CleaverBrooks

Model ICB

Packaged Boiler

100 to 800 HP
Steam and Hot Water
Light Oil, Gas or Combination

Operation, Service, and Parts

750-196
09/2010

MODEL ICB

Packaged Boiler

Operation, Service, and Parts Manual

100 to 800 Horse Power Steam and Hot Water
Fuel: Light Oil, Gas or Combination

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

Manual Part No. 750-196

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⚠ WARNING

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

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

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

TO: Owners, Operators and/or Maintenance Personnel

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

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

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

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

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

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

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

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

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

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

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

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

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Chapter 1
Basics of Firetube Operation

A. GENERAL

Figure 1-1. Firetube Boiler Cutaway

Figure 1-2. ICB Firetube Boiler

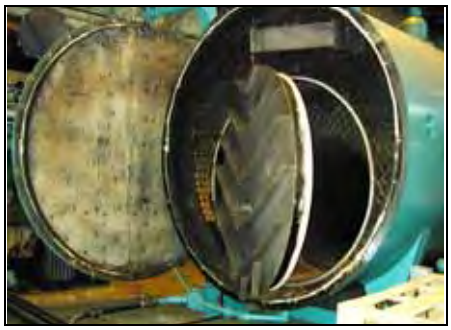


Figure 1-3. Rear Access Way

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 ICB boiler (Intercooled Back Boiler) utilizes a rear access way and rear door, to provide the maximum heat to water transfer. 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.

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 Model ICB 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

Table 1-1. Model ICB 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	Louver Type (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 above series comply, when equipped with optional equipment, to Industrial Risk Insurers (IRI), Factory Mutual (FM), or other insuring underwriters requirements.

Figure 1-4. ICB Firetube Boiler

B. THE BOILER

The Model ICB 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, ICB700-250 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.

The ICB design incorporates a hinged intercooled rear access plate to allow full access for tube maintenance and repair of the furnace and second pass tubes.

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 baffles at the front of the boiler direct the hot combustion gases to the to the third or forth tube passes. The ICB boiler can be configured as a three pass or four pass design.

Figure 1-5. Front Baffle Four Pass Design

Figure 1-6. Deaerator in Feedwater System

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.

⚠ 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 (**Figure 1-7**).

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 1-7. ASME Welding on Firetube Boiler

D. Steam Controls (All Fuels)

1. Operating Limit Pressure Control (**Figure 1-8.**): 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 1-8.**): 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 1-8.**): 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 1-9.**): Float-operated control responds to the water level in the boiler. It performs two distinct functions:

Figure 1-8. Pressure Controls

Figure 1-9. Water Column and Low Water Cut-Off

Figure 1-10. Auxiliary Low Water Cutoff

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 1-9.**): Houses the low-water cutoff and pump control and includes the gauge glass and gauge glass shutoff cocks.
6. Water Column Drain Valve (**Figure 1-9.**): 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 1-9.**): Provided to flush the gauge glass.
8. Vent Valve: Allows the boiler to be vented during filling, and facilitates routine boiler inspection as required by ASME Code.
9. Auxiliary Low Water Cutoff (**Figure 1-10.**): Breaks the circuit to stop burner operation in the event boiler water drops below the master 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 1-11.**): Prevent buildup over the design pressure of the vessel. The size, rating and number of valves on a boiler is determined by the ASME Boiler Code. The safety valves and the discharge piping are to be installed to conform to the ASME code requirements. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and code-required drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat area. Apply only a moderate amount of pipe compound to male threads and avoid overtightening, which can distort the seats. Use only flat-jawed wrenches on the flats provided. When installing a flange-connected valve, use a new gasket and draw the mounting bolts down evenly. Do not install or remove side outlet valves by using a pipe or wrench in the outlet.

⚠ Warning

Only properly certified personnel such as the 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 1-11. Safety Valves

E. HOT WATER CONTROLS (ALL FUELS)

1. Water Temperature Gauge (**Figure 1-12.**): Indicates the boiler internal water pressure.
2. Operating Limit Temperature Control (**Figure 1-12.**): 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 1-12.**): 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.
4. Low Water Cutoff (**Figure 1-13.**) (Optional probe type): Breaks the circuit to stop burner operation if the water level in the boiler drops below the master low-water cutoff point.

Figure 1-12. Hot Water Controls

Safety Valve(s) (**Figure 1-14.**): 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.

Figure 1-13. LWCO Probe Type

⚠ 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.

Figure 1-14. Safety Valves Check

F. BURNERS

The ICB range of boilers utilizes the ProFire F Series (see **Figure 1-15.**) or D series (see **Figure 1-16.**) or the low NOx Series (LND). The style of burner varies depending on the design and size of the boiler vessel. The ICB boiler is available as a 3 pass or 4 pass boiler; this also varies the style and size of the burner required for rated operation. The following tables cover the various design layouts.

Figure 1-15. ProFire F Series Burner

The setup of the smaller F series ProFire burners is described in Chapter 5. The D Series Profire burner setup is detailed in Chapter 6.

Gas & #2 Oil				
BHP	Gas & #2 Oil		Low Nox (30 ppm)	
	3-pass	4-pass	3-pass	4-pass
100	Profire-F3	Profire-F3	Profire-LND	Profire-LND
125	Profire-F3	Profire-F3	Profire-LND	Profire-LND
150	Profire-F3	Profire-F3	Profire-LND	Profire-DLN
200	Profire-F4	Profire-F4	Profire-LND	Profire-LND
250	Profire-F4	Profire-F4	Profire-LND	Profire-LND
300	Profire-F4	Profire-D	Profire-LND	Profire-LND
350	Profire-F4	Profire-D	Profire-LND	Profire-LND
400	Profire-D	Profire-D	Profire-LND	Profire-LND
500	Profire-D	Profire-D	Profire-LND	Profire-LND
600	Profire-D	Profire-D	Profire-LND	Profire-LND
700	Profire-D	Profire-D	Profire-LND	Profire-LND
800	Profire-D	Profire-D	Profire-LND	Profire-LND

Figure 1-16. ProFire D Series Burner

Chapter 2
Waterside Care and Requirements

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.

Figure 2-1. Water Column

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 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.

B. WATER REQUIREMENTS

1. Hot Water Boiler

Air Removal

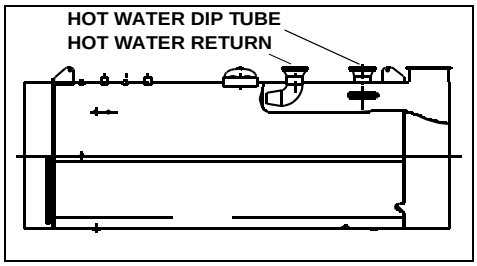


Figure 2-2. Dip Tube

The hot water outlet includes a dip tube 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.

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.

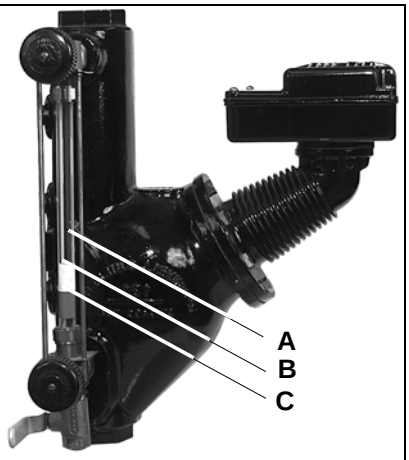
Pressure

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.

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.

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.

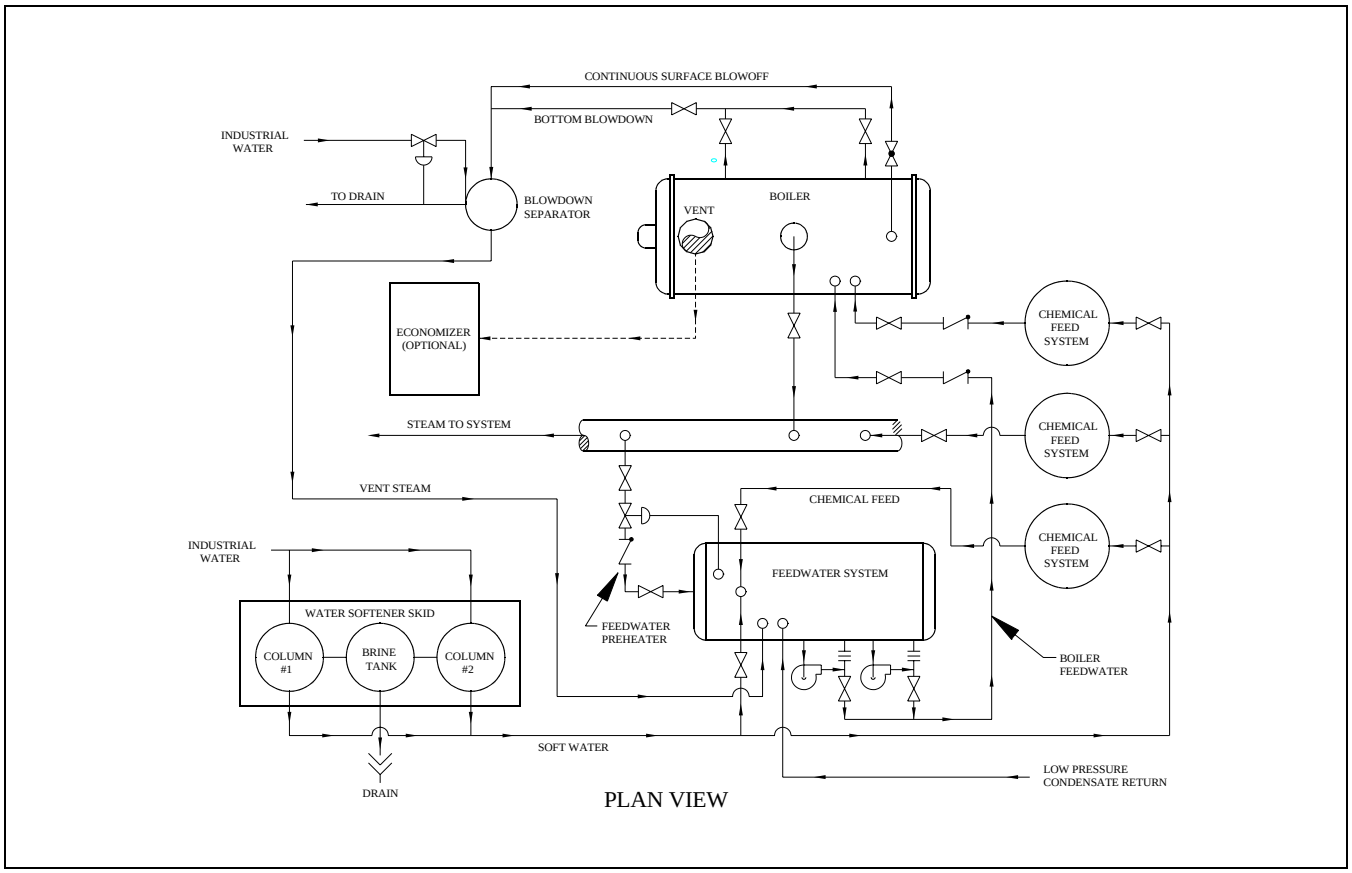


A. Normal level of water: feed pump turns off at this point. Fill pressure vessel initially to this height.
B. Pump turns on when water level reaches B. Distance between A-B is approximately 3/4".
C. Low water cut-off point.
First visible point in gauge glass.

Figure 2-3. Water Level Gauge Glass

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



1. CONTINUOUS BLOWDOWN
2. HIGH WATER CUT OFF
3. AUXILIARY LOW WATER CUTOFF
4. LOW WATER CUTOFF WATER COLUMN AND SITE GAUGE

Figure 2-4. Low-Water Cutoff Auxiliary Low Water Cutoff and High Water Cutoff

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 (Optional) Operation

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.

⚠ 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.

C. WATER TREATMENT

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.

Note: 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.

⚠ 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.

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. 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.

⚠ 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.

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.

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.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.

E. BLOWDOWN STEAM BOILER

Figure 2-6. Bottom Blowdown Valves

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.

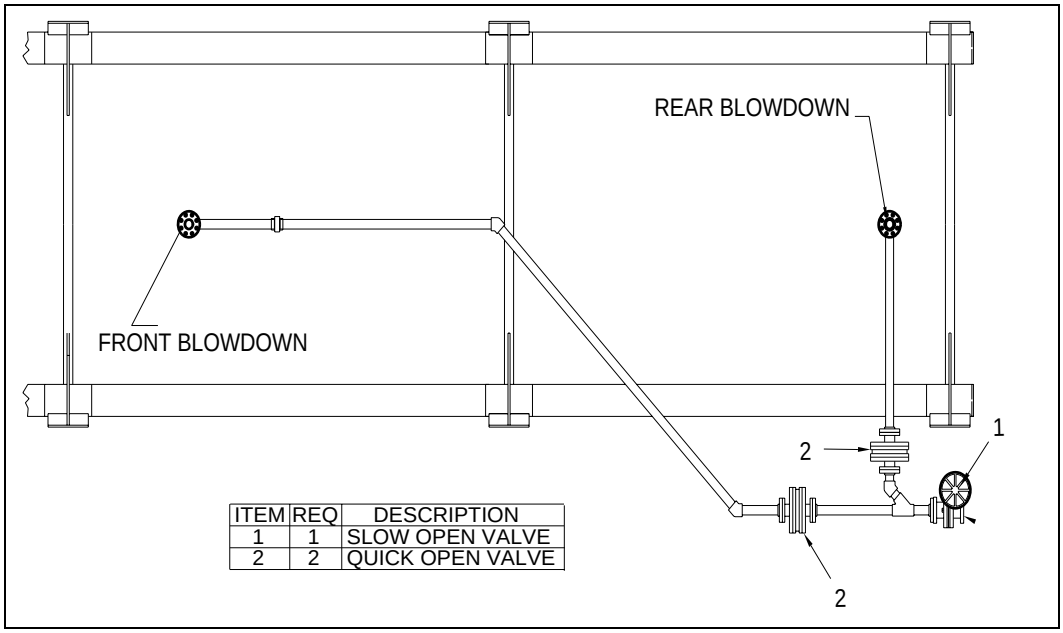


Figure 2-7. Bottom Blowdown Layout

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.

⚠ 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.

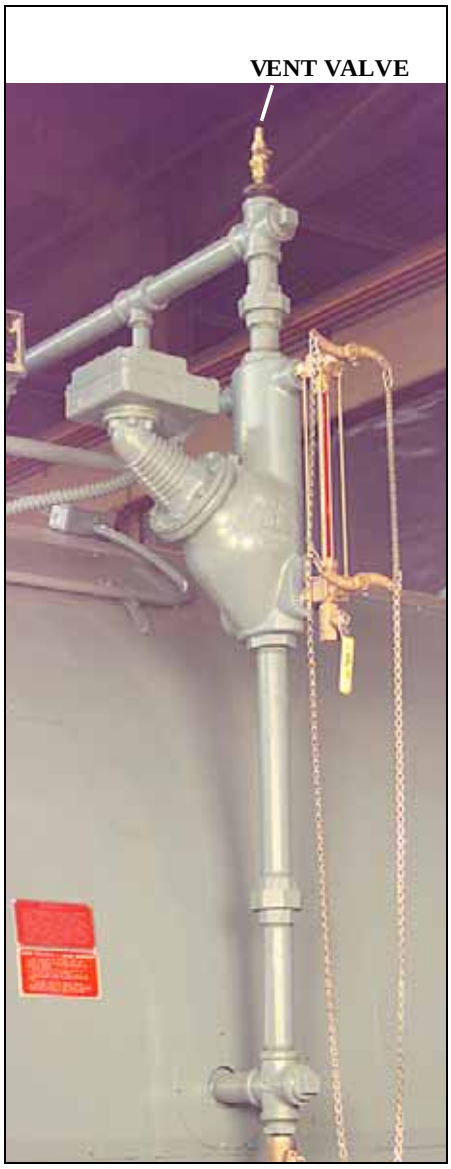


Figure 2-8. Vent Valve on Water Column

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.

F. 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 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.

G. 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.

Chapter 3
Sequence of Operation

A. GENERAL

This chapter 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 lnterlock 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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
ACMF	Air Compressor Motor Fuses
ACMS	Air Compressor Motor Starter
ACMSI	Air Compressor Motor Starter Interlock
AH	Alarm Horn
ALFR	Assured Low Fire Relay
ALWCO	Auxiliary Low Water Cutoff
AM	Ammeter
AMS	Atomizing Media Switch
AOV	Auxiliary Oil Valve
APR	Air Purge Relay
APV	Air Purge Valve
AR	Alarm Relay
AS	Auxiliary Switch (Suffix)
ASR	Alarm Silencing Relay
ASS	Alarm Silencing Switch
ASV	Atomizing Steam Valve
AT	Annunciator Transformer
AWCBDS	Auxiliary Water Column Blowdown Switch
B	
B	Blue (Color of Pilot Light)
BC	Bias Control
BDCS	Breeching Damper Closed Switch
BDOS	Breeching Damper Open Switch
BDRS	Blowdown/Reset Switch
BFPL	Boiler Feed Pump Light
BFPM	Boiler Feed Pump Motor
BFPMCB	Boiler Feed Pump Motor Circuit Breaker
BFPMF	Boiler Feed Pump Motor Fuses
BFPMS	Boiler Feed Pump Motor Starter
BFPS	Boiler Feed Pump Switch
BFTS	Back Flow Temperature Switch
BHS	Boiler — Header Switch
BIOL	Boiler in Operation Light
BIOR	Boiler In Operation Relay
BM	Blower Motor
BMCB	Blower Motor Circuit Breaker
BMCR	Blower Motor Control Relay
BMF	Blower Motor Fuses
BMPR	Blower Motor Power Relay
BMPS	Blower Motor Purge Switch
BMR	Blower Motor Relay
BMS	Blower Motor Starter
BMSI	Blower Motor Starter Interlock
BMSS	Boiler Master Selector Switch

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
BS	Burner Switch
BSS	Boiler Selector Switch
BWPM	Booster Water Pump Motor
BWT	Booster Water Thermostat
C	
CAFL	Combustion Air Failure Light
CAFR	Combustion Air Failure Relay
CAP	Capacitor
CAPS	Combustion Air Proving Switch
CCCB	Control Circuit — Circuit Breaker
CCF	Control Circuit Fuse
CCRS	Control Circuit Reset Switch
CCT	Control Circuit Transformer
CIPL	Changeover in Progress Light
CL	Canopy Light
CLS	Canopy Light Switch
COPS	Changeover Pressure Switch
COR	Changeover Relay
COTD	Changeover Time Delay
CPOL	Control Power on Light
CR	Control Relay
CSSS	Control System Selector Switch
CWPM	Circulating Water Pump Motor
CWPMCB	Circulating Water Pump Motor Circuit Breaker
CWPMF	Circulating Water Pump Motor Fuses
CWPMS	Circulating Water Pump Motor Starter
CWPMSI	Circulating Water Pump Motor Starter Interlock
CWPR	Circulating Water Pump Relay
CWPS	Circulating Water Pump Switch
CWSV	Cooling Water Solenoid Valve
D	
D	Denotes Digester Gas Equipment (Prefix)
DCVM	Direct Current Voltmeter
DG	Draft Gauge
DGHPV	Digester Gas Housing Purge Valve
DHWC	Deaerator High Water Control
DHWL	Deaerator High Water Light
DHWR	Deaerator High Water Relay
DISC	Disconnect (Entrance Switch)
DLWC	Deaerator Low Water Control
DLWL	Deaerator Low Water Light
DLWR	Deaerator Low Water Relay

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
LLPR	Low Limit Pressure Relay
LLR	Lead Lag Relay
LLTC	Low Limit Temperature Control
LLTR	Low Limit Temperature Relay
LOPL	Low Oil Pressure Light
LOPR	Low Oil Pressure Relay
LOPS	Low Oil Pressure Switch
LOTL	Low Oil Temperature Light
LOTR	Low Oil Temperature Relay
LOTS	Low Oil Temperature Switch
LPAPS	Low Plant Air Pressure Switch
LPCO	Low Pressure Cutoff
LPS	Low Pressure Switch
LSPAR	Low Steam Pressure Alarm Relay
LSPC	Low Steam Pressure Control
LSPL	Low Steam Pressure Light
LSPR	Low Steam Pressure Relay
LSPS	Low Steam Pressure Switch
LTS	Lamp Test Switch
LWA	Low Water Alarm
LWAR	Low Water Alarm Relay
LWCO	Low Water Cutoff
LWFL	Low Water Flow Light
LWL	Low Water Light
LWR	Low Water Relay
LWRR	Low Water Reset Relay
M	
MA	Milli-amp
MAS	Manual-Automatic Switch
MAM	Micrometer
MC	Modulating Control
MCS	Manual Control Switch
MDM	Modulating Damper Motor
MDMAS	Modulating Damper Motor Auxiliary Switch
MFC	Manual Flame Control (Potentiometer)
MFGRTS	Minimum Flue Gas Recirculation Temperature Switch
MFVL	Main Fuel Valve Light
MFWV	Motorized Feed Water Valve
MGV	Main Gas Valve
MGVAS	Main Gas Valve Auxiliary Switch
MGVEL	Main Gas Valve Energized Light
MGVV	Main Gas Vent Valve
MLC	Modulating Level Control

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
(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
OPRS	Oil Pressure Sensor

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
PTS	Pump Transfer Switch
PUCR	Purge Complete Relay
PUR	Purge Relay
R	
R	Red (Color of Pilot Light)
RAR	Remote Alarm Relay
RATD	Remote Alarm Time Delay
RES	Resistor
RML	Run Mode Light
RMR	Release to Modulate Relay
RS	Range Switch
RSR	Remote Start Relay
RTD	Resistance Temperature Detector
S	
SBFPL	Stand By Feed Pump Light
SBFPM	Stand By Feed Pump Motor
SBFPMCB	Stand By Feed Pump Motor Circuit Breaker
SBFPMF	Stand By Feed Pump Motor Fuses
SBFPMS	Stand By Feed Pump Motor Starter
SBOV	Surface Blow Off Valve
SBPS	Sootblower Pressure Switch
SBR	Sootblower Relay
SC	Scanner
SCTS	Supervisory Cock Test Switch
SDL	Steam Demand Light
SHT	Steam Heater Thermostat
SHV	Steam Heater Valve
SLCL	Safety Limits Complete Light
SPIR	System Pump Interlock Relay
SPS	Steam Pressure Sensor
SS	Selector Switch
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

Table 3-1. Electrical Nomenclature (Continued)

Mnemonic	Description
TB	Terminal Block
T/C	Thermocouple
TC	Time Clock
TCR	Time Clock Relay
TD	Time Delay
TDAS	Time Delay Auxiliary Switch
TFWR	Transistorized Feedwater Relay
TPL	Transfer Pump Light
TPM	Transfer Pump Motor
TPMCB	Transfer Pump Motor Circuit Breaker
TPMF	Transfer Pump Motor Fuses
TPMS	Transfer Pump Motor Starter
TPS	Transfer Pump Switch
U	
UVFD	Ultra-Violet Flame Detector
V	
V	Voltmeter
VDR	Voltage Differential Relay
W	
W	White (Color of Pilot Light)
WC	Water Column
WCBDS	Water Column Blow Down Switch
WF	Water Feeder
WFNL	Water Flow Normal Light
WLC	Water Level Control
WO	Denotes Waste Oil Equipment (Prefix)
WTS	Water Temperature Sensor
Y	
Y	Yellow (Color of Pilot Light)

Chapter 4

Starting and Operating Instructions

ProFire F Series Burners

100 – 350 HP (3 Pass)
100 – 250 HP (4 Pass)

Milwaukee, Wisconsin

www.cleaver-brooks.com

A. GENERAL

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 **Chapter 1** and **Chapter 2**. Instructions for adjusting major components are given in Chapters 4. 5 6 and 7and should be reviewed prior to firing. The wiring diagram should also have been studied, along with the firing sequence outlined in Chapter 3.

Figure 4-1. “F” Series Oil Train

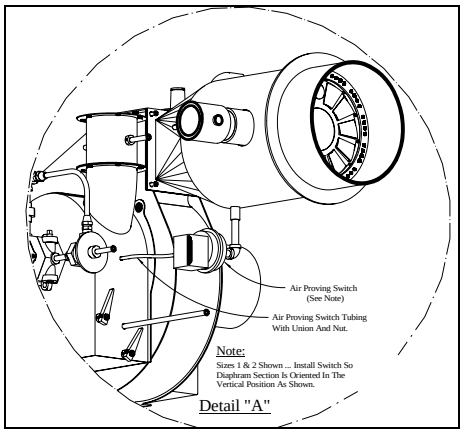


Figure 4-2. “F” Series Burner

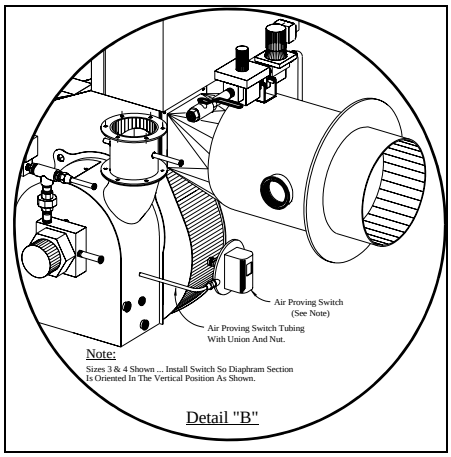


Figure 4-3. “F” Series Burner

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.

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 hot water 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.

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.

Check all linkage for full and free movement of the shutter and metering valves. 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 ICB, when viewed from the motor side of the burner (see **Figure 4-4**). The air pump rotation is clockwise when viewed from its drive end (see **Figure 4-5**).

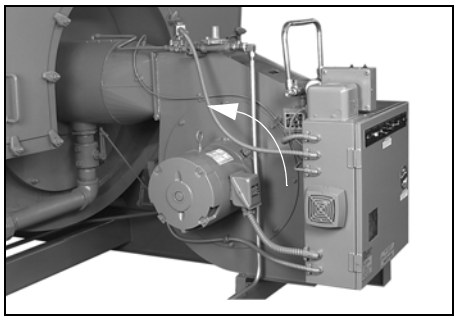


Figure 4-4. Fan Motor ICB ProFire

B. PREPARATION FOR INITIAL START-UP

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

1. Fuel Supply

Before initial start-up, 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/CGA and the responsible insurance carrier if applicable

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

Fuel oil piping for oil-fired systems is shown pictorially in Figures 4-6 and 4-7. 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.

Before burner start-up, 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 bypass 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.

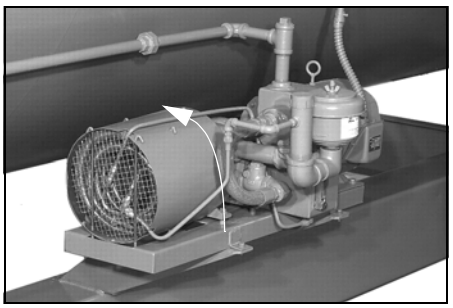


Figure 4-5. Air Compressor

Note: The pressure vessel support legs are welded to mounting skids in front and secured by bolts at the rear of the pressure vessel. The bolts are tightened for shipment. When the boiler is installed, and prior to initial firing, the bolts securing the rear legs to the skid must be loosened to allow for expansion and contraction caused by differences in temperature between pressure vessel and skids and to avoid damage to the equipment.

