the elements and clean as required.

Inspect the manifold each time the heater is removed. Flush all accumulated sludge and sediment before reinstalling the heater. Heater must be full of oil before power is turned on.

OIL STRAINERS

Oil strainers should be cleaned frequently to maintain a free and full flow of fuel. The strainer screen must be removed and cleaned at regular intervals. The screen should be removed and clean thoroughly by immersing it in solvent and blowing it dry with compressed air. Light oil strainers should be cleaned each month. Heavy oil strainers should be checked and cleaned as often as the experience indicates the necessity.

I. GAS SYSTEM

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 shutoff to determine that it opens and closes. If the valve has a visual indicator, observe its position for correct operation.

SOLENOID VALVES

A slight 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 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 manufacturers 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 body.

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

J. ELECTRICAL SYSTEM

Because of the many types of flame safeguard systems applicable to this equipment, complete descriptions of all D/Series burner electrical systems are beyond the scope of this manual. An individual electrical schematic drawing is shipped with each burner and complete operation and troubleshooting instructions are available from the various flame safeguard system manufacturers

ELECTRIC MOTORS

Motor supply voltage must not vary more than 10 percent from nameplate ratings. At initial start-up and at least once a year

thereafter, check the motor current with a meter while the burner is in high fire position. If the 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 accordance with the manufacturers instructions.

K. 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 the flame safeguard control and store in a dry atmosphere.

L. TROUBLESHOOTING

⚠ Warning

TROUBLE SHOOTING SHOULD BE PERFORMED ONLY BY PERSONNEL WHO ARE FAMILIAR WITH THE EQUIPMENT AND WHO HAVE READ AND UNDERSTOOD 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.

The points set forth under each heading are briefly, possible causes, suggestions or clues to simplify locating the source of the 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 Section should be referred to for assistance in pinpointing problems that may be not 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 that much easier. Costly downtime

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. By following a set routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

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

⚠ Warning

THE CAUSE FOR LOSS OF FLAME OR ANY OTHER UNUSUAL CONDITION SHOULD BE INVESTIGATED AND CORRECTED BEFORE ATTEMPTING TO RESTART. FAILURE TO DO SO MAY RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

⚠ Warning

DO NOT REPEAT UNSUCCESSFUL LIGHTING ATTEMPTS WITHOUT RECHECKING THE BURNER AND PILOT ADJUSTMENTS. DAMAGE TO THE BOILER OR SERIOUS PERSONAL INJURY OR DEATH MAY RESULT.

⚠ Warning

DO NOT RE-LIGHT THE PILOT OR ATTEMPT TO START THE MAIN BURNER, EITHER OIL OR GAS, IF THE COMBUSTION CHAMBER IS HOT AND/OR IF GAS OR OIL VAPOR COMBUSTION GASES ARE PRESENT IN THE FURNACE OR FLUE PASSAGES OR WHEN EXCESS OIL HAS ACCUMULATED. PROMPTLY CORRECT ANY CONDITIONS CAUSING LEAKAGE. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

M. EMERGENCY SHUT DOWN

In case of emergency, shut down the burner by turning the On-Off switch to the "OFF" position. Turn the fuel selector switch to the OFF position. Shut off the main manual fuel shut off valves on the fuel supply line. The unit can also be shut down with the main electrical power disconnect. Inspect the burner carefully and trouble shoot before re-starting the unit.

Chapter 7
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.

This chapter 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, this 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 troubleshooting much easier. Costly downtime 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.

A. Burner Does Not Start

1. No voltage at program relay power input terminals.
   - 1.1 Main disconnect switch open.
   - 1.2 Blown control circuit fuse.
   - 1.3 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.
   - 3.1 Pressure or temperature is above setting of operation control. (Load demand light will not glow.)
   - 3.2 Water below required level.
     - 3.2.1 Low-water light (and alarm horn) should indicate this condition.
     - 3.2.2 Check manual RESET button, if provided, on low-water control.
   - 3.3 Fuel pressure must be within settings of low pressure and high pressure switches.
4. Fuel valve interlock circuit not completed.
   - 4.1 Fuel valve auxiliary switch not closed.

B. No Ignition

1. Lack of spark.
   - 1.1 Electrode grounded or porcelain cracked.
   - 1.2 Improper electrode setting.
   - 1.3 Loose terminal on ignition cable; cable shorted.
   - 1.4 Inoperative ignition transformer.
   - 1.5 Insufficient or no voltage at pilot ignition circuit terminal.
2. Spark but no flame.
   - 2.1 Lack of fuel — no gas pressure, closed valve, empty tank, broken line, etc.
   - 2.2 Inoperative pilot solenoid.
   - 2.3 Insufficient or no voltage at pilot ignition circuit terminal.
   - 2.4 Too much air.
3. Low fire switch open in low fire proving circuit.
   - 3.1 Damper motor not closed, slipped linkage, defective switch.
   - 3.2 Damper jammed or linkage binding.
4. Running interlock circuit not completed.
   - 4.1 Combustion or atomizing air proving switches defective or not properly set.

4.2 Motor starter interlock contact not closed.

5. Flame detector defective, sight tube obstructed, or lens dirty.

C. Pilot Flame, But No Main Flame

1. Insufficient pilot flame.
2. Gas fired unit:
   - 2.1 Manual gas cock closed.
   - 2.2 Main gas valve inoperative.
   - 2.3 Gas pressure regulator inoperative.
3. Oil fired unit:
   - 3.1 Oil supply cut off by obstruction, closed valve, or loss of suction.
   - 3.2 Supply pump inoperative.
   - 3.3 No fuel.
   - 3.4 Main oil valve inoperative.
   - 3.5 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

D. 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, cams, setscrews, etc.

E. 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:
   - 6.1 Check fuel lines and valves.
   - 6.2 Check flame detector.
   - 6.3 Check for open circuit in running interlock circuit.
   - 6.4 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 (lean fire).
   - 7.1 Slipping linkage.
   - 7.2 Damper stuck open.
   - 7.3 Fluctuating fuel supply.
     - 7.3.1 Temporary obstruction in fuel line.
     - 7.3.2 Temporary drop in gas pressure.
8. Interlock device inoperative or defective.

F. 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.
   - 3.1 Motor defective.
   - 3.2 Loose electrical connection.
   - 3.3 Damper motor transformer defective.
4. Motor does not operate on demand.
   - 4.1 Manual/automatic switch in wrong position.
   - 4.2 Modulating control improperly set or inoperative.
   - 4.3 Motor defective.
   - 4.4 Loose electrical connection.
   - 4.5 Damper motor transformer defective.

Notes:

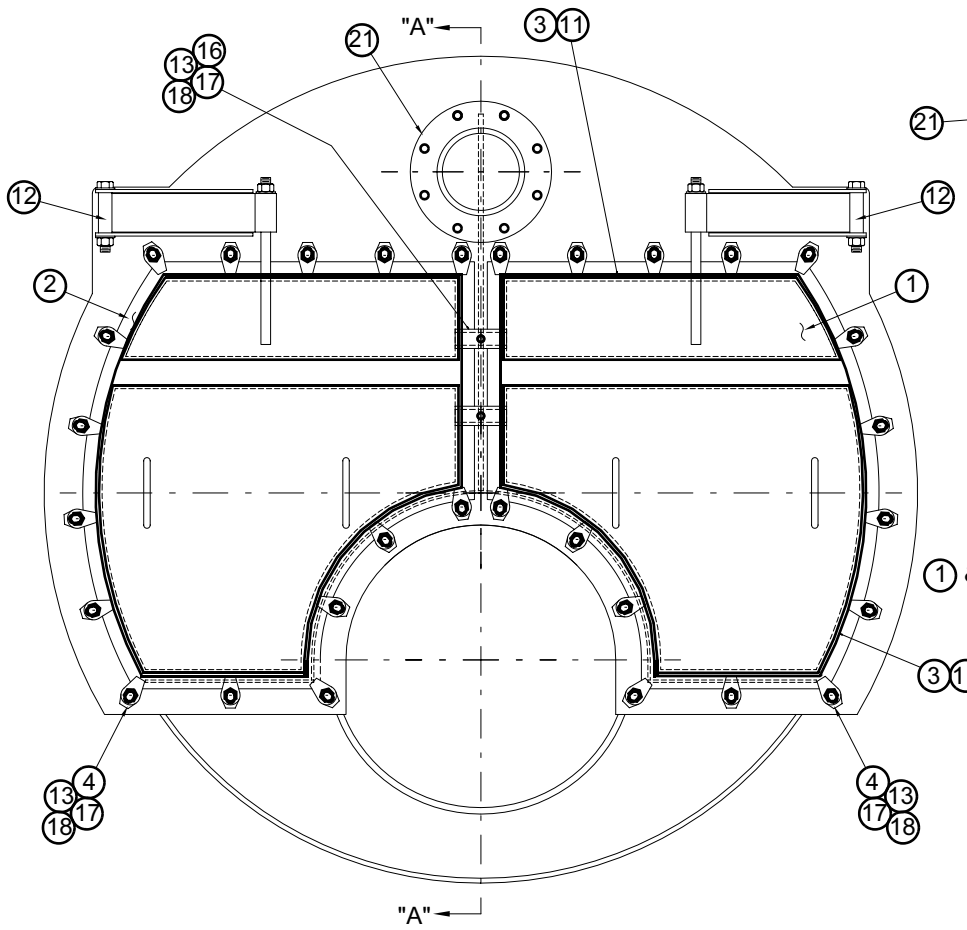
Chapter 8
Parts

Table Of Contents

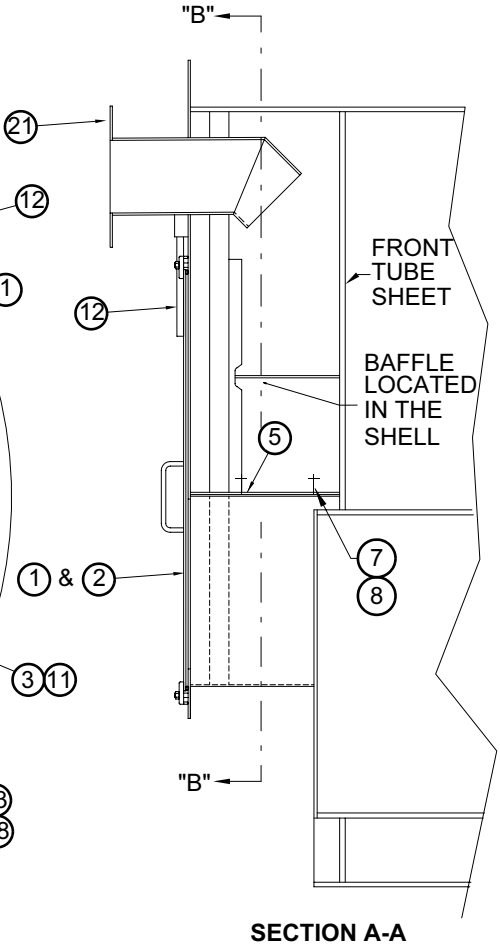
FRONT DOOR & SMOKEBOX, 60"-85", 100-400 HP

BILL OF MATERIAL									
		60", 100-125 HP		67", 150-200 HP		78", 250-300 HP		85", 350-400 HP	
ITEM	DESCRIPTION	QTY.	PART NUMBER	QTY.	PART NUMBER	QTY.	PART NUMBER	QTY.	PART NUMBER
1	DOOR ASSEMBLY, R.H.	1	465-02500	1	465-02502	1	465-02504	1	465-02506
2	DOOR ASSEMBLY, L.H.	1	465-02499	1	465-02501	1	465-02503	1	465-02505
3	ADHESIVE, GENERAL PURPOSE SPRAY	1	797-01813	1	797-01813	1	797-01813	1	797-01813
4	LOCKING LUG	30	103 00375	34	103 00375	36	103 00375	38	103 00375
5	WET FELT, 1/4" x 11-5/8"	71" LG.	872 00412	83" LG.	872 00412	95" LG.	872 00412	102" LG.	872 00412
6	INSULATING BOARD,1-1/2" THK.	12SF	872 01008	12SF	872 01008	24SF	872 01008	42SF	872 01008
7	PIN WELDING, #10 GA x 4" LG. SST.	66	903 00299	91	903 00299	88	903 00299	102	903 00299
8	CLIP, INSUL. RETAINER, 1-1/2" SQ., #10 GA. SST.	74	828 00034	99	828 00034	98	828 00034	114	828 00034
9	INSULATING BLANKET, 1" THK. X 6"	20" LG.	872 00362	21" LG.	872 00362	24" LG.	872 00362	26" LG.	872 00362
10	PIN WELDING, #10 GA x 5" LG. SST.	8	903 00298	8	903 00298	10	903 00298	12	903 00298
11	ROPE, FIBERFAX, 1/2"DIA.	240" LG.	872 00622	252" LG.	872 00622	288" LG.	872 00622	340" LG.	872 00622
12	HINGE DETAIL	2	462 00025	2	462 00025	2	462 00025	2	462 00026
13	STUD, 1/2"x 2"	32	841 00331	37	841 00331	39	841 00331	41	841 00331
14	INSUL. BLANKET, 1" x 3"	60" LG.	872 00362	64" LG.	872 00362	76" LG.	872 00362	82" LG.	872 00362
15	WIRE MESH, 1/2"MESH, .047" WIRE, 6"	9" LG.	930 00135	10" LG.	930 00135	11" LG.	930 00135	14" LG.	930 00135
16	CHANNEL, 1 1/2"x 1/2"x 1/8"x 4.00"	2	149 00917	2	149 00917	2	149 00917	3	149 00917
17	BRASS NUT, 1/2"	32	869 00029	37	869 00029	39	869 00029	41	869 00029
18	FLATWASHER, 1/2"	32	952 00108	37	952 00108	39	952 00108	41	952 00108
19	INSULATION, CAULK- TUBE	1	872 00757	1	872 00757	1	872 00757	1	872 00757
20	INSULATNG BOARD, 1-1/2"THK.x 24" x 36"	4	872 00792	4	872 00792	8	872 00792	7	872 00792
* 21	FLUE GAS INLET FLANGE (SEE NOTE)	1	029A2027	1	029A2027	1	**SEE NOTE	1	029A2027

NOTE: * ITEM 21 USED WITH FGR ONLY.
** ITEM 21 P/N WITH FGR FOR 78" DIA BOILERS:
6" FGR USE P/N 029A02027.
8" FGR USE P/N 029A02022.



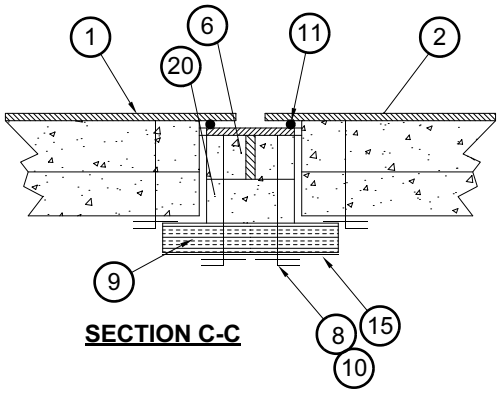
FRONT VIEW



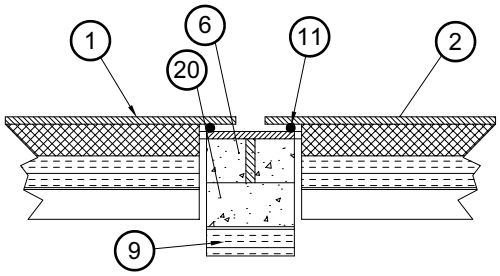
SECTION A-A

SIDE VIEW

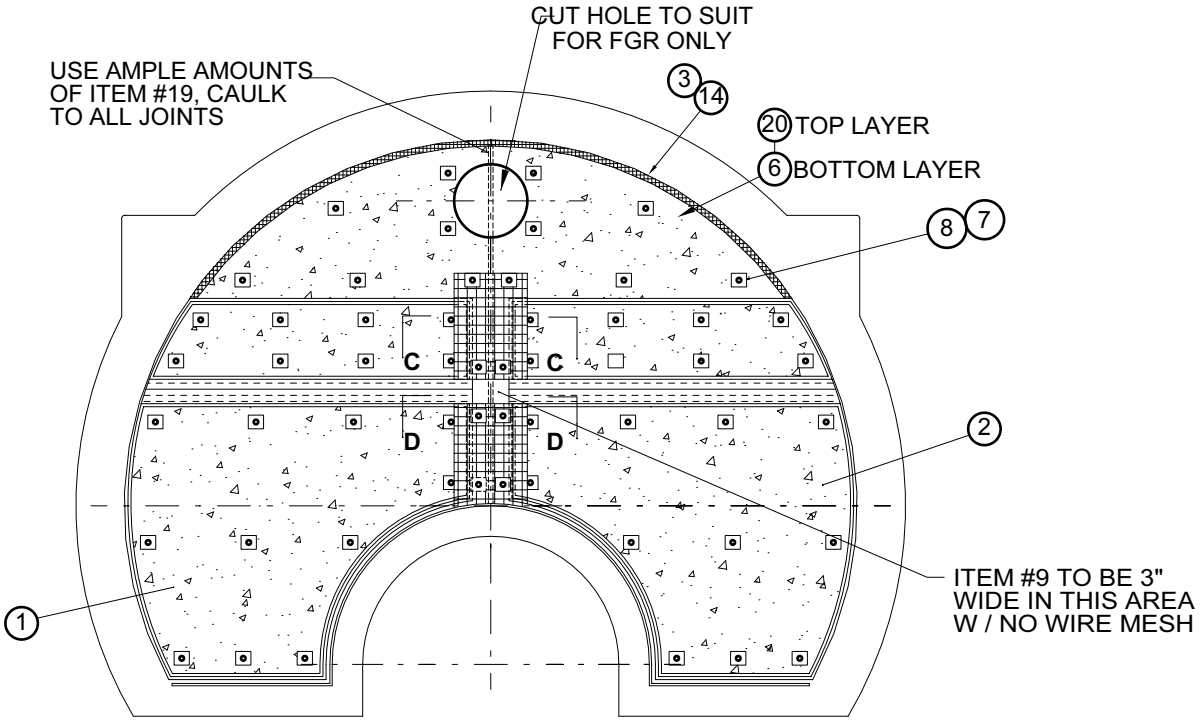
FRONT DOOR & SMOKEBOX, 60"-85", 100-400 HP