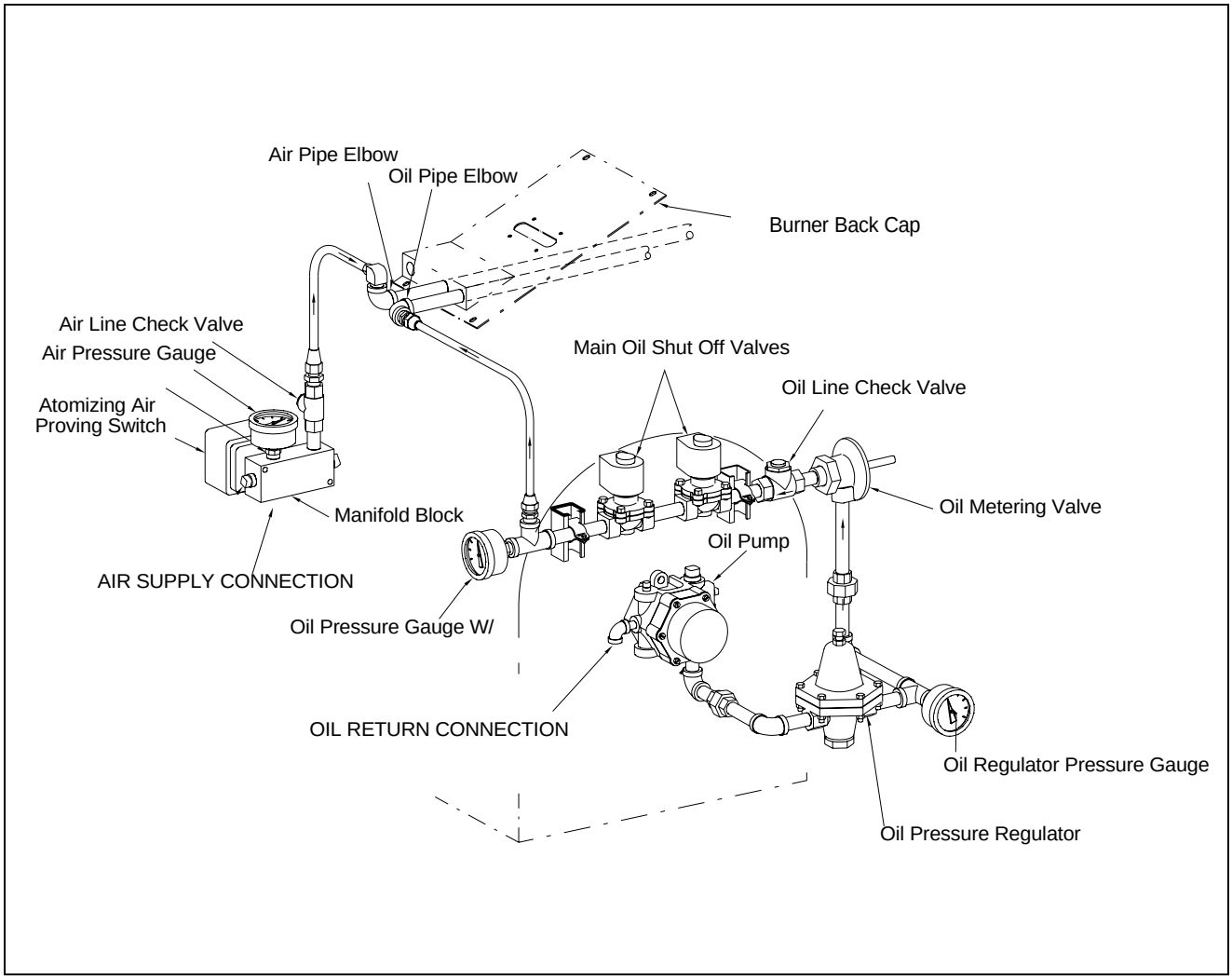


Figure 4-6. ProFire Burner Air Atomized, Direct Drive System (Light Oil)

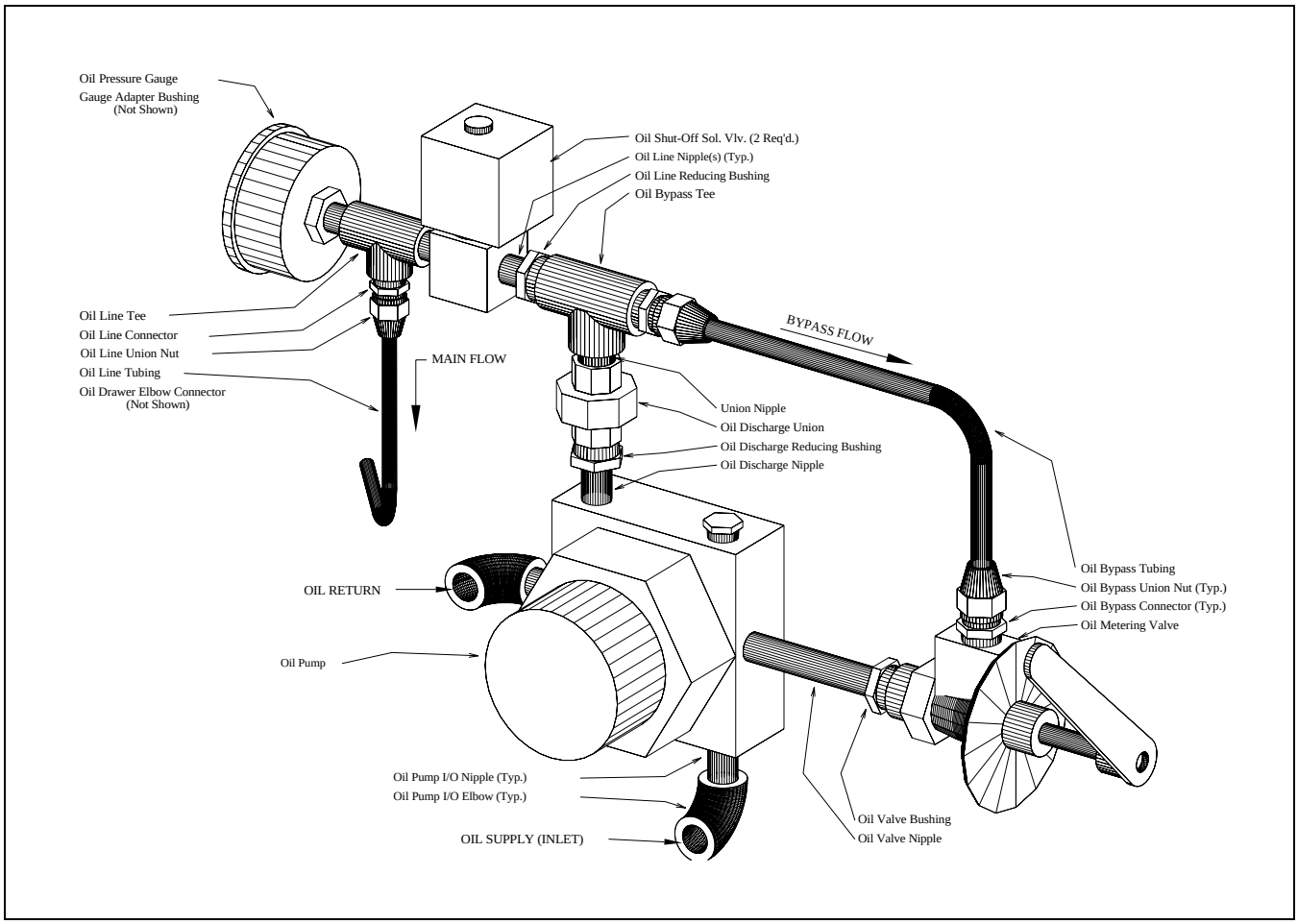


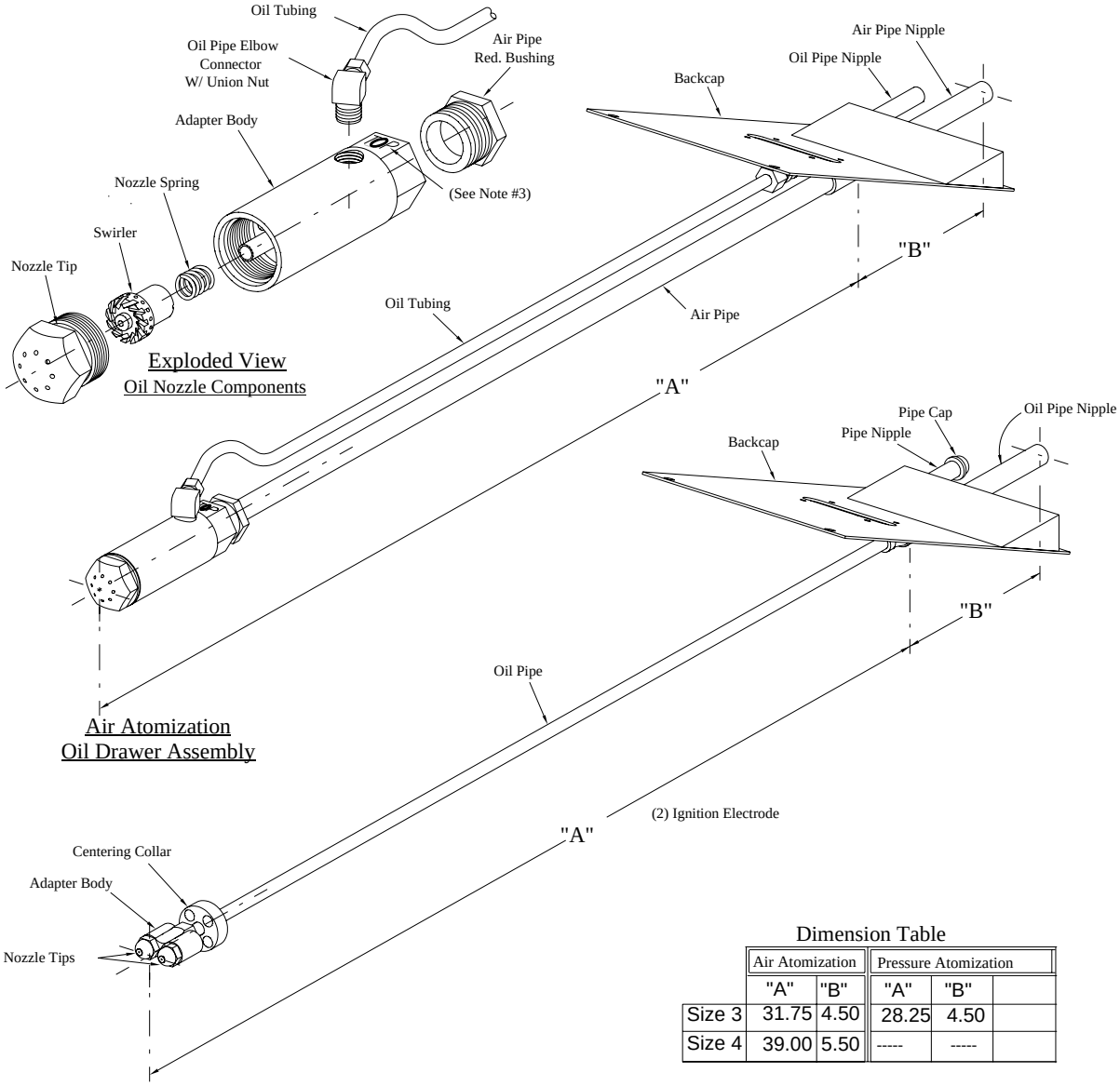
Figure 4-7. ProFire Burner Pressure Atomized

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 bypass circuit, which increases the oil flow to the burner nozzle.

⚠ Caution

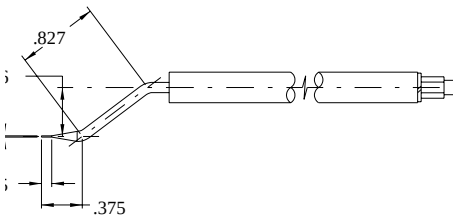
When oil pumps are driven directly, oil circulation is required at all times. Do not start the burner with closed stop valves in the suction or return lines or serious damage will occur.

It is a requirement 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

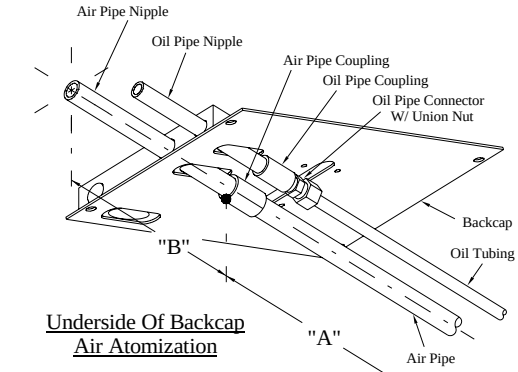


Dimension Table

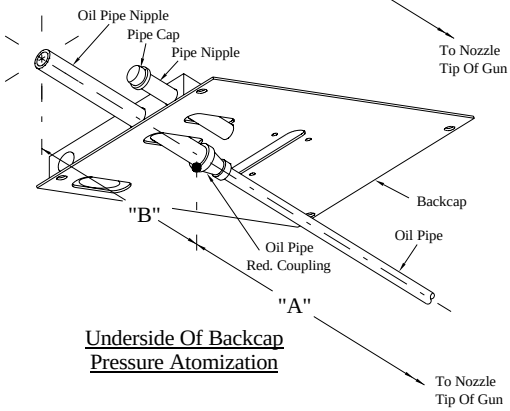
	Air Atomization		Pressure Atomization		
	"A"	"B"	"A"	"B"	
Size 3	31.75	4.50	28.25	4.50	
Size 4	39.00	5.50	-----	-----	



Electrode Tip
Preparation Detail



Underside Of Backcap
Air Atomization



Underside Of Backcap
Pressure Atomization

Dimension Table

	Air Atomization		Pressure Atomization		
	"A"	"B"	"A"	"B"	"C"
Size 3	31.75	4.50	28.25	4.50	-----
Size 4	39.00	5.50	-----	-----	-----

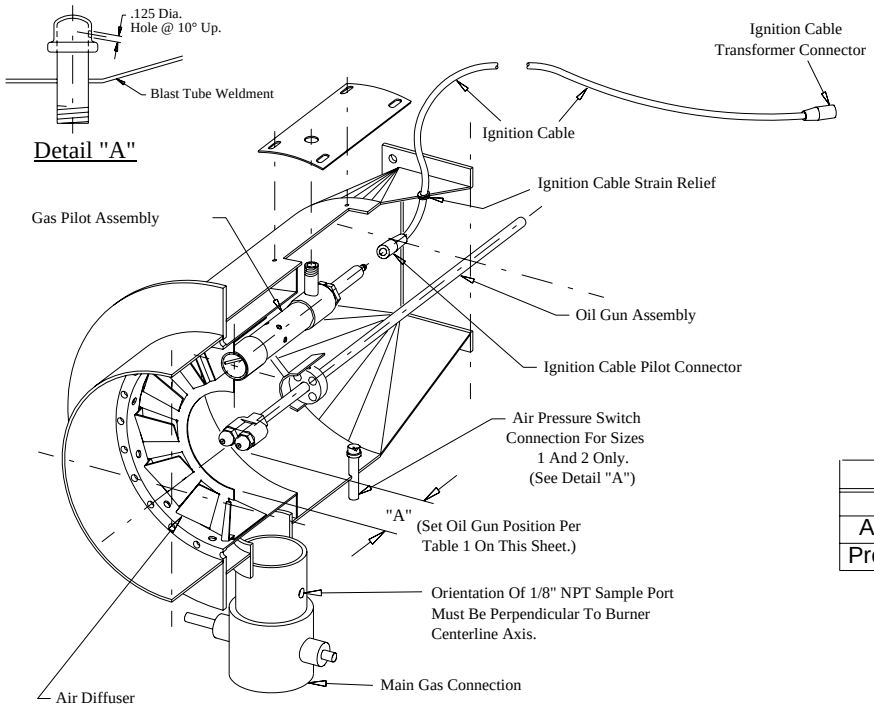


TABLE 1		
Dim. "A"	Size 3	Size 4
Air Atomization	0.750	0.500
Pressure Atomization	4.000	----

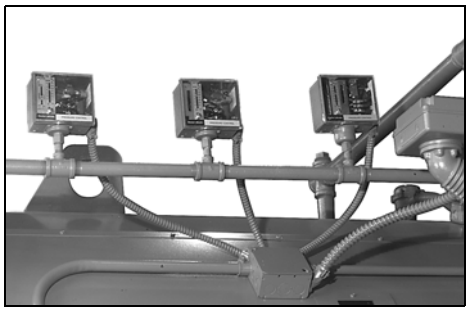


Figure 4-8. Pressure Controls

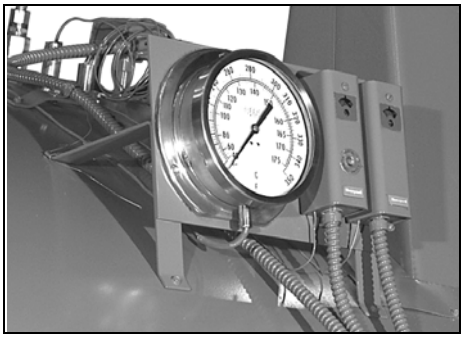


Figure 4-9. Temperature Controls

2. Control Settings — Steam and Hot Water

See Chapter 5 for adjustment instructions for the following controls.

Inspect the operating limit control for proper setting.

1. 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.
2. The temperature control on a hot water boiler should be set slightly above the highest desired water temperature and within the limits of the pressure vessel.

Inspect the high limit control for proper setting.

Electrical Requirements and Connections

⚠ 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. 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.

4. Burner Settings

To ensure reliable and safe burner performance, the location and gap setting of the electrodes for the direct-spark igniters, and the relative positions of the burner nozzle and diffuser components must be correctly set (see pages 4-6 and 4-7). These items are preset at the factory, but must be checked prior to placing the burner into initial service, or after conducting any service work that may have altered their positions.

The nozzle assembly must be removed from inside the burner to enable measurement and adjustment of the oil-spark-ignition electrodes (furnished only on oil burners) and the nozzle relative to the diffuser.

1. Remove the nozzle assembly as follows:

⚠ Warning

Inadvertent burner operation can cause serious injury, or death. Do not perform maintenance on a burner without first disabling the electrical power supply. Lock out and tag the electrical power supply to prevent inadvertent burner start-up during checkout or maintenance activities. Failure to follow these instructions could result in serious personal injury or death.

A. Lock out and tag the electrical power supply to the burner to prevent inadvertent operation during checkout or maintenance activities.

B. Disconnect the high-voltage power supply from the oil-spark-ignition electrodes (if installed).

C. Disconnect the oil piping from the end of the blast tube.

D. Remove the fasteners that secure the nozzle/diffuser assembly to the top of the fan housing, and remove the nozzle assembly from the burner.

2. Measure the position and gap of the pilot electrodes, and compare these to the dimensions shown on page 4-6. If necessary, adjust the position of the electrodes relative to the nozzle as follows:

   A. Loosen the locking screws on the spark ignition clamp assembly.

   B. Rotate and slide each electrode in the clamp, as necessary, to achieve the correct position relative to the burner tip.

   C. Tighten the locking screws securely to lock the electrodes in position. Apply a lock-tight type compound to the screws before tightening.

3. Refer to page 4-7 and measure the distance from the tip of the nozzle to the diffuser inside the blast tube. If necessary, adjust the position of the diffuser as follows:

   A. Loosen the locking screw on the backcap.

   B. Slide the oil pipe fore or aft along the length of the burner pipe until the correct dimension is achieved.

   C. Tighten the locking screw securely to the oil pipe. Apply a lock-tight type compound to the screws before tightening.

4. Carefully install the adjusted nozzle assembly into the burner. Then re-connect the oil supply and high-voltage power cable to the assembly.

C. START-UP PROCEDURES

1. Prestart Tasks and Checklist — All Fuels

Before proceeding with system start-up and adjustment, be sure that overall installation is complete. Review this boiler Operation and Maintenance Manual 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:

1. 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.
2. Check the combustion air fan motor for correct rotational direction.
3. 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.
4. Verify that there is proper gas pressure at the gas train, if this is a gas or combination burner. See the burner specification plate for minimum and maximum natural gas pressure requirements.
5. 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.
6. Check that the flame safeguard has been properly installed inside the control panel.
7. Verify that the prestart checklist for the boiler has been thoroughly completed.
8. Provide the following test equipment on site:
   A. Combustion analyzer for O_2.
   B. U-tube manometer, or pressure gauge, to measure gas pressures (main and pilot).
   C. Inclined manometer to measure draft pressures.
   D. Smoke spot tester for oil fired units. (CO analyzer for gas fired burners).
   E. Voltmeter.
   F. Thermometers and thermocouples.

⚠ Caution

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

2. 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, and the combustion set-point objectives for optimum combustion performance:

Air Flow Adjustments

ProFire burners have a unique air shutter design that enables precise, independent, air flow rate adjustment for both the high-fire and the low-fire operating points. This design incorporates a variable main air shutter (mounted on a shaft and direct-coupled to the modulating motor), plus two adjustable, but non-modulating, air shutters.

The modulating main air shutter regulates the flow of inlet air through the fan at flow rates between high-fire and low-fire conditions. One non-modulating air shutter (for high-fire combustion air control) is adjusted to provide the correct amount of air while the system is operating at the high-fire fuel input rate with the main air shutter fully open. The other non-modulating shutter (low-fire combustion air control) is adjusted to provide the correct amount of air with the system operating at the low-fire fuel input rate with the main shutter completely closed.

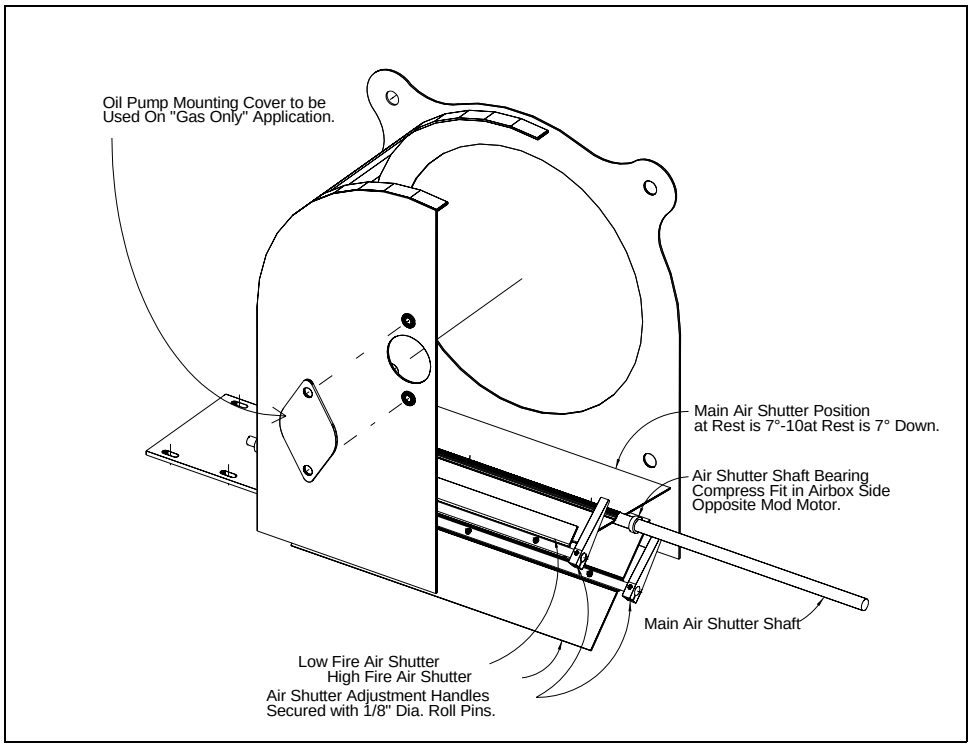


Figure 4-10. Air Box and Air Shutters

The three air shutters are mounted inside the airbox assembly. The high-fire and low-fire air shutters are mounted on independent shafts. A pointer, mounted on each shaft, indicates the set position of each non-modulating shutter. Adjustment of these shutters is accomplished by loosening a setscrew that holds the shutter shaft within a stationary collar mounted on the airbox.

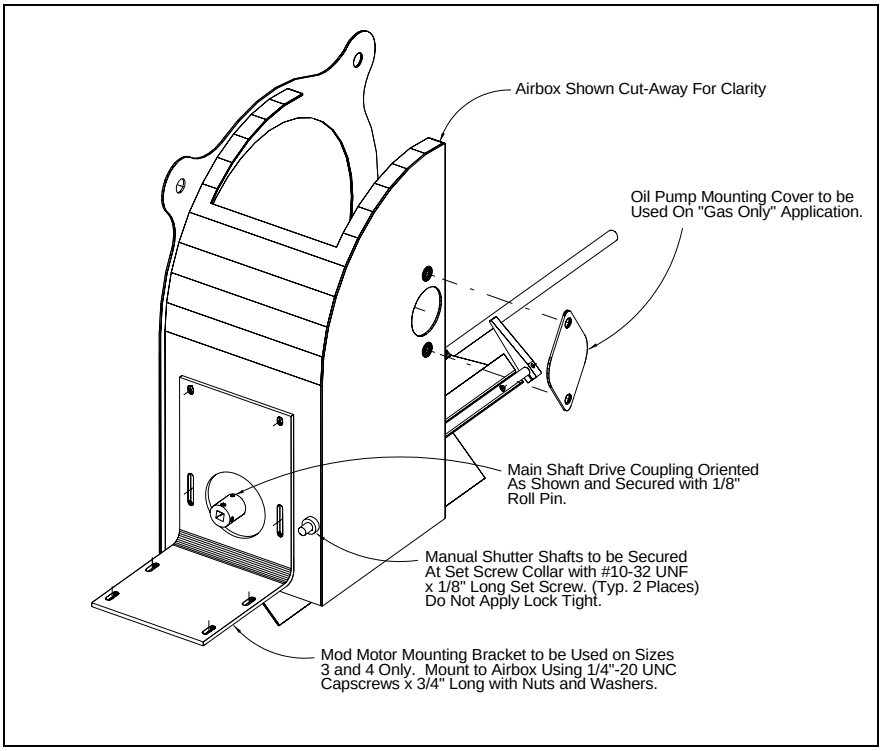


Figure 4-11. Air Box and Air Shutters

Combustion Settings

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

Turndown capability for oil is less than that 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.

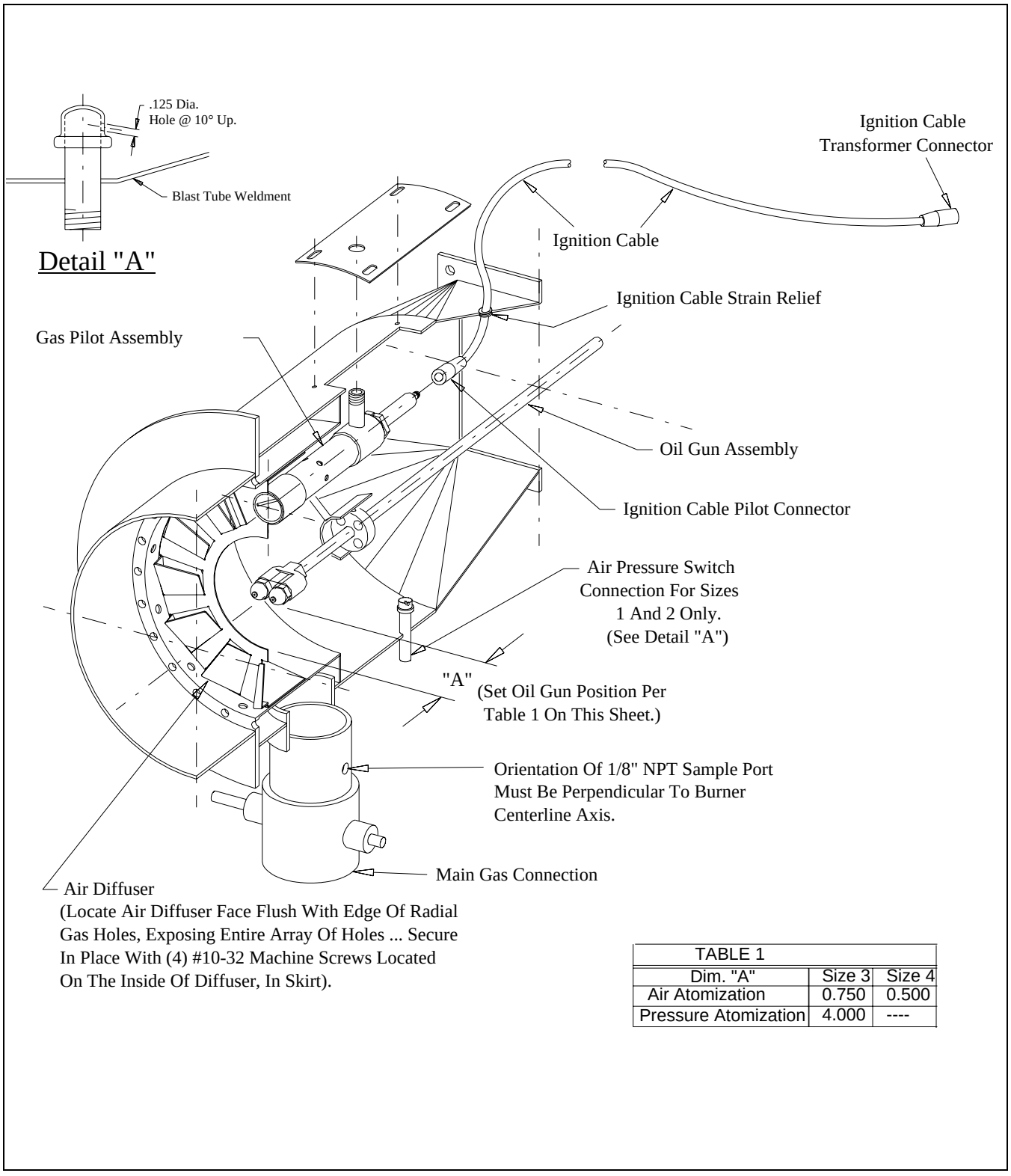


TABLE 1		
Dim. "A"	Size 3	Size 4
Air Atomization	0.750	0.500
Pressure Atomization	4.000	----

Figure 4-12. Blast Tube and Diffuser Start-Up Dimensions

ProFire burners are capable of operating at CO levels of less than 50 ppm at all firing rates. The burner should be set up and maintained to yield

smoke spot levels less than a #1 spot (ASTM D2156 Shell-Bacharach Scale) to minimize soot buildup in the boiler.

D. 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 excess oxygen in the flue gas accordingly.

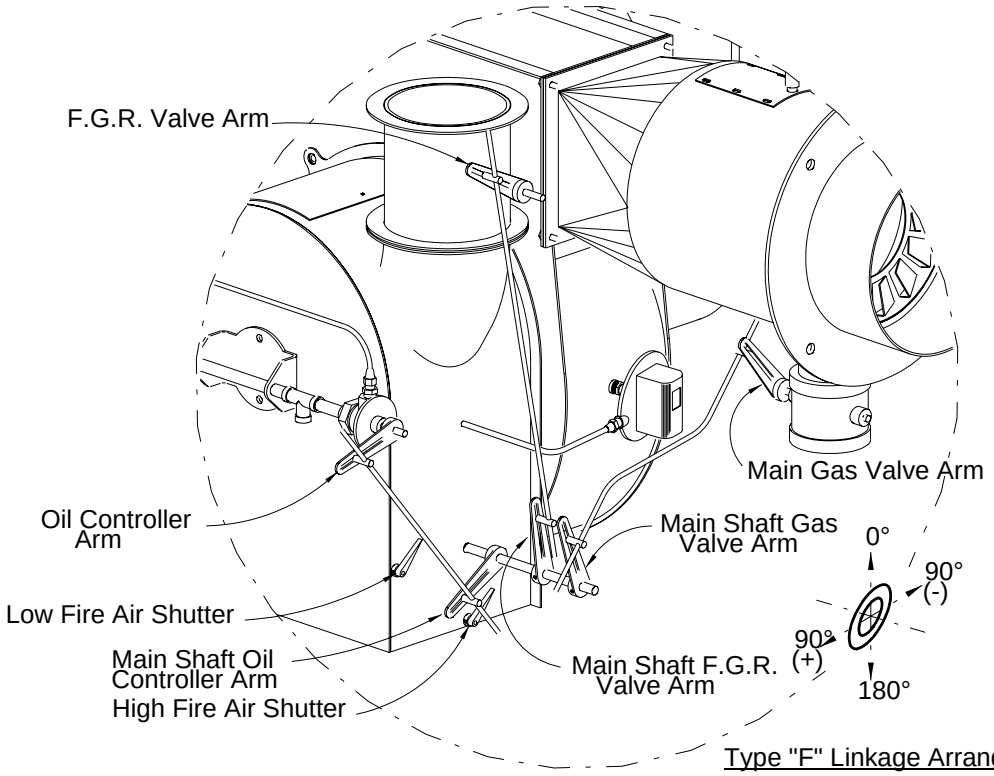
This section provides detailed procedures for setup and adjustment of a gas-fired combustion system. Similar discussions are also presented in this chapter for start-up and adjustment of oil-fired and combination-fueled gas or oil systems.

Burner Linkage Setup

These procedures assume that the pre-start-up tasks, checklists, and adjustments covered in this manual have been completed, and that the boiler system is prepared for initial start-up. All necessary test equipment, specified in **Section C**, should be available on-site and installed.

Type "F" Burners Only

SYSTEM TYPE	DESCRIPTION See Detail "B"	LINKAGE ARM ANGULAR ORIENTATION (In Degrees) BOILER HORSEPOWER / INPUT (MMbh)						
		100 4.19	125 5.23	150 6.28	200 8.37	250 10.5	300 12.6	350 14.7
STRAIGHT GAS AND GAS / AIR ATOMIZED OIL COMBINATION	MAIN SHAFT GAS VALVE ARM	0	+20	+20	+28	+15	+15	+15
	MAIN GAS VALVE ARM	+15	+25	+15	+30	-15	-15	-10
	GAS VALVE SETTING (Deg. Open)	10	20	10	10	10	20	15
GAS WITH PRESSURE ATOMIZATION OIL COMBINATION	MAIN SHAFT GAS VALVE ARM	-20	+20	+20	-10	--	--	--
	MAIN GAS VALVE ARM	+30	+30	+20	+35	--	--	--
	GAS VALVE SETTING	25	28	15	20	--	--	--
PRESSURE ATOMIZED #2 OIL	MAIN SHAFT OIL CONTROLLER ARM	+120	+90	+80	+50	--	--	--
	OIL CONTROLLER ARM	+75	+32	+40	+40	--	--	--
	OIL VALVE SETTING (Ref. No.)	6	5.5	11	9.5	--	--	--
AIR ATOMIZED #2 OIL	MAIN SHAFT OIL CONTROLLER ARM					+115	+115	+115
	OIL CONTROLLER ARM					-20	-20	-15
	OIL VALVE SETTING (Ref. No.)					1.5	1.5	2

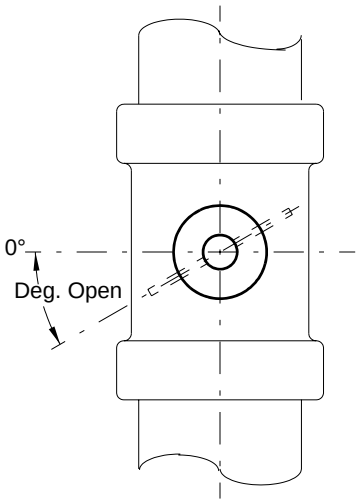


Type "F" Linkage Arrangement

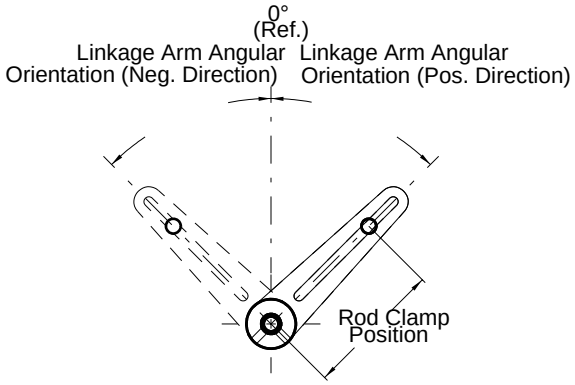
Figure 4-1. Initial "F" Series ProFire Settings

Type "F" Burners Only

SYSTEM TYPE	DESCRIPTION See Detail "B"	ROD CLAMP POSITION FROM CENTER POINT (In Inches) BOILER HORSEPOWER / INPUT (MMbh)							
		100 4.19	125 5.23	150 6.28	200 8.37	250 10.5	300 12.6	350 14.7	
STRAIGHT GAS AND GAS / AIR ATOMIZED OIL COMBINATION	MAIN SHAFT GAS VALVE ARM	2.50	2.50	2.50	2.50	3.00	3.00	3.00	
	MAIN GAS VALVE ARM	3.50	3.50	4.00	3.00	3.75	3.75	3.75	
	GAS VALVE SETTING (Deg. Open)	--	--	--	--	--	--	--	
	MAIN SHAFT F.G.R. VALVE ARM								
	OIL REGULATOR SET PRESSURE								
	F.G.R. VALVE ARM								
	F.G.R. VALVE SETTING (Deg. Open)	--	--	--	--	--	--	--	
GAS WITH PRESSURE ATOMIZATION OIL COMBINATION	MAIN SHAFT GAS VALVE ARM	2.50	2.50	2.50	2.25	--	--	--	
	MAIN GAS VALVE ARM	3.50	3.25	4.00	3.75	--	--	--	
	GAS VALVE SETTING	--							
	OIL REGULATOR SET PRESSURE								
	MAIN SHAFT F.G.R. VALVE ARM								
	F.G.R. VALVE ARM								
	F.G.R. VALVE SETTING	--							
PRESSURE ATOMIZED #2 OIL	MAIN SHAFT OIL CONTROLLER ARM	2.00	2.00	3.00	3.25	--	--	--	
	OIL CONTROLLER ARM	3.00	3.75	3.25	3.00	--	--	--	
	OIL VALVE SETTING (Ref. No.)								
	OIL REGULATOR SET PRESSURE								
AIR ATOMIZED #2 OIL	MAIN SHAFT OIL CONTROLLER ARM								
	OIL CONTROLLER ARM								
	OIL VALVE SETTING (Ref. No.)	--	--	--	--				
	OIL REGULATOR SET PRESSURE								



Valve Open Position Detail



Linkage Arm Orientation Detail
(As Viewed From Mod Motor End)

Figure 4-13. Initial "F" Series ProFire Settings

⚠ Caution

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

1. Controls Setup

Complete the following burner system control setup steps before beginning the natural gas start-up procedure:

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

Note: 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 settings on page 4-15 and 4-16

Figure 4-14. F Series Control Panel

2. Place the burner switch to the OFF position (see Figure 4-14).
3. Place the Manual/Auto mode switch to the MANUAL position).
4. Place the manual flame control potentiometer in the CLOSED (low-fire) position .

2. Start-Up

Proceed with start-up of the natural gas-fired system as follows:

1. Close the manual shutoff valves on 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)
4. Verify that the gas metering valve is nearly closed.
5. Turn the burner switch on. This will start the blower motor and initiate the pre-purge sequence.
6. When the pre-purge 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 observing the stem move from the CLOSED to the OPEN position.

Note: For initial boiler start-up, 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.

8. After the main flame has been established, the gas manifold 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 and compare to the burner data plate. This will provide an approximation of the burner input. Obtain a stable operating point by adjusting the butterfly valve to the pressure indicated on the burner data plate. Select the temporary firing rate. This rate for start-up is not critical, but merely an acceptable starting point to begin the high fire adjustment procedures.

9. 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 shows the acceptable O_2 range for the gas burner. Normally, O_2 levels are set between 4 and 5 percent at low fire, depending on the application and burner size (see the burner specification plate for the minimum firing rate).

Table 4-1. Recommended Stack Gas 0_2 Concentration at Various Rates (Natural Gas)

BHP	Minimum 0_2 (%)	Maximum 0_2 (%)
Size 3		
100	3.0	5.5
125	2.5	5.0
150	2.5	5.0
Size 4		
200	2.5	5.0
250	2.5	5.0
300	2.5	4.5
350	3.0	4.5

Note: Table presents the maximum recommended range of operating levels of excess oxygen in the flue gas for various burner sizes, operating at given levels of natural gas input to the burner. Data is valid for conditions at standard atmospheric temperature and pressure. Results will vary under environmental conditions differing from standard.

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 O_2 levels remain within the range listed 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).

11. Adjust the high fire gas input to match the maximum rating. At high fire, the butterfly valve should be near the full OPEN position. Adjust gas pressure to obtain the correct fuel input. (Maximum pressure is 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_2O correction to Pgas. Consult meter calibration data.

$$\text{Gas Input} = (\text{HHV}) \times \left[\frac{\text{Patm} + \text{Pgas}}{29.92}\right] \times \left[\frac{520}{\text{Tgas} + 460}\right] \times \left[3600 \frac{\text{s}}{\text{hr}}\right] \times \left[\text{RATE} \frac{\text{ft}^3}{\text{s}}\right] = \left[\frac{\text{Btu}}{\text{hr}}\right]$$

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.

12. Adjust the high-fire excess air rate using the high-fire shutter adjustment (see pages 4-15 and 4-16).
13. Modulate the burner to low fire. The butterfly valve should be adjusted to provide the correct fuel flow at the low-fire position in accordance with the burner data plate minimum gas pressure rating.
14. Adjust the low-fire (see pages 4-15 and 4-16) damper again to obtain the correct low-fire excess air level within the range of 5 – 6% O_2.

Note: Gas train configurations are subject to change. The above configurations reflect components at the date of this Operation and Maintenance manual publication date.

Table 4-2 Gas Train Insurance Designations

	Gas Train Insurance Designations		
Boiler Horsepower	**Standard**	**FM**	**IRI**
100	M2	M2	M4
125 – 200	M3	M3	M4
200 – 250	M3	M3	M4
300 – 350	M4	M4	M4

E. BURNER ADJUSTMENTS, SINGLE FUEL, OIL-FIRED (PRESSURE ATOMIZATION)

This section of the manual presents detailed procedures for initial start-up 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 excess oxygen in the flue gas accordingly.

⚠ 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.

The following procedures assume that the pre-start-up tasks, checklists, and adjustments discussed in this manual have been completed, and that the boiler system is prepared for initial start-up. All necessary test equipment specified in **Section C** should be available on-site.

⚠ Caution

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

1. Controls Setup

Complete the following combination system control setup steps before beginning the oil-fired burner start-up 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 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 information presented on pages 4-15 and 4-16.

2. Place the burner switch to the OFF position (see Figure 4-14).
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. Completely open the low-fire and high-fire shutters.

2. Start-Up

Proceed with initial start-up 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 nearly open.

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 pre-purge sequence.
4. When the pre-purge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.

Note: 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.

5. After the main flame has been established, the oil pressure entering the burner nozzle should be read (by reading the oil pressure gauge downstream of the oil solenoid valves) to get an initial estimate of the fuel oil input rate. Oil pressure should be about 80 psi when operating at low-fire. Adjust the oil metering valve if the actual pressure is not within the range of 80 to 90 psi.

Table 4-2 Recommended Stack Gas O2 Concentration at Various Rates (Light Oil)

BHP	Minimum 0_2 (%)	Maximum 0_2 (%)
Size 3		
100	3.0	5.0
125	3.0	5.0
150	3.0	5.0
Size 4		
200	3.0	5.0
250	3.0	5.0
300	3.0	4.5
350	3.0	4.5
Note: Table presents the maximum recommended range of operating levels of excess oxygen in the flue gas for various burner sizes, operating at given levels of natural gas input to the burner. Data is valid for conditions at standard atmospheric temperature and pressure. Results will vary under environmental conditions differing from standard.		

6. Operate the boiler at low fire until it is thoroughly warmed. Then, modulate to high fire by turning the manual flame potentiometer to the OPEN position. This will cause the oil metering valve to close, resulting in an increase in the oil pressure feeding the burner nozzle. Check the excess air in the flue gas (see Table 4-2) for acceptable excess O_2 levels), while modulating to high-fire. Adjust the oil pressure if needed.
7. Set the high-fire fuel input pressure to match the maximum oil pressure specification on the burner data plate by adjusting the fuel input. The oil metering valve should be in the fully closed position and the fuel pressure should be about 300 psi.
8. Adjust the high-fire shutter to obtain the correct excess air level (see pages 4-15 and 4-16 for the adjustment location).

9. Modulate to low fire using the manual flame control. Be sure O_2 levels are within limits in Table 4-1.
10. Set the proper fuel input for low fire by adjusting the linkage to drive the oil metering valve to the proper position (see Pages 4-15 and 4-16 for oil metering valve linkage adjustments).
11. Adjust low fire air shutter to obtain 4.5-5.5% O_2.
12. Check intermediate positions for proper combustion. Adjust the linkage, as required, to match the fuel and air ratios indicated in table 4-2.
13. Modulate and recheck combustion air at different firing rates. When large adjustments are made at one rate, they may adversely affect settings at another rate.

F. BURNER ADJUSTMENTS, COMBINATION

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 section of the manual presents procedures to be followed for initial start-up of a combination ProFire burner.

⚠ 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.

These procedures assume that the pre-start-up tasks, checklists, and adjustments discussed in this manual have been completed, and that the boiler system is prepared for initial start-up. All necessary test equipment specified in this Chapter should be available on-site.

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 shutters when tuning the combination burner for combustion of natural gas.

⚠ Caution

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

1. Controls Setup

Complete the following system control setup steps before beginning the combination burner start-up 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 information provided on pages 4-14 and 4-15.

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. Open the low-fire and high-fire shutters completely.

2. Start-Up

Proceed with initial start-up using oil as follows:

1. Position the fuel selector switch (located inside the control panel) to OIL.
2. Proceed with start-up and combustion adjustments using the same procedures defined for oil-fired burner initial start-up.
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. Turn the burner switch on. This will start the blower motor and initiate the pre-purge sequence.
10. When the pre-purge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.
11. 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 start-up, to ensure proper operation

of the automatic gas valves. This valve can then be slowly opened when the pilot is established and proven.

12. 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 start-up is not critical, but merely an acceptable starting point to begin the high fire adjustment procedures.

13. After a few seconds, the 0_2 analyzer should have an accurate reading of the 0_2 present in the flue gas. Table 4-1 provides a representation of the acceptable 0_2 range for the gas burner. Normally, the 0_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).

14. 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 0_2 levels remain within the range shown in Table 4-1 and 4-2. 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).

15. 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.

$$\text{Gas Input} = (\text{HHV}) \times \left[\frac{\text{Patm} + \text{Pgas}}{29.92}\right] \times \left[\frac{520}{\text{Tgas} + 460}\right] \times \left[3600 \frac{s}{hr}\right] \times \left[\text{RATE } \frac{ft^3}{s}\right] = \left[\frac{\text{Btu}}{hr}\right]$$

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.

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

16. 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 (see Figure 4-13). 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:

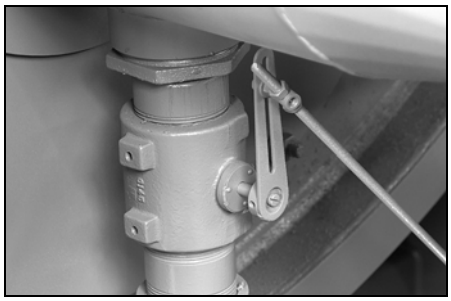


Figure 4-15. Gas Butterfly Valve

1. Maximum flow rate is established by operating the burner at high-fire with the butterfly valve (Figure 5-15) 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.
2. 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:

1. 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 bypass 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. START-UP, OPERATING AND SHUTDOWN — ALL FUELS

1. Start-Up

Depending upon the fuel being burned, the applicable previous sections should be reviewed for preliminary instructions.

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

Set the manual-automatic switch (Figure 4-14) 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.

Note: 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.

⚠ 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.

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. Close the steam header.

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 to no higher than 1/4 of the modulation motor rotation. 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. Refer to the adjustment procedures in Chapter 5 and the start-up sequences earlier in this chapter. After making the high-fire adjustment, manually decrease the firing rate, stopping at several places 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.

2. 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:

1. **The burner is manually turned “OFF.”**
2. **A low-water condition is detected by low-water level control.**
3. **The electrical or fuel supply is interrupted.**
4. **The combustion air pressure or atomizing air pressure drops below minimum level.**

Note: 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 8.

3. 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 de-energized 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 air pump motor of an oil-fired burner is also turned off. The timer has returned to its original starting position and stops. The unit is ready to restart.

⚠ 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 Tests

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 or water temperature 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 pump operating control, if used). Proper operation of the flame failure device should be checked at start-up and at least once a week thereafter. Refer to

Chapter 9 for information on flame safety checks. Check the program relay's annunciation for any system failure. Observe the promptness of ignition of the pilot flame and the main flame.

Check for tight shut-off of all fuel valves. Despite precautions and strainers, foreign material may lodge under a valve seat and prevent tight closure. Promptly correct any conditions that cause leakage.

Chapter 5

Adjustment Procedures

F Series Burners

Milwaukee, Wisconsin

www.cleaver-brooks.com

A. GENERAL

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

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

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

The adjustment procedures in Chapter 5 apply to standard components furnished on steam or hot water boilers fired with gas and/or light oil.

B. LINKAGE — MODULATING MOTOR AND AIR DAMPER

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

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

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

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

⚠ Caution

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

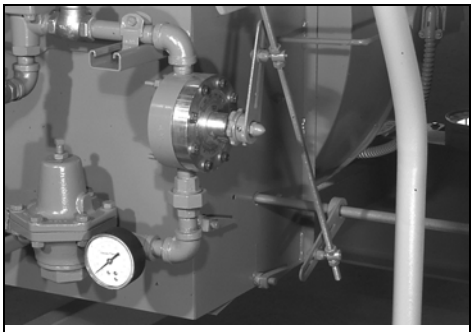
2. Initial adjustment should be made with the motor in full closed position, that is with the shaft on the power end of the motor in its most counterclockwise position.
3. The closer the connector is to the drive shaft, the less the arm will travel; the closer the connector is to the driven shaft, the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

Prior to initially firing a boiler, it is advisable to check for free movement of the linkage by electrically driving the damper motor. The damper motor must be allowed to complete its full stroke and the damper must move freely from low- to high-fire position. Adjustment of linkage connected to a gas butterfly valve.

Modulating Motor

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

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



ADJUST THE LINKAGE TOWARD THE DRIVE SHAFT FOR LESS MOVEMENT. ADJUST AWAY FROM THE DRIVE SHAFT FOR MORE LINKAGE MOVEMENT.

Figure 5-1. Linkage Assembly — Combination Gas and Oil

C. MODULATING MOTOR SWITCHES — LOW FIRE AND HIGH FIRE

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

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

D. BURNER OPERATING CONTROLS — GENERAL

Note: Adjustments to the boiler operating controls should be made by an authorized Cleaver-Brooks Service Technician.

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

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

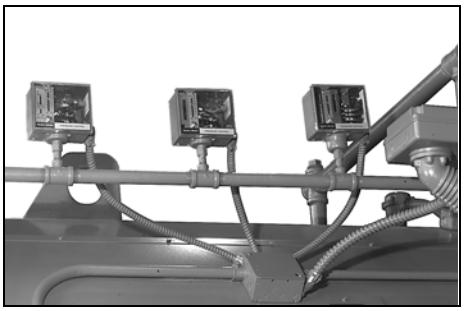


Figure 5-2. Steam Operating Controls

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

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

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

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

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

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

Figure 5-3. Hot Water Operating Controls

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

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

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

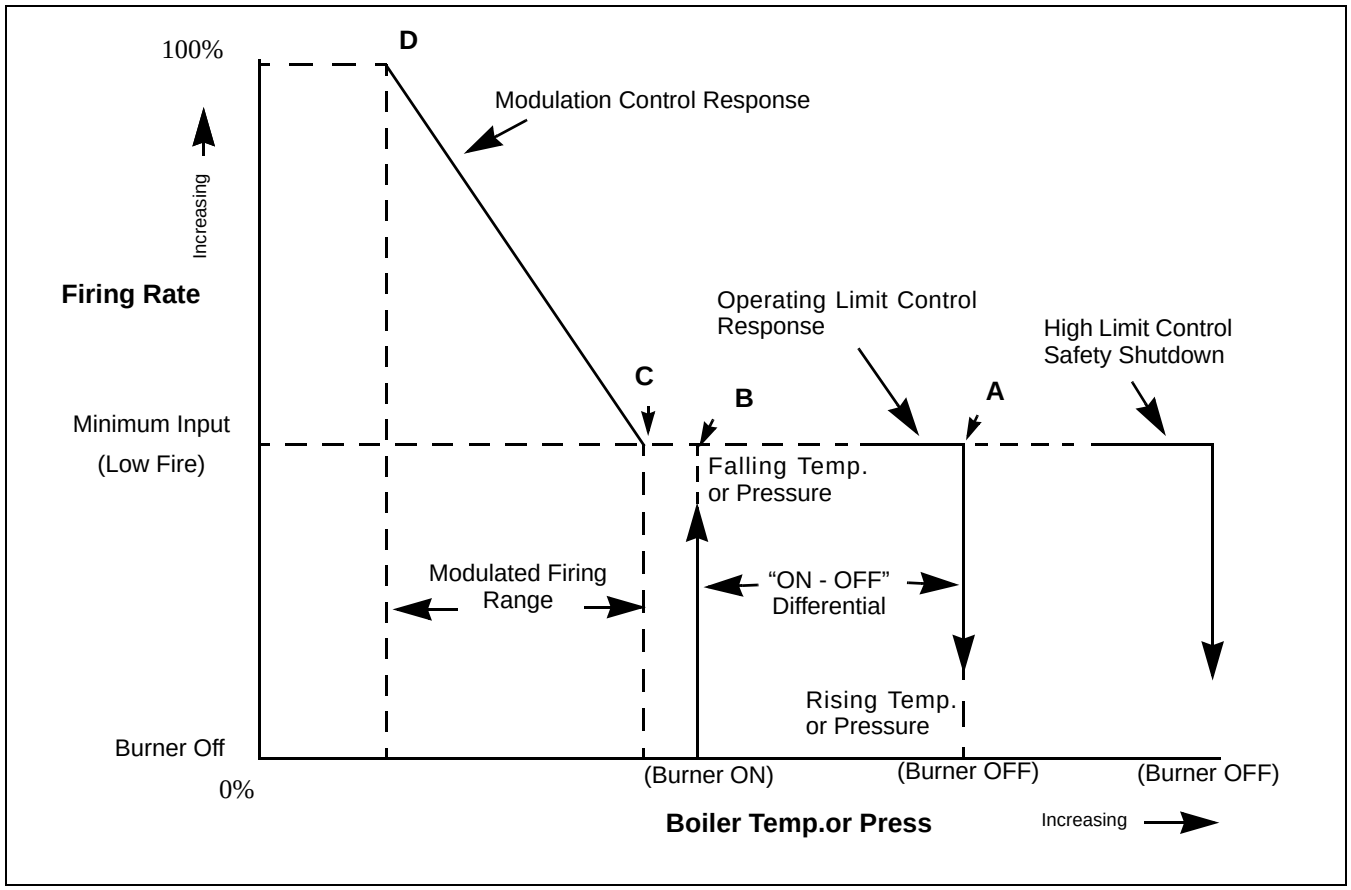


Figure 5-4. Firing Graph

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

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

The firing graph (Figure 6-4) shows that point **B** and point **C** do not coincide. Extreme load conditions could require that the points be closely matched.

When set as shown, with a time lag between **B** and **C**, the burner will be in a low-fire position upon a restart and will fire at that rate for a short

period of time before falling pressure or temperature requires an increase in the firing rate.

Note: On-Off cycling in excess of 8 cycles per hour will shorten the life of the combustion air motor and cause excessive wear on switch gear and pilot electrodes.

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

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

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

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

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

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

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

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

The **operating limit** control should now be adjusted and the differential established. In an installation that does not require a very close control of steam pressure or water temperature, the adjustable differential (Figure 6-4, **A** to **B**) should be set as wide as conditions permit, since a wide setting will provide less frequent burner cycling.

The **high limit control** provides a safety factor to shut the burner off in the event the **operating limit control** should fail. The setting of the

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

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

E. MODULATING PRESSURE CONTROL (STEAM)

Turn the adjusting screw until the indicator is opposite the low point of the desired modulating range. Modulated firing will range between the low point and a higher point equal to the modulating range of the particular control. In 0 – 15 psi controls the range is 1/2 lb; in 5 – 150 psi controls the range is 5 lbs; in 10 – 300 psi controls the range is 12 lbs.

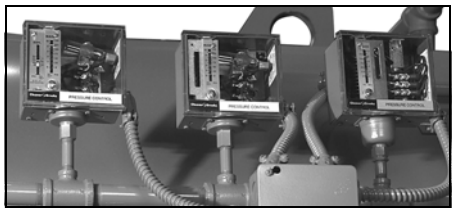
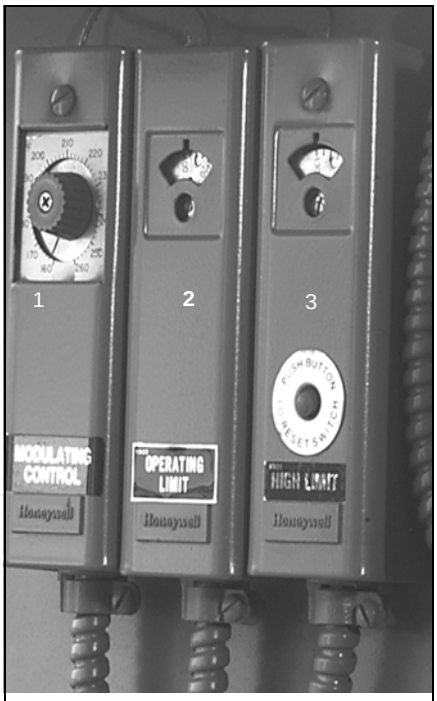


Figure 5-5. Steam Operating Controls

⚠ Caution

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



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

Figure 5-6. Hot Water Controls

F. OPERATING LIMIT PRESSURE CONTROL (STEAM)

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

G. HIGH LIMIT PRESSURE CONTROL (STEAM)

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

H. MODULATING TEMPERATURE CONTROL (HOT WATER)

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

⚠ Caution

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

I. OPERATING LIMIT TEMPERATURE CONTROL (HOT WATER)

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

J. HIGH LIMIT TEMPERATURE CONTROL (HOT WATER)

Set the "cut-out" (burner off) temperature on scale using the adjusting screw. The control will break the circuit and **lock out** on a rise in water temperature above the setting. The setting should be sufficiently above the operating limit temperature to avoid unnecessary shutdowns. On a 30 psig hot water boiler, the setting is not to exceed 240° F. The control requires manual resetting after tripping on a temperature increase. To reset, allow the water temperature to drop below the cut-out setting less differential, and then press the manual RESET button.

K. LOW WATER CUTOFF DEVICES (STEAM AND HOT WATER)

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

L. COMBUSTION AIR PROVING SWITCH

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

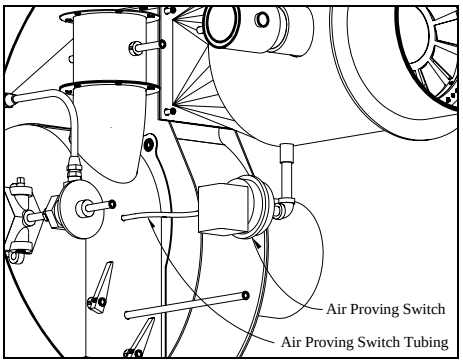


Figure 5-7. Combustion Air Proving Switch

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

Note: On an oil fired boiler, the atomizing air proving switch (AAPS) must also be closed.