SECTION C-C



SECTION D-D



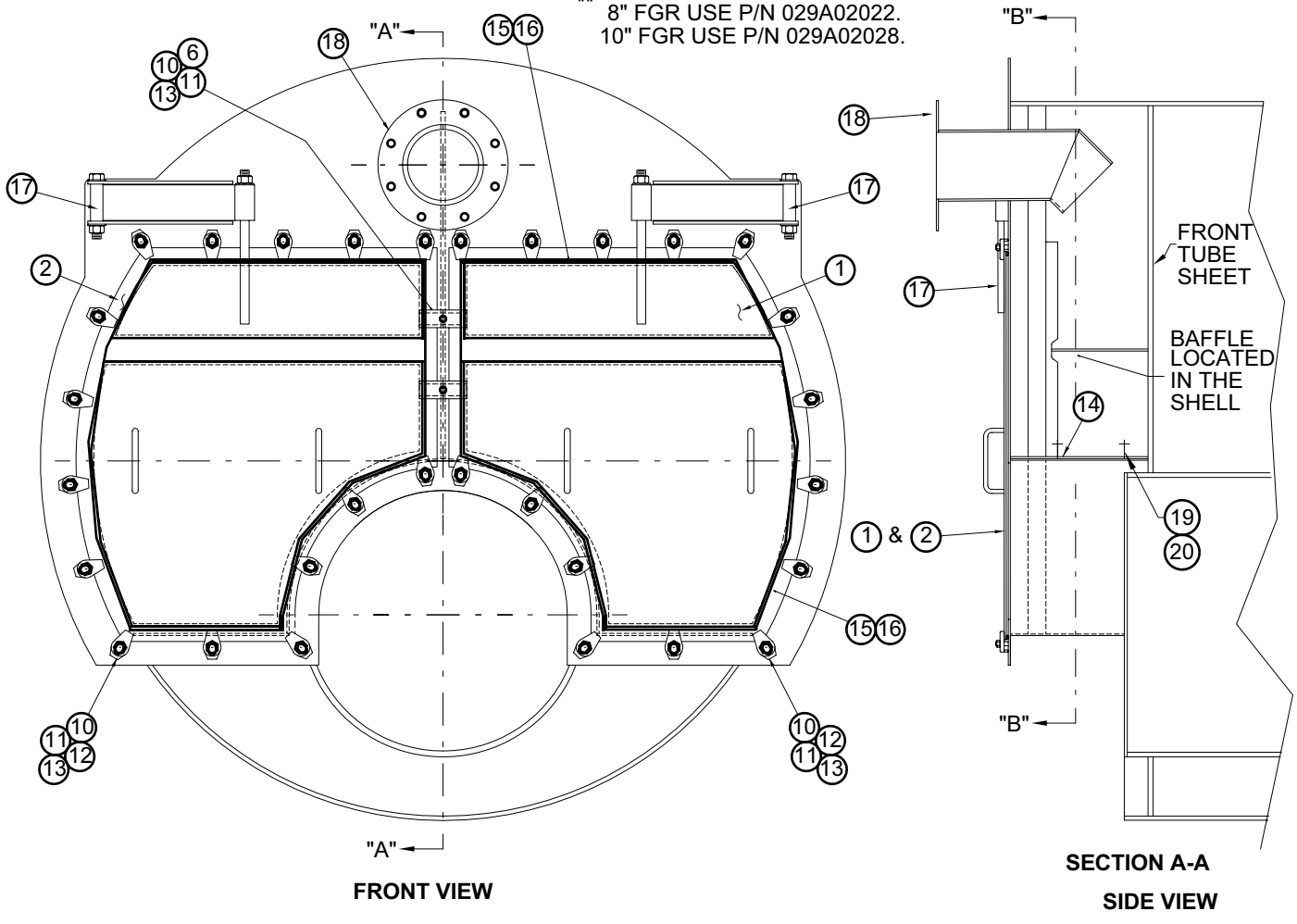
SECTION B-B

REAR VIEW

FRONT DOOR & SMOKEBOX, 96"-106", 500-800 HP

BILL OF MATERIAL					
		96", 500-600 HP		106", 700-800 HP	
ITEM	DESCRIPTION	QTY.	PART NUMBER	QTY.	PART NUMBER
1	DOOR ASSEMBLY, R.H.	1	465 002508	1	465 02510
2	DOOR ASSEMBLY, L.H.	1	465 002507	1	465 02509
3	INSULATING BLANKET, 1" THK. x 6"	14" LG.	872 00362	28" LG.	872 00362
4	PIN WELDING, #10 GA x 5" LG. SST.	8	903 00298	10	903 00298
5	WIRE MESH, 1/2"MESH, .047" WIRE, 6"	14" LG.	930 00135	19" LG.	930 00135
6	CHANNEL, 1 1/2" x 1/2" x 1/8" x 4"	3	149-00917	4	149-00917
7	WIRE MESH, 1/2" x 1/2", 19 GA., 304S.S.	32 SF	930-00135	32 SF	930-00135
8	RIGIDIZER	6 oz	872-00443	32 oz	872-00443
9	INSUL. BLANKET,1-1/2" x (DBL. LAYERED)	64 SF	872-00678	83 SF	872-00678
10	STUD, 1/2"-13UNC x 2"	49	841-00331	50	841-00331
11	NUT, 1/2"-13UNC, BRASS	49	869-00029	50	869-00029
12	LOCKING LUG	46	103-00375	46	103-00375
13	WASHER, 1/2", PLAIN.	49	952-00108	50	952-00108
14	WET FELT, 16-1/4"	116" LG.	872-00412	128" LG.	872-00412
15	ROPE, 1/2"	370" LG.	872-00622	392" LG.	872-00622
16	SUPER TACK ADHESIVE	1	797-01813	1	797-01813
17	HINGE DETAILS	2	462-00026	2	462-00058
* 18	FGR INLET DUCT (SEE NOTE)	1	** SEE NOTE	1	029A02028
19	PIN, WELDING, DOUBLE POINTED #10 GA. x 4" LG, SST.	116	903-00299	154	903-00299
20	CLIP, INSUL. RETAINER, 1-1/2" SQ., #10GA. SST.	124	828-00034	164	828-00034

NOTE: * ITEM 18 USED WITH FGR ONLY.
** ITEM 18 P/N WITH FGR FOR 96" DIA BOILERS:
8" FGR USE P/N 029A02022.
10" FGR USE P/N 029A02028.

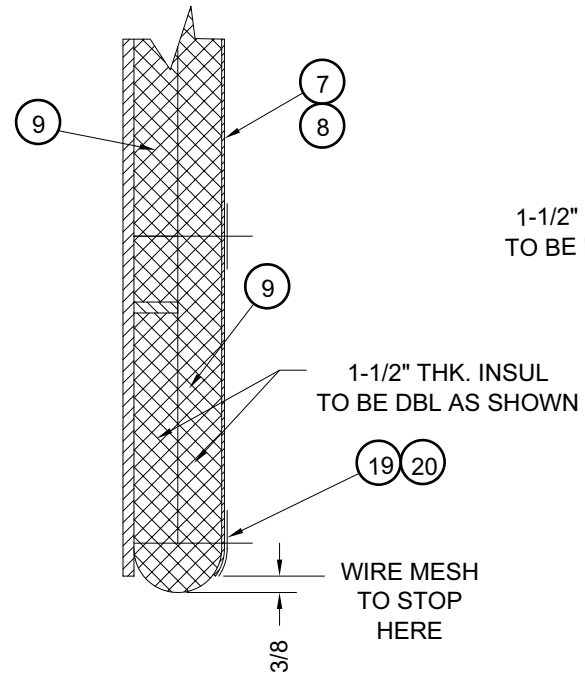


FRONT VIEW

SECTION A-A

SIDE VIEW

FRONT DOOR & SMOKEBOX, 96"-106", 500-800 HP



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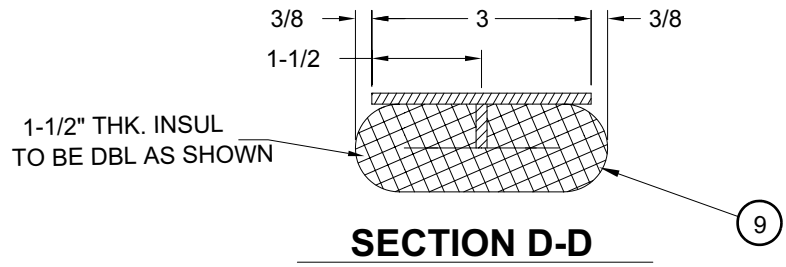

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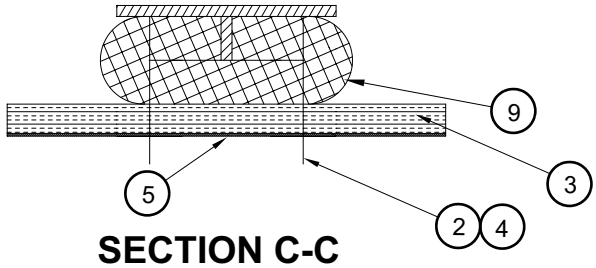
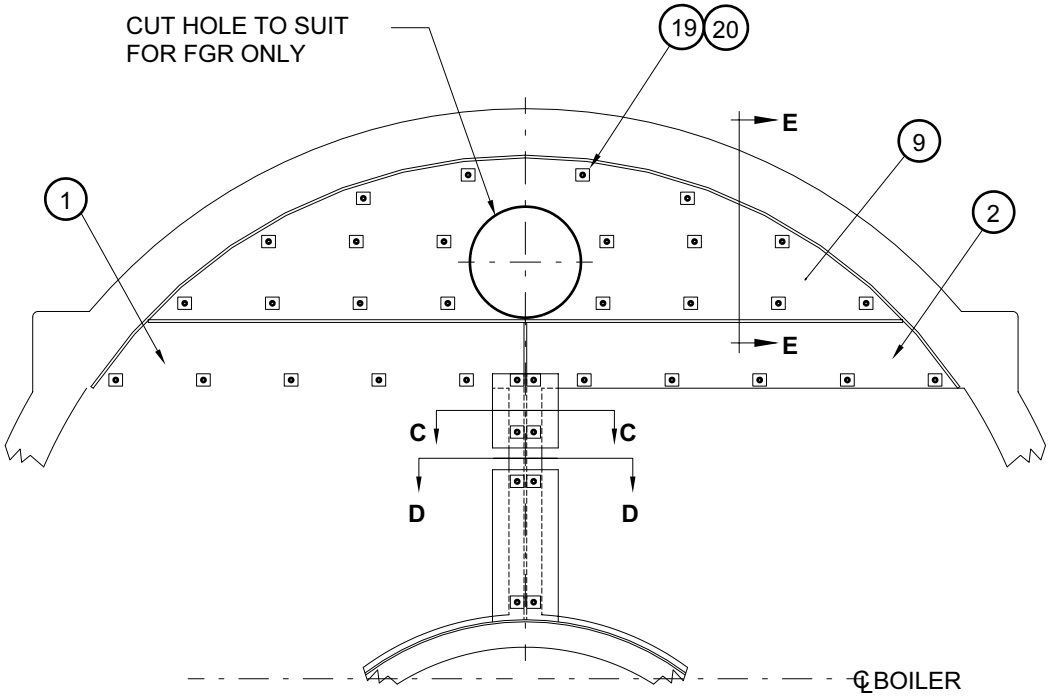


SECTION C-C

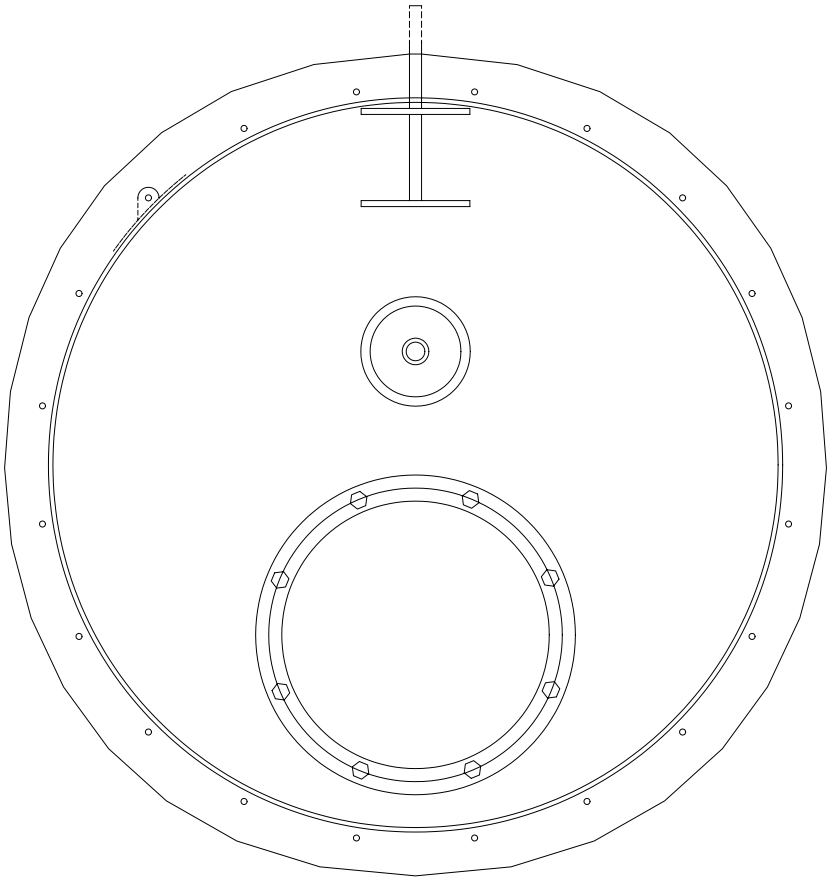


SECTION B-B

REAR VIEW

REAR DOOR INSULATED ASSEMBLY

BOILER DIA	REAR DOOR INSULATED	PART NO
60"	WITHOUT COMBUSTION DOOR	457-03445
	WITH COMBUSTION DOOR	457-03446
67"	WITHOUT COMBUSTION DOOR	457-03441
	WITH COMBUSTION DOOR	457-03442
78"	WITHOUT COMBUSTION DOOR	457-03449
	WITH COMBUSTION DOOR	457-03450
85"	WITHOUT COMBUSTION DOOR	457-03453
	WITH COMBUSTION DOOR	457-03454
96"	WITHOUT COMBUSTION DOOR	457-03447
	WITH COMBUSTION DOOR	457-03448
106"	WITHOUT COMBUSTION DOOR	457-03451
	WITH COMBUSTION DOOR	457-03452

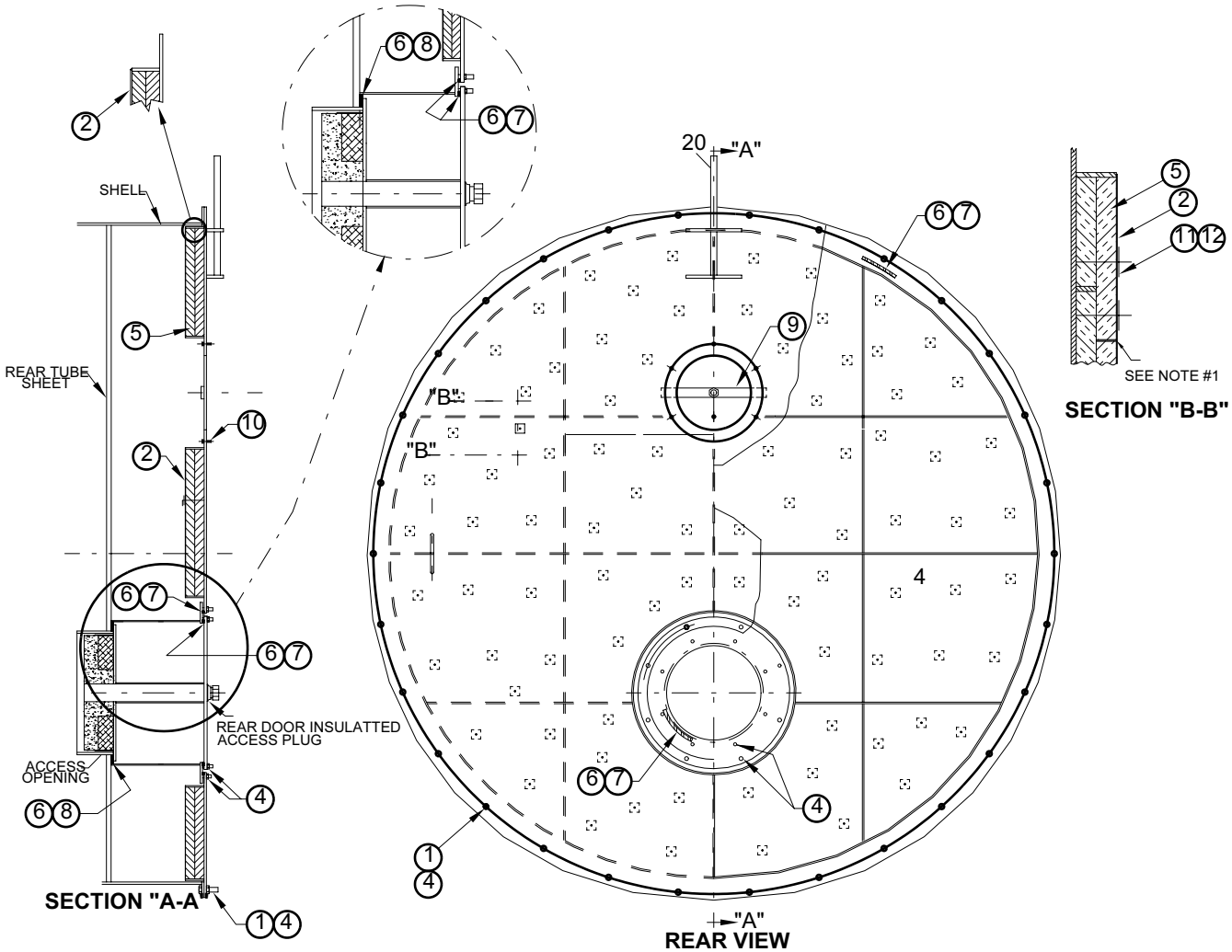


NOTE:

REAR DOOR INSULATED ACCESS PLUG NOT INCLUDED,
FOLLOWIG PAGE FOR PART NUMBER.

REAR DOOR INSULATION COMPONENT LIST

ITEM	QTY 60"	QTY 67"	QTY 78"	QTY 85"	QTY 96"	QTY 106"	PART NO.	DESCRIPTION
1	20	20	24	24	30	30	868-00102	BULT, HEX
2	58.75" DIA	65.75" DIA	76.75" DIA	83.75" DIA	94.75 DIA	104.75" DIA	930-00057	SCREEN
3	30 OZ	30 OZ	30 OZ	30 OZ	30 OZ	30 OZ	872-00443	RIGIDIZER
4	36	36	40	40	46	46	869-00029	NUT, HEX
5	38 SQ FT	47 SQ FT	71 SQ FT	78 SQ FT	100 SQ FT	123 SQ FT	872-00678	INSULATION
6	1	1	1	1	1	1	797-01813	ADHESIVE
7	350"	375"	432"	432"	466"	497"	872-00622	ROPE GASKET 1/2"
8	72"	72"	72"	72"	72"	72"	872-00651	ROPE GASKET 1"
9	1	1	1	1	1	1	004-00026	BAR, MOUNTING
10	6	6	6	6	6	6	868-00158	CAPSCREW, HEX
11	35	44	70	75	80	90	903-00182	PIN, WELDING
12	35	44	70	75	80	90	828-00039	CLIP, WELD PIN

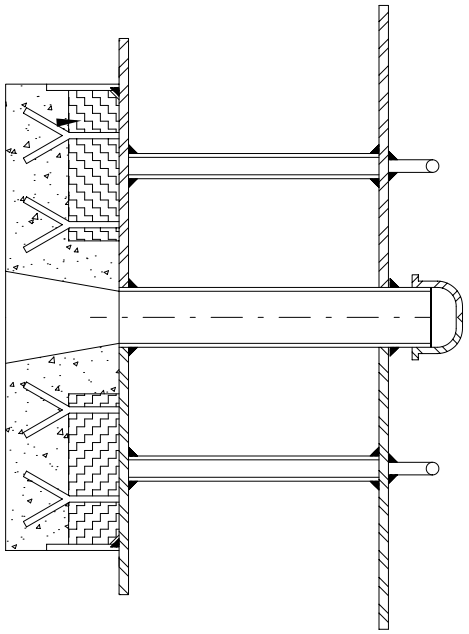


NOTES:

1. ALL SEAMS OF TOP LAYER OF INSULATION (ITEM #5) SHALL BE STAGGERED A MIN. OF 3" FROM ANY SEAMS OF BOTTOM LAYER OF ITEM #5.
2. COAT INSULATION (ITEM #5) WITH 3200 F RIGIDIZER (ITEM #3) MIXED WITH WATER TO A 50:50 SOLUTION, APPROXIMATELY 1/4" DEEP, AFTER SCREEN IS INSTALLED.

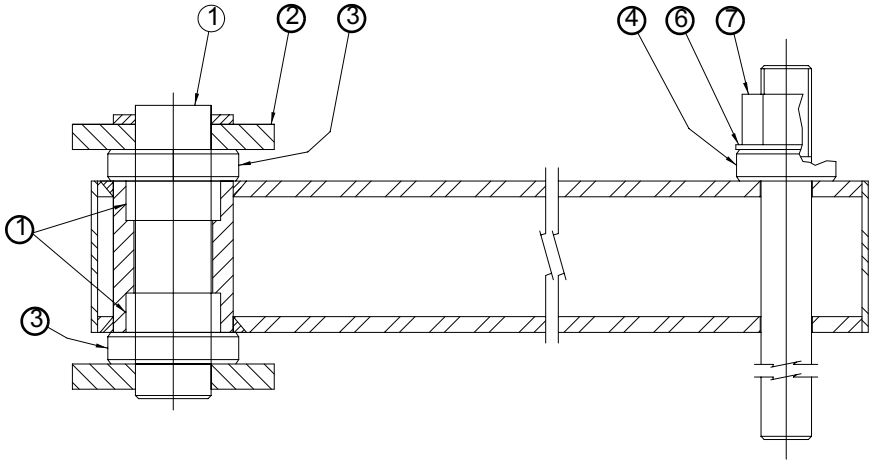
REAR DOOR INSULATED ACCESS PLUG

BOILER DIAMETER	PLUG ASSEMBLY PART NO.
60" & 67"	465-02389
78" & 85"	465-02372
96" & 106"	465-02380



REAR DOOR DAVIT PARTS LIST

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	135-03633	SIZED ROD	60" - 96"
	1	135-03634	SIZED ROD	106"
2	1	066-00573	RING, RETAINER, PEDESTAL PIN, REAR DOOR	ALL
3	2	807-00439	BEARING, BALL THRUST	ALL
4	1	807-00438	BEARING, BALL THRUST	ALL
5	2	807-00440	BEARING, NEEDLE ROLLER	ALL
6	1	952-00132	WASHER, FLAT, 1"	ALL
7	1	869-00157	NUT, SELF LOCKING HEX- 1"-8UNC	ALL



BURNER SELECTION/INSTALLATION 60"-106" 100-800 HP

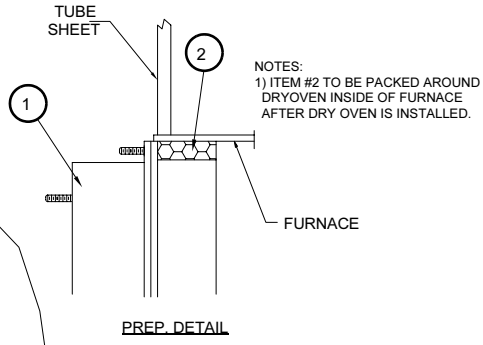
ITEM	QTY.	PART NUMBER	DESCRIPTION	
1	1	SEE TABLE	DRY OVEN	
2	1	872-00620	ROPE, 1/4"DIA. X 48" LG.	PROFIRE SERIES
		872-00500	BLANKET, INSUL., 1-1/2" X 10" X 139"	D/LND SERIES
3	1	872-00622	ROPE, 1/2"DIA. X 144" LG.	
4	1	SEE TABLE	BLANKET GASKET	
5	"A"	952-00094	LOCKWASHER, 1/2"	
6	"B"	869-00017	NUT,HEX., 5/8" - 11UNC	
7	"B"	952-00084	LOCKWASHER, 5/8"	
8	"A"	869-00015	NUT, HEX., 1/2" - 13UNC	

BOILER / BURNER CHART				ITEM #1		ITEM #4	"A"		"B"	
BOILER DIA.	BOILER (HP)	BURNER MODEL-SIZE		DRY OVEN		BLANKET GASKET				
		STANDARD	30 PPM	STANDARD	30 PPM	D/LND SERIES	STD	30 PPM	STD	30 PPM
60"	100	PROFIRE 3	LND-54S	059-07477	059-07419	032-91095	10	6	N/A	8
	125	PROFIRE 3	LND-63P	059-07477	059-07419	032-91095	10	6	N/A	8
67"	150	PROFIRE 3	LND-84P	059-07479	059-07392	032-91096	10	18	N/A	N/A
	200	PROFIRE 4	LND-105P	059-07480	059-07392	032-91096	10	18	N/A	N/A
78"	250	PROFIRE 4	LND-145S	059-07478	059-07409	032-91097	10	18	N/A	N/A
	300	PROFIRE 4	LND-145P	059-07478	059-07409	032-91097	10	18	N/A	N/A
85"	350	D145P	LND-175P	059-07578	059-07107	032-91098	6	18	N/A	N/A
	400	D175P	LND-210P	059-07107	059-07107	032-91098	6	18	N/A	N/A
96"	500	D210P	LND-252P	059-07575	059-07413	032-91099	6	6	N/A	12
	600	D252P	LND-300P	059-07413	059-07413	032-91099	6	6	12	12
106"	700	D300P	LND-378P	059-07307	059-07111	032-91132	6	6	12	12
	800	D378P	LND-420P	059-07111	059-07111	032-91132	6	6	12	12

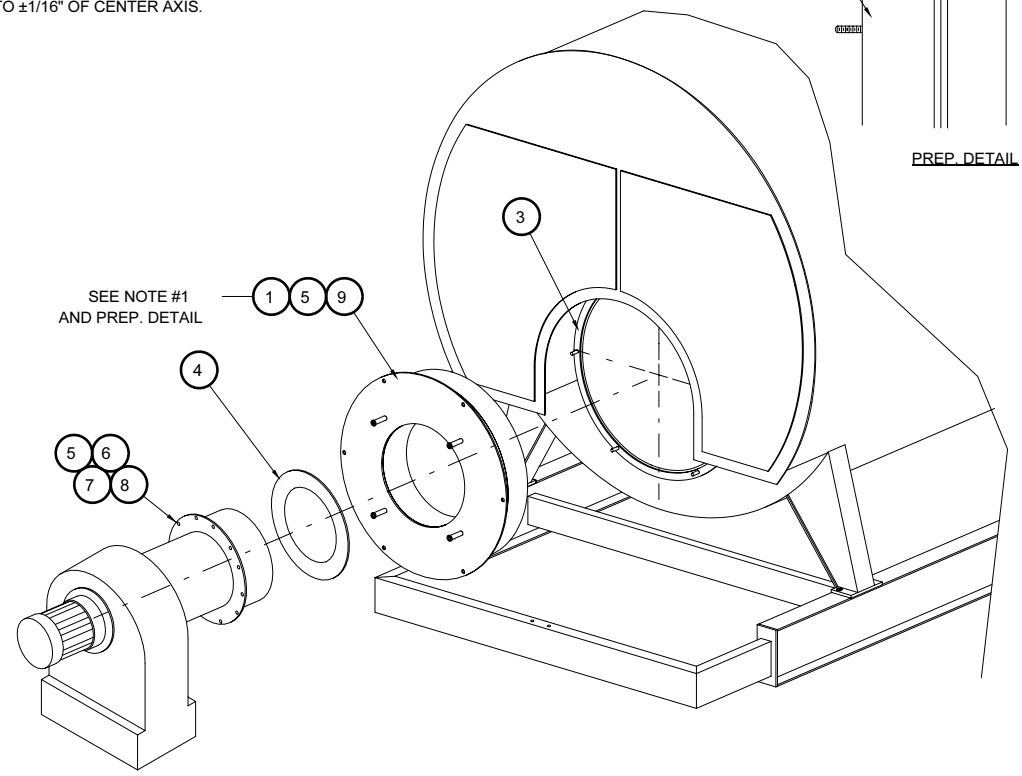
NOTES:

1. POSITION DRY OVEN SO THAT HOLES STADDLE VERTICAL CENTERLINE EQUALLY ON BURNER SIDE.

2. CENTER AXIS OF BURNER AND CENTER AXIS OF DRY OVEN MUST BE IN LINE WITH EACH OTHER, I.E. - INSIDE DIAMETER OF BURNER MOUNTING FLANGE AND INSIDE DIAMETER OF DRY OVEN REFRACTORY MUST BE CONCENTRIC TO ±1/16" OF CENTER AXIS.



PREP. DETAIL



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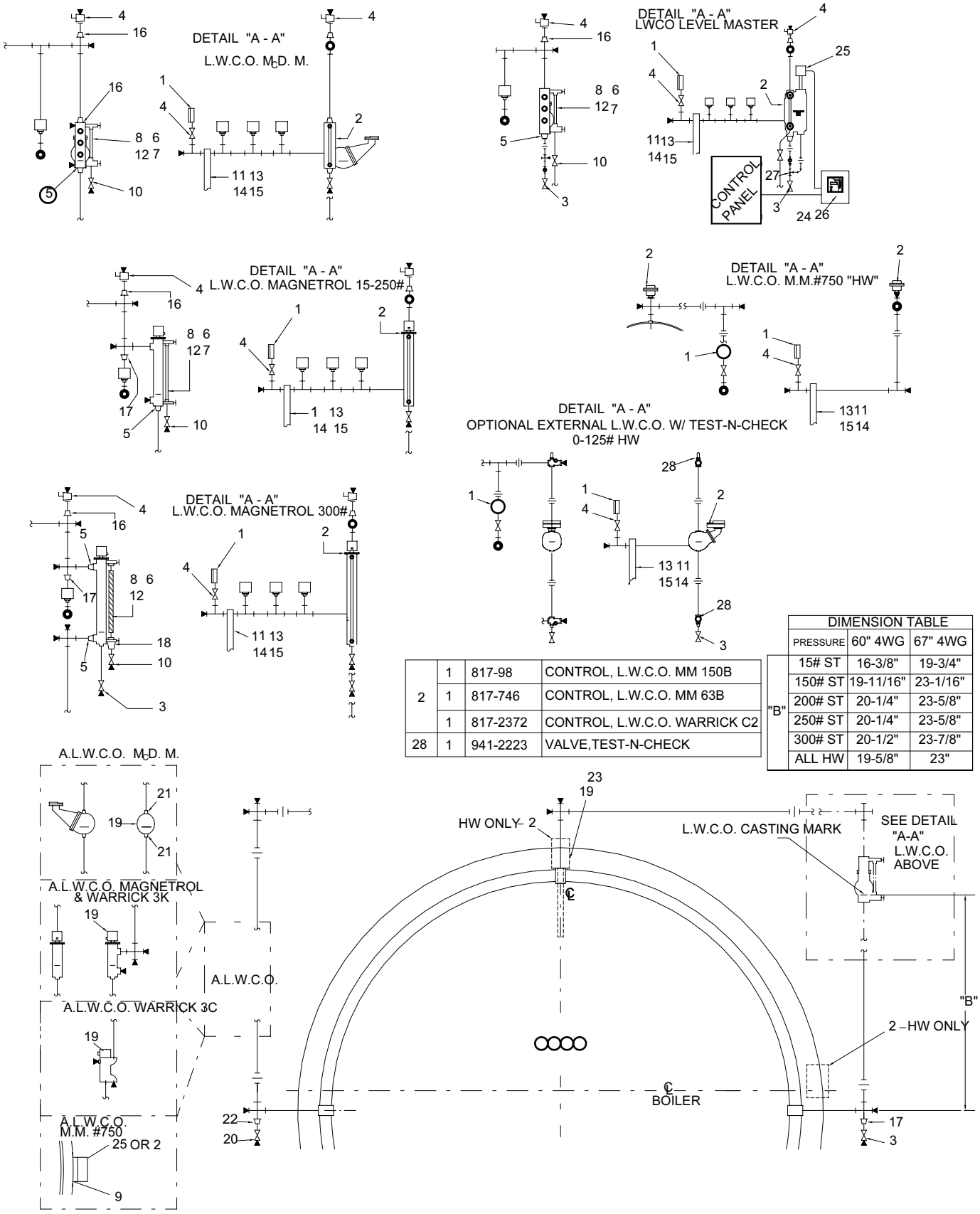
WATER COLUMN PIPING, 60"-67", 100-200 HP