Note: On a combination fuel fired burner, the fuel selector switch could be set at “gas” to eliminate the atomizing air proving switch from the circuitry.

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

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

M. ATOMIZING AIR PROVING SWITCH

The air pressure against the diaphragm actuates the switch which, when closed, completes a circuit to prove the presence of atomizing air. Since the pressure of the atomizing air is at its minimum value when there is no fuel present at the nozzle, adjustment of the switch should be done while the unit is running but not firing. The control should be set slightly below the minimum pressure, but not too close to that point to cause nuisance shutdowns.

The control adjustment may be made during the pre-purge period of operation by stopping the programmer during the pre-purge period through the use of the TEST switch. Refer to the control instruction bulletin for details.

The adjustment screw of the atomizing air proving switch can then be adjusted until it breaks the circuit. Here, the programmer will lock out and must be manually reset before it can be restarted. Turn the adjusting screw up a half turn or so to remake the circuit.

Since the adjustment of the air switch may be made either during the damper closed or damper open position of pre-purge, it is also possible to make the adjustment with the relay stopped in the damper open position

in a similar manner to the adjustment of the combustion air proving switch described in **Section L**.

After making the adjustment, recycle the control to be sure that normal operation is obtained. The TEST switch must be set to RUN position.

N. GAS PILOT FLAME ADJUSTMENT

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

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

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

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

To Measure and Adjust Pilot:

1. When making a pilot adjustment, turn the manual-automatic switch to “MANUAL” and the manual flame control to “CLOSE.” Open both the pilot cutoff cock and the pilot adjusting cock. The main gas cock should remain closed.

   The regulator in the pilot line, if provided, is to reduce the gas pressure to suit the pilot’s requirement of between 5 to 10" WC. Regulator adjustment is not critical; however, with a lower pressure the final adjustment of the pilot flame with adjusting cock is less sensitive.

2. Connect the micro-ammeter as outlined earlier.

3. Turn the burner switch on. Let the burner go through the normal pre-purge cycle. When the ignition trial period is signaled, set the test switch to the TEST position to stop the sequence.

4. If the pilot flame is not established within 10 seconds, turn off the burner switch. Repeat the lighting attempt.

Note: On an initial starting attempt, portions of the fuel lines may be empty and require “bleeding” time. It is better to accomplish this with repeated short lighting trial periods with intervening purge periods than to risk prolonged fuel introduction. If the pilot does not light after several attempts, check all components of the pilot system.

5. When the pilot flame is established, and with the pilot adjusting cock wide open, remove the flame detector from the burner plate. The pilot flame can then be observed through this opening.

⚠ Warning

Wear a protective shield or suitable glasses and keep eyes sufficiently away from the sight tube opening to avoid serious personal injury or death. Never remove the flame detector while the main burner is firing. Failure to follow these instructions could result in serious personal injury or death.

⚠ Warning

When checking the pilot flame, be aware the electrode is energized. Failure to follow these instructions could result in serious personal injury.

6. To make the final adjustment, slowly close the gas pilot adjusting cock until the flame can no longer be seen through the sight tube. Then slowly open the cock until a flame providing full sight tube coverage is observed.

The adjustment must be accomplished within the time limit of the safety switch or approximately 30 seconds after the detector is removed. If the control shuts down, manually reset it. Replace the detector and repeat the process from step 5.

7. When a suitable flame as indicated in paragraph 6 is obtained, replace the detector. Observe the reading on the micro-ammeter. The reading should be between 2-1/4 and 5 microamps when using a lead sulfide detector and a standard amplifier. See the flame signal table in the manufacturer's bulletin for values of other combinations.

The flame signal indicated on the annunciator type relay should not be less than 10 VDC, and may be as high as 20 VDC or greater.

The reading must be steady. If the reading fluctuates, recheck the adjustment. Be sure that the flame detector is properly seated and that the lens is clean.

8. Return the test switch to the RUN position.
9. If main flame has not been previously established, proceed to do so in accordance with instructions elsewhere in the manual.
10. The reading of the main flame signal should also be checked. Observe the flame signal for pilot alone, pilot and main burner flame together and the main burner flame at high, low, and intermediate firing rate positions. Readings should be steady and in the range indicated in paragraph 7. If there are any deviations, refer to the troubleshooting section in the technical bulletin.

O. GAS PRESSURE AND FLOW INFORMATION

Because of variables in both the properties of gas and the supply system, it will be necessary to regulate the pressure of the gas. Regulating the gas produces a steady, dependable flame that yields high combustion efficiency at rated performance yet prevents overfiring. See below for the

standard gas train data. Once the optimum pressure has been established, it should be recorded and periodic checks made to verify that the regulator is holding the pressure at this level. Occasional modification in fuel composition or pressure by the supplier may, at times, require readjustment to return the burner to peak efficiency. Since the gas pressure regulator itself is usually furnished by others, detailed adjustment instructions and adjusting procedures recommended by the manufacturer should be followed.

Pressure

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

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

The pressure requirement varies with boiler size, altitude, and type of gas train. Refer to Table 6-1 for standard pressure requirements.

The pressures listed are based on 1000 Btu/cu-ft natural gas at elevations up to 700 feet above sea level. For installation at higher altitudes, multiply the selected pressure by the proper factor from **Table 5-1**.

Table 5-1. Pressure Correction Factors

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

Model ICB, Standard, Minimum Required Gas Pressure at Entrance to Standard, FM & IRI Gas Trains (Upstream of Gas Pressure Regulator)

BOILER HP	STD PIPE SIZE (Inches)	PRESSURE REQUIRED, 3 PASS ("WC)		PRESSURE REQUIRED, 4 PASS ("WC)	
		Minimum	Maximum	Minimum	Maximum
100	2	8.5	27.7	10.5	27.7
125	2	13.5	27.7	16	27.7
150	2	17	27.7	21	27.7
200	2-1/2	20	27.7	26	138.5
250	2-1/2	32.5	138.5	33	138.5
300	2-1/2	45	138.5	45.5	138.5
350	3	46	138.5	46.5	138.5
400	3	38	138.5	43.5	138.5
500	3	56	138.5	56	138.5
600	3	120	277	120	277
700	3	138.5	277	138.5	277
800	3	86	277	86	277

Note: For undersized or oversized gas trains or altitudes above 700 feet, contact your local Cleaver-Brooks

Model ICB, Low Nox, Minimum Required Gas Pressure at Entrance to Standard, FM & IRI Gas Trains (Upstream of Gas Pressure Regulator)

BOILER HP	STD PIPE SIZE (Inches)	PRESSURE REQUIRED, 3 PASS ("WC)		PRESSURE REQUIRED, 4 PASS ("WC)	
		Minimum	Maximum	Minimum	Maximum
100	2	13	27.7	15	27.7
125	2	19.5	27.7	17.5	27.7
150	2	20	27.7	21.5	27.7
200	2-1/2	27	138.5	32.5	138.5
250	2-1/2	30	138.5	35.5	138.5
300	2-1/2	43	138.5	47.5	138.5
350	3	45	138.5	49.5	138.5
400	3	40.5	138.5	42.5	138.5
500	3	53.5	138.5	58.5	138.5
600	3	120	277	120	277
700	3	138.5	277	138.5	277
800	3	86	277	86	277

Note: For undersized or oversized gas trains or altitudes above 700 feet, contact your local Cleaver-Brooks

Gas Flow

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

Input = Btu/Hr

Output = Btu/ Hr

Gas Flow = Ft^3/Hr

$$INPUT = \frac{OUTPUT \times 100\%}{EFFICIENCY}$$

$$GAS\ FLOW = \frac{INPUT}{GAS\ BTUs/Ft^3}$$

$$= \frac{\textbf{OUTPUT @ 100\%}}{\textbf{EFFICIENCY x GAS BTUs/Ft}^{\textbf{3}}}$$

Figure 5-8.

Pressure Correction

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

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

Conversely:
To determine what the meter index reading should be in order to provide the volume of gas required for input, divide the desired flow rate by the proper pressure correction factor. This answer indicates the number of cubic feet at line pressure which must pass through the meter to deliver the equivalent number of cubic feet at base pressure.

As an example:
Assume that a 300 horsepower boiler is installed at 2,000 feet above sea level; is equipped with a standard gas train and that 1,000 Btu natural gas is available with an incoming gas pressure of 3 psig. The pressure and flow requirements can be determined as follows:

Pressure

Correction for the 2,000 feet altitude must be made since altitude has a bearing on the net regulated gas pressure. The standard gas train requires 36.4" WC gas pressure at sea level indicates a correction factor of 1.07 for 2,000 feet. Multiplying results in a calculated net regulated gas requirement of approximately 38.9" WC. This is the initial pressure to which the regulator should be adjusted. Slight additional adjustment can be made later, if necessary, to obtain the gas input needed for burner rating.

Flow

Since the gas flow rate is based on standard conditions of flow, correction must be made for the supply pressure through the meter of 3 psig. Determine the flow rate by dividing the Btu content of the gas into the burner input and “correct” this answer by applying the correction factor for 3 psig.

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

OR

12,550,000 = 12,550 CFH (At 14.7 Ib-atmospheric 1,000 base pressure)

THEN

12,550 = 10,635 CFH
1.18

This is the CFH (at line pressure) that must pass through the meter so that the equivalent full input requirement of 12,550 CFH (at base pressure) will be delivered.

Checking Gas Flow

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

Final adjustment of the gas fuel is carried out by means of the adjusting rods and linkage arms while performing a combustion efficiency analysis.

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

P. GAS FUEL COMBUSTION ADJUSTMENT

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

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

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

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

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

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

It's important to understand what the readings shown on an instrument refer to when setting combustion in a boiler. One of the products of combustion is CO_2 (Carbon Dioxide). This is shown in percentage.

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

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

It is generally recommended that O_2 readings of between 3% to 4% be attained with less than 400 ppm CO, at high fire.

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

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

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

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

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

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

When proper gas flow is obtained, take a flue gas reading. The O_2 should be between 3% and 4% at high fire.

If the fuel input is correct, but the O_2 values do not fall within this range, the high-fire air damper may need to be adjusted.

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

1. Adjusting the Burner Linkage

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

Since the input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of gas fuel at that setting. The adjustment is made to the metering valve by means of the adjustable linkage. Flow rate is highest when the butterfly valve actuating rod assembly is closest to the jackshaft.

⚠ Warning

Initial setup and firing must only be performed by a qualified Cleaver-Brooks service representative. Appropriate instrumentation and equipment must be utilized for burner setup and adjustment. *Failure to follow this warning could result in serious personal injury or death.*

2. Standard Burner Low Fire Adjustment

The fuel input should be adjusted to approximately 25% of that at high fire. At low fire the O_2 flue gas reading should be between 6 – 7%.

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

Q. LOW-GAS-PRESSURE SWITCH

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

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

R. HIGH-GAS-PRESSURE SWITCH

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

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

S. Fuel Oil Pressure

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

Table 5-2. Fuel Oil /Atomizing Air Requirements

F Series Size 3			
	Low Fire	Intermediate	High Fire
Oil pressure psig at regulator	40.1	38.7-37.8	37.6
Oil pressure psig at gun	11.7	15.9-20.1	21.2
Atomizing air pressure psig	13.6	21.8-28.3	20.2

F Series Size 4			
	Low Fire	Intermediate	High Fire
Oil pressure psig at regulator	37.8	36.3-35.8	34.5
Oil pressure psig at gun	7.8	12.7-16.5	18.4
Atomizing air pressure psig	9.2	13.1-16.2	18.4

T. Fuel Oil Combustion Adjustment

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

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

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

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

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

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

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

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

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

Take a flue gas analysis reading. If necessary, adjust the fuel pressure regulator to increase or decrease oil pressure. Adjustments to the pressure should be done before attempting to adjust the linkage.

After being certain that the air control damper and its linkage are operating properly, final adjustment can be made, if necessary, to the linkage to obtain a constant fuel/air ratio through the entire firing range.

Since the input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of fuel at that setting. The adjustment is made to linkage by sliding the push rod in or out on the linkage arm. Flow rate is highest when the push rod assembly is closest to the jackshaft. If oil pressure, primary air pressure, and linkages are properly adjusted, the metering valve should require minimal adjustment.

Notes

Chapter 6
Profire D Series Burner

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 6-1.

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.

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

Figure 6-1. Mounted D Series Burner

B. OPERATING CONTROLS / CONTROL PANEL

See Figure 6-2

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.

Figure 6-2. Burner Control Panel

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 6-3)

Figure 6-3. Flame Safety Inside Burner Control Panel

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

D. COMBUSTION AIR HANDLING SYSTEM

The combustion air handling system consists of three major components: (See **Figure 6-4**)

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 and for firing against either moderate or high furnace pressure.

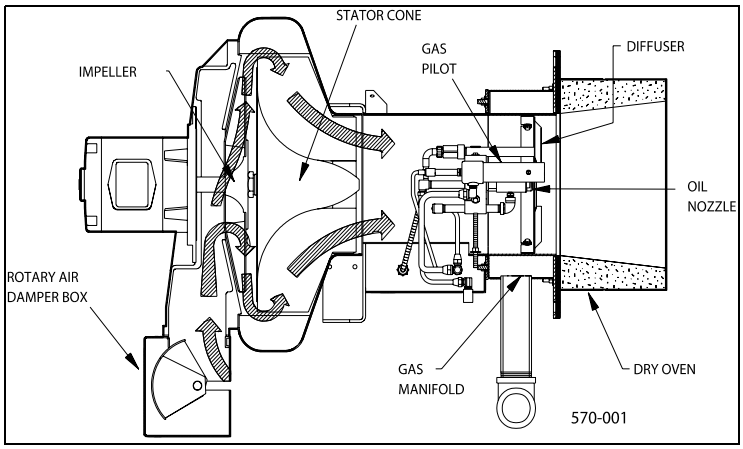


Figure 6-4. Combustion Air Handling System

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.

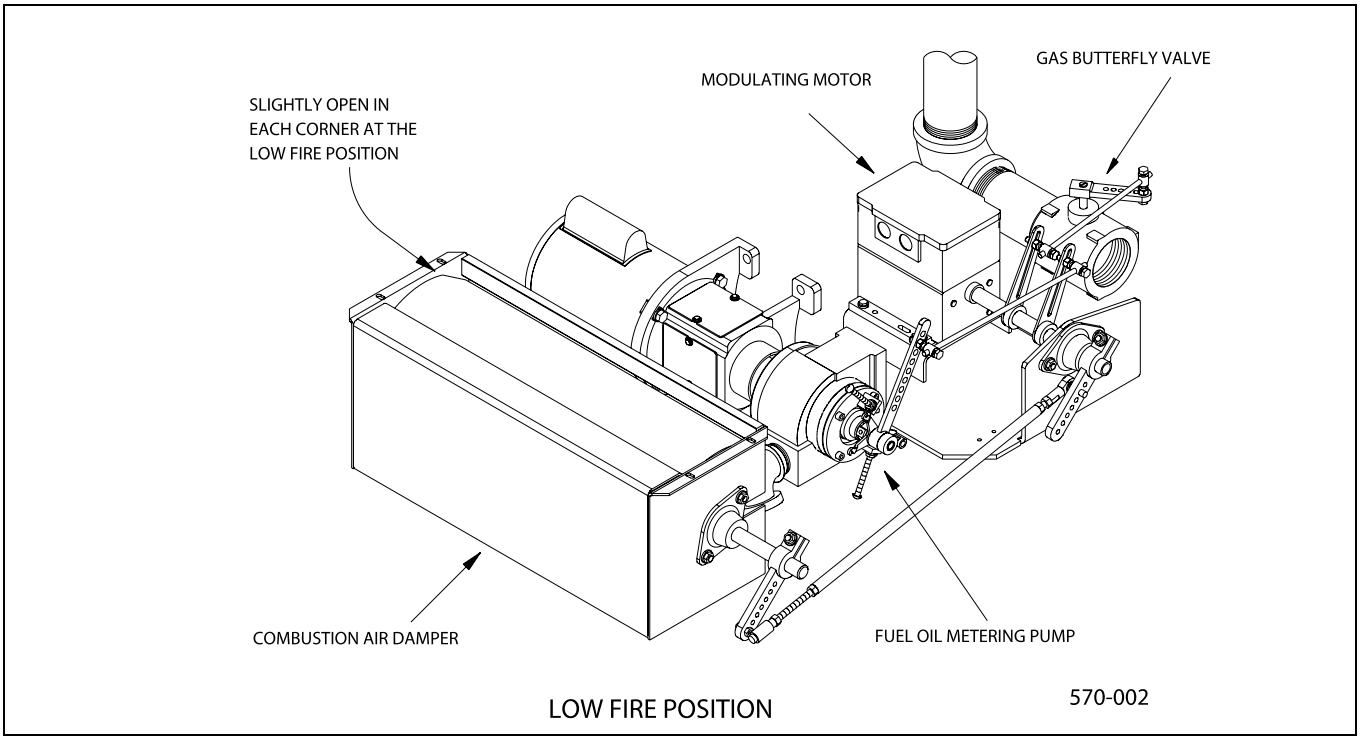


Figure 6-5. Low Fire Position

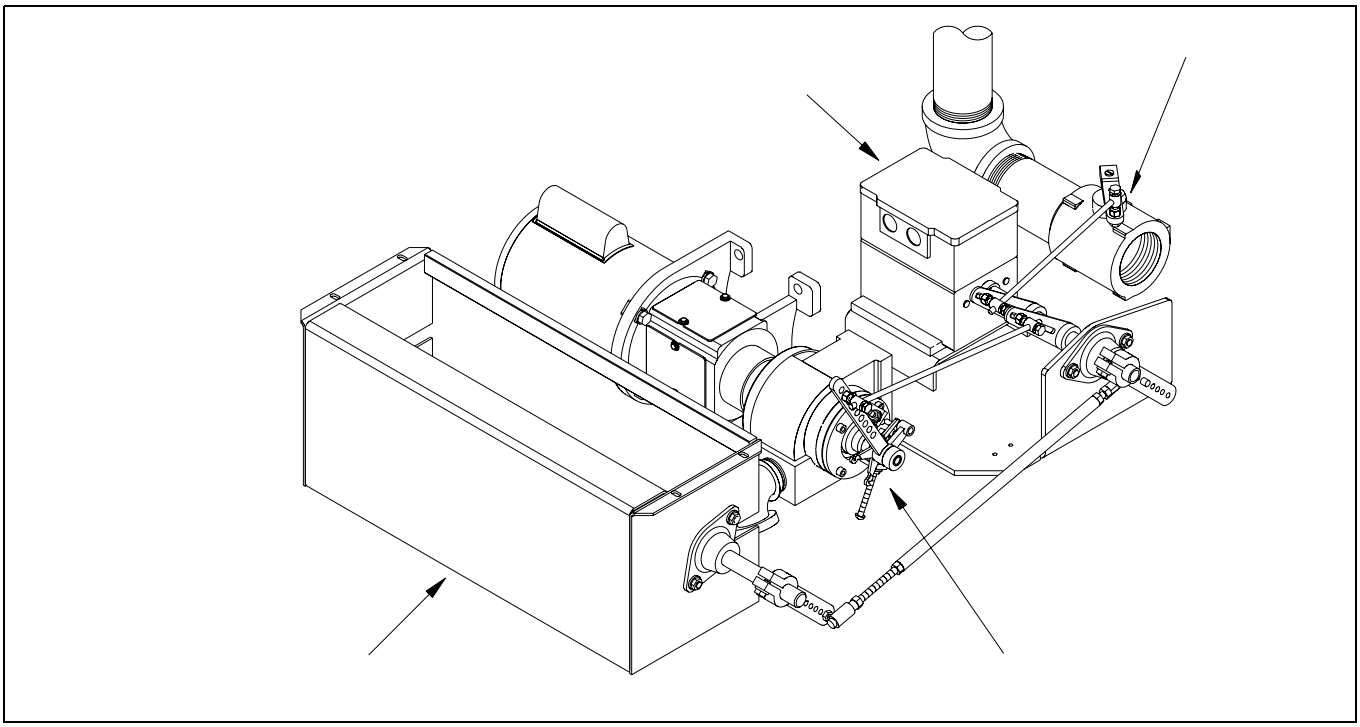


Figure 6-6. High Fire Position

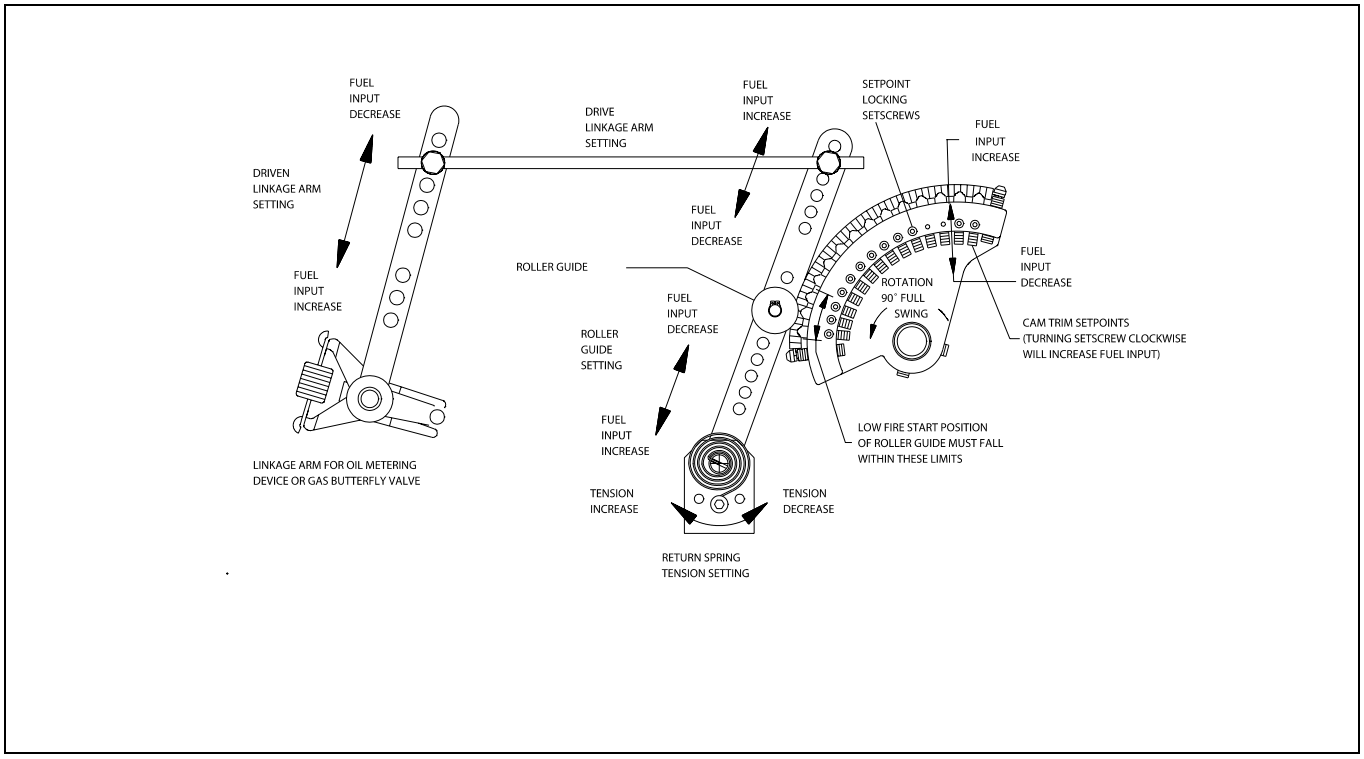


Figure 6-7. Cam Trim Adjustment

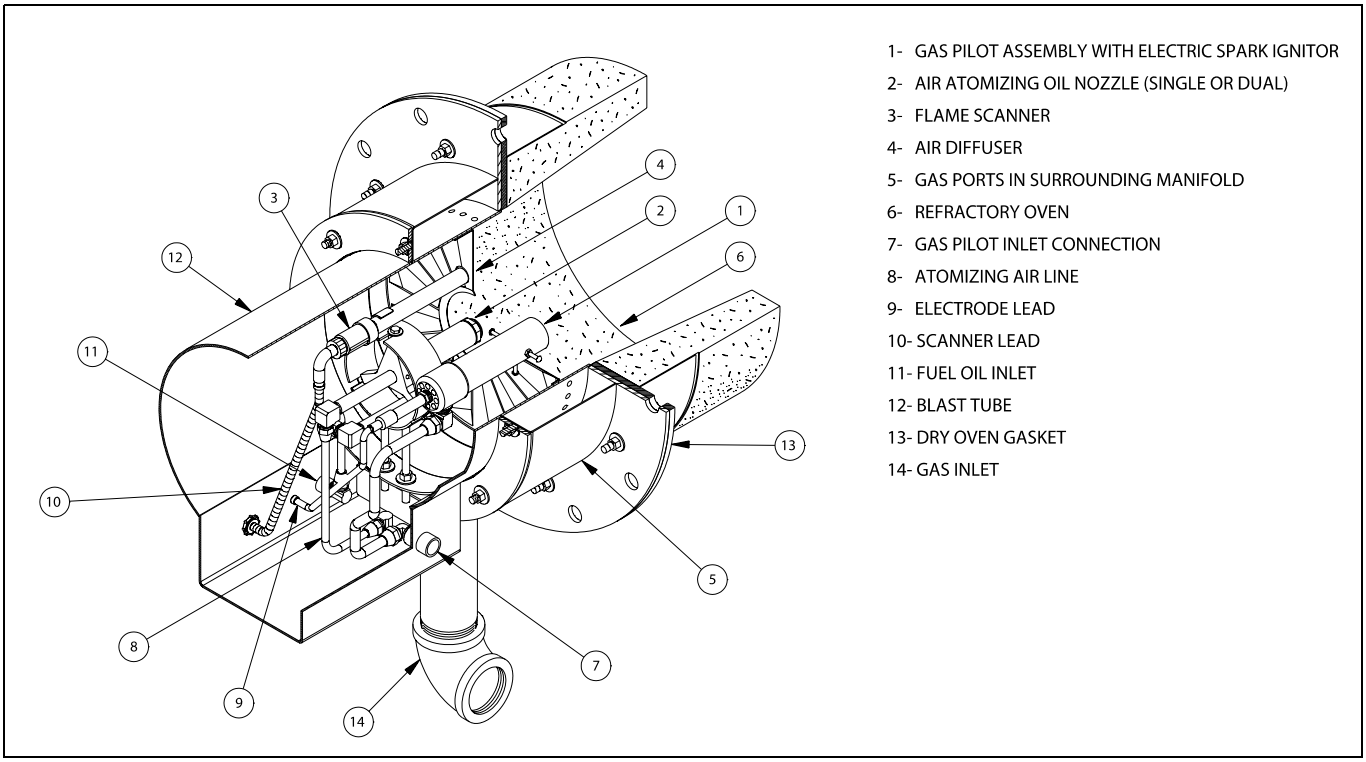


Figure 6-8. Firing Head Assembly

E. FIRING RATE CONTROLS

Regardless of the fuel used, burner input is fully modulated between low fire and high fire on boiler demand. 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. Lever on the modulating motor shafts actuate the high fire position proving switch.

F. FIRING HEAD

Access to the firing head is provided by swinging open the impeller housing; see **Figure 6-9**. First, disconnect the damper linkage, release the housing latch, 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 6-9. 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.

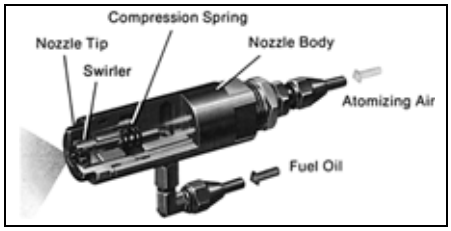


Figure 6-10. Oil Nozzle Cutaway

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.

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.

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.

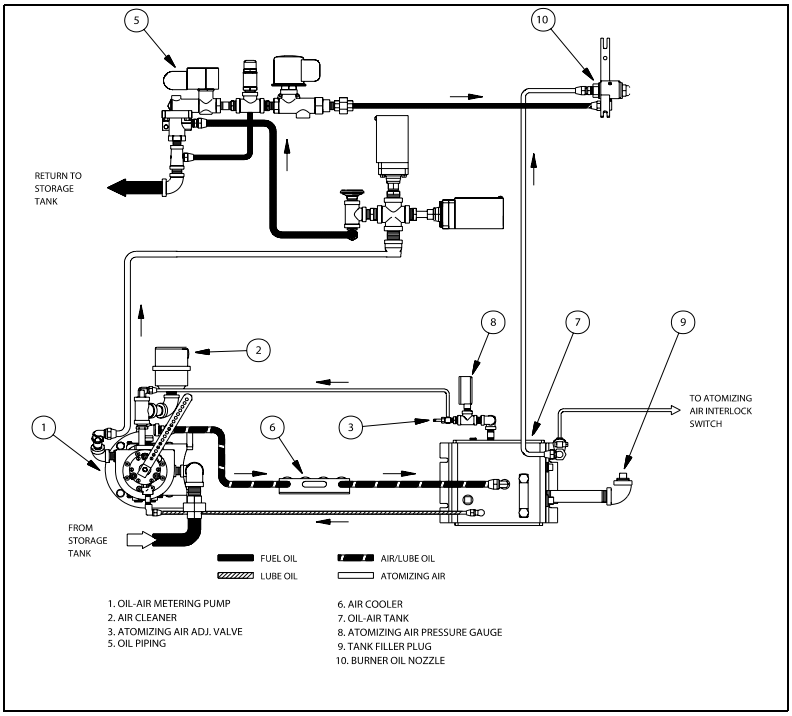


Figure 6-11. Integral Compressor Oil-Air Metering System

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 6-11**

AIR COMPRESSOR.