2	1	817-98	CONTROL, L.W.C.O. MM 150B
	1	817-746	CONTROL, L.W.C.O. MM 63B
	1	817-2372	CONTROL, L.W.C.O. WARRICK C2
28	1	941-2223	VALVE,TEST-N-CHECK

DIMENSION TABLE		
PRESSURE	60" 4WG	67" 4WG
"B" 15# ST	16-3/8"	19-3/4"
150# ST	19-11/16"	23-1/16"
200# ST	20-1/4"	23-5/8"
250# ST	20-1/4"	23-5/8"
300# ST	20-1/2"	23-7/8"
ALL HW	19-5/8"	23"

WATER COLUMN PIPING, 60"-67", 100-200 HP

BILL OF MATERIAL					
ITEM	QTY	PART NO. McD. M.	PART NO. MAGNETROL	DESCRIPTION	USED ON
1	1	850-243		PRESSURE GAUGE , 4-1/2"	15# ST
	1	850-122		PRESSURE GAUGE , 4-1/2"	150-200# ST
	1	850-178		PRESSURE GAUGE , 4-1/2"	250# ST
	1	850-217		PRESSURE GAUGE , 4-1/2"	300# ST
	1	850-50		PRESSURE GAUGE , 4-1/2"	30# HW
	1	850-153		PRESSURE GAUGE , 4-1/2"	60# HW
	1	850-114		PRESSURE GAUGE , 4-1/2"	125# HW
	1	850-122		PRESSURE GAUGE , 4-1/2"	150# HW
2	1	817-2406	817-163	LOW WATER CUT-OFF	15# ST
	1	817-2406	817-163	LOW WATER CUT-OFF	150# ST
	1	817-303	817-163	LOW WATER CUT-OFF	200-250# ST
	1	————	817-1962	LOW WATER CUT-OFF	300# ST
	1	817-2305	CONTROL, WATER LEVEL PROBE TYPE, MDL. 750		ALL HW
	1	817-2306	REMOTE SENSOR, PROBE HOLDER, MDL. 750		
	1	067-871	ROD, ELECTRODE, 12"LG,FOR REMOTE SENSOR		
3	1	941-401		VALVE, GLOBE 3/4"	15-300# ST
4	2	825-31		COCK, UNION, BRASS	15-250# ST
	2	————	941-318	VALVE, GLOBE 1/4", BRONZE	300# ST
5	2	847-432	————	BUSHING 1-1/4" X 1"	150# ST CANADA ONLY
	2	847-472	————	BUSHING 1-1/4" X 1"	200-250# ST
	1	————	847-432	BUSHING 1-1/4" X 1"	15-150# ST
	1	————	847-472	BUSHING 1-1/4" X 1"	200-250# ST
	2	————	847-472	BUSHING 1-1/4" X 1"	300# ST
6	1	851-199	851-38	GAUGE GLASS	15-250# ST
	1	————	851-391	GAUGE GLASS	300# ST
7	4	912-85	————	ROD, GAUGE GLASS	15-250# ST
	2	————	912-38	ROD, GAUGE GLASS	15-250# ST
8	1	825-132		SET, GAUGE GLASS	15-200# ST
	1	825-352		SET, GAUGE GLASS	250# ST
	1	————	825-370	SET, GAUGE GLASS	300# ST
9	1	8-1152		BRACKET	M.M. #750
10	1	941-55		VALVE, GLOBE 1/4", BRONZE	15-150# ST
	1	941-318		VALVE, GLOBE 1/4", BRONZE	151-300# ST
11	1	8-A-868		BRACKET, PRESSURE CONTROL	15-300# ST
12	*	830-28		CHAIN SASH	250-300 ST
13	1	869-234		NUT & LOCKWASHER	15-300# ST

* - 6 FT ON 250#, 12 FT ON 300#.

LWCO W/ MODULATING SWITCH 193-7 & 194-7

15-150# ST	817-1100
200-250# ST	817-1211

LWCO W/ SWITCH FOR MOTORIZED FEED VALVE 158, 193, & 194

15# ST	817-781
150# ST	817-733
200-250# ST	817-304

OPTIONAL REPLACEMENT FOR ITEM 2

BILL OF MATERIAL					
ITEM	QTY	PART NO. 15-150#	PART NO. 200-250#	PART NO. 300#	DESCRIPTION	USED ON
14	1	928-44			CLAMP, ONE - HOLE	-
15	1	868-136			CAPSCREW HEX. HD. 1/4-20	-
16	1	847-424	847-467		BUSHING, RED. 1" X 1/4"	ALL ST
17	2	847-426	847-469		BUSHING, RED. 1" X 3/4"	MAGNETROL
	1	847-426	847-469		BUSHING, RED. 1" X 3/4"	ALL ST
18	1	-		847-612	BUSHING, RED. 1/2" X 1/4"	MAGNETROL
19	1	SEE TABLE			CONTROL, AUX. L.W.C.O.	
20	1	941-401			VALVE, GLOBE 3/4"	
21	2	847-432	847-472		BUSHING 1-1/4" x 1"	
22	1	847-426	847-469		BUSHING 1-1/4" x 3/4"	

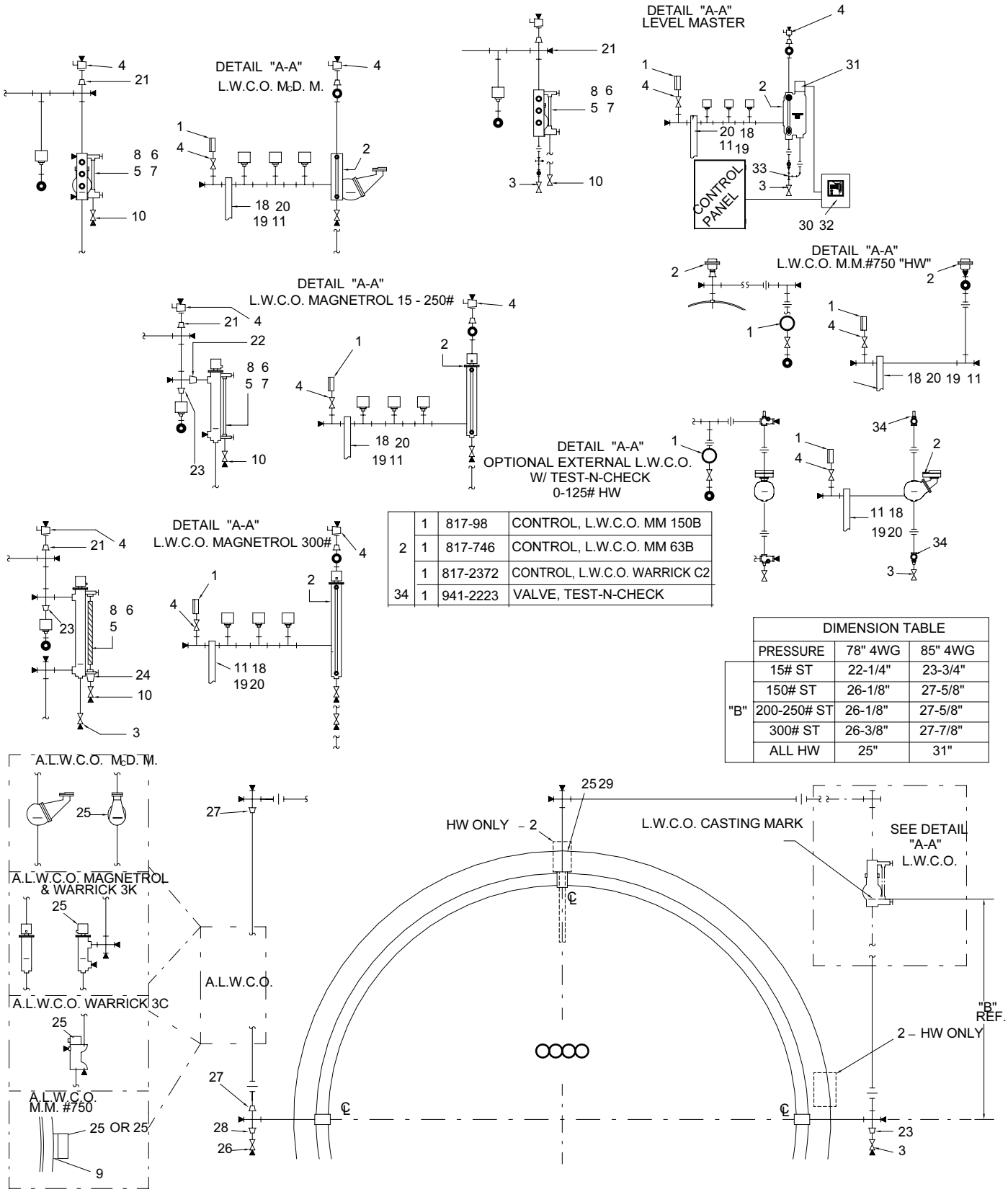
EXTERNAL A.L.W.C.O.					
M DCM.	19	1	817-2408	CONTROL, AUX. L.W.C.O. (AUTO RESET)	15#
		1	817-2407	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	150#
		1	817-306	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	200-250#
MAGNETROL	19	1	817-301	CONTROL, AUX. L.W.C.O.	15-250#
		1	817-1251	CONTROL, AUX. L.W.C.O.	300#
WARRICK	19	1	817-2372	CONTROL, AUX. L.W.C.O. WARRICK 3C2A	15-250#
		1	817-820	CONTROL, AUX. L.W.C.O. WARRICK 3C3B	15-250#
		1	817-2259	CONTROL, AUX. L.W.C.O. WARRICK 3K3A	15-250#

INTERNAL A.L.W.C.O. (ABOVE 15# ONLY)					
WARRICK	19	1	817-740	CONTROL, AUX. L.W.C.O. WARRICK 3E2B	30#-200#
		1	817-1020	CONTROL, AUX. L.W.C.O. WARRICK 3E3B	30#-200#
		1	817-2305	CONTROL, AUX. L.W.C.O. MM 750-MT120	15#-250#
	23	2	817-2307	ROD,ELECTRODE, 1/4" DIA X 24" LG.	3E2B
		3	817-2307	ROD,ELECTRODE, 1/4" DIA X 24" LG.	3E3B
		1	817-2306	REMOTE SENSOR, PROBE HOLDER, McD. 750	
		1	817-2307	PROBE EXT.,24"LG,FOR REMOTE SENSOR, McD. 750	

LEVEL MASTER EQUIPMENT STANDARD FOR 150-250 PSI STEAM CB				
2	1	289-154	LOW WATER CUTOFF	15-250#
3	1	941-402	VALVE, GLOBE, 1" NPT	15#-250#
6	1	851-199	GAUGE GLASS	15#-250#
7	1	912-85	ROD, GAUGE GLASS	15#-250#
17	1	847-472	BUSHING, 1-1/4" X 1"	15#-250#
24	1	623-116	LEVEL MASTER CONTROL PANEL	15#-250# A.R.
	1	623-117		15#-250# M.R.
25	1	623-163	LEVEL MASTER PROBE	15#-250#
26	1	8-3267	BRACKET	15#-250#
27	1	847-279	RDCR. TEE, 1" x 1" x 1/2"	15#-150#
	1	847-986		151#-250#

NOTE 1.
IF REFLEX GAUGE GLASS IS REQ`D REPLACE LWCO P/N 289-154 W/ 289-155 AND USE P/N 851-389 AND 825-369.
2. FOR ALL OTHER TRIM REFER TO STANDARD BOM

WATER COLUMN PIPING, 78"-85", 250-400 HP



2	1	817-98	CONTROL, L.W.C.O. MM 150B
	1	817-746	CONTROL, L.W.C.O. MM 63B
	1	817-2372	CONTROL, L.W.C.O. WARRICK C2
34	1	941-2223	VALVE, TEST-N-CHECK

DIMENSION TABLE			
	PRESSURE	78" 4WG	85" 4WG
"B"	15# ST	22-1/4"	23-3/4"
	150# ST	26-1/8"	27-5/8"
	200-250# ST	26-1/8"	27-5/8"
	300# ST	26-3/8"	27-7/8"
	ALL HW	25"	31"

WATER COLUMN PIPING, 78"-85", 250-400 HP

BILL OF MATERIAL					
ITEM	QTY	PART NO. M.D. M.	PART NO. MAGNETROL	DESCRIPTION	USED ON
1	1	850-230		PRESSURE GAUGE- 6"	15 ST
	1	850-222		PRESSURE GAUGE- 6"	150-200 ST/150 HTHW
	1	850-320		PRESSURE GAUGE- 6"	250 ST
	1	850-400		PRESSURE GAUGE- 6"	300 ST
	1	850-223		PRESSURE GAUGE- 6"	30 HW
	1	850-221		PRESSURE GAUGE- 6"	125 HW
2	1	817-621	817-163	LOW WATER CUT-OFF	15 ST
	1	817-2405	817-163	LOW WATER CUT-OFF	150 ST
	1	817-303	817-163	LOW WATER CUT-OFF	200 - 250ST
	1	-	817-1962	LOW WATER CUT-OFF	300ST
	1	817-2305		CONTROL, WATER LEVEL PROBE TYPE, MDL. 750	ALL HW
	1	817-2306		REMOTE SENSOR, PROBE HOLDER, MDL. 750	
	1	067-871		ROD, ELECTRODE., 12"LG, FOR REMOTE SENSOR	
3	1	941-401		VALVE, GLOBE 3/4"	15-250 ST
	2	941-401		VALVE, GLOBE 3/4"	300 ST
4	2	825-31	————	COCK, UNION, BRASS	15-250 ST
	2	941-318	————	GLOBE,VALVE	300 ST.
5	9FT	830-28		CHAIN SASH	15-300 ST
6	1	851-44	851-38	GAUGE, GLASS	15-150 ST
	1	851-199	851-38	GAUGE, GLASS	200-250 ST
	1	---	851-391	GAUGE, GLASS	300 ST
7	4	912-34	912-34	ROD, GAUGE GLASS	15-150 ST ONLY
	4	912-85	912-34	ROD, GAUGE GLASS	200-250 ST
8	1	825-132		SET, GAUGE GLASS	15-200 ST
	1	825-352		SET, GAUGE GLASS	250 ST
	1	---	825-370	SET, GAUGE GLASS	300 ST
9	2	8-1152		BRACKET	M.M. #750
10	1	941-55		VALVE, BALL 1/4"	15-200 ST
	1	941-318		VALVE, GLOBE 1/4"	250-300 ST
11	1	971-13		FLAT BAR, 1/8" x 1" x 36"	15-300 ST
ITEMS 12 THRU 17 ARE NOT USED					
18	1	869-234		NUT & LOCKWASHER 1/4"	-
19	1	928-44		ONE-HOLE CLAMP	-
20	1	868-136		CAPSCREW HEX. HD. 1/4-20	-
21	1	847-428	847-470	BUSHING 1-1/4" x 1/4"	ALL ST
22	1	847-432	847-472	BUSHING 1-1/4" x 1"	MAGNETROL
23	1	847-431	847-471	BUSHING 1-1/4" x 3/4"	ALL ST
	2	847-431	847-471	BUSHING 1-1/4" x 3/4"	MAGNETROL
24	1	847-612		BUSHING 1/2" X 1/4"	300# ONLY
25	1	SEE TABLE		CONTROL, AUX. L.W.C.O.	-
26	1	941-401		VALVE, GLOBE 3/4"	15-300#
27	2	847-432		BUSHING 1-1/4" x 1"	15-150#
	2	847-472		BUSHING 1-1/4" x 1"	200-300#
28	1	847-431		BUSHING 1-1/4" x 3/4"	15-150#
	1	847-471		BUSHING 1-1/4" x 3/4"	200-300#

LEVEL MASTER EQUIPMENT				
2	1	289-155	LOW WATER CUTOFF	15-250#
3	1	941-402	VALVE, GLOBE, 1" NPT	15#-250#
6	1	851-44	GAUGE GLASS	15#-250#
7	1	912-34	ROD, GAUGE GLASS	15#-250#
23	1	847-472	BUSHING, 1-1/4" X 1"	15#-250#
30	1	623-116	LEVEL MASTER CONTROL PANEL	15#-250# AUTO RESET
	1	623-117		15#-250# MANUAL RESET
31	1	623-163	LEVEL MASTER PROBE	15#-250#
32	1	8-3267	BRACKET	15#-250#
33	1	847-279	RDCR. TEE, 1" x 1" x 1/2"	15-150#
	1	847-986		151#-250#
NOTE 1. FOR REFLEX GAUGE GLASS USE P/N 851-389 AND 825-369. 2. FOR ALL OTHER TRIM REFER TO STANDARD BOM				

EXTERNAL A.L.W.C.O.					
M.D. M.	25	1	817-2408	CONTROL, AUX. L.W.C.O. (AUTO RESET)	15#
		1	817-2407	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	150#
		1	817-306	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	200-250#
MAGNETROL	25	1	817-301	CONTROL, AUX. L.W.C.O.	15-250#
		1	817-1251	CONTROL, AUX. L.W.C.O.	300#
WARRICK	25	1	817-2372	CONTROL, AUX. L.W.C.O. WARRICK 3C2A	15-250#
		1	817-820	CONTROL, AUX. L.W.C.O. WARRICK 3C3B	15-250#
		1	817-2259	CONTROL, AUX. L.W.C.O. WARRICK 3K3A	15-250#

INTERNAL A.L.W.C.O. (ABOVE 15# ONLY)					
WARRICK	25	1	817-740	CONTROL, AUX. L.W.C.O. WARRICK 3E2B	30#-200#
WARRICK		1	817-1020	CONTROL, AUX. L.W.C.O. WARRICK 3E3B	30#-200#
M.D. M.		1	817-2305	CONTROL, AUX. L.W.C.O. MM 750MT-120	15#-250#
	29	2	67-873	ROD, ELECTRODE, 1/4" DIA X 24" LG.	3E2B
		3	67-873	ROD, ELECTRODE, 1/4" DIA X 24" LG.	3E3B

OPTIONAL REPLACEMENT FOR ITEM (2)

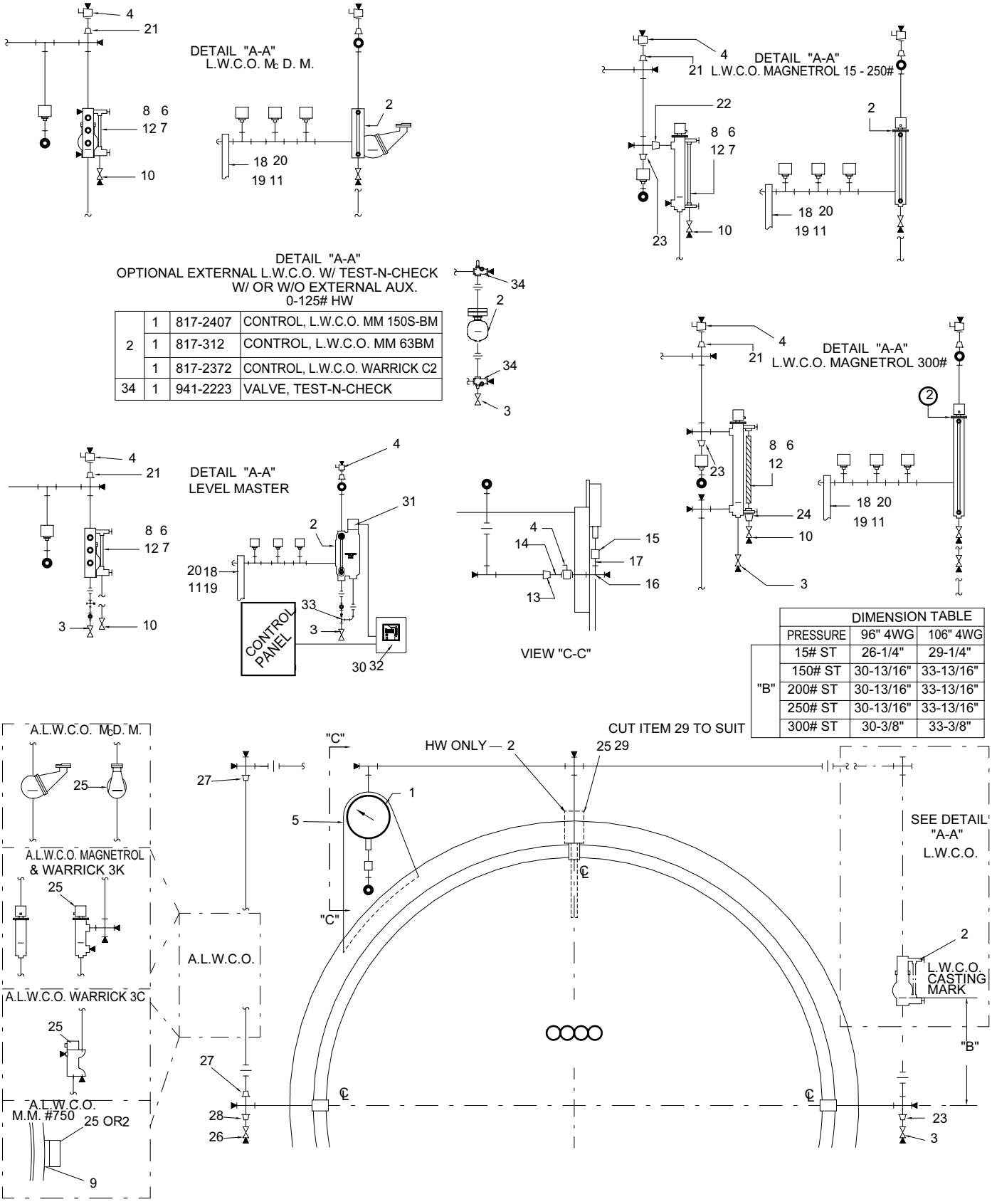
LWCO W/ MODULATING SWITCH 193-7 & 194-7

15-150# ST	817-1307
200-250# ST	817-1211

LWCO W/ SWITCH FOR MOTORIZED FEED VALVE 158, 193, & 194

15# ST	817-1161
150# ST	817-1155
200-250# ST	817-304

WATER COLUMN PIPING, 96"-106", 500-800 HP



2	1	817-2407	CONTROL, L.W.C.O. MM 150S-BM
	1	817-312	CONTROL, L.W.C.O. MM 63BM
	1	817-2372	CONTROL, L.W.C.O. WARRICK C2
34	1	941-2223	VALVE, TEST-N-CHECK

DIMENSION TABLE			
	PRESSURE	96" 4WG	106" 4WG
"B"	15# ST	26-1/4"	29-1/4"
	150# ST	30-13/16"	33-13/16"
	200# ST	30-13/16"	33-13/16"
	250# ST	30-13/16"	33-13/16"
	300# ST	30-3/8"	33-3/8"

WATER COLUMN PIPING, 96"-106", 500-800 HP

BILL OF MATERIAL					
ITEM	QTY	PART NO. McD. M.	PART NO. MAGNETROL	DESCRIPTION	USED ON
1	1	850-264		PRESSURE GAUGE- 8-1/2"	15 ST
	1	850-104		PRESSURE GAUGE- 8-1/2"	150-200 ST
	1	850-150		PRESSURE GAUGE- 8-1/2"	250 ST
	1	850-172		PRESSURE GAUGE- 8-1/2"	300 ST
	1	850-101		PRESSURE GAUGE- 8-1/2"	30# HW
	1	850-103		PRESSURE GAUGE- 8-1/2"	125# HW
	1	850-104		PRESSURE GAUGE- 8-1/2"	150# HTHW
2	1	817-621	817-163	LOW WATER CUT-OFF	15 ST
	1	817-2405	817-163	LOW WATER CUT-OFF	150 ST
	1	817-303	817-163	LOW WATER CUT-OFF	200-250 ST
	1	————	817-1962	LOW WATER CUT-OFF	300 ST
	1	817-2305		CONTROL, WATER LEVEL PROBE TYPE	ALL HW
	1	817-2306		REMOTE SENSOR, PROBE HOLDER	
	1	067-871		ROD, ELECTRODE., FOR REMOTE SENSOR	
3	1	941-401		VALVE, GLOBE 3/4"	15-250 ST
	2	941-401		VALVE, GLOBE 3/4"	300 ST
4	2	825-31	————	COCK, UNION, BRASS	15-250 ST
	2	————	941-318	VALVE, GLOBE 1/4", BRASS	300 ST
5	1	8-3340		BRACKET, STEAM GAUGE	STEAM ONLY
6	1	851-44	851-38	GAUGE, GLASS	15-150 ST
	1	851-199	851-38	GAUGE, GLASS	200-250 ST
	1	————	851-391	GAUGE, GLASS	300 ST
7	4	912-34	912-34	ROD, GAUGE GLASS	15-150 ST ONLY
	4	912-85	912-34	ROD, GAUGE GLASS	200-250 ST ONLY
8	1	825-352		SET, GAUGE GLASS	0-250 ST
	1	————	825-370	SET, GAUGE GLASS	300 ST
10	1	941-55		VALVE, BALL 1/4"	15-200 ST
	1	941-318		VALVE, GLOBE, 1/4"	250-300 ST
11	1	971-13		FLAT BAR, 1/8" x 1" x 36"	15-300 ST
12	*	830-28		CHAIN SASH	15-300 ST

ITEM	QTY	PART NO. 15-150#	PART NO. 200-250#	PART NO. 300#	DESCRIPTION	USED ON
13	1	847-1687	858-1009	858-1009	COUPLING 1" X 1/4"	-
14	1	857-448		857-726	BRASS NIPPLE, 1/4" x 1-1/2"	-
15	1	858-856		858-768	COUPLING 1/4" R.H. THREAD	-
16	1	859-54		859-32	BRASS TEE 1/4"	-
17	1	857-452		857-676	BRASS NPL. (X-HEAVY) 1/4" x 1-1/2"	-
18	1	869-234			NUT & LOCKWASHER 1/4"	-
19	1	928-44			ONE-HOLE CLAMP	-
20	1	868-136			CAPSCREW HEX. HD. 1/4-20 x 3/4"	-
21	1	847-428	847-470		BUSHING 1-1/4" x 1/4"	ALL ST
22	1	847-432	847-472	————	BUSHING 1-1/4" x 1"	MAGNETROL
23	1	847-431	847-471		BUSHING 1-1/4" x 3/4"	ALL ST
	2	847-431	847-471		BUSHING 1-1/4" x 3/4"	MAGNETROL
24	1	————		847-612	BUSHING 1/2" X 1/4"	MAGNETROL
25	1	SEE TABLE			CONTROL, AUX. L.W.C.O.	-
26	1	941-401			VALVE, GLOBE 3/4"	15-300#
27	2	847-432			BUSHING 1-1/4" x 1"	15-150#
	2	847-472			BUSHING 1-1/4" x 1"	200-300#
28	1	847-431			BUSHING 1-1/4" x 3/4"	15-150#
	1	847-471			BUSHING 1-1/4" x 3/4"	200-300#

* - 9FT. ON 78", 12FT. ON 96"

EXTERNAL A.L.W.C.O.					
McD. M.	25	1	817-2408	CONTROL, AUX. L.W.C.O. (AUTO RESET)	15#
		1	817-2407	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	150#
		1	817-306	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	200-250#
MAGNETROL	25	1	817-301	CONTROL, AUX. L.W.C.O.	15-250#
		1	817-1251	CONTROL, AUX. L.W.C.O.	300#
WARRICK	25	1	817-2372	CONTROL, AUX. L.W.C.O. WARRICK 3C2A	15-250#
		1	817-820	CONTROL, AUX. L.W.C.O. WARRICK 3C3B	15-250#
		1	817-2259	CONTROL, AUX. L.W.C.O. WARRICK 3K3A	15-250#

INTERNAL A.L.W.C.O. (ABOVE 15# ONLY)					
WARRICK	25	1	817-740	CONTROL, AUX. L.W.C.O. WARRICK 3E2B	30#-200#
WARRICK		1	817-1020	CONTROL, AUX. L.W.C.O. WARRICK 3E3B	30#-200#
McD. M.		1	817-2305	CONTROL, AUX. L.W.C.O. MM 750 MT-120	15#-200#
	29	2	67-873	ROD,ELECTRODE, 1/4" DIA X 24" LG.	3E2B
		3	67-873	ROD,ELECTRODE, 1/4" DIA X 24" LG.	3E3B
		1	817-2306	REMOTE SENSOR, PROBE HOLDER,	MDL. 750
		1	817-2383	PROBE EXT., 36"LG, FOR REMOTE SENSOR,	MDL. 750

LEVEL MASTER EQUIPMENT STANDARD FOR 150-250 PSI STEAM				
2	1	289-155	LOW WATER CUTOFF	15-250#
3	1	941-402	VALVE, GLOBE, 1" NPT	15#-250#
6	1	851-44	GAUGE GLASS	15#-250#
7	1	912-34	ROD, GAUGE GLASS	15#-250#
23	1	847-472	BUSHING, 1-1/4" X 1"	15#-250#
30	1	623-116	LEVEL MASTER CONTROL PANEL	15#-250# AUTO RESET
	1	623-117		15#-250# MANUAL RESET
31	1	623-163	LEVEL MASTER PROBE	15#-250#
32	1	8-3267	BRACKET	15#-250#
33	1	847-279	RDCR. TEE, 1" x 1" x 1/2"	15#-150#
	1	847-986		151#-250#
NOTE 1. FOR REFLEX GAUGE GLASS USE P/N 851-389 AND 825-369. 2. FOR ALL OTHER TRIM REFER TO STANDARD BOM				

OPTIONAL REPLACEMENT FOR ITEM 2

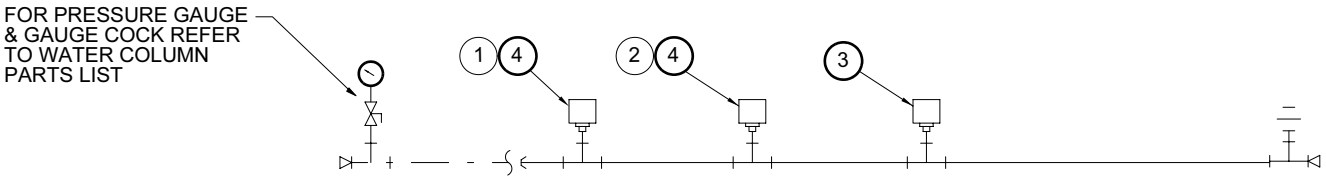
LWCO W/ MODULATING SWITCH 193-7 & 194-7

15-150# ST	817-1307
200-250# ST	817-1211

LWCO W/ SWITCH FOR MOTORIZED FEED VALVE 158, 193, & 194

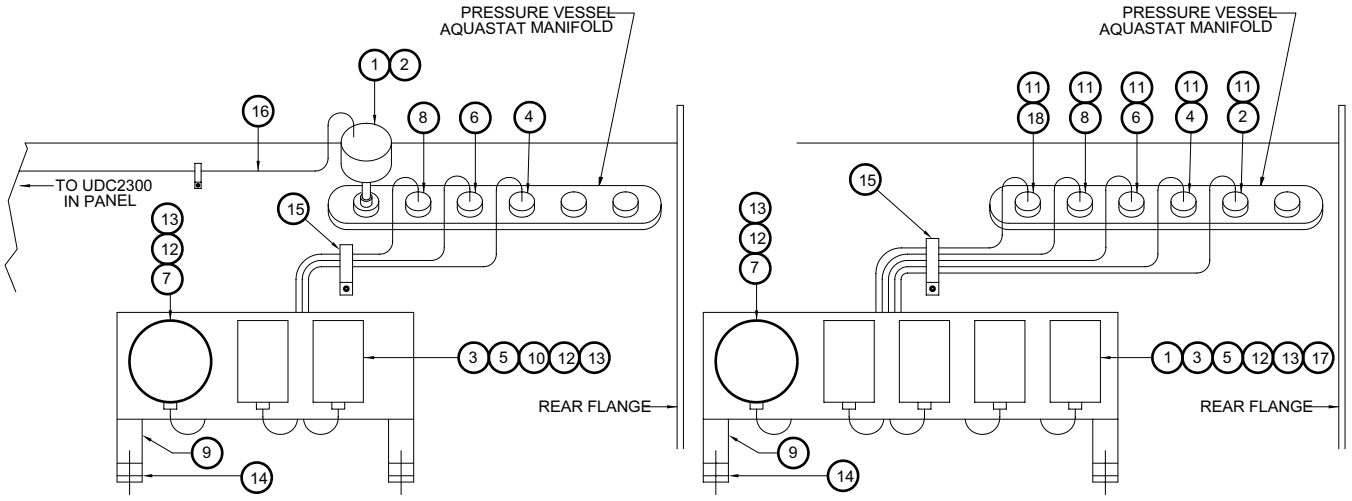
15# ST	817-1161
150# ST	817-1155
200-250# ST	817-304