Air is drawn into the vane-type, rotary compressor section of the air/oil unit through an air cleaner (see **Figure 6-12**). 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.

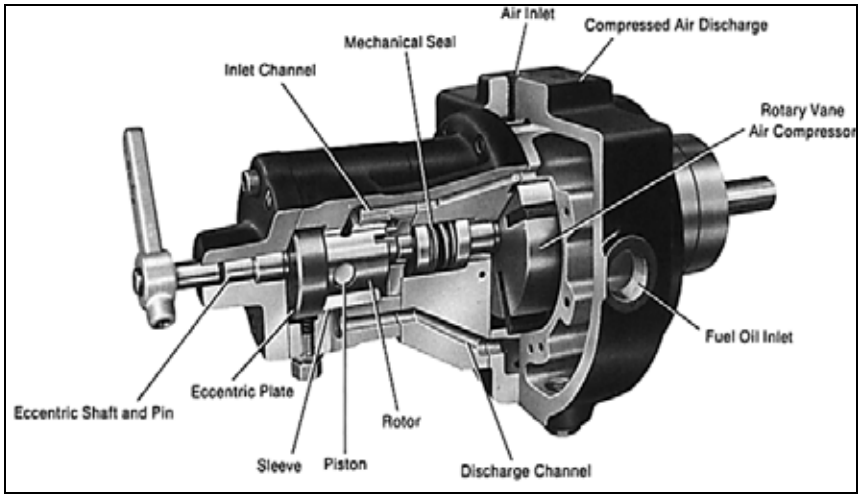


Figure 6-12. Air Compressor Cutaway

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.

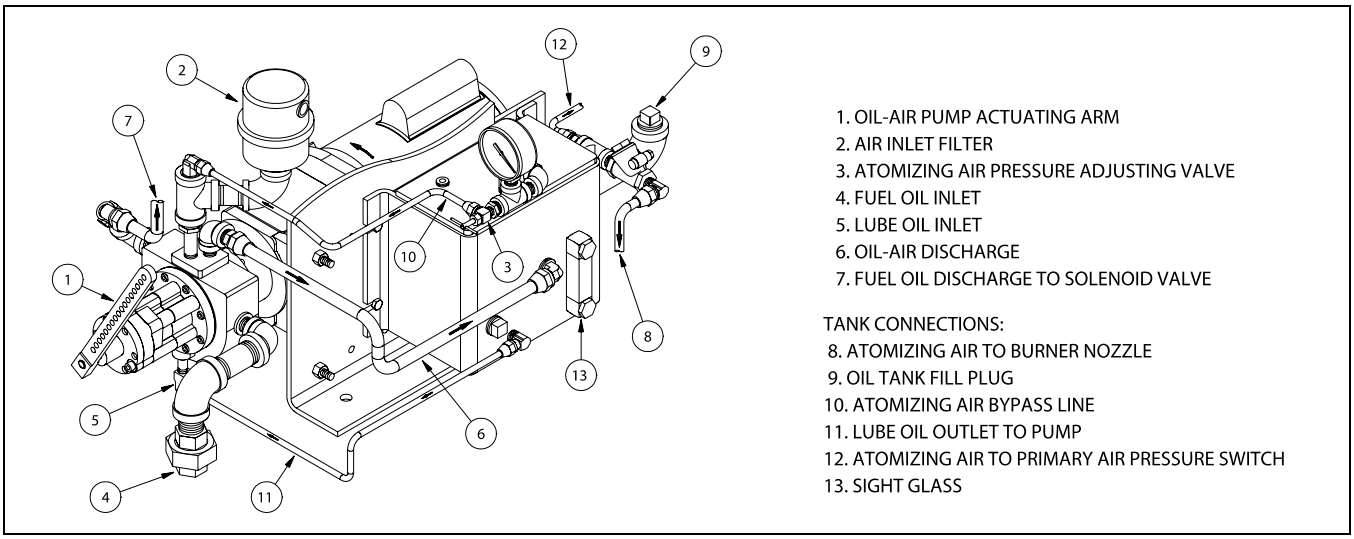


Figure 6-13. Oil Metering Pump and Tank Assembly, Integral Compressor

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.

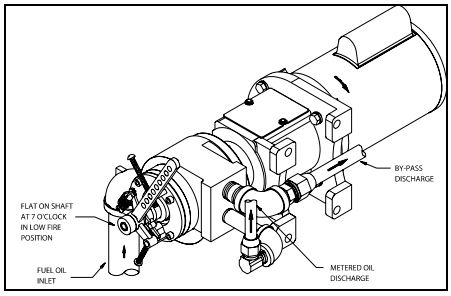


Figure 6-14. Separate Fuel Oil Metering Pump

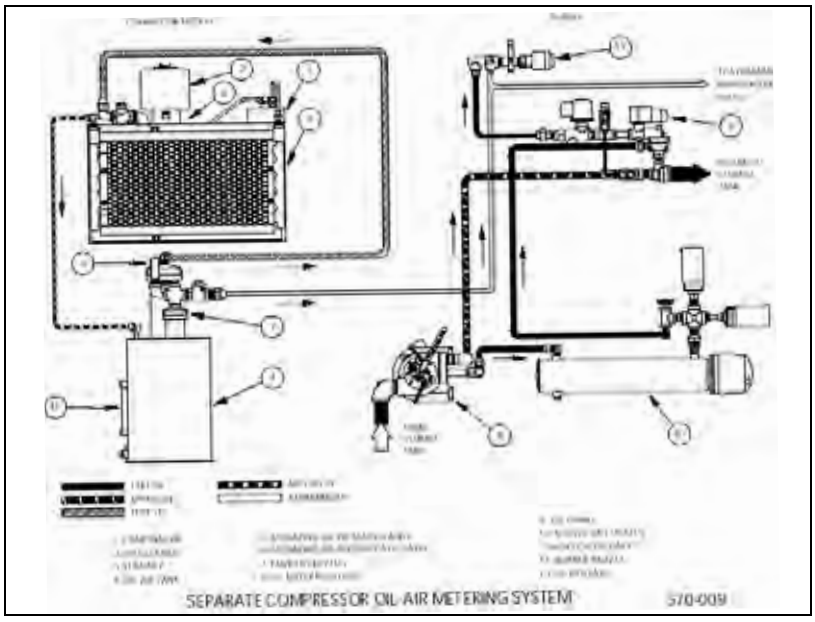


Figure 6-15. Separate Compressor - Air Metering System

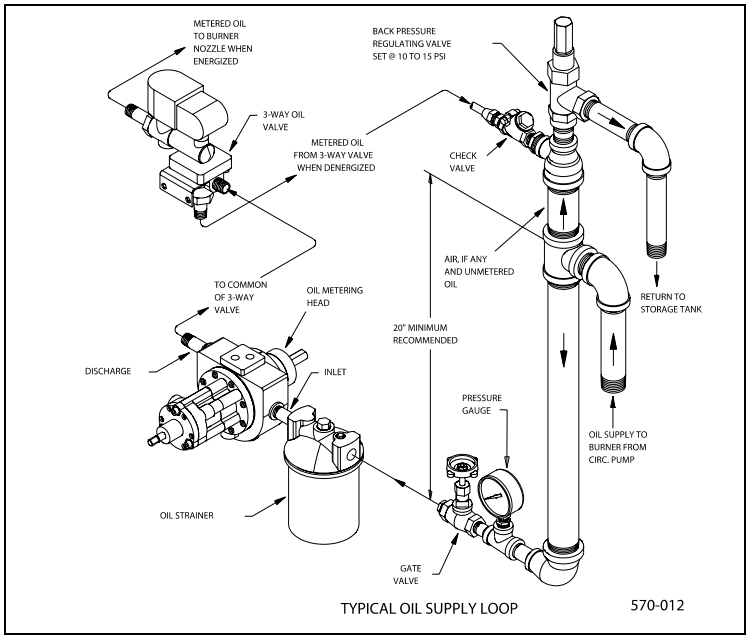


Figure 6-16. Typical Oil Supply Loop

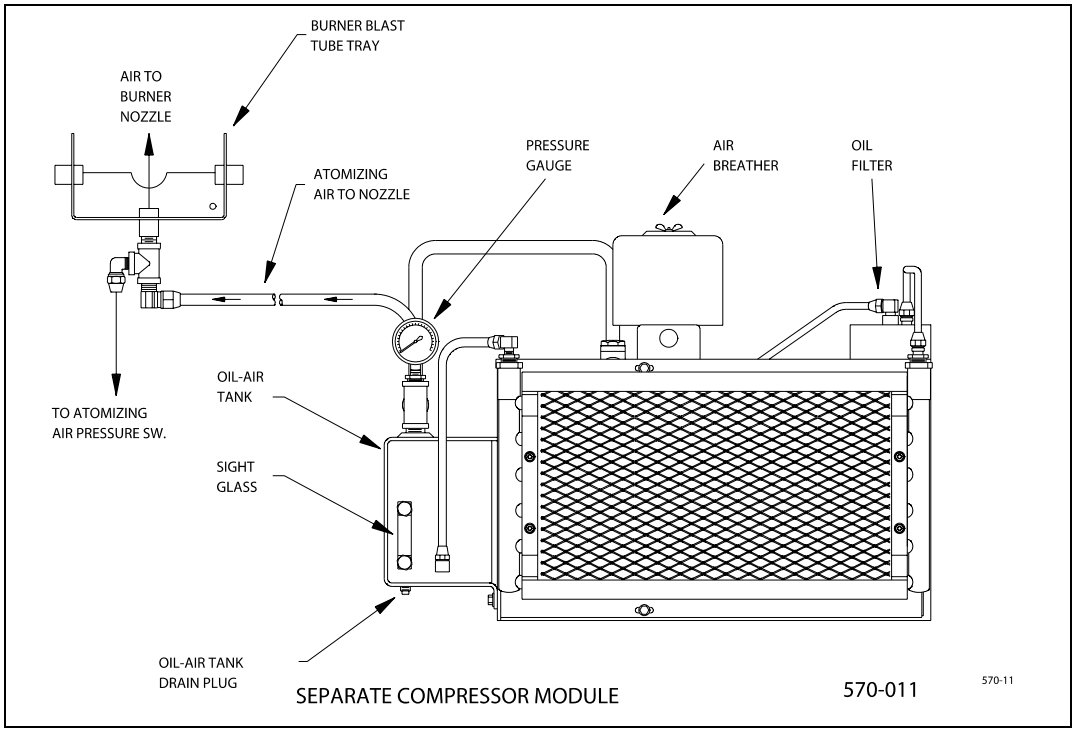


Figure 6-17. Separate Compressor Module

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 Section 2. 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 2-19, 1-20 and 2-21.

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.

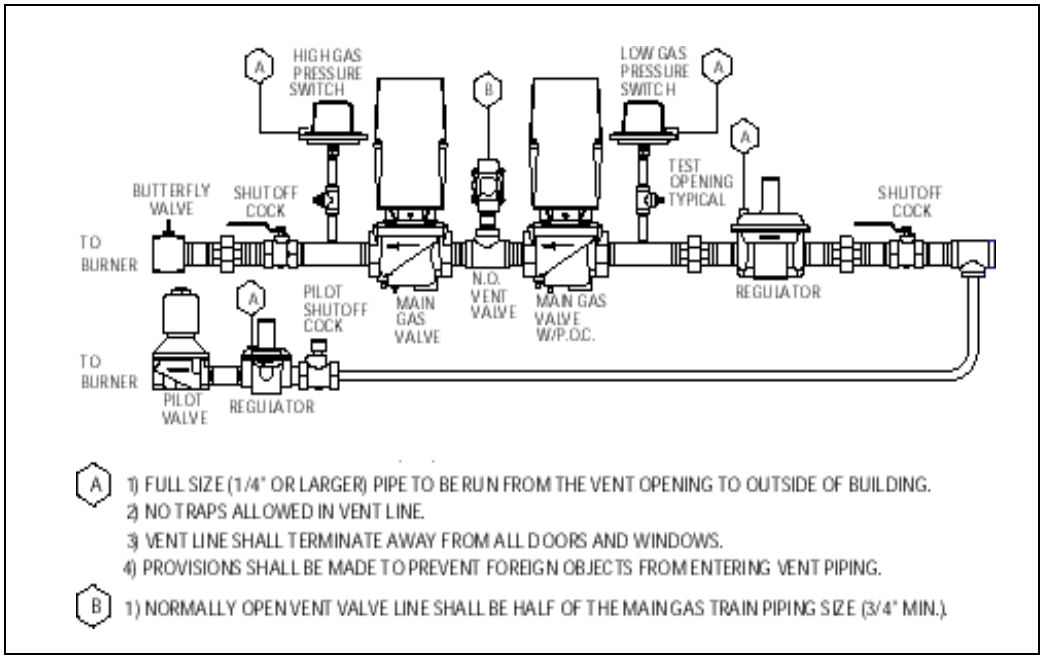


Figure 6-18. Typical UL Gas Train Over 12.5 MMBtu, Full Modulation

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.

PILOT GAS TRAIN, GAS PILOT VALVE

A solenoid valve that opens during the ignition period to admit fuel to the pilot. It closes after main flame is established.

GAS PRESSURE REGULATOR.

Reduces gas pressure to that required by the pilot.

GAS PILOT 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.

OIL FLOW

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.

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 to deter

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.

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 6-19. 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 6-20. 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.

Notes

Chapter 7
ProFire D Series Burner Maintenance

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 manufacturers bulletin.

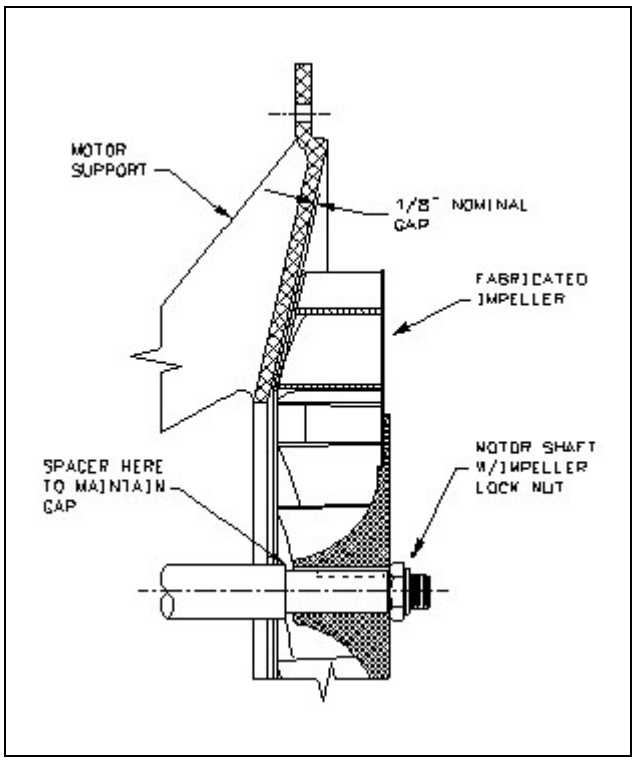


Figure 7-1. Impeller Cutaway

IMPELLER AND STATOR CONE

Refer to **Figure 7-1.**.

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.

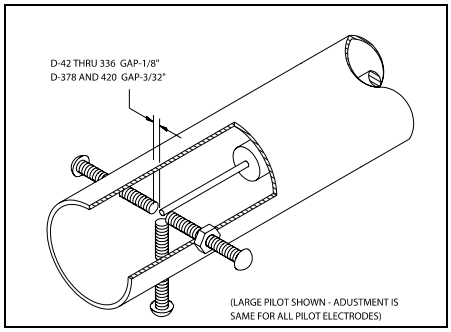


Figure 7-2. Gas Pilot Electrode

D. FIRING HEAD INSPECTION

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 7-2.** 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 7-3.**. 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.

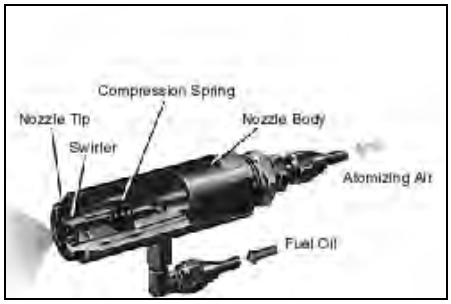


Figure 7-3. Oil Nozzle Cutaway

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.

⚠ 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.

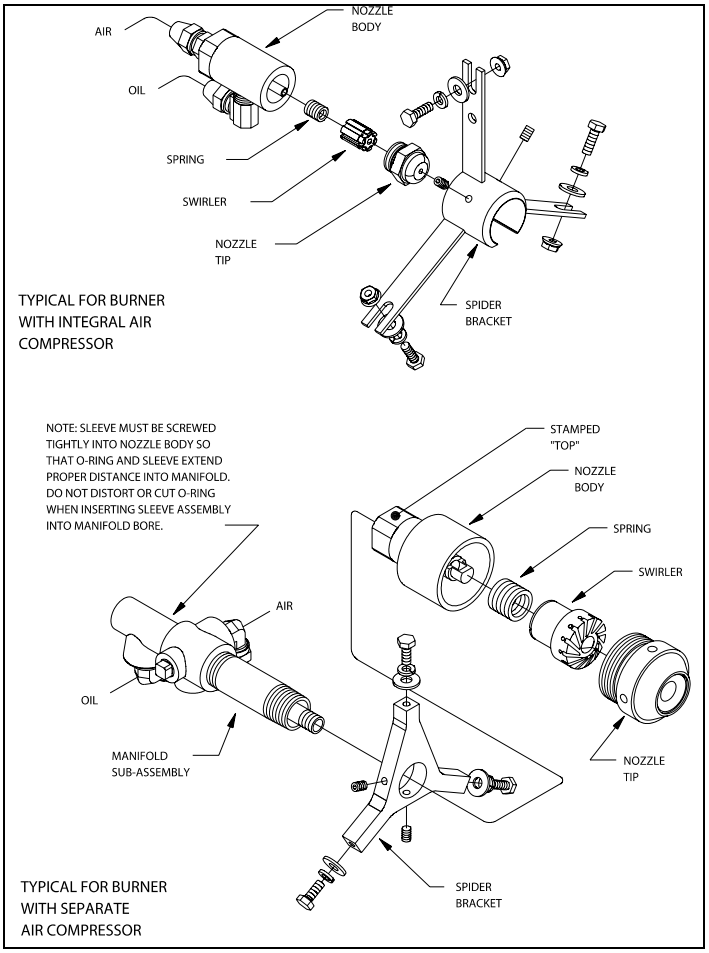


Figure 7-4. Oil Nozzle Assemblies

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.

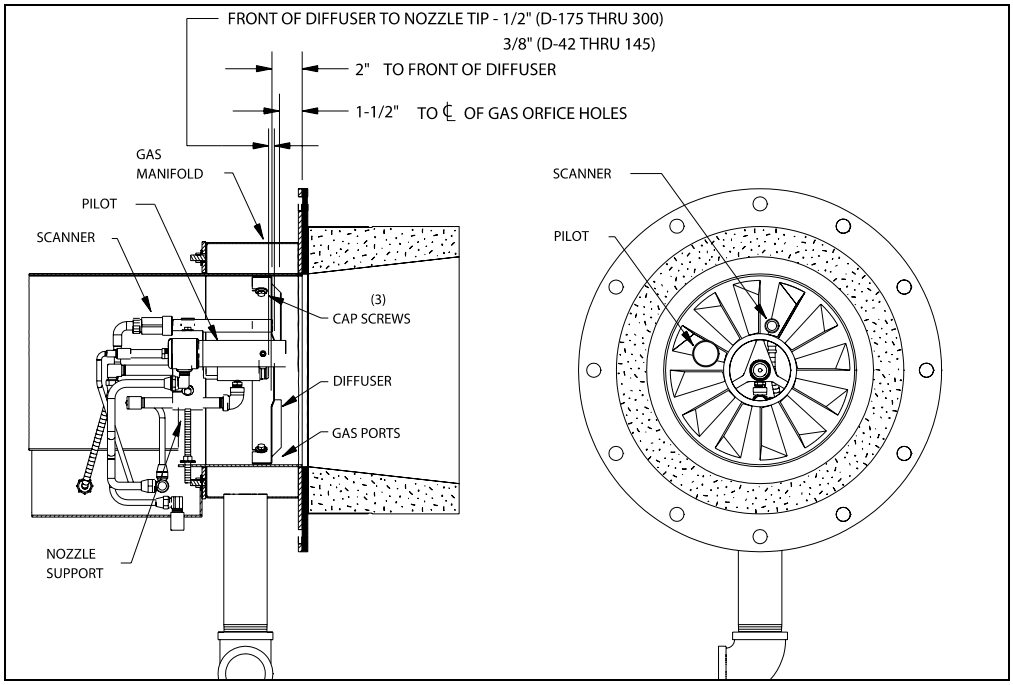


Figure 7-5. Firing Head Assembly

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.

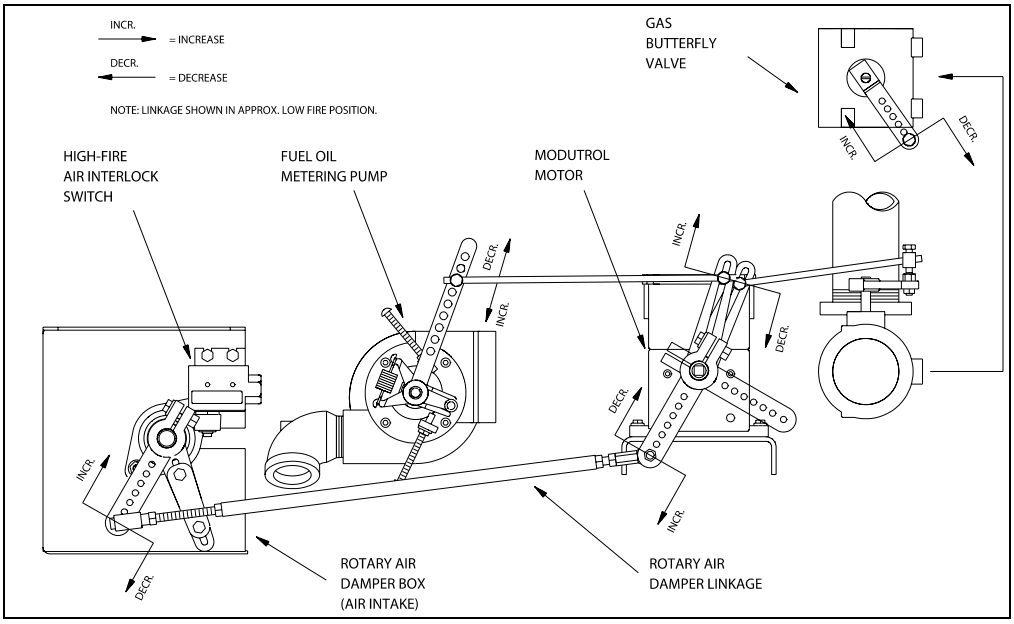


Figure 7-6. Firing Rate Controls

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

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.

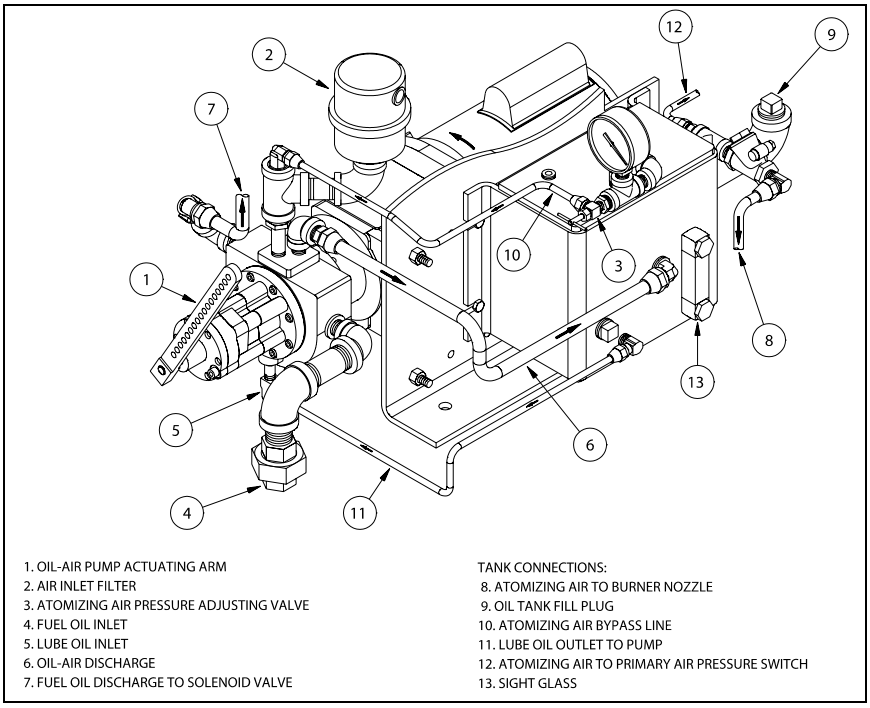


Figure 7-7. Integral Oil Air Metering System and Tank

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. TROUBLE SHOOTING

⚠ 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 8
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.
   - A. Main disconnect switch open.
   - B. Blown control circuit fuse.
   - C. Loose or broken electrical connection.
2. Program relay safety switch requires resetting.

3. Limit circuit not completed — no voltage at end of limit circuit program relay terminal.
   A. Pressure or temperature is above setting of operation control. (Load demand light will not glow.)
   B. Water below required level.
      1). Low-water light (and alarm horn) should indicate this condition.
      2). Check manual RESET button, if provided, on low-water control.
   C. Fuel pressure must be within settings of low pressure and high pressure switches.
4. Fuel valve interlock circuit not completed.
   A. Fuel valve auxiliary switch not closed.

B. NO IGNITION

1. Lack of spark.
   A. Electrode grounded or porcelain cracked.
   B. Improper electrode setting.
   C. Loose terminal on ignition cable; cable shorted.
   D. Inoperative ignition transformer.
   E. Insufficient or no voltage at pilot ignition circuit terminal.
2. Spark but no flame.
   A. Lack of fuel — no gas pressure, closed valve, empty tank, broken line, etc.
   B. Inoperative pilot solenoid.
   C. Insufficient or no voltage at pilot ignition circuit terminal.
   D. Too much air.
3. Low fire switch open in low fire proving circuit.
   A. Damper motor not closed, slipped linkage, defective switch.
   B. Damper jammed or linkage binding.
4. Running interlock circuit not completed.
   A. Combustion or atomizing air proving switches defective or not properly set.
   B. 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:
   A. Manual gas cock closed.

B. Main gas valve inoperative.

C. Gas pressure regulator inoperative.

3. Oil fired unit:

   A. Oil supply cut off by obstruction, closed valve, or loss of suction.

   B. Supply pump inoperative.

   C. No fuel.

   D. Main oil valve inoperative.

   E. Check oil nozzle, gun and lines.

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

5. Insufficient or no voltage at main fuel valve circuit terminal

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:

   A. Check fuel lines and valves.

   B. Check flame detector.

   C. Check for open circuit in running interlock circuit.

   D. The flame failure light is energized by ignition failure, main flame failure, inadequate flame signal, or open control in the running interlock circuit.

7. Improper air/fuel ratio (lean fire).

   A. Slipping linkage.

   B. Damper stuck open.

   C. Fluctuating fuel supply.

      1). Temporary obstruction in fuel line.

      2). Temporary drop in gas pressure.

8. Interlock device inoperative or defective.

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.
   A. Motor defective.
   B. Loose electrical connection.
   C. Damper motor transformer defective.
4. Motor does not operate on demand.
   A. Manual/automatic switch in wrong position.
   B. Modulating control improperly set or inoperative.
   C. Motor defective.
   D. Loose electrical connection.
   E. Damper motor transformer defective.

Chapter 9
Vessel Inspection and Maintenance

A. GENERAL

A well-planned maintenance program will help avoid unnecessary downtime or costly repairs, promote safety, and aid boiler inspectors. An inspection schedule with a listing of procedures should be established. It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly, and yearly maintenance activities provides a valuable guide and aids in obtaining economical and lengthy service from Cleaver-Brooks equipment. A boiler inspection schedule is shown in Table 9-1. It is important to realize that the frequency of inspection will depend on variable conditions: such as load, fuel, system requirements, boiler environment (indoor/outdoor) etc.