STEAM PRESSURE CONTROLS, 60"-106", 100-800 HP



300#	151#- 250 #	16#- 150 #	15#	BILL OF MATERIAL				
PART NO.	PART NO.	PART NO.	PART NO.	ITEM	QTY	PART NO.	DESCRIPTION	USED ON
817-00111	817-00111	817-00110	817-00016	①	1	SEE TABLE	CONTROL PRESSURE (OLC)	-
817-00900	817-00900	817-00109	817-00415	②	1	SEE TABLE	CONTROL PRESSURE (HLC)	-
817-00234	817-00234	817-00204	817-00251	③	1	SEE TABLE	CONTROL PRESSURE (MC)	-
-	880-00605	-	-	④	2	SEE TABLE	LIMIT STOP ASSEMBLY	UL & / OR CSD-1

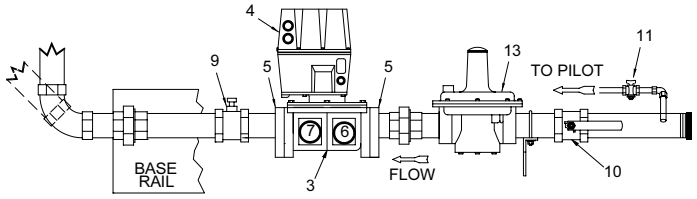
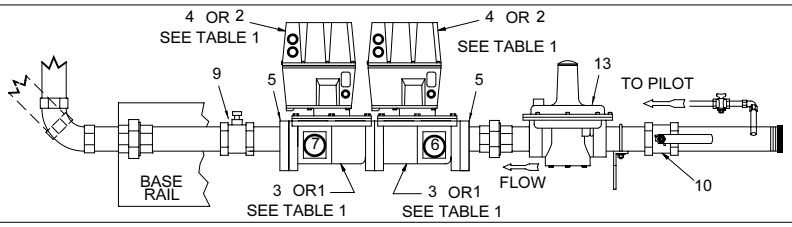
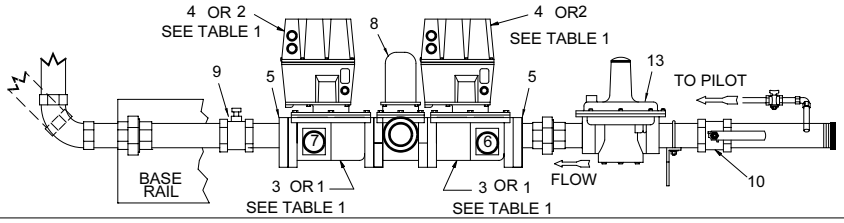
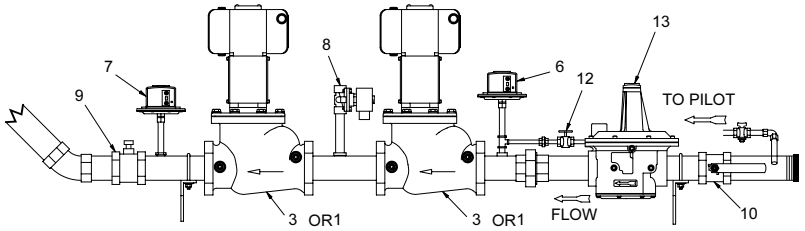
HOT WATER TEMPERATURE CONTROLS, 60"-106", 100-800 HP



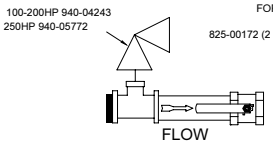
H.T.H.W. 30-125#

281-360 DEG F. HTHW	240-280 DEG F. HTHW	30-125# HW	BILL OF MATERIAL				
			ITEM	QTY	PART NO.	DESCRIPTION	USED ON
832-02091	832-02091	817-01244	1	1	SEE TABLE	TEMPERATURE CONTROL, MODULATING (MC)	-
937-00772	937-00772	817-00378	2	1	SEE TABLE	WELL, SEPARABLE	
817-01257	817-01281	817-02402	3	1	SEE TABLE	TEMPERATURE CONTROL, HIGH LIMIT (HLC)	-
817-00699	817-00699	817-00399	4	1	SEE TABLE	WELL, SEPARABLE	
817-00700	817-00698	817-00400	5	1	SEE TABLE	TEMPERATURE CONTROL, OPERATING LIMIT (OLC)	-
817-00699	817-00699	817-00399	6	1	SEE TABLE	WELL, SEPARABLE	
937-00710	937-00710	937-00787	7	1	SEE TABLE	THERMOMETER	60"-67", 100-200 HP
937-00673	937-00673	937-00027			SEE TABLE	THERMOMETER	78"-106", 250-800 HP
937-00658	937-00658	817-03103	8	1	SEE TABLE	WELL, SEPARABLE	60"-67", 100-200 HP
		817-00641			SEE TABLE	WELL, SEPARABLE	78"-106", 250-800 HP
008-00995	008-00995	008-00967	9	1	SEE TABLE	BRACKET, LIMIT CONTROLS	60"-67", 100-200 HP
008-00995	008-00995	008-00995			SEE TABLE	BRACKET, LIMIT CONTROLS	78"-106", 250-800 HP
008-01317	008-01317	-	10	2	SEE TABLE	MOUNTING BRACKET, MERCOID CONTROLS	-
-	-	5	11	SEE TABLE	847-00466	BUSHING, REDUCING, 3/4" x 1/2", F.S.	-
			12	9	860-00004	MACH. SCR. #10-32 x 3/4"	
			13	9	869-00009	NUT, MACH. SCR. #10-32	
			14	4	841-00571	SHT. MTL. SCR. #10-32 x 5/8"	
			15	1	928-00039	STRAP, PIPE	
			16	24 FT	950-00414	WIRE, THERMOCOUPLE, TYPE-J	-

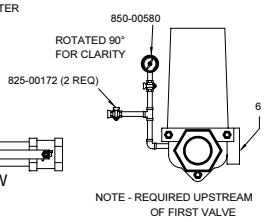
MAIN GAS TRAIN, 60"-106" 100-800 HP STANDARD, FM, IRI, & F&I INSURANCES

STD or FM		IRI or F&I		MAIN GAS TRAIN
BOILER HORSEPOWER	TRAIN SIZE	BOILER HORSEPOWER	TRAIN SIZE	
100	2"	-	-	
125-150 200-250	2" 2.5"	-	-	
300 350	2.5" 3"	100-150 200-300 350	2" 2.5" 3"	
400-800	3"	400-800	3"	

RELIEF VALVE
REQUIRED ON CSD-1 WHEN SUPPLY PRESSURE IS GREATER THAN 5 PSI.



PRESSURE GAUGE
REQUIRED FOR NFPA 8501



LEAKAGE TEST
REQUIRED FOR FM, F&I, OR CSD-1

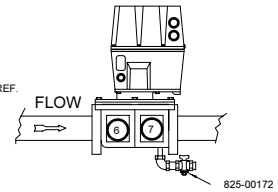


TABLE 1	MAIN GAS VALVE, & ACTUATOR QUANTITY REQUIREMENTS BY INSURANCE							
	STD		FM		IRI		F&I	
HORSEPOWER	STD	POC	STD	POC	STD	POC	STD	POC
100	-	1	-	1	2	-	2	-
125-250	1	1	1	1	1	1	1	1
300-800	1	1	-	2	1	1	-	2

NOTE-WHEN STD & POC ARE BOTH SUPPLIED MOUNT POC VALVE DOWNSTREAM OF STD VALVE

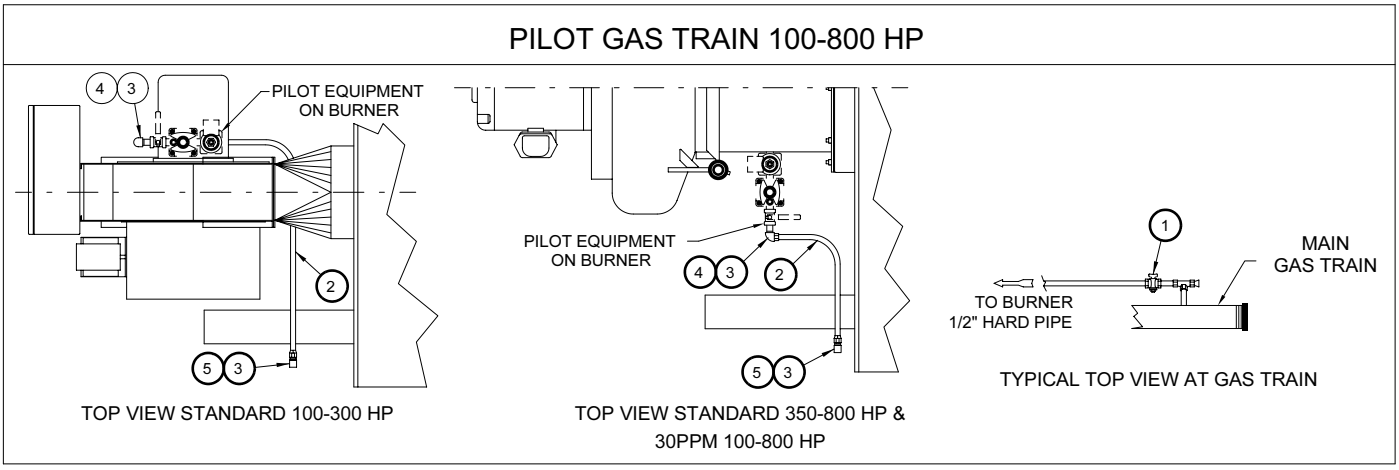
			MAIN GAS TRAIN SIZE				
			100-350 HP			400-500 & 800 HP	600-700 HP
ITEM	DESCRIPTION	QTY	2"	2.5"	3"	3"	3"
1	MAIN GAS VALVE (STD)	SEE TABLE 1	940-05812	940-05812	940-05812	949-00385	949-00385
2	ACTUATOR (STD)		945-00139	945-00139	945-00139	-	-
3	MAIN GAS VALVE (W/POC)		940-05813	940-05813	940-05813	949-00384	949-00384
4	ACTUATOR (W/POC)		945-00143	945-00143	945-00143	-	-
5	ADAPTER FLANGES	2	800-00083	800-00084	800-00085	-	-
6	LOW GAS PRESSURE SWITCH	1	SEE TABLE 2				
7	HIGH GAS PRESSURE SWITCH	1					
8	VENT VALVE (WHEN REQUIRED)	1	948-00345	948-00345	948-00345	948-00054	948-00054
9	MANUAL SHUTOFF VALVE	1	941-01947	941-00129	941-00130	941-00130	941-00130
10	MANUAL SHUTOFF VALVE	1	941-01947	941-00129	941-00130	941-00130	941-00129
11	GAS COCK	1	825-00030	825-00030	825-00030	825-00030	825-00030
12	NEEDLE VALVE (600-800 HP)	1	-	-	-	941-02156	941-02156
13	GAS PRESSURE REGULATOR	1	SEE TABLE 3				

TABLE 2		
ITEM	H.P.	P/N
6	100-150	817-02414
	200-350	817-02419
	400-600	817-02417
	700-800	817-02423
7	100-150	817-02421
	200-350	817-02415
	400-600	817-02416
	700-800	817-02418

TABLE 3		
ITEM	H.P.	P/N
10	100	918-00650
	125-150	918-0705
	200-250	918-0283
	300	918-00682
	350-500	918-00521
	600-700	918-00523
	800	918-00804

10 PSI. MAX INLET PRESSURE

PILOT GAS TRAIN, 60"-106" 100-800 HP STANDARD, FM, IRI, & F&I INSURANCES

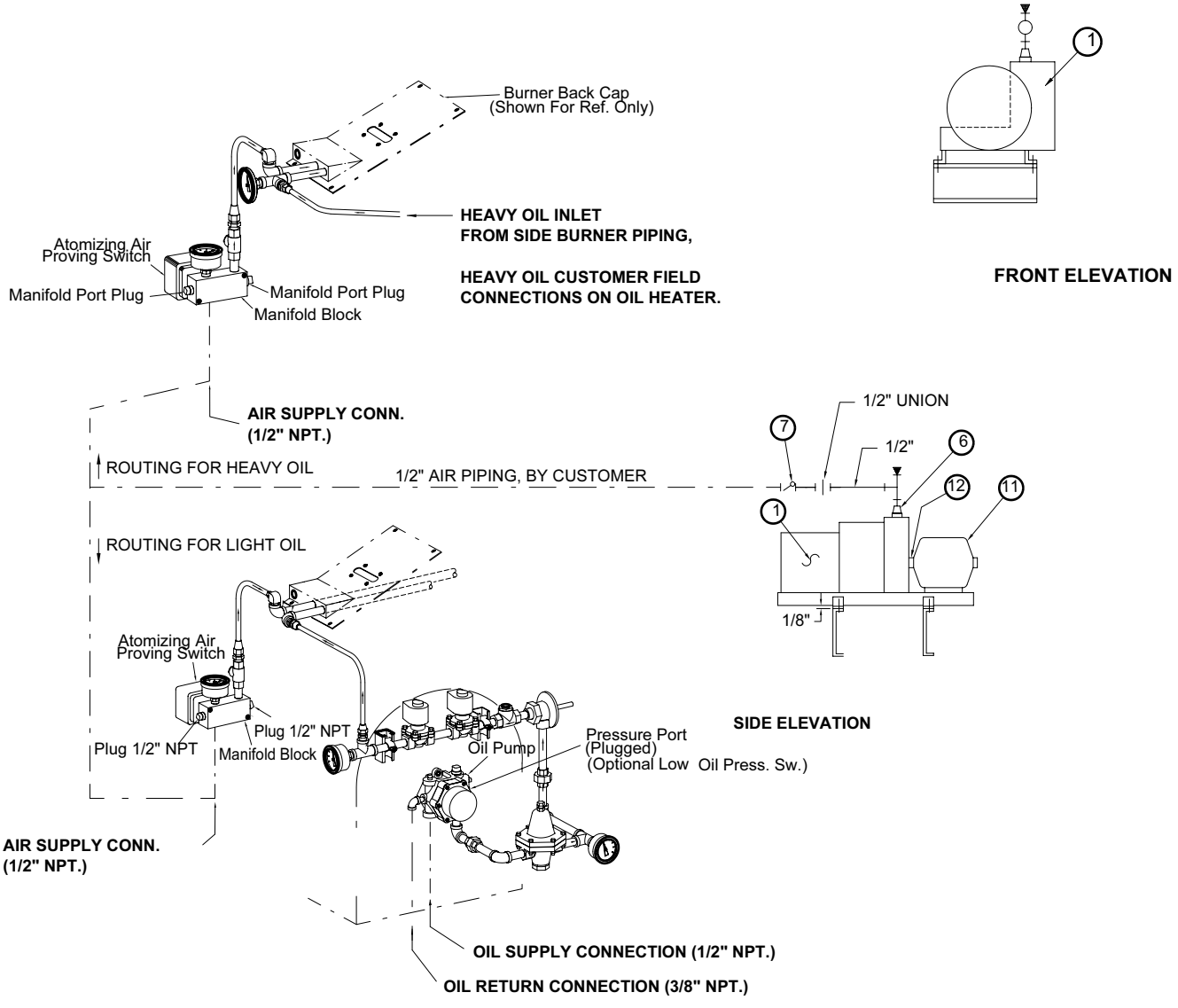


ITEM	P/N	DESCRIPTION	QTY
1	825-00030	GAS COCK	1
2	939-00265	TUBING, ALUMINUM	1
3	845-00224	NUT, SHORT, 45° FLARED	2
4	845-00313	ELBOW, MALE, ODT. x NPT.	1
5	845-00312	CONNECTOR, MALE, ODT. x NPT.	1

AIR OIL PIPING 60''-78'' 100-300HP

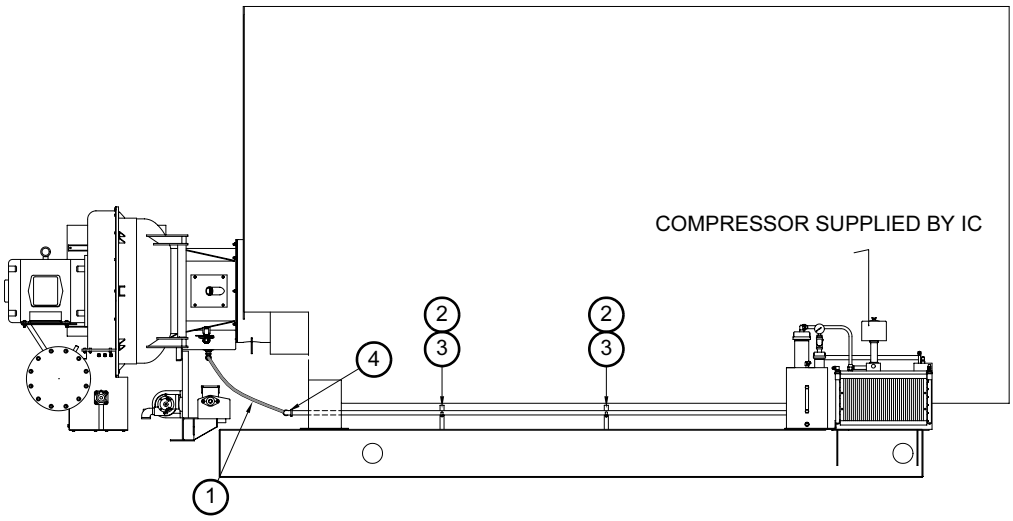
ITEM	QTY 60"	QTY 78"	PART NO.	DESCRIPTION	
1	1		615-23	COMPRESSOR ASSY 182T/184T	
6	1		847-56	BUSHING, RED. 1" X 1/2"	
7	1		940-2470	VALVE, HORIZONTAL LIFT CHECK	
11	1		SEE TABLE	MOTOR, 2 HP , 1200 SRPM,	60"
		1	SEE TABLE	MOTOR, 3 HP , 1800 SRPM	78"
12	1		819-00158	COUPLING, HALF	

	100-150HP			200-300HP		
ITEM	200-208V (60 HZ)	230/460V (60 HZ)	600V (60 HZ)	200-208V (60 HZ)	230/460V (60 HZ)	600V (60 HZ)
(11)	894-3661	894-3662	894-2788	894-3430	894-3653	894-3432

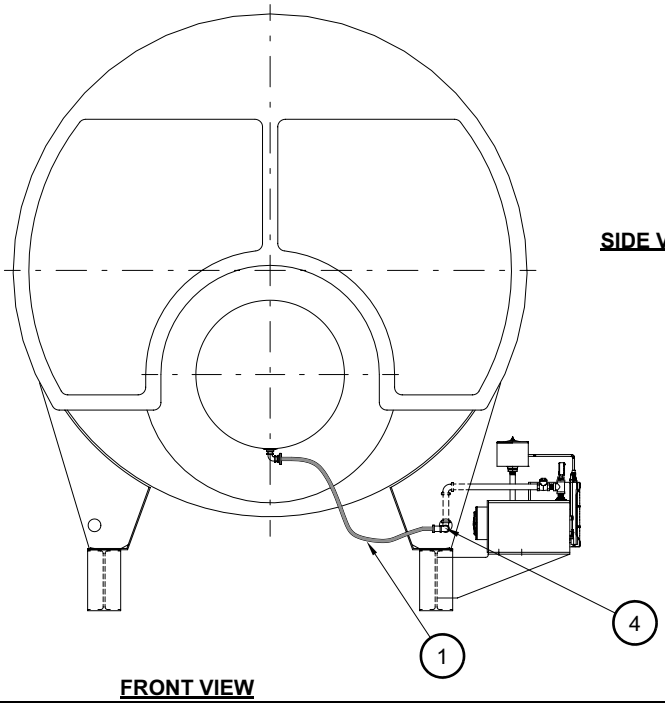


AIR COMPRESSOR PIPING 85'' - 106'' 350-800 HP

MATERIAL LIST			
ITEM	PART NUMBER	DESCRIPTION	QTY.
1	861-439	FLEX HOSE, 1/2" FEMALE UNION END x MALE NIPPLE END	1
2	8-753	BRACKET, AIR LINE	2
3	928-105	CLAMP	1
4	847-548	REDUCING ELBOW, 3/4" x 1/2"	1



SIDE VIEW



FRONT VIEW

AIR COMPRESSOR ASSEMBLY P/N 615-00023, 60-78", 100-300 HP

ITEM	REQ.	PART NO.	DESCRIPTION
1	1	003-01326	COMPRESSOR BASE ASSEMBLY
2	1	868 00157	CAPSCREW, HEXHEAD, 3/8"-16 UNC x 1-1/4" LG.
3	1	507 05637	TUBING ASSY, FINNED TUBING TO COMPRESSOR
4	1	538 00125	AIR OIL TANK ASSY.
5	1	505 00107	PUMP, AIR ASSEMBLY
6	1	651 00262	TUBING, FINNED
7	1	023 00124	CYLINDER, FINNED TUBING
8	4	056 00277	PIN, CYLINDER
9	1	819 00136	COUPLING, HALF, 1" BORE 1/4" W/ 1/8" KEYWAY
10	1	035 00322	COUPLING GUARD
11	1	858 00088	PIPE PLUG, 1/8"
12	1	857 00129	NIPPLE, 1/4" x 1-1/2" LG. SCH. 40
13	1	277 00171	ORIFICE-A, #55 DRILL
14	1	841 00060	KEY, 3/16" x 3/16" x 7/8" LG.
15	2	813 00146	FAN BLADE
16	1	507 03011	TUBING, COMPRESSOR ASSEMBLY
17	1	923 00079	CLEANER, AIR, 3/4" NPT.
18	2	008 01869	BRACKET, COMPRESSOR
19	1	008 01874	BRACKET, HEAT EXCHANGER
20	1	072 00048	SCREEN, FINNED TUBING
21	1	015 00048	CLAMP, AIR OIL TANK
22	1	845 00073	UNION, FLARED, 3/8" ODC.
23	1	845 00426	UNION, ELBOW, 3/8" ODC.
24	1	845 00202	ELBOW, MALE, 3/8" ODC. x 1/4" NPT.
25	1	845 00263	ELBOW, MALE, 3/8" ODC. x 3/8" NPT.
26	1	845 00183	NUT, 3/8" ODC.
27	1	847 00056	BUSHING, REDUCER, 1" x 1/2" NPT.

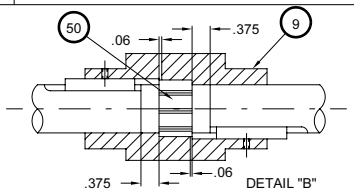
ITEM	REQ.	PART NO.	DESCRIPTION
28	1	940 03656	VALVE, SWING CHECK, 1/2" NPT.
29	1	861 00345	HOSE, FLEXIBLE
30	1	857 00153	NIPPLE, 1/2" x 1-1/2" LG.
31	1	859 00118	STREET ELBOW, 1/2" NPT. x 45°
32	1	861 00347	ADAPTER, 1/2" MPT. x 7/8" -14 MPT.
33	1	847 00152	BUSHING, RED, 3/4" x 1/2"
34	1	171 00114	FILTER BASKET
35	1	825 00104	GAS COCK, TEE HEAD- 3/4" NPT.
36	2	857 00163	NIPPLE, 3/4" x CLOSE
37	1	859-00025	TEE, 3/4" 150 LB.
38	1	857 00166	NIPPLE, 3/4" x 2" LG.
39	1	847 01628	ELBOW, REDUCING, 1-1/2" x 3/4"
40	1	157 01217	FITTING ASSEMBLY, PIPE, FILTER
41	1	919 00194	CAP,1-1/2" CAPLUG #CD-24
42	2	857 00167	NIPPLE, 3/4" x 2-1/2" LG.
43	8	868 00056	CAPSCREW, HEX HD, 3/8"-16 UNC x 1" LG.
44	10	952 00093	LOCKWASHER, 3/8"
45	10	952 00106	WASHER, 3/8"
46	1	858 00022	COUPLING, 3/4"
47	2	015 00053	CLAMP, MOTOR
48	1	868 00450	CAPSCREW, HEX HD, 3/8"-16 x 4" LG.
49	1	859-00081	ELBOW, 3/4" 150 LB.
50	1	819 00056	INSERT, COUPLING
51	2	841 00804	SCREW, SELF-TAPPING #10-32 x 3/8" LG.
52	2	952 00117	LOCKWASHER, #10
53	1	952 00144	WASHER, 3/8"
54	1	813 00124	FAN BUSHING

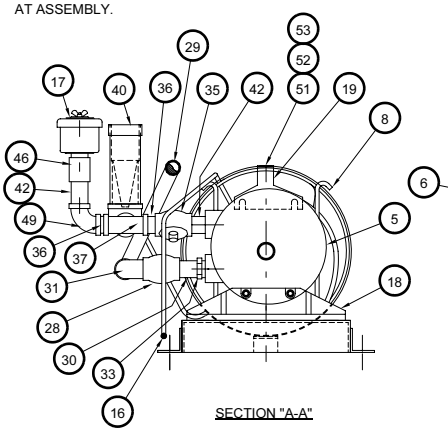
ASSEMBLY PROCEDURE

1. ASSEMBLE THE AIR COMPRESSOR TO THE BASE. WITH THE USE OF SHIMS, ADJUST THE CENTERLINE OF THE AIR COMPRESSOR TO WITHIN .008". NOTE DETAIL "B" FOR COUPLING ASSEMBLY. SECURE THE AIR COMPRESSOR TIGHTLY TO THE BASE.
2. SLIDE THE FAN ONTO THE SHAFT UNTIL IT IS BOTTOMED. TIGHTEN THE SETSCREW AGAINST THE KEY FIRST, THEN TIGHTEN THE SETSCREW AGAINST THE SHAFT.
3. BOLT THE TANK TO THE BASE.
4. FIT THE PIPING AS SHOWN.
5. CUT TUBE 3 TO SUIT, INSTALL NUT 26 & FLARE AT ASSEMBLY.

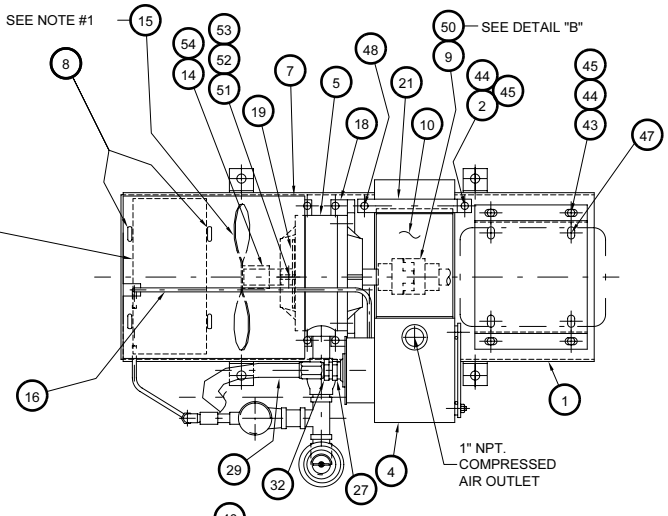
NOTES:

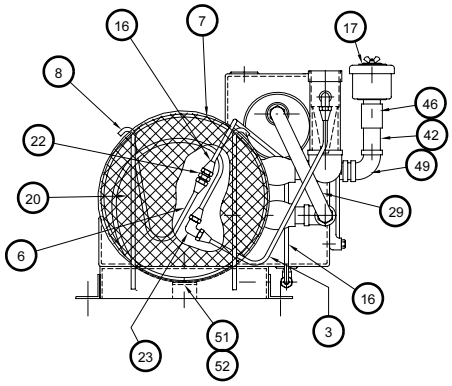
1. FAN SHOULD BE ASSEMBLED SUCH THAT THE SIDE OF THE BLADE 15 MARKED BLOWER IS TOWARD THE HUB 54 .

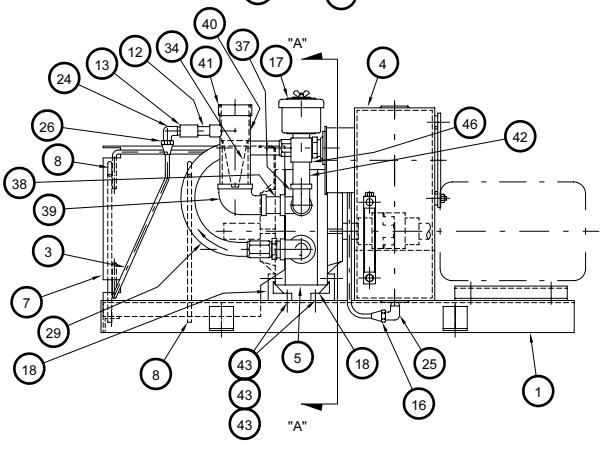




SECTION "A-A"







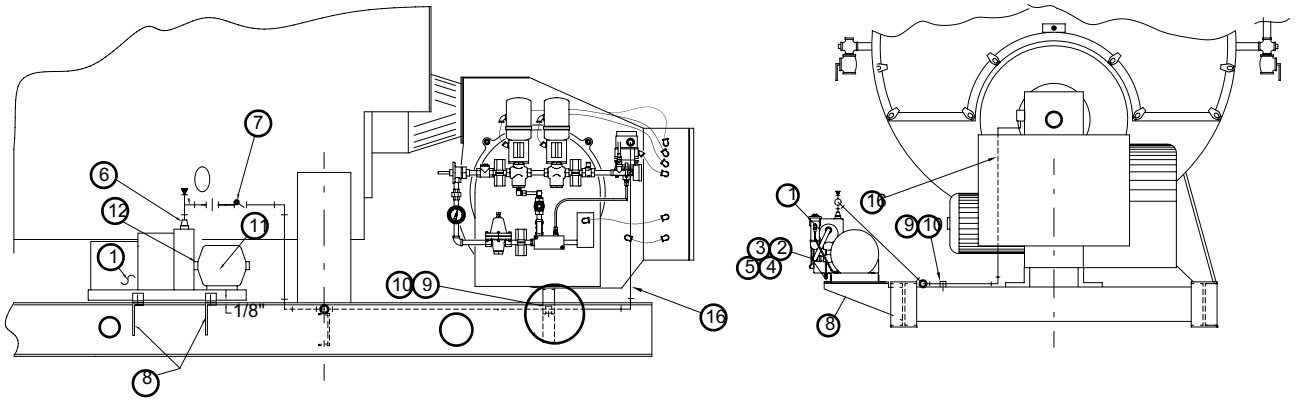
Air Compressor Piping - 96''

ITEM	QTY	PART NO.	DESCRIPTION
1	1	-	-
		615-D-23	COMPRESSOR ASSEMBLY182T/184T
2	4	869-36	NUT 5/16"-18
3	4	868-104	CAPSCREW, HEX. HD. 5/16"-18 X 1" LG.
4	4	952-114	LOCKWASHER, 5/16"
5	4	952-133	WASHER, 5/16"
6	1	847-56	BUSHING, RED. 1" X 1/2"
7	1	940-2470	VALVE, HORIZONTAL LIFT CHECK, 1/2"
9	3	928-44	CLAMP, PIPE, 1/2"
10	1	841-1407	SCREW, SELF TAP, 1/4"-20 X 5/8" LG.

ITEM	QTY	PART NO.	DESCRIPTION
11	1	SEE TABLE	MOTOR, 2 HP , 1200 SRPM
	1	SEE TABLE	MOTOR, 3 HP , 1800 SRPM
12	1	819-00158	COUPLING, HALF
13	1	008-00753	BRACKET, AIR PIPING CBE/CEW
	0	-	N/A
14	1	861-00439	FLEX HOSE, 1/2", FEMALE UNION END x MALE NIPPLE END

	100-150HP			200-300HP		
ITEM	200-208V	230/460V	600V	200-208V	230/460V	600V
(11)	894-3661	894-3662	894-02788	894-3430	894-3653	894-3432

NOTE: 100-150 HP. 4WG
UNITS ARE STANDARDLY PRESSURE ATOMIZED AND DO NOT GET AN AIR COMPRESSOR. THIS INFORMATION APPLIES ONLY WHEN THE CUSTOMER CALLS FOR AIR ATOMIZED OPTION.