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

Even though the boiler has electrical and mechanical devices that make it automatic or semi-automatic in operation, the devices require systematic and periodic maintenance. Any automatic feature does not relieve the operator from responsibility, but rather frees the operator from certain repetitive chores providing time to devote to upkeep and maintenance.

Alertness in recognizing an unusual noise, improper gauge reading, leaks, etc., can make the operator aware of a developing malfunction and permit prompt corrective action that may prevent extensive repairs or unexpected downtime. Any leaks — fuel, water, steam, exhaust gas — should be repaired promptly and under conditions that observe necessary safety precautions. Preventive maintenance measures, such as regularly checking the tightness of connections, locknuts, setscrews, packing glands, etc., should be included in regular maintenance activities.

Periodic Inspection

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

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

Replacement spare parts, if not on hand, should be ordered sufficiently prior to shutdown.

Note: Cleaver-Brooks genuine parts should be used to ensure proper operation. Contact your local Cleaver-Brooks representative for parts information and ordering.

Cleaver-Brooks boilers are designed, engineered, and built to provide long life and excellent service. Good operating practices and conscientious maintenance and care will assure efficiency and economy from their operation, and will contribute to many years of performance.

A total protection plan includes a Planned Maintenance Program that covers many of the items included in this chapter.

For information regarding a total protection plan, contact your local Cleaver-Brooks authorized representative.

Real Parts Real Service From Cleaver-Brooks

Figure 9-1. Authorized Cleaver-Brooks Parts

B. 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 can be used as a guide to clean-out intervals since an accumulation of soot deposits will raise the flue gas temperature.

Tube cleaning is accomplished by opening the front and rear doors. 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.

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.

C. WATER LEVEL CONTROLS

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

Figure 9-2. Low Water Cut Off Blow Down

Always be sure of the boiler water level. On steam boilers, the water column should be blown down daily. Check samples of boiler water and condensate in accordance with procedures recommended by your local Cleaver-Brooks authorized representative.

Since low-water cutoff devices are generally set by the original manufacturer, no attempt should be made to adjust these controls to alter the point of low-water cutoff or point of pump cut-in or cut-out. If a low-water device should become erratic in operation, or if its setting changes from previously established levels, contact your local Cleaver-Brooks authorized representative.

1. Steam Boiler

Figure 9-3 shows the low-water cutoff plate which is attached to a steam boiler. The instructions should be followed on a definite schedule. The controls normally function for long periods of time, which may lead to laxity in testing on the assumption that normal operation will continue indefinitely.

Figure 9-3. Low Water Cut-Off Warning Plate

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

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

A blowdown of the water controls on a steam boiler should be performed daily.

Table 9-1. Recommended Boiler Inspection Schedule

Daily
Check water level
Check combustion visually
Blow down boiler
Blow down water column
Record feedwater pressure/temperature
Record flue gas temperature
Record oil pressure and temperature
Record gas pressure
Record atomizing air pressure
Record boiler water supply and return temperatures
Record makeup water usage
Record steam pressure
Note unusual conditions, noises, etc.
Treat water according to the established program
Weekly
Check for tight closing of fuel valve
Check fuel and air linkage
Check indicating lights and alarms
Check operating and limit controls
Check safety and interlock controls
Check for leaks, noise, vibration, unusual conditions, etc.
Monthly
Inspect burner
Inspect for flue gas leak
Inspect for hot spots
Check cams
Check for tight closing of fuel valve
Check fuel and air linkage
Check indicating lights and alarms
Check operating and limit controls
Check safety and interlock controls
Check for leaks, noise, vibration, unusual conditions, etc.
Analyze Combustion
Semi-Annually
Clean low water cutoff
Clean oil pump strainer, filter
Clean air cleaner and air/oil separator
Clean air pump coupling alignment
Inspect refractory
Remove and clean oil preheater
Annually
Clean fireside surfaces
Clean breeching
Inspect waterside surfaces
Check operation of safety valves

2. Hot Water Boiler

It is impractical to blow down the low-water cutoff devices on a hot water boiler since the entire water content of the system would become involved. Many hot water systems are fully closed and any loss of water will require make-up and additional feedwater treatment that might not otherwise be necessary. Since the boiler and system arrangement usually make it impractical to perform daily and monthly maintenance of the low-water cutoff devices, it is essential to verify proper operation. Remove the operating mechanism from the bowl annually or more frequently, if possible, to check and clean float ball, internal moving parts, and the bowl housing. Also check the cross-connecting piping to be certain that it is clean and free of obstruction. If equipped with a probe type LWCO with a test switch, the control should be tested per the manufacturer's instructions on the regulator.

D. WATER GAUGE GLASS

Figure 9-4. Low Water Cutoff Gauge Glass

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

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

It is recommended that the boiler is off and cool when the glass is replaced. However if the glass is replaced while the boiler is in service, open the blowdown and slowly bring the glass to operating temperature by opening the gauge valves slightly. After glass is warmed up, close the blowdown valve and open the gauge valves completely.

⚠ Warning

Do not attempt to change the gauge glass while the boiler is in service. Failure to follow these instructions could result in serious personal injury or death.

Check try-cocks and gauge cocks for freedom of operation and clean as required. It is imperative that the gauge cocks are mounted in exact alignment. If they are not, the glass will be strained and may fail prematurely.

⚠ Caution

Inspection and maintenance should be performed only by trained personnel who are familiar with this equipment. Failure to follow these instructions could result in equipment damage.

E. MAINTENANCE AND CARE OF THE PROFIRE BURNER

⚠ Caution

The following measures must be taken to guard against possible long-term damage to the burner.

STRAINERS. It is recommended that all oil firing burners be equipped with an oil strainer (if not included with the burner) to prevent particles from clogging the nozzle. The largest opening in the strainer should be .028 inches with a minimum of 15 square inches open area. Check to be sure the strainer is marked to handle the fuel flow at the maximum flow rate of the pump. It is essential to follow the strainer manufacturer's maintenance schedule to ensure proper filtration.

OIL NOZZLE. The oil nozzle is a critical part of the burner. Inside the nozzle lies a small screen that keeps out any particles not caught by the strainer. These particles will interfere with the normal oil flow pattern exiting the nozzle. During initial operation, it may be necessary to inspect and clean the nozzle and screen frequently.

IMPELLER. The backwards inclined impeller requires cleaning once a year. If a sharp decrease in performance is seen, check the impeller blades for dirt buildup.

⚠ Warning

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

PILOT. The pilot should be checked monthly for loosening of components and carbon buildup.

DIFFUSER. The diffuser should be checked and cleaned monthly to prevent soot buildup.

OIL PUMP (Oil Fired Units). The oil pump is a critical component. When firing gas for long periods of time, disconnect the flexible coupling between the combustion motor shaft and the oil pump shaft (if the oil

pump is burner mounted). This is accomplished by removing the airbox cover and loosening the two setscrews on the flex coupling. Disconnecting the oil pump eliminates wear.

PILOT REMOVAL. When removal of the pilot assembly is required, first be sure that the fuel supply is shut off, then proceed as follows:

- Disconnect the pilot gas supply line.
- Remove the screws on the pilot access plate.
- Disconnect the high voltage ignition cable by pulling it straight back, away from the pilot assembly.

The pilot gun assembly will slide back away from the flame side of the burner. Once the pilot assembly is clear of the burner head bracket, turn the pilot assembly and retract it through the access hole.

LOCK DOWN AND LAY UP PROCEDURES. 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.

MAINTENANCE SCHEDULE. Refer to the following check list for recommended periodic testing of the combustion system components:

Mechanical inspection, cleaning, and/or replacement of the following must be completed per the minimum frequency indicated:

Weekly: Check all burner linkages for tightness, and tighten if required.

Monthly:

1. Remove, inspect and clean the flame scanner for soot buildup.
2. Check and clean the diffuser for soot buildup.
3. Check the pilot assembly for loosening of components, foreign objects, erosion or carbon buildup.

Annually:

1. Replace or clean the oil strainer element (oil fired units).
2. Clean the combustion air impeller.

Table 9-2. Fusing Sizing Chart

Electrical Load Motor HP	Single-Phase 50/60 Hertz		Three-Phase 50/60 Hertz				
	110 – 120 V	220 – 240 V	200 – 208 V	220 – 240 V	346 – 416 V	440 – 480 V	550 – 660 V
1/4	10	5-6/10	1-8/10	1-8/10	–	1	8/10
1/3	12	6-1/4	1-8/10	1-8/10	–	1	8/10
1/2	17-1/2	9	4-1/2	4	2	2	1-6/10
3/4	20	10	7	5-6/10	3-2/10	2-8/10	2-1/4
1	25	12	9	8	4-1/2	4	3-2/10
1-1/2	35	17-1/2	12	10	6-1/4	5-6/10	4-1/4
2	40	20	15	12	7	6-1/4	5
3	60	30	20	17-1/2	10	9	7
5	–	50	30	30	15	15	12
7-1/2	–	60	40	40	20	20	17-1/2
10	–	90	60	50	30	25	20
15	–	–	80	60	45	40	30
20	–	–	110	80	50	50	40
25	–	–	125	100	60	60	50
30	–	–	175	125	70	70	60
40	–	–	200	175	100	80	70
50	–	–	300	200	125	100	80
60	–	–	350	300	175	150	110
75	–	–	400	350	200	175	150
100	–	–	500	400	250	200	175
125	–	–	600	500	300	300	200
150	–	–	–	600	–	350	250

Fuse Sizes Above Are Class RK5 Dual Element, Time Delay Table at the right shows vendor types.

	Bussman	Gould	Littelfuse
0 – 250 V	FRN	TR	FLN
251 – 600 V	FRS	TRS	FLS

Figure 9-5. Electrical Cabinet

F. ELECTRICAL CONTROLS

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

Examine any mercury tube switches for damage or cracks. Dark scum over the normally bright surface of the mercury may lead to erratic switching action. Be certain that controls are correctly leveled. The piping leading to the pressure control actuators should be cleaned, if necessary. Covers should be left on controls at all times.

Dust and dirt can cause excessive wear and overheating of motor starter and relay contacts. Use a burnishing tool or a hard surface paper to clean and polish contacts. Starter contacts are plated with silver and are not harmed by discoloration and slight pitting. Replacement of the contacts is necessary only if the silver has worn thin.

⚠ Caution

Do not use files or abrasive materials such as sandpaper on the contact points. Failure to follow these instructions could result in equipment damage.

Thermal relay units (overloads) are of the melting-alloy type and, when tripped, the alloy must be given time to re-solidify before relay can be reset. If the overloads trip out repeatedly when the motor current is normal, replace them with new overloads. If the condition continues after replacement, it will be necessary to determine the cause of excessive current draw at the overloads.

Power supply to the boiler must be protected with dual element fuses (fusetrons) or circuit breakers. Similar fuses should be used in branch circuits. Standard one-shot fuses are not recommended. Information given in **Table 9-2** is included for guidance to fuse requirements.

G. FLAME SAFETY CONTROL

The microprocessor-based control requires minimal maintenance because the safety and logic timings are inaccessible. There also are not any accessible contacts. Check to see that the retaining screw is securely holding the chassis to the mounting base. Also check to see that the amplifier and the program module are tightly inserted.

The relay's self-diagnostic ability includes advising when it or its plug-in modules are at fault and require replacement.

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

It is recommended that service be rotated between the active and a spare control to assure a working replacement is available.

⚠ Warning

When replacing a control, be sure to lock out the main power supply switch since the control is "hot" even though the burner switch is off. Failure to follow these instructions could result in serious personal injury or death.

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

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

A safety check procedure should be established to test the complete safeguard system at least once a month, or more often. Tests should verify safety shutdown and a safety lockout upon failure to ignite the pilot, upon failure to ignite the main flame, and upon loss of flame. Each of the conditions should be checked on a scheduled basis.

The following tests should be used to test the complete safeguard system. If the sequence of events is not as described, then a problem may exist. Contact your local Cleaver-Brooks authorized representative for assistance.

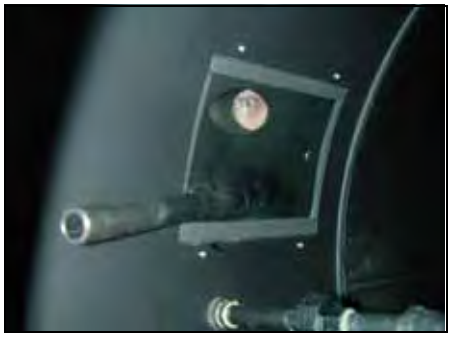


Figure 9-6. Site Port and Pilot, "D" Series

1. Checking Pilot Flame Failure

Close the gas pilot shutoff cock. Also shut off the main fuel supply. Turn the burner switch "ON."

The pilot ignition circuit will be energized at the end of the pre-purge period. There should be an ignition spark, but no flame. Since there is no flame to be detected, the program relay will signal the condition. The ignition circuit will de-energize and the control will lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop.

Turn the burner switch off. Reset the safety switch. Reopen the gas pilot shutoff cock and re-establish main fuel supply.

2. Checking Failure to Light Main Flame

Leave the gas pilot shutoff cock open. Shut off the main burner fuel supply. Turn the burner switch on. The pilot will light upon completion of the pre-purge period. The main fuel valve(s) will be energized, but there should be no main flame.

The fuel valve(s) de-energize within four seconds after the main burner ignition trial ends. The control will lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop.

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

3. Checking Loss of Flame

With the burner in normal operation, shut off the main burner fuel supply to extinguish main flame.

The fuel valve(s) will be de-energized and the relay will signal the condition within four seconds. The control will then lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop.

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

H. OIL BURNER MAINTENANCE

The burner should be inspected for evidence of damage due to improperly adjusted combustion. Any soot buildup on the diffuser or the oil nozzle should be removed. The setting of the oil nozzle in relation to the diffuser and other components is important for proper firing and should be checked.

1. Oil Strainers

Oil strainers should be cleaned frequently to maintain a free and full flow of fuel.

2. Light Oil Strainers

The fuel oil strainer screen must be removed and cleaned at regular intervals. It is advisable to remove the screen each month and clean thoroughly by immersing it in solvent and blowing it dry with compressed air. To remove, loosen the cover cap screw, being careful not to lose the copper gasket. If necessary, tap the strainer cover gently to loosen. Check the cover gasket for damage and replace if necessary. Slip pliers into the cross on the top of the strainer and twist counterclockwise to remove the basket. Reassemble in reverse order.

3. Cleaning Oil Nozzle

The design of the burner makes it unnecessary to clean the oil nozzle during periods of operation. A routine check and any necessary cleaning should be made during off periods or when the burner is firing on gas.

If at any time the burner flame appears “stringy” or “lazy,” it is possible that the nozzle tip or swirler has become partially clogged or worn. Any blockage within the tip will cause the air pressure gauge (if air atomized) to increase above its normal value.

Disassemble with the power off. Insert the nozzle body into the hanger vice and use the spanner wrench to remove the tip. Carefully remove the swirler and seating spring being careful not to drop or damage any parts.

Perform any necessary cleaning with a suitable solvent. Use a soft fiber brush or pointed piece of soft wood for cleaning. Do not use wire or a sharp metallic object, which could scratch or deform the orifices as well as the precision ground surfaces of the swirler and tip. Inspect for scratches or signs of wear or erosion, which may make the nozzle unfit for further use. Take the necessary precautions in working with solvents.

The tip and swirler are a matched set, which are precision lapped at the time of assembly. The close fit of the lapped surfaces must be maintained in order to provide optimum performance. Additional lapping may be required to provide better atomization for more efficient combustion. Do not interchange parts if a spare is kept. In reassembling, be certain that the seating spring is in place and that it is holding the swirler tightly against the tip. The swirler is stationary and does not rotate, but rather imparts a swirling motion to the oil.

See that the plugged hole is at the bottom of the nozzle body when the gun is installed.

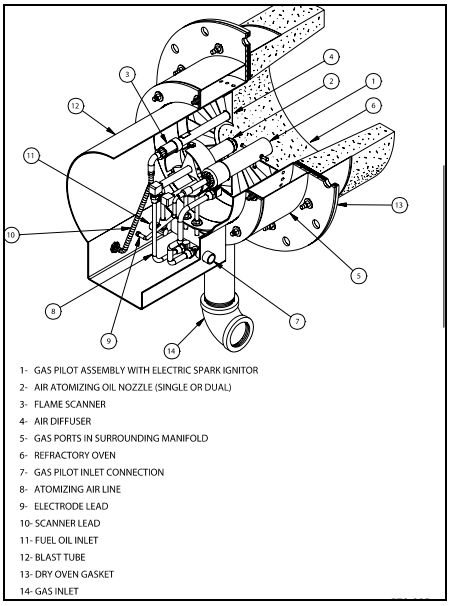


Figure 9-7. Burner Head “D” Series

4. Ignition System

For best results, maintain the proper gap and dimensions of the ignition electrode(s).

Inspect the electrode tip for signs of pitting or combustion deposits and dress as required with a fine file. Inspect the porcelain insulator(s) for any cracks that might be present. If there are cracks, replace the electrode since they can cause grounding of the ignition voltage. Since carbon is an electrical conductor, it is necessary to keep the insulating portion of electrode(s) wiped clean if any carbon is present. Ammonia will aid in removing carbon or soot.

Check ignition cables for cracks in the insulation. Also see that all connections between the transformer and the electrodes are tight.

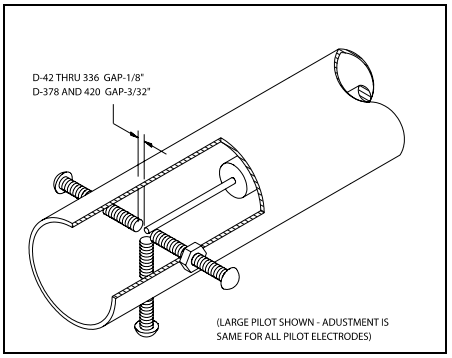


Figure 9-8. Ignition Pilot “D” Series Burner

I. GAS BURNER MAINTENANCE

The gas burner components should be inspected for evidence of damage due to improperly adjusted combustion. Combustion adjustments should be checked monthly.

Check periodically for a proper seal between the end of the blast tube and boiler refractory. Any deterioration of the seal should be corrected, as an improper or poor seal allows air leaks, which can cause overheating or burning of the blast tube.

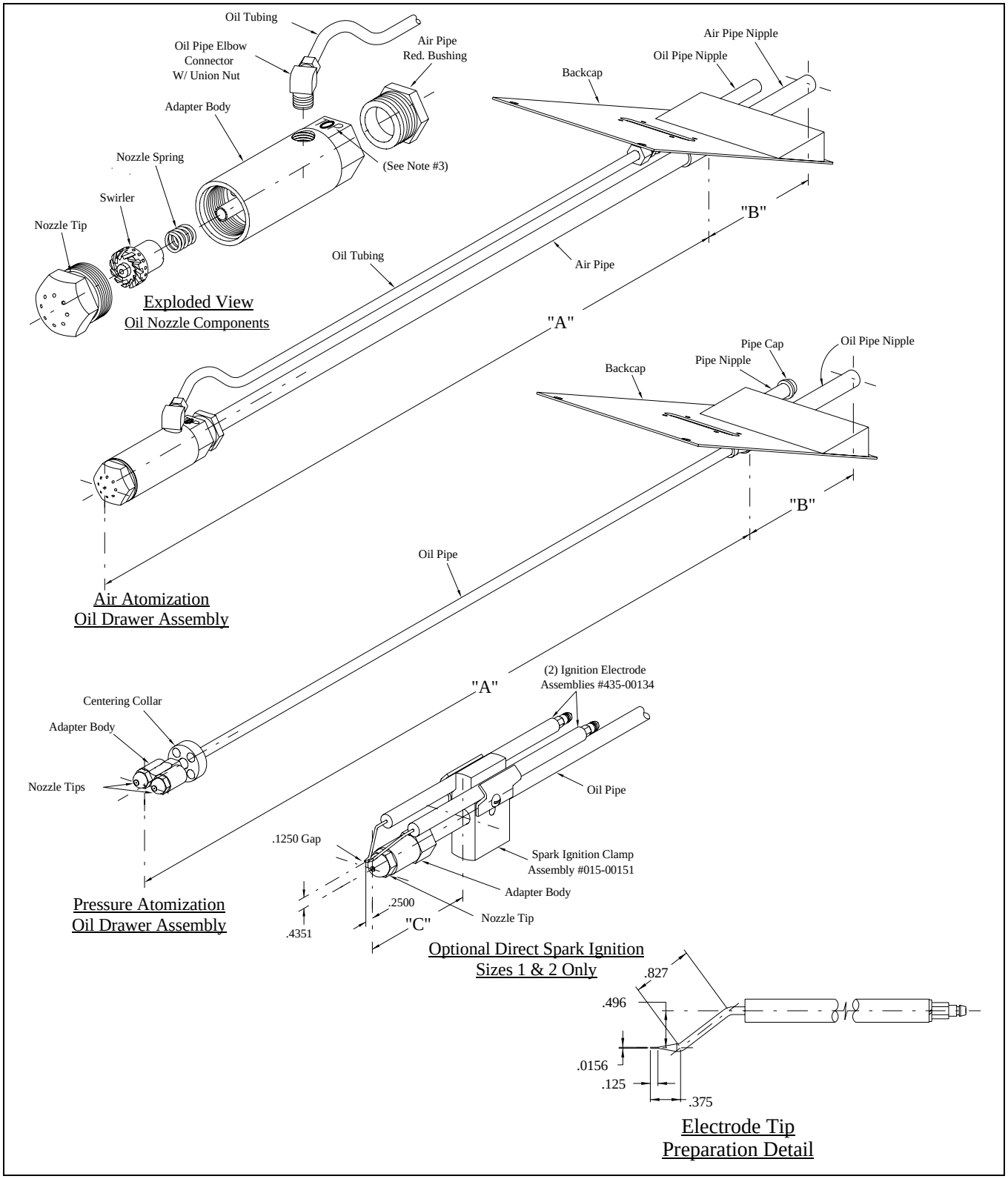


Figure 9-9. "F" Series Burner Nozzle and Electrode

Check the electrode setting for any cracks that might be present on the porcelain insulator. Replace the electrode if cracking is evident, since cracking can cause grounding of the ignition voltage. Inspect the tip of the electrode for signs of pitting, combustion deposits and wear, and dress as required with a fine file.

Check the ignition cables for cracks in the insulation. Verify that all connections between the transformer and the electrode are tight.

J. SOLENOID VALVES

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

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

Coils may be replaced without removing the valve from the line.

⚠ Warning

Be sure to turn off power to the valve in order to avoid electrical shock. Failure to follow these instructions could result in serious personal injury or death.

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

K. Air Control Damper, Linkage

The burner air control damper should be checked for free movement as a part of the monthly inspection. Any resistance to movement or excessive play in the support bearing should be investigated and corrected before the burner is put back in operation.

The overall tightness of the linkage assembly should be checked monthly. If necessary, tighten the setscrews and the connections at the uniballs. Check the uniballs for wear and replace if necessary.

The linkage assembly should be tight but should not bind. If the linkage assembly is binding, determine the cause of the binding and correct as necessary.

Linkage rod end attachment points should be marked on the variable displacement linkage arms as an aid in subsequent reassembly.

Inspection of the air damper and linkage bearings should be performed on a more frequent basis if the boiler is operating in a dirty environment.

Lubricate occasionally with a non-gumming, dripless, high-temperature lubricant such as graphite or a silicone derivative.

⚠ Caution

Combustion should be checked and readjusted as required whenever the burner is removed or any control linkage is disturbed. Failure to follow these instructions could result in equipment damage.

Note: If the boiler is installed in a dusty location, check the vanes occasionally for deposits of dust or dirt. These buildups can cause a decrease in air capacity, or lead to an unbalanced condition or cause damage to the equipment.

L. SAFETY VALVES

The safety valve is a very important safety device and deserves attention accordingly.

Follow the recommendations of your boiler inspector regarding valve inspection and testing. The frequency of testing, either by the use of the lifting lever or by raising the steam pressure, should be based on the recommendation of your boiler inspector and/or the valve manufacturer, and in accordance with sections VI and VII of the ASME Boiler and Pressure Vessel Code.

Avoid excessive operation of the safety valve; even one opening can provide a means of leakage. Safety valves should be operated only often enough to assure that they are in good working order. When a pop test is required, raise the operating pressure to the set pressure of the safety valve, allowing it to open and reseat as it would in normal service.

Do not hand operate the valve with less than 75% of the stamped set pressure exerted on the underside of the disc. When hand operating, be sure to hold the valve in an open position long enough to purge accumulated foreign material from the seat area and then allow the valve to snap shut.

Frequent usage of the safety valve will cause the seat and disc to become wire drawn or steam cut. This will cause the valve to leak and necessitate downtime of the boiler for valve repair or replacement. Repair of a valve must be done only by the manufacturer or his authorized representative.

Avoid having the operating pressure too near the safety valve set pressure. A 10% differential is recommended. An even greater differential is desirable and will assure better seat tightness and valve longevity.

M. REFRACTORY

The boiler is shipped with completely installed refractory on the inner turn around door. Normal maintenance requires little time and expense, and prolongs the operating life of the refractory.

Preventive maintenance through periodic inspection will keep the operator informed of the condition of the refractory, and will guard against unexpected and unwanted downtime and major repairs.

Frequent wash coating of the refractory surfaces is recommended. High-temperature bonding, air-dry type mortar, diluted with water to the

consistency of light cream, is used for wash coating. Recoating intervals will vary with operating loads and are best determined by the operator when the boiler is opened for inspection.

Inner Turn Around Door

This door is lined with insulation 1 1/2” Board and 4” high temperature refractory material and refractory board.

Higher stack temperature and/or lower fan pressure may indicate:

- Leaking gasket.
- Improper seal.
- Door retaining studs insufficiently or unevenly tightened.
- Refractory trouble.

Before assuming that refractory requires reworking:

- Check condition of gasket.
- Check for cracks in refractory material.
- Check tightness of door bolts.

It is normal for refractories exposed to hot gases to develop thin “hairline” cracks. This by no means indicates improper design or workmanship. Since refractory materials expand and contract to some extent with changes in temperature, they should be expected to show minor cracks due to contraction when examined at low temperature. Cracks up to approximately 1/8" across may be expected to close at high temperature. If there are any cracks that are relatively large (1/8" to 1/4" in width) clean and fill them with high-temperature bonding mortar.

After opening the door, clean the surface of the refractory carefully with a fiber brush to avoid damaging the surface. Remove all dried sealing material. Wash-coat the lower half of the rear door refractory prior to closing.

N. 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. This will prevent sagging and facilitate opening of the door. After opening rear access way, check the gaskets and seating surfaces. Replace the door gaskets if the rope gasket is hard or brittle. The outer door is sealed with 1/2” rope gasket material. Clean the sealing surfaces of the door and tube sheet to be sure or an air tight seal. Rust particles or soot buildup could prevent proper sealing. Use a spray adhesive to hold the gasket in place during installation.

Figure 9-10. Tighten Davit Nut

2. Inner Access Way

Access to the first to second pass gas turn around area is accomplished through opening of the rear door and inner access way door. Inspect refectory and gasket seal area prior to closing. When sealing the inner access way use 1” rope and spray adhesive. Be sure the sealing surfaces are clean and rust free. Check the Parts section to find the length of rope gasket needed when sealing the inner access way and rear door.

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.

Note: 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.

Figure 9-11. Use Thread Die to Chase Threads if Damaged

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.

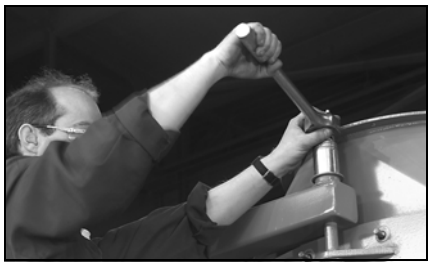


Figure 9-12. Release Tension on Davit Arm After the Door is Secured in Place

O. LUBRICATION

1. Electric Motors

Manufacturers of electric motors vary in their specifications for lubrication and care of motor bearings; their specific recommendations should be followed.

Ball-bearing-equipped motors are pre-lubricated. The length of time a bearing can run without having grease added will depend upon many factors, including the rating of the motor, type of motor enclosure, duty, atmospheric conditions, humidity, and ambient temperatures.

Complete renewal of grease, when necessary, can be accomplished by forcing out the old grease with the new grease. Thoroughly wipe those portions of the housing around the filler and drain plugs (above and below bearings). Remove the drain plug (bottom) and free the drain hole of any hardened grease which may have accumulated. With the motor not running, add new grease through the filler hole until clear grease starts to come out of the drain hole. Before replacing the drain plug, run the motor for 10 to 20 minutes to expel any excess grease. The filler and drain plugs should be thoroughly cleaned before they are replaced.

The lubricant used should be clean and equal to one of the good commercial grades of grease locally available. Some lubricants that are distributed nationally are:

- Gulf Oil - Precision Grease No. 2
- Humble Oil - Andok B
- Texaco - Multifak No. 2
- Phillips - 1B + RB No.2
- Fiske Bros. - Ball Bearing Lubricant
- Standard/Mobil - Mobilux No. 2

NOTE: Siemens TEFC motors use a different grease, not compatible with those listed above. High temperature aluminum complex grease required - may not be mixed with any other grease.