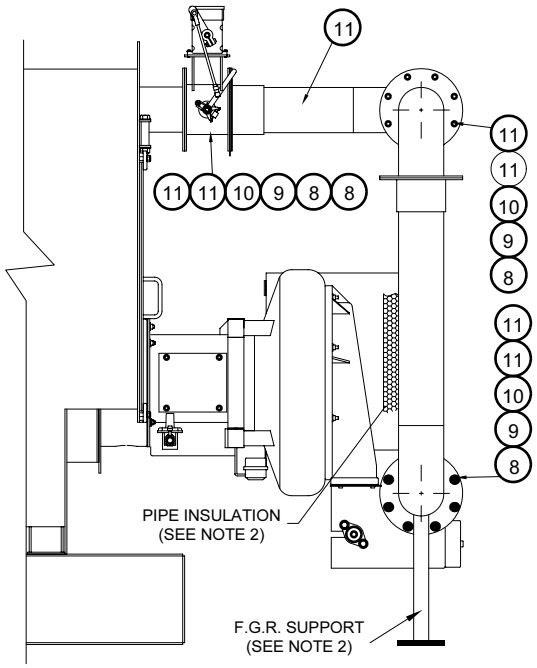


FGR PIPING, 60"-106" 100-800 HP

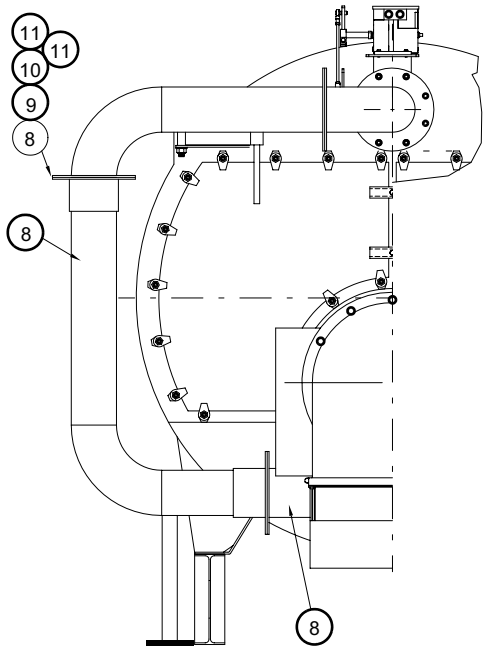
BILL OF MATERIAL			
ITEM	QTY	PART NO.	DESCRIPTION
1	1	SEE TABLE	FGR DUCT ASSEMBLY
2	1	SEE TABLE	FGR SHUTOFF VALVE
3	1	SEE TABLE	FGR CONTROL VALVE
4	"A"	868-00197	CAPSCREW
5	"A"	869-00018	NUT
6	"A"	952-00124	FLAT WASHER
7	"A"	952-00095	LOCK WASHER
8	5	"B"	GASKET, FGR FLANGE

BOILER DIA.	BOILER HP	BURNER MODEL	ITEM #1 ASS'Y NO.	ITEM #2 P/N.	ITEM #3 P/N.	ITEM #8 P/N.	DUCT O.D.
60"	100 HP	LND 54S	619-00765	940-91441	940-91418	853-00550	6"
	125 HP	LND 63P	619-00741		940-91420		
67"	150 HP	LND 84P	619-00734	940-91441	940-91420	853-00550	6"
	200 HP	LND 105P					
78"	250 HP	LND 145S	619-00736	940-91441	940-91420	853-00550	6"
	300 HP	LND 145P	619-00761	940-91443	940-91421	853-00868	8"
85"	350 HP	LND 175P	619-00732	940-91443	940-91421	853-00868	8"
	400 HP	LND 210	619-00762			853-00868	
96"	500 HP	LND 252	619-00763	940-91443	940-91421	853-00868	8"
	600 HP	LND 300	619-00740	940-91445	940-91422	853-00869	10"
106"	700 HP	LND 378	619-00735	940-91445	940-91422	853-00869	10"
	800 HP	LND 420					

NOTES:
1.) CUSTOMER MUST PROVIDE MEANS FOR VENTING STEAM OR HOT WATER TO ALLOW THE BOILER TO BE OPERATED AT HIGH FIRE FOR UP TO ONE HOUR.
2.) CONTRACTOR TO SUPPLY PIPING SUPPORTS AND INSULATION PER O.S.H.A. PERSONAL PROTECTION.



LEFT SIDE VIEW



FRONT VIEW

60”-106”, 100-800 HP FEEDWATER PIPING W/3 VALVE BYPASS

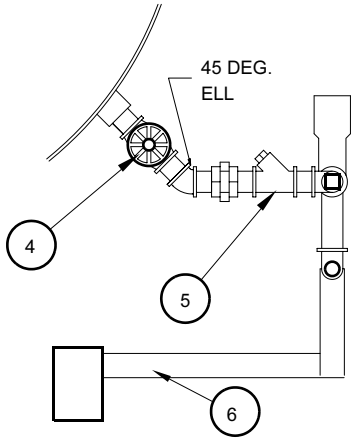
ITEM	QTY	PART NO. 15-150# ST	PART NO. 200#-300# ST	DESCRIPTION	USED ON
1	2	941-236	941-316	VALVE, GATE, 1-1/4"	100 H.P.
	2	941-333	941-693	VALVE, GATE, 1-1/2"	125-150 H.P.
	2	941-237	941-172	VALVE, GATE, 2"	200-300 H.P.
	2	-	941-172	VALVE, GATE, 2"	350-800 H.P.
	2	941-950	941-850	VALVE, GATE, 2-1/2"	350-800 H.P.
2	1	941-143	941-403	VALVE, GLOBE, 1-1/4"	100 H.P.
	1	941-144	941-404	VALVE, GLOBE, 1-1/2"	125-150 H.P.
	1	941-405	941-406	VALVE, GLOBE, 2"	200-300 H.P.
	1	-	941-406	VALVE, GLOBE, 2"	350-800 H.P.
	1	941-407	941-408	VALVE, GLOBE, 2-1/2"	350-800 H.P.
3	1	SEE TABLE		VALVE, FEEDWATER	350-800 H.P.
4	1	SEE TABLE		VALVE, GLOBE	350-800 H.P.
5	1	SEE TABLE		VALVE, CHECK	100 H.P.
6	1	8B3306		BRACKET	ALL

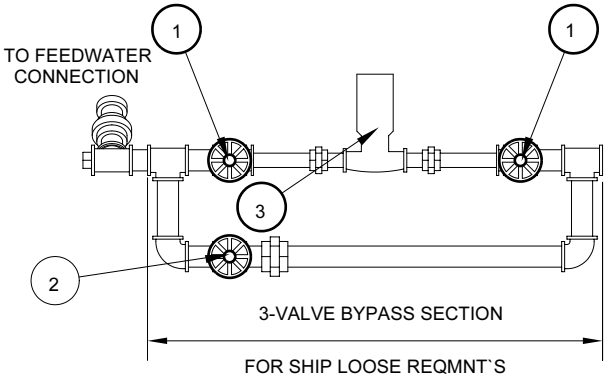
TABLE-BOILER FEED VALVES ITEMS 4 & 5

HORSEPOWER	STEAM PRESS.	ITEM 4 PART NO.	ITEM 5 PART NO.
100	150#	941-143	940-144
	200#	941-403	940-456
	250#-300#	941-1872	940-1380
125-150	150#	941-144	940-145
	200#	941-404	940-2461
	250#-300#	941-1873	940-2161
200-300	150#	941-405	940-146
	200#	941-406	940-2460
	250#-300#	941-1874	940-2378
350-800	150#	941-407	940-336
	200#	941-408	940-352
	250#-300#	941-1874	940-2378

TABLE-FEEDWATER VALVE ITEM 3

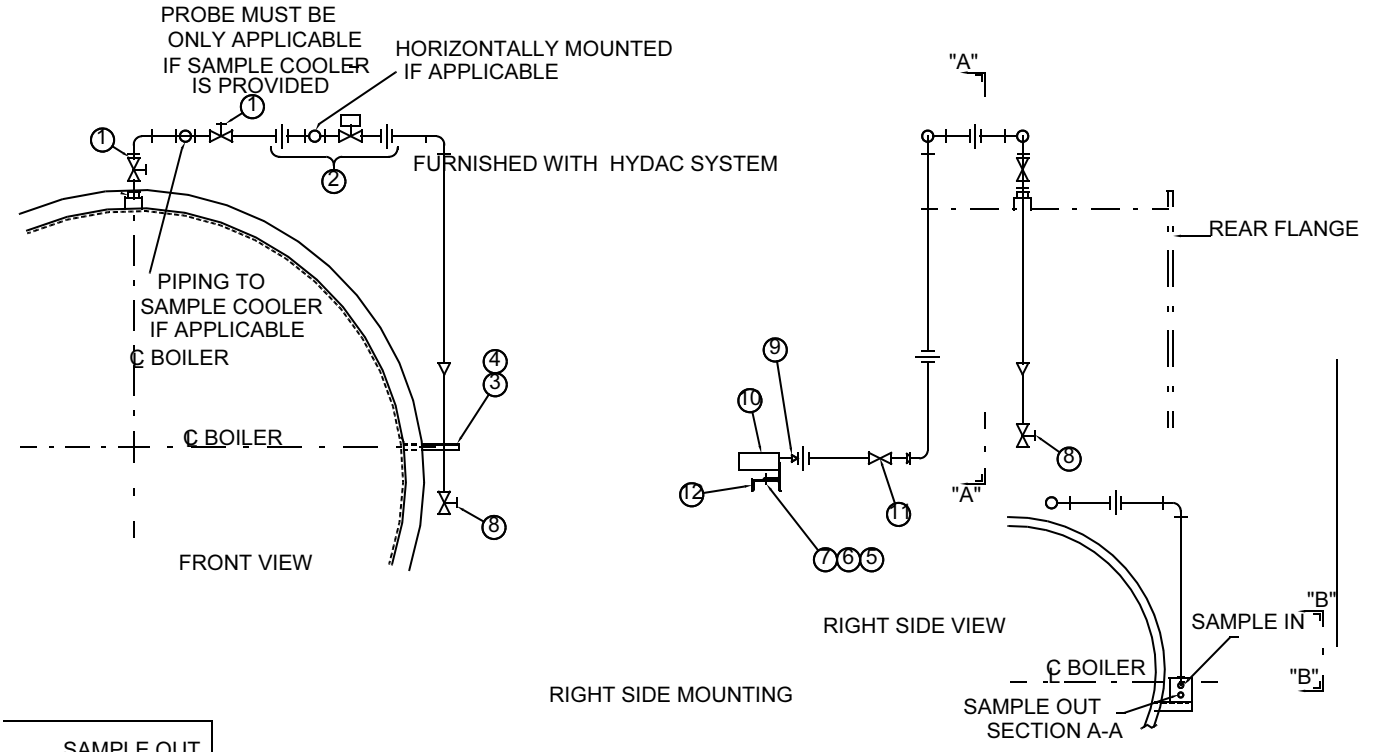
	VENDOR NAME				
	JORDAN 15-300#	BARBER-COLMAN 15-250#		HONEYWELL	
	MARK 33 SERIES	PROPORTIONAL VP-SERIES	ON-OFF VC-SERIES	15# STEAM	150-250# STEAM
VALVE SIZE	PART NO.	PART NO.	PART NO.	PART NO.	PART NO.
3/4"	940-4908	949-320	949-311	949-358	949-83
1"	940-4909	949-321	949-312	949-359	949-359
1-1/4"	940-4910	949-322	949-313	949-360	-
1-1/2"	940-4911	949-323	949-314	949-361	-
2"	940-4912	-	949-315	-	-

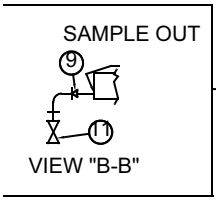


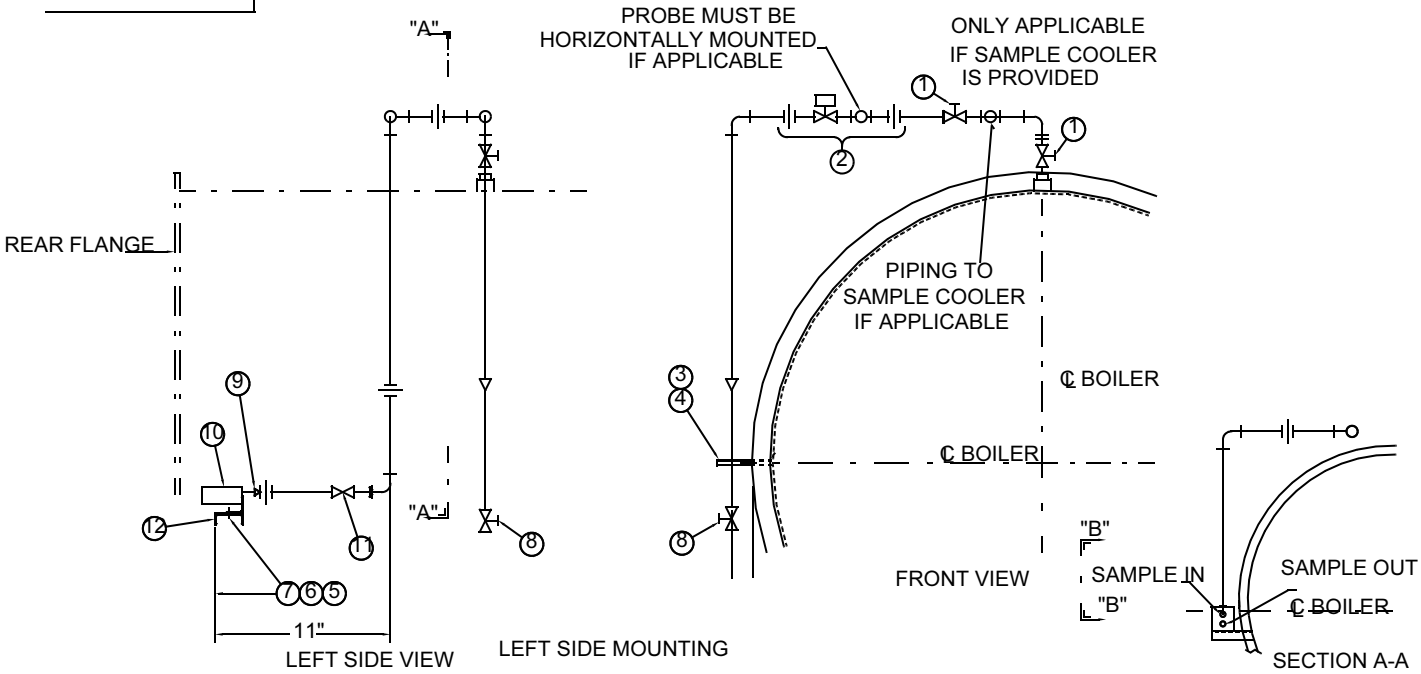


FRONT VIEW

60”-106”, 100-800 HP SURFACE BLOWOFF W/ & W/O HYDAC AND SAMPLE COOLER







60” 106”, 100-800 HP SURFACE BLOWOFF W/ & W/O HYDAC AND SAMPLE COOLER

CONTINOUS SURFACE BLOWOFF

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	941-170	VALVE, GATE, 3/4" NPT	100HP 125-250 HP 300-800 HP
2	-	-	NOT USED	
3	1	8-753	BRACKET	ALL
4	1	841-1119	U-BOLT, 1/2" P.S.	100-250HP
		841-1120	U-BOLT, 3/4" P.S.	300-800 HP
6	-	-	-	
7	-	-	-	
8	1	941-1900	VALVE, FLOW CONTROL, 1/4" NPT	100HP
		941-558	VALVE, FLOW CONTROL, 1/2" NPT	125-250 HP
		941-1244	VALVE, FLOW CONTROL, 3/4" NPT	300-800 HP

AUTOMATIC CONTINOUS SURFACE BLOWOFF

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	941-170	VALVE, GATE, 3/4" NPT	100HP 125-250 HP 300-800 HP
2	1	817-2378	HYDAC VALVE AND ORFICE ASSY	100-800 HP
3	1	8-753	BRACKET	ALL
4	1	841-1119	U-BOLT, 1/2" P.S.	100-250HP
		841-1120	U-BOLT, 3/4" P.S.	300-800 HP
6	-	-	-	
7	-	-	-	
8	1	941-1900	VALVE, FLOW CONTROL, 1/4" NPT	100HP
		941-558	VALVE, FLOW CONTROL, 1/2" NPT	125-250 HP
		941-1244	VALVE, FLOW CONTROL, 3/4" NPT	300-800 HP

CONTINOUS SURFACE BLOWOFF W/ SAMPLE COOLER

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	2	941-170	VALVE, GATE, 3/4" NPT	100HP 125-250 HP 300-800 HP
2	-	-	NOT USED	
3	2	8-753	BRACKET	ALL
4	2	841-1119	U-BOLT, 1/2" P.S.	100-250HP
		841-1120	U-BOLT, 3/4" P.S.	300-800 HP
6	-	-	-	
7	-	-	-	
8		941-1900	VALVE, FLOW CONTROL, 1/4" NPT	.100HP
	1	941-558	VALVE, FLOW CONTROL, 1/2" NPT	125-250 HP
		941-1244	VALVE, FLOW CONTROL, 3/4" NPT	300-800 HP
9	2	845-457	CONNECTOR, MALE, 1/4" ODT x 1/4" MPT	ALL
10	1	863-510	SAMPLE COOLER	
11	2	941-2113	VALVE, GATE, 1/4"	
12	1	125-116	SIZED CHANNEL, 5" @ 6.7#/FT x 10" LG.	

AUTOMATIC CONTINOUS SURFACE BLOWOFF W/ SAMPLE COOLER

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	2	941-170	VALVE, GATE, 3/4" NPT	100HP 125-250 HP 300-800 HP
2	1	817-2378	HYDAC VALVE AND ORFICE ASSY	100-800 HP
3	2	8-753	BRACKET	ALL
4	2	841-1119	U-BOLT, 1/2" P.S.	15-250HP
		841-1120	U-BOLT, 3/4" P.S.	300-800 HP
6	-	-	-	
7	-	-	-	
8	1	941-1900	VALVE, FLOW CONTROL, 1/4" NPT	100HP
		941-558	VALVE, FLOW CONTROL, 1/2" NPT	125-250 HP
		941-1244	VALVE, FLOW CONTROL, 3/4" NPT	300-800 HP
9	2	845-457	CONNECTOR, MALE, 1/4" ODT x 1/4" MPT	ALL
10	1	863-510	SAMPLE COOLER	
11	2	941-2113	VALVE, GATE, 1/4"	
12	1	125-116	SIZED CHANNEL, 5" @ 6.7#/FT x 10" LG.	

Notes:

NOTES

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