NOTE: For Siemens motors: Contains re-greasable bearings. The shaft end (impeller end) requires the use of CB's high temperature auto grease system (PN 884-133) for proper lubrication.

The opposite shaft end (end opposite impeller) can be greased by the auto grease system or by hand pump, using two or three pumps every three months with a grease compatible with a high temperature aluminum complex grease.

2. Control Linkage

Apply a non-gumming, dripless, high temperature lubricant, such as graphite or a silicone derivative to all pivot points and moving parts. Work lubricant in well and wipe excess. Repeat application at required intervals to maintain freedom of motion of parts.

3. Solenoid and Motorized Valves

Solenoid valves and motorized valves require no lubrication.

P. COMBUSTION

The frequency of burner adjustments depends upon several factors, including: type of burner, type of fuel, load conditions, ambient temperature, climatic variables, and general maintenance practices.

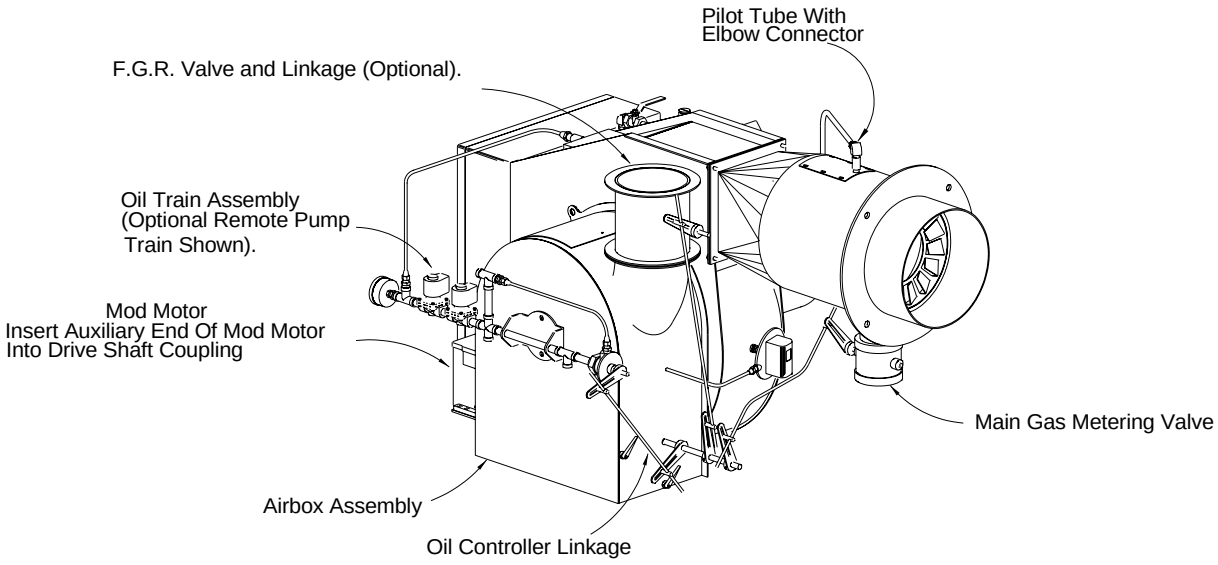
The air-fuel ratio should be checked monthly in order to alert the operator to losses in efficiency, which do not produce visible flame change. Any time maintenance is performed on the burner linkage, the air-fuel ratio should be checked. Readjustment of the burner may be required due to variations in fuel composition. A combustion analyzer should be used to adjust air-fuel ratio for maximum operating efficiency. If your burner requires adjustments, contact your local Cleaver-Brooks authorized representative for assistance.

Chapter 10A
Parts

F Series ProFire Burners

Figure 10-1. Burner Assembly

Common Burner Components on Page 10A-4



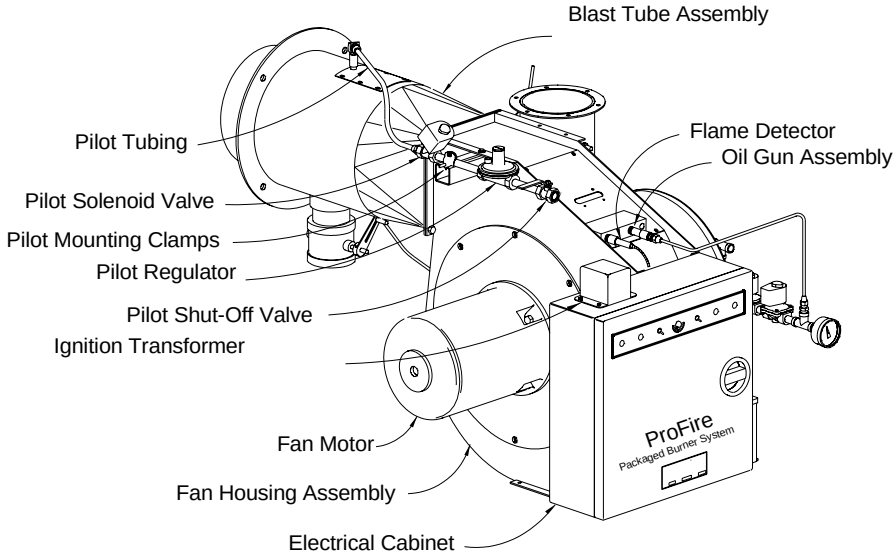
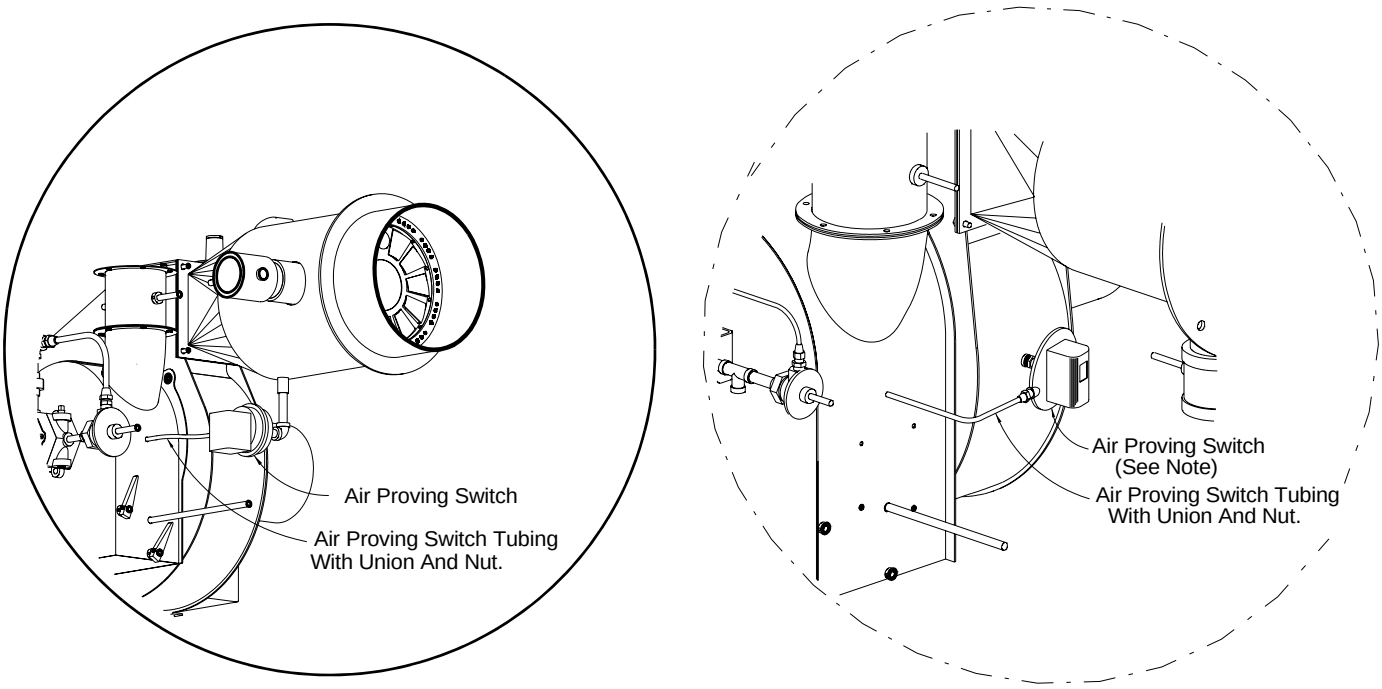
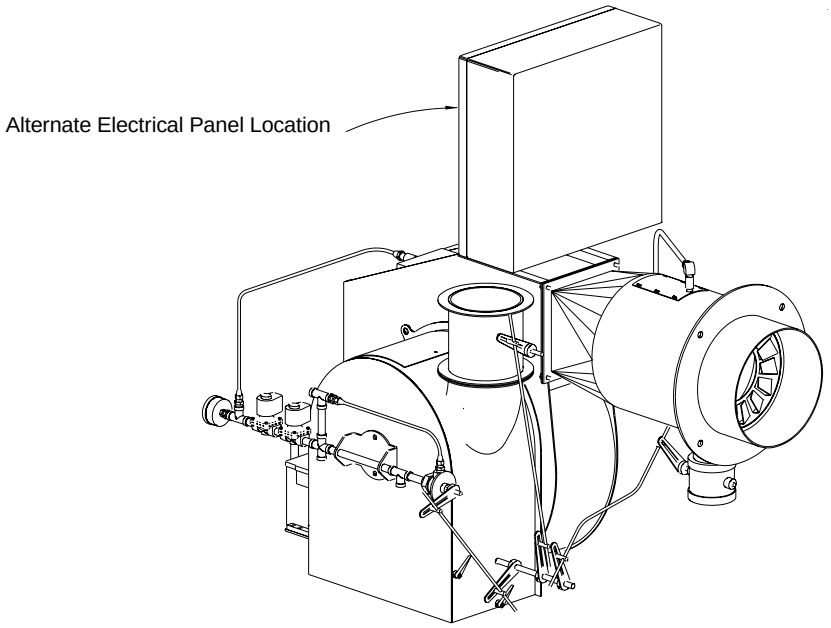


Figure 10-2. Alternate Burner Assembly

Common Burner Components on Page 10A-4



Detail "A" **Detail "B"**



ALTERNATE ASSEMBLY TYPE "F"

Figure 10-3. Common Burner Components

Common Components	Size 3		Size 4	
Fan Hsng Wldmnt.	1	459-496	1	459-503
Backcap	1	317-104	1	
Sight Port Cover	1	851-382	1	851-382
Sight Port Cover Clmp.	2	15-59	2	15-59
Scanner Sight Tube	1		1	
Back Cap Set Screws	2	860-26	2	860-26
Modulating Motor	1	894-3466	1	894-3466
Mod Motor Fasteners	8	868-136	8	868-136
Mod Motor Fstnr Wash.	8	952-145	8	952-145
Main Capscrew Pkg.	12	868-155	12	868-155
Main Washer Pkg.	14	952-106	14	952-106
Air Prov. Sw.	1	817-2363	1	817-2363
Air Prov Sw Elb Conn.	1	845-429	1	845-429
Air Prov Sw Union Nut	1	845-8	1	845-8
Air Prov Sw Mtg. Nipple	1	857-246	1	857-246
Air Prov Sw Tube	1	939-25	1	939-25
Blast Tube Fasteners	4		4	841-89
Blast Tube Fstnr Wash.	4	952-145	4	952-133

Pilot Accs. Cvr. (Type 'F')	1	19-1341	1	19-1342

Figure 10-4. Airbox Component Orientation

Component Lists Page 10A-7

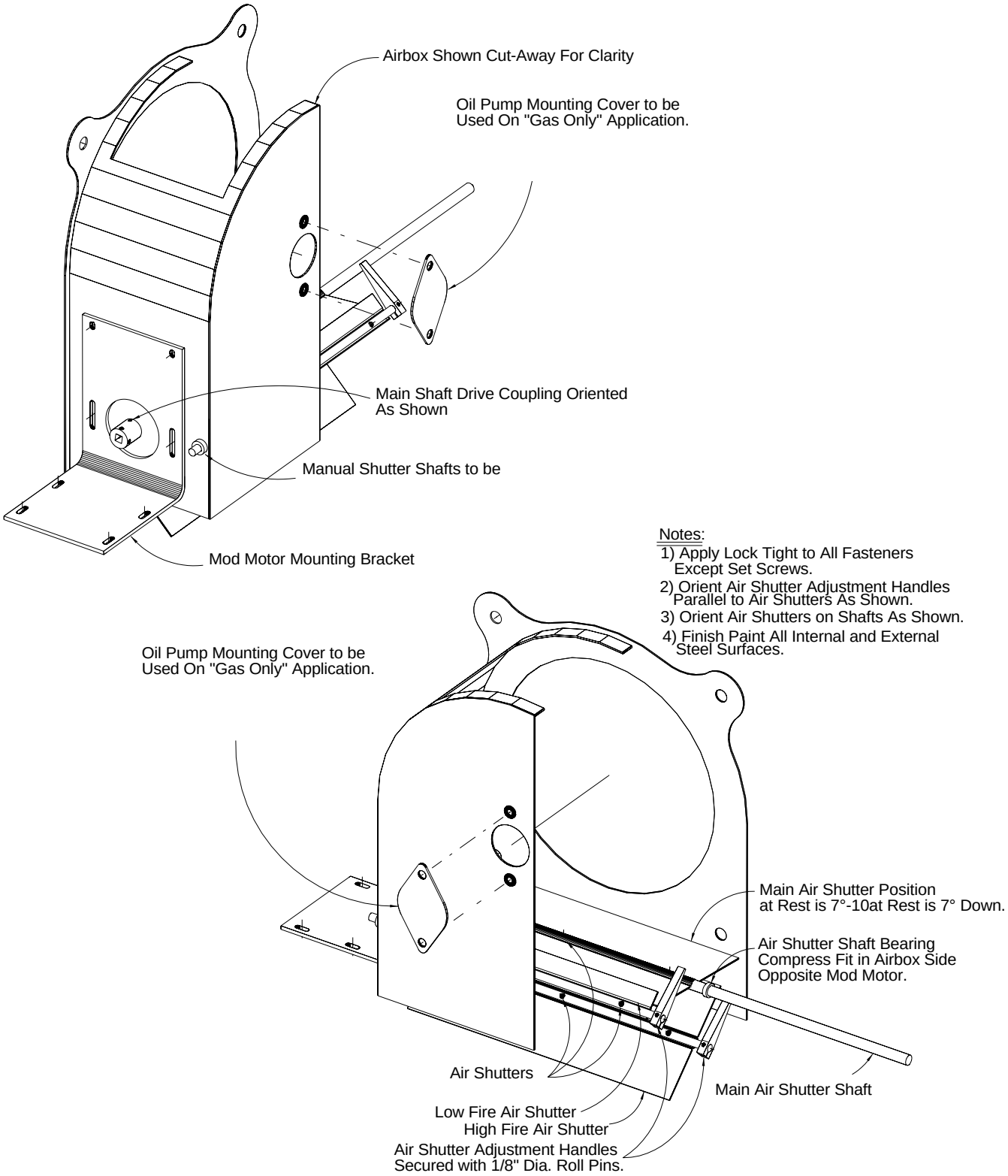
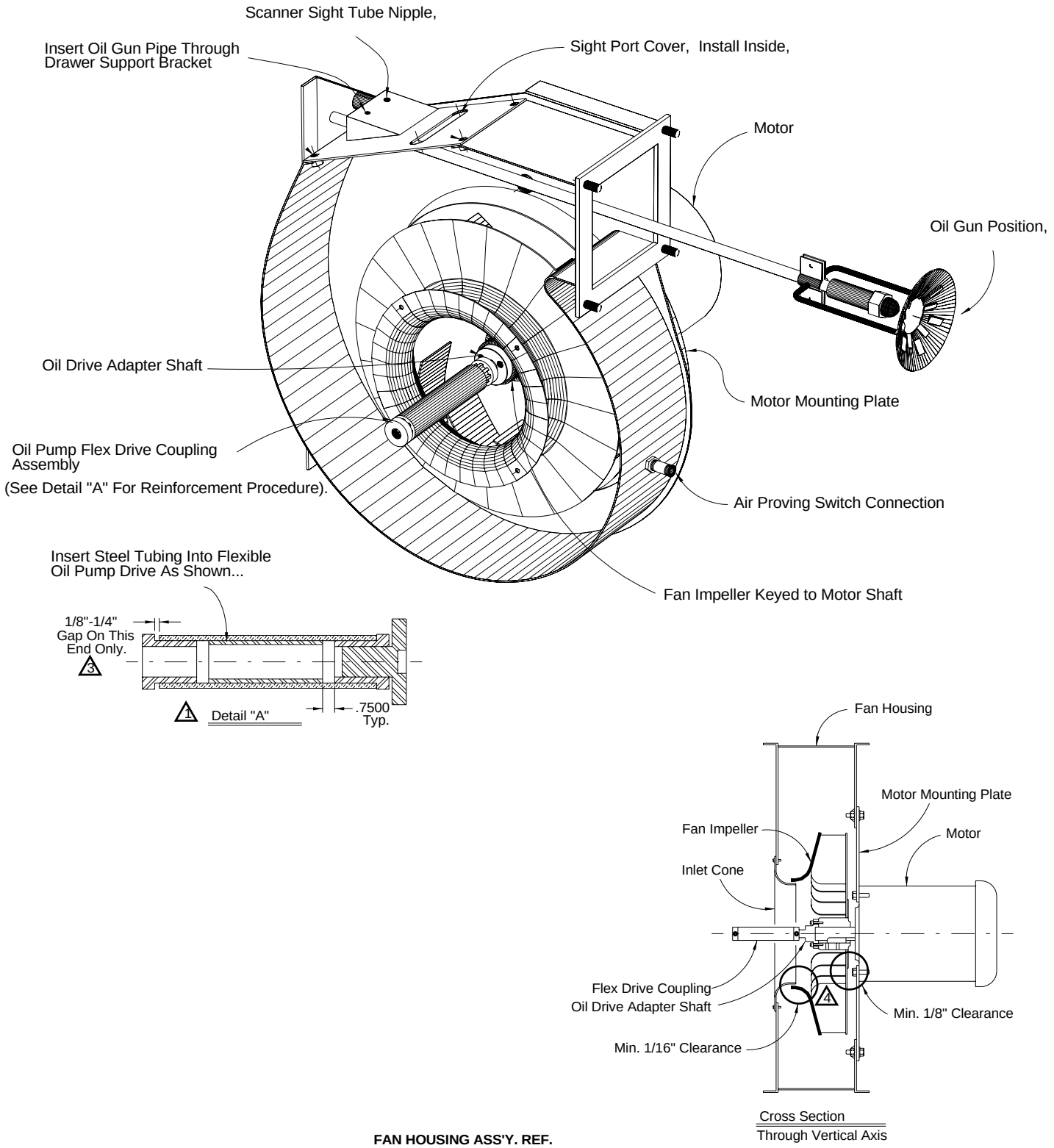


Figure 10-5. Fan Housing Assembly

Component Lists Page 10A-7



FAN HOUSING ASS'Y. REF. 146 00030

Figure 10-6. Airbox Assemblies

Standard Airbox	Size 3		Size 4	
	Qty.	P/N	Qty.	P/N
Airbox Weldment	1	459-499	1	459-504
Airbox, Oil-Drv Acc Cvr.	1	19-1330	1	19-1337
Acss. Cvr. Mtg. Screws	2	860-81	2	860-81
Main Air Shutter	1	108-128	1	108-131
Low-Fire Man Air Shtr.	1	108-127	1	108-130
High-Fire Man Air Shtr.	1	108-129	1	108-132
Air Shutter Mtg. Screws	9	860-81	12	860-81
Main Air-Shutter Shaft	1	74-263	1	74-275
Man Air-Shutter Shaft	2	74-272	2	74-273
Man Air Shtr Shft Set Scr	4	860-453	4	860-453
Air Shtr Adj Handle	2	2-355	2	2-355
Adj. Handle Roll Pin	2	903-138	2	903-138
Main Shtr Shaft Bearing	1	807-428	1	807-428
Main Shft Drv Cpl.	1	20-150	1	20-150
Drive Cpl Roll Pin	1	903-212	1	903-212
Drive Cpl Set Screws	2	860-26	2	860-26
Mod Motor Mnt Bkt.	1	8-3115	1	8-3115
IFGR Airbox				
Airbox Weldment	1	459-501	1	459-505
Airbox, Oil-Drv Acc Cvr.	1	19-1330	1	19-1337
Acss. Cvr. Mtg. Screws	2	860-81	2	860-81
IFGR Valve	1	941-2101	1	941-2103
IFGR Shaft Set Screws	2	860-453	2	860-453
IFGR Vlv. Mtg. Screws	6	860-81	6	860-81
Main Air Shutter	1	108-128	1	108-131
Low-Fire Man Air Shtr.	1	108-127	1	108-130
High-Fire Man Air Shtr.	1	108-129	1	108-132
Air Shutter Mtg. Screws	9	860-81	12	860-81
Main Air-Shutter Shaft	1	74-263	1	74-275
Man Air-Shutter Shaft	2	74-272	2	74-273
Man Air Shtr Shft Set Scr	4	860-453	4	860-453
Air Shtr Adj Handle	2	2-355	2	2-355
Adj. Handle Roll Pin	2	903-138	2	903-138
Main Shtr Shaft Bearing	1	807-428	1	807-428
Main Shft Drv Cpl.	1	20-150	1	20-150
Drive Cpl Roll Pin	1	903-212	1	903-212
Drive Cpl Set Screws	2	860-26	2	860-26
Mod Motor Mnt Bkt.	1	8-3115	1	8-3115
IFGR Vlv. Act. Arm	1	945-205	1	945-205
Main Shaft Actuator Arm	1	945-205	1	945-205
Mod Linkage Ball Joint	2	945-207	1	945-207
Mod Linkage Rod Nuts	4	869-53	4	869-53

Figure 10-7. Direct Drive Pressure Atomized Light Oil Components

Component Lists Page 10A-11

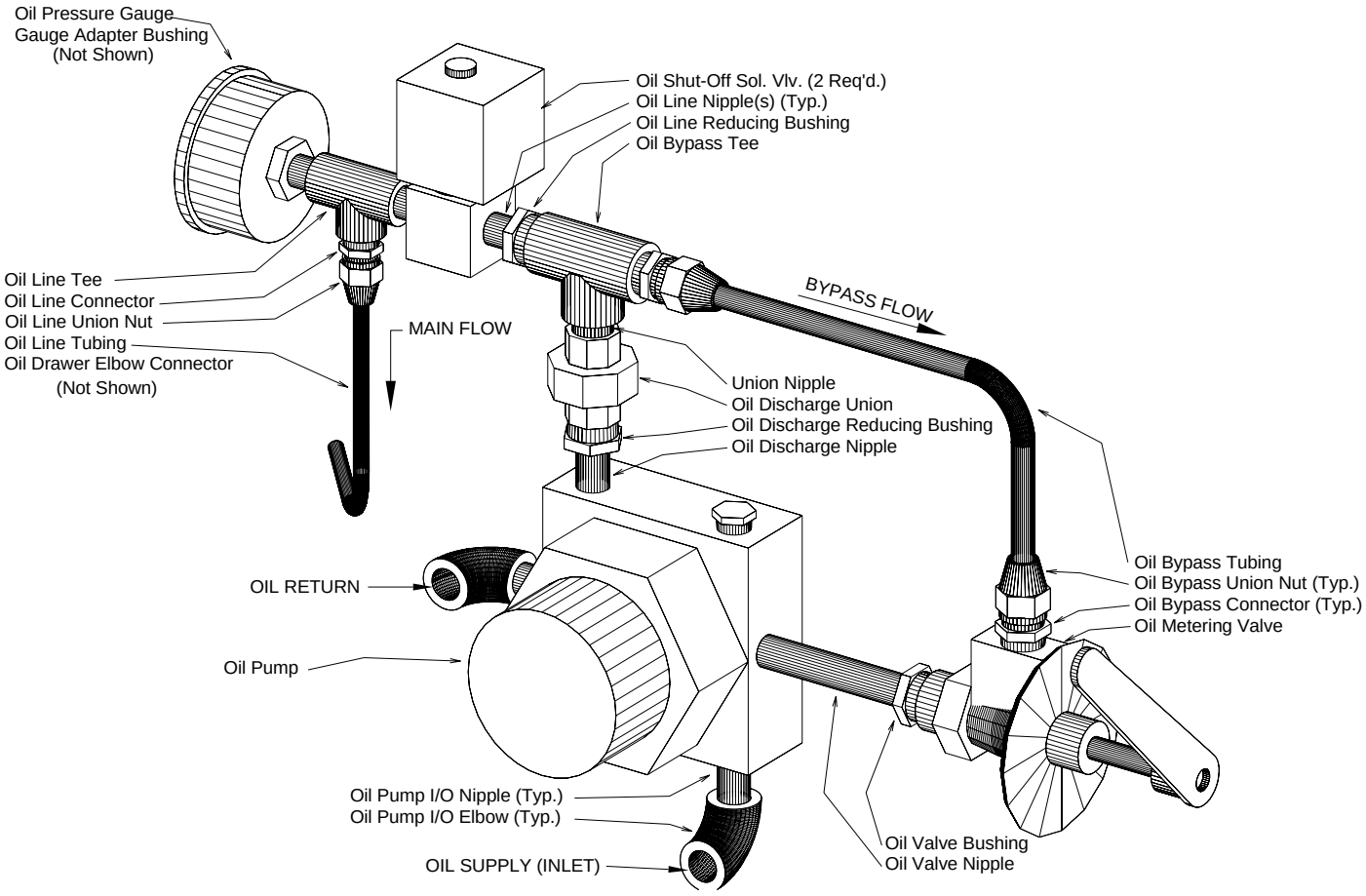
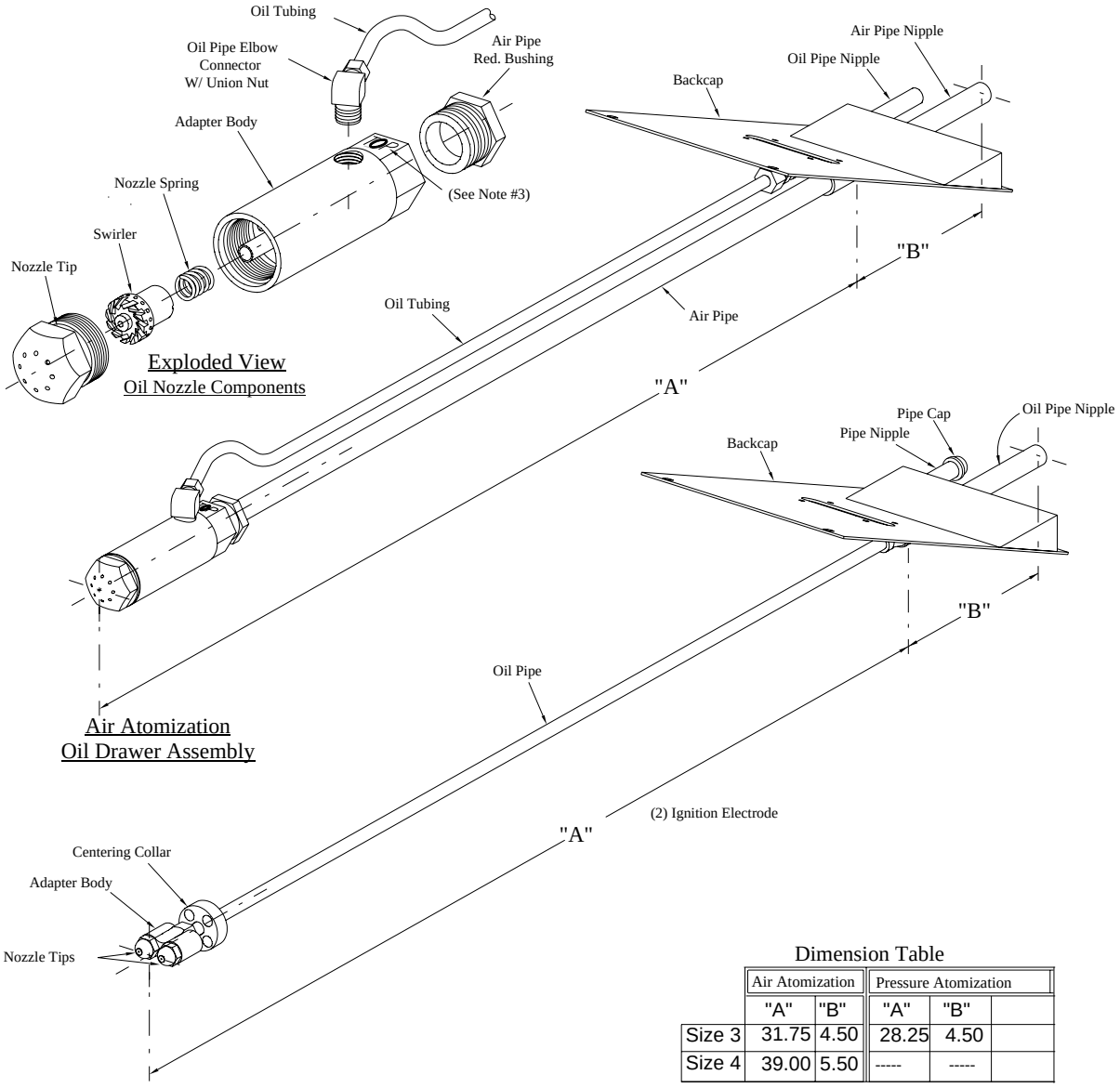


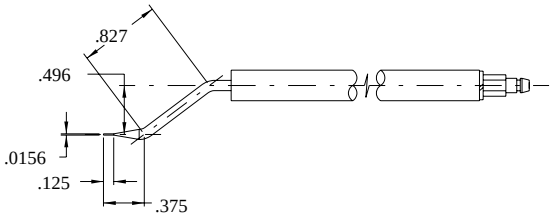
Figure 10-8. Oil Drawer Assemblies

Component Lists Page 10A-11

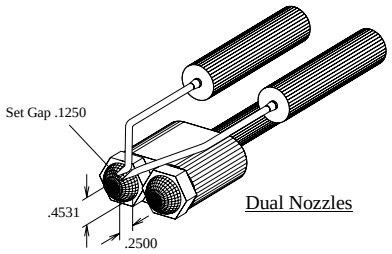


Dimension Table

	Air Atomization		Pressure Atomization		
	"A"	"B"	"A"	"B"	
Size 3	31.75	4.50	28.25	4.50	
Size 4	39.00	5.50	-----	-----	



Electrode Tip
Preparation Detail

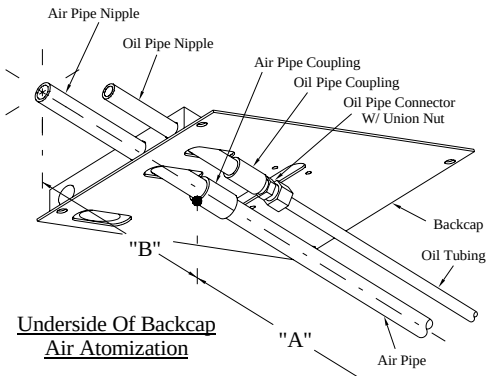


Dual Nozzles

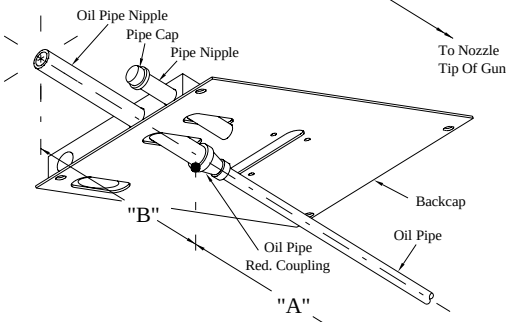
Note:
Measured From Nozzle Tip
To Tip Of Electrode.

Figure 10-9. Oil Gun Assemblies

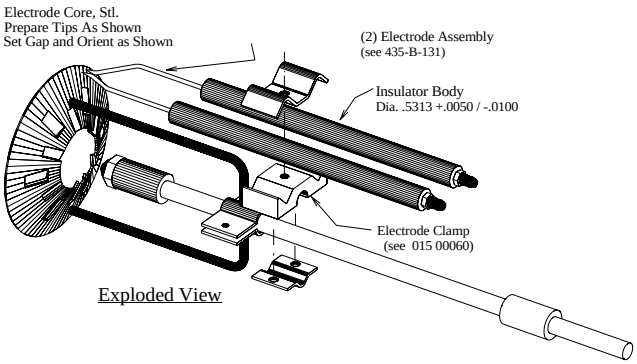
Component Lists Page 10A-11



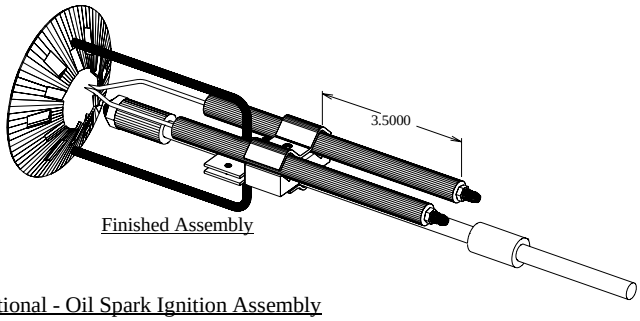
Underside Of Backcap
Air Atomization



Underside Of Backcap
Pressure Atomization
To Nozzle
Tip Of Gun



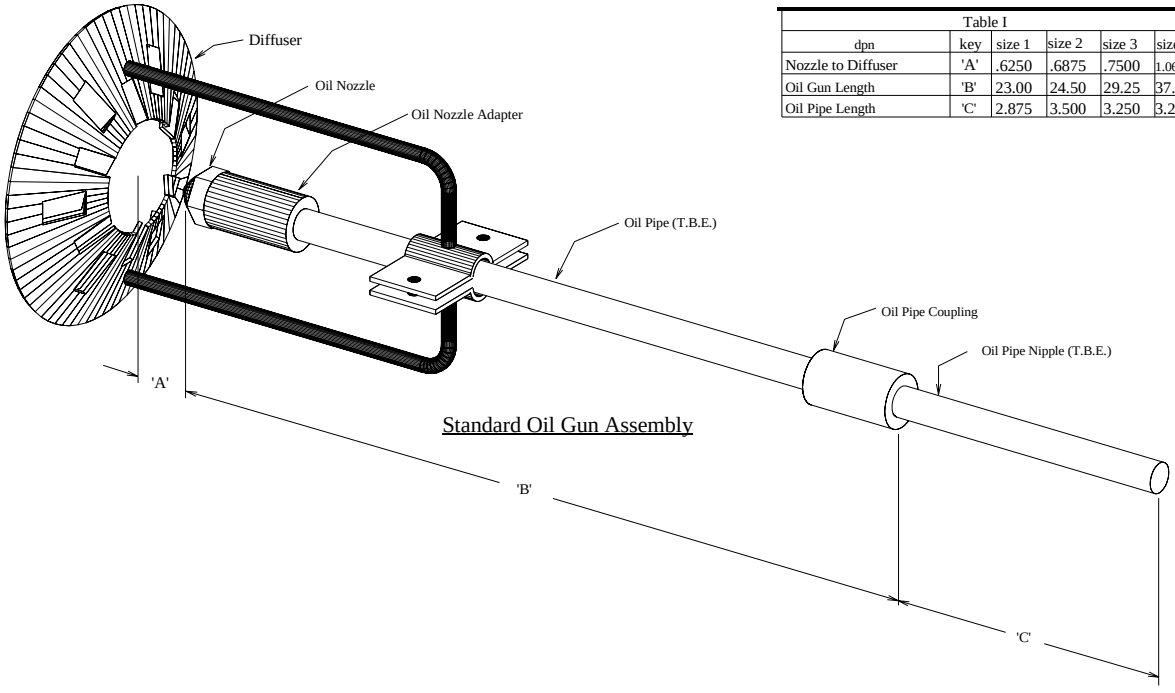
Exploded View



Finished Assembly

Optional - Oil Spark Ignition Assembly

Table I					
dpn	key	size 1	size 2	size 3	size 4
Nozzle to Diffuser	'A'	.6250	.6875	.7500	1.0625
Oil Gun Length	'B'	23.00	24.50	29.25	37.00
Oil Pipe Length	'C'	2.875	3.500	3.250	3.250



Standard Oil Gun Assembly

Figure 10-10. Direct Drive, Pressure Atomized Light Oil (Std. Oil, Gas-Oil Fired Units, 100-150 HP)

Oil Train Components	Size 3			Size 4 (Derated Burners)		
Oil Discharge Nipple	1	.25 NPT x SH	857-129	1	.25 NPT x SH	857-129
Oil Disch. Red. Bsh.	1	.375 x .25	847-1082	1	.375 x .25	847-1082
Oil Valve Bushing	1	.375 x .25	847-1082	1	.375 x .25	847-1082
Oil Valve Nipple	1			1		
Main Oil Valve	2	ASCO .375 NPT	948-319	2	ASCO .375 NPT	948-319
Oil Pressure Gauge	1	Ash. 2.5"0-300	850-1247	1	Ash. 2.5"0-300	850-1247
Gauge Adaptor Bush.	1	.375 x .25	847-1082	1	.375 x .25	847-1082
Oil Drawer Elb. Conn.	1	.375 FP x .375 OD	845-316	1	.375 FP x .375 OD	845-316
Oil Line Connector	1	.375 MP x .375 OD	845-46	1	.375 MP x .375 OD	845-46
Oil Line Union Nut	2	.375 ODT, Short	845-43	2	.375 ODT, Short	845-43
Oil Line Tubing	1	.375 ODT x .032	939-70	1	.375 ODT x .032	939-70
Oil Line Nipple	3	.375 NPT x SH	857-23	3	.375 NPT x SH	857-23
Oil Line Tee	1	.375 NPT Tee	859-23	1	.375 NPT Tee	859-23
Oil Line Red. Bsh.	N/A			N/A		
Oil Bypass Connector	2	.375 x .375 OD	845-46	2	.375 x .375 OD	845-46
Oil Bypass Union Nut	2	.375 ODT, Short	845-43	2	.375 ODT, Short	845-43
Oil Bypass Tubing	1	.375 ODT x .032	939-70	1	.375 ODT x .032	939-70
Oil Bypass Tee	1	.375 NPT Tee	859-23	1	.375 NPT Tee	859-23
Oil Discharge Union	1	.375 NPT Union	858-160	1	.375 NPT Union	858-160
Union Nipple	1	.375 NPT x CL	857-139	1	.375 NPT x CL	857-139
Oil Pump I/O Nipple	2	.375 NPT x 1.5	857-141	2	.375 NPT x 1.5	857-141
Oil Pump I/O Elbow	2	.375 NPT 90 Deg	859-79	2	.375 NPT 90 Deg	859-79
Oil Nozzle Adptr (Body)	1	Dual, .125 NPT	899-233	1	Dual, .125 NPT	899-233
Oil Pipe Ctr. Collar		(Note 2)			(Note 3)	
Oil Pipe (Appox. Lg. Ft.)	2.5	.125 NPT	900-409	3.1	.125 NPT	900-409
Oil Pipe Red. Coupling	1	.125 x .375	847-718	1	.125 x .375	847-718
Oil Pipe Nipple	1	.375 NPT x 4	857-146	1	.375 NPT x 4	857-146
Oil Port Nipple	1	.25 NPT x SH	857-129	1	.25 NPT x SH	857-129
Oil Port Cap	1	.25 NPT Cap	858-126	1	.25 NPT Cap	858-126
Pump Capscrew Pkg.	2	.375 - 16 x 1, Stl.	868-56	2	.375 - 16 x 1, Stl.	868-56
Oil Mtr. Vlv. Actr. Arm	1	Arm .76 (IC 2-184)	945-209	1	Arm .76 (IC 2-184)	945-209
Main Shaft Actr. Arm	1	Vly Tool, .500	945-205	1	Vly Tool, .500	945-205
Mod Linkage Ball Joint	2	Vly Tool, .25 - 20	945-207	2	Vly Tool, .25 - 20	945-207
Mod Linkage Rod Nuts	4	.3125-24 Hex Nut	869-53	4	.3125-24 Hex Nut	869-53
Mod Linkage Drive Rod	0.8	.3125 Thd. Rod	971-137	0.8	.3125 Thd. Rod	971-137
Radial Orifice Plugs	12	(Note 7)	860-579	12	(Note 7)	860-580
Data Tag	1		118-3138	1		118-3138
Oil Strainer		(Note 5)	843-252		(Note 5)	843-252

Figure 10-11. Remote Pump, Pressure Atomized Light Oil (Opt. Oil, Gas-Oil Fired Units, 100-150 HP)

Component List Page 10A-13

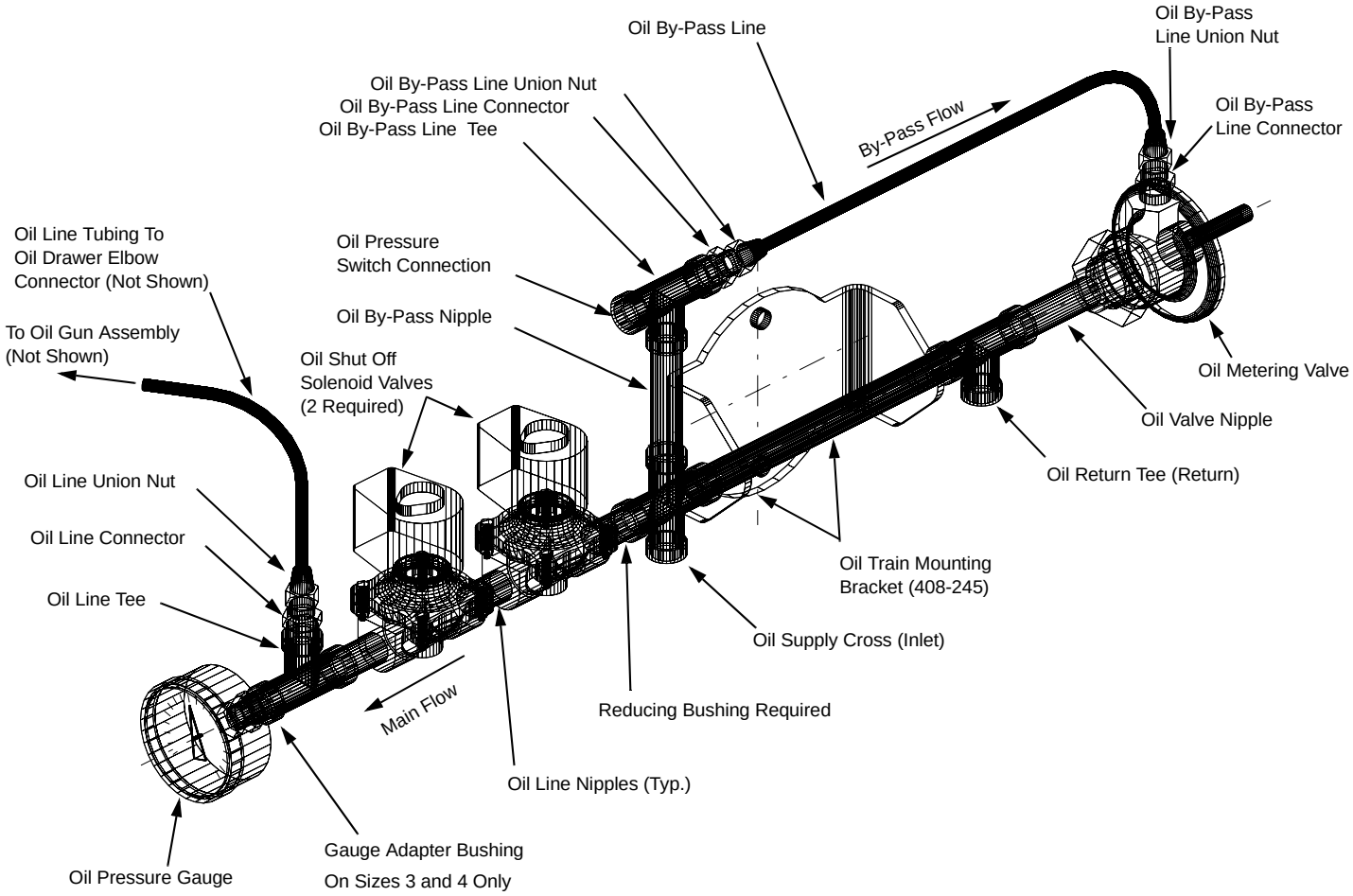


Figure 10-12. Remote Pump, Pressure Atomized Light Oil (Opt. Oil, Gas-Oil Fired Units, 100-150 HP)

Oil Train Components	Size 3		Size 4	
Oil Valve Nipple	1		1	
Main Oil Valve	2	948-319	2	948-319
Oil Pressure Gauge	1	850-1247	1	850-1247
Oil Drawer Elb. Conn.	1	845-316	1	845-316
Oil Line Connector	1	845-46	1	845-46
Oil Line Union Nut	2	845-43	2	845-43
Oil Line Tubing	1	939-70	1	939-70
Oil Line Nipple	3	857-23	3	857-23
Oil Line Tee	1	859-23	1	859-23
Oil Line Red. Bsh.	N/A		N/A	
Oil Bypass Connector	2	845-46	2	845-46
Oil Bypass Union Nut	2	845-43	2	845-43
Oil Bypass Tubing	1	939-70	1	939-70
Oil Bypass Tee	1	859-23	1	859-23
Oil Bypass Nipple	1	857-143	1	857-143
Oil Supply Cross	1	859-261	1	859-261
Oil Return Tee	1	859-23	1	859-23
Oil Nozzle Adptr (Body)	1	899-233	1	899-233
Oil Pipe Ctr. Collar				
Oil Pipe (Appox. Lg. Ft.)	2.5	900-409	3.1	900-409
Oil Pipe Red. Coupling	1	847-718	1	847-718
Oil Pipe Nipple	1	857-156	1	857-156
Low Oil Pressure Switch	1	817-2312	1	817-2312
Low Oil Sw. Mtg. Scr.	2	868-136	2	868-136
Low Oil Sw. Tube Conn.	2	845-7	2	845-7
Low Oil Conn. Union Nut	2	845-8	2	845-8
Low Oil Press Sw. Tube	1	939-25	1	939-25
Oil Port Nipple	1	857-129	1	857-129
Oil Port Cap	1	858-126	1	858-126
Oil Train Mtg. Bkt.	1	408B245	1	408B245
Mtg. Fasteners	2	868-56	2	868-56
Oil Mtr. Vlv. Actr. Arm	1	945-209	1	945-209
Main Shaft Actr. Arm	1	945-206	1	945-206
Mod Linkage Ball Joint	2	945-207	2	945-207
Mod Linkage Rod Nuts	4	869-53	4	869-53
Mod Linkage Drive Rod	0.8	971-137	0.8	971-137
Radial Orifice Plugs	12	860-579	12	860-580
Data Tag	1	118-3138	1	118-3138
Oil Strainer		843-252		843-252

Figure 10-13. Direct Drive, Air Atomized Light Oil (Opt. Type 'F', Oil, Gas-Oil Fired Units, <= 8.37 MMbh)

Component List Page 10A-15

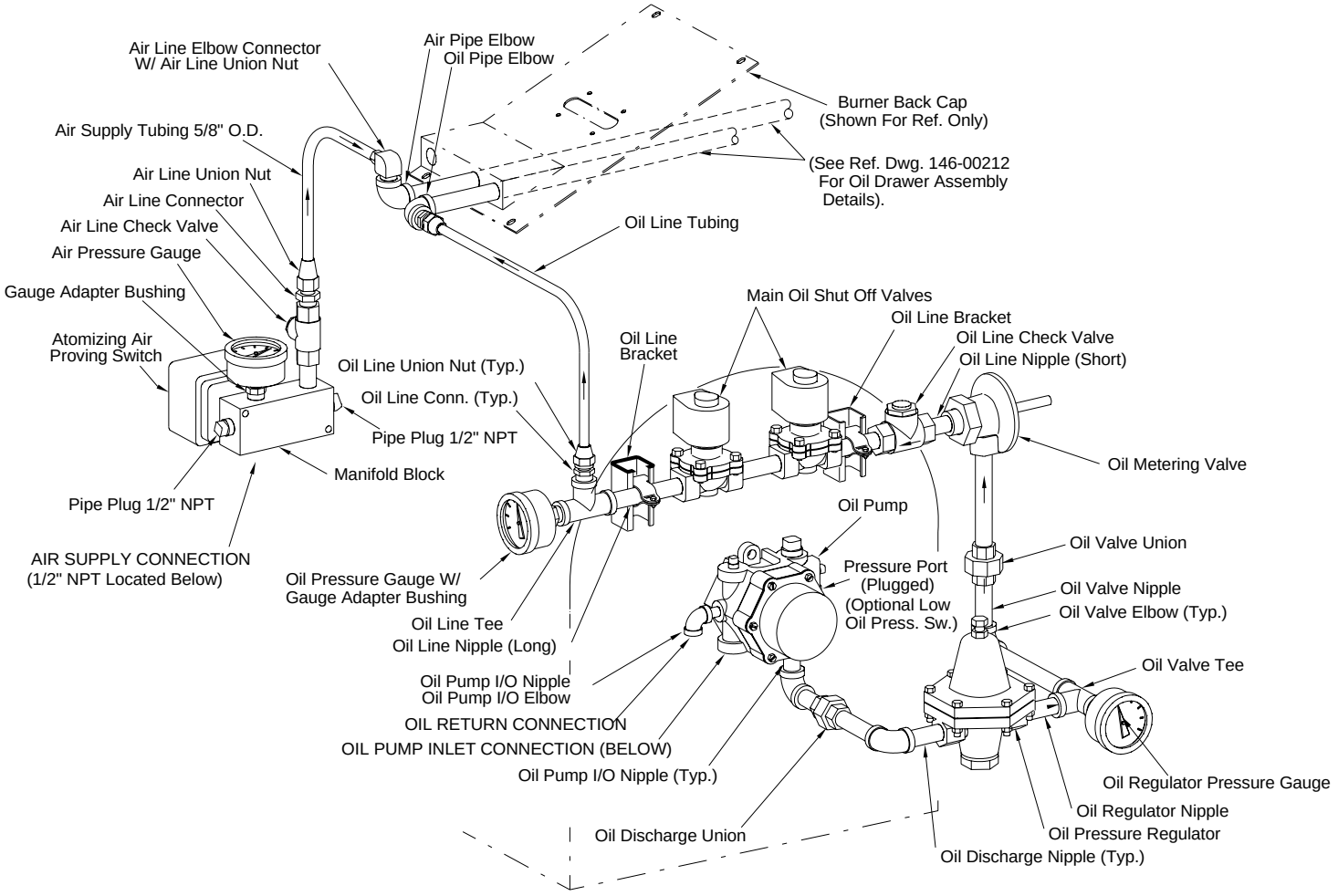


Figure 10-14. Direct Drive, Air Atomized Light Oil (Opt. Type 'F', Oil, Gas-Oil Fired Units, <= 8.37 MMbh)

Air Train	All Sizes		
	Qty.	Detail Dpn.	P/N
AIr Pressure Gauge	1	C-B 2.5"CBM 100#	850-391
Atom. Air Prov. Sw.	1	Dietz #161-p15	836-418
Air Check Valve	1	.50 NPT Ch Vlv	940-5689
Air Line Nipple	1	.50 NPT x SH	857-153
Air Line Conn.	1	.50 MP x.625 OD	845-44
Air Line Elb. Conn.	1	.375 MP x.625 OD	845-601
Air Line Union Nut	2	.625 ODT, Short	845-45
AIr Line Tubing	1.5	.625 ODT x .035	939-26
Air Pipe Elbow	1	.375 NPT 90 Deg.	859-79
Manifold Port Plug	2	.50 NPT Plug	858-266
Manifold Block	1	Mfd. Blck, Air Atm.	38B346

Oil Train Components	**Size 3**			**Size 4**		
Oil Disch. Nipple	4	.375 NPT x SH	857-141	4	.375 NPT x SH	857-141
Oil Discharge Union	1	.375 NPT Union	858-160	1	.375 NPT Union	858-160
Oil Discharge Elbow	2	.375 NPT 90 Deg.	859-79	2	.375 NPT 90 Deg.	859-79
Oil Regulator Nipple	1			1		
Oil Valve Nipple	2			2		
Oil Valve Tee	1	.375 NPT Tee	859-23	1	.375 NPT Tee	859-23
Oil Valve Elbow	1	.375 NPT 90 Deg.	859-79	1	.375 NPT 90 Deg.	859-79
Oil Valve Union	1	.375 NPT Union	858-160	1	.375 NPT Union	858-160
Oil Line Nipple (Long)	2	.375 NPT x 3	857-144	2	.375 NPT x 3	857-144
Oil Line Nipple (Short)	2	.375 NPT x SH	857-141	2	.375 NPT x SH	857-141
Oil Line Check Valve	1	.375 NPT Ch Vlv	940-5670	1	.375 NPT Ch Vlv	940-5670
Oil Line Tee	1	.375 NPT Tee	859-23	1	.375 NPT Tee	859-23
Main Oil Vlv.	1	ASCO .375 NPT	948-292	1	ASCO .375 NPT	948-292
Oil Pressure Gauge	1	C-B 2.5"CBM 100#	850-391	1	C-B 2.5"CBM 100#	850-391
Gauge Adaptor Bush.	1	.375 MP x .25 FP	847-1082	1	.375 MP x .25 FP	847-1082
Oil Reg. Press. Gauge	1	C-B 2.5"CBM 100#	850-391	1	C-B 2.5"CBM 100#	850-391
Gauge Adaptor Bush.	1	.375 MP x .25 FP	847-1082	1	.375 MP x .25 FP	847-1082
Oil Line Bracket (Matl.)	1	Unistrut #P1000	972-572	1	Unistrut #P1000	972-572
Oil Line Mnting. Clamp	2	Unistrut #P1109	928-178	2	Unistrut #P1109	928-178
Oil Line Conn.	1	.375 MP x.375 OD	845-46	1	.375 MP x.375 OD	845-46
Oil Line Elb. Conn.	1	.25 FP x .375 OD	845-317	1	.25 FP x .375 OD	845-317

Figure 10-15. Fan & Firing Head Components, 60 Hz (700 ft. altitude)

Oil Train Components (Note 7)			Size 3			Size 4
Oil Line Union Nut	2	.375 ODT, Short	845-43	2	.375 ODT, Short	845-43
Oil Line Tubing	1	.375 ODT x .032	939-70	1	.375 ODT x .032	939-70
Low Oil Pressure Switch	1	ASCO 400# UL,FM	817-2312	1	ASCO 400# UL,FM	817-2312
Low Oil Sw. Mtg. Scr.	2	.25-20 x .75 Stl.	868-136	2	.25-20 x .75 Stl.	868-136
Low Oil Sw. Tube Conn.	2	.25 ODT x .25 MP	845-7	2	.25 ODT x .25 MP	845-7
Low Oil Conn. Union Nut	2	.25 ODT, Short	845-8	2	.25 ODT, Short	845-8
Low Oil Press Sw. Tube	1	.25 ODT x .030	939-25	1	.25 ODT x .030	939-25
Oil Press. Relief Valve	1	Cash,0.5MC 115#	940-5692	1	Cash,0.5MC 115#	940-5692
Oil Relief Vlv. Nipple	2	0.50 NPT x SH	857-153	2	0.50 NPT x SH	857-153
Oil Return Tee	1	.50 NPT Tee	859-24	1	.50 NPT Tee	859-24
Oil Bypass Red. Bsh.	2	.50 MP x .375 FP	847-613	2	.50 MP x .375 FP	847-613
Oil Bypass Elbow	1	.375 NPT 90 Deg.	859-79	1	.375 NPT 90 Deg.	859-79
Oil Bypass Check Vlv.	1	.375 NPT Ch Vlv	940-5670	1	.375 NPT Ch Vlv	940-5670
Oil Bypass Conn.	2	.375 MP x.375 OD	845-46	2	.375 MP x.375 OD	845-46
Oil Bypass Union Nut	2	.375 ODT, Short	845-43	2	.375 ODT, Short	845-43
Oil Bypass Tubing	1	.375 ODT x .032	939-70	1	.375 ODT x .032	939-70
Oil Nozzle Adptr. (Body)	1	Nozl. Bdy. Size 3	100C386	1	Nozl. Bdy. Size 4	100C385
Oil Nozzle Spring	1	Spring, Oil Nozl.	82-33	1	Spring, 250-350	82A6
Oil Pipe Elbow Conn.	1	.125 MP x .375 OD	845-662	1	.25 MP x .375 OD	845-317
Oil Pipe Conn.	1	.25 MP x .375 OD	845-177	1	.25 MP x .375 OD	845-177
Oil Pipe Union Nut	2	.375 ODT, Short	845-43	2	.375 ODT, Short	845-43
Oil Tubing	2.5	.375 ODT x .032	939-70	3.1	.375 ODT x .032	939-70
Oil Pipe Coupling	1	.25 NPT	858-19	1	.25 NPT	858-19
Oil Pipe Nipple	1	.25 NPT x 4	857-134	1	.25 NPT x 4	857-134
Oil Temperature Gauge	1	2" .25 CBM,300 Deg.	937-49	1	2" .25 CBM,300 Deg.	937-49
Oil Pipe Tee	1	.375 NPT Tee	859-23	1	.375 NPT Tee	859-23
Oil Pipe Red. Bsh.	2	.375 MP x .25 FP	847-1082	2	.375 MP x .25 FP	847-1082
Air Pipe Red. Bsh.	1	.75 MP x .375 FP	847-465		1.0 MP x .375 FP	847-1611
Air Pipe	2.5	.375 NPS	900-75	3.1	.375 NPS	900-75
Air Pipe Coupling	1	.375 NPT	858-20	1	.375 NPT	858-20
Air Pipe Nipple	1	.375 NPT x 4	857-156	1	.375 NPT x 4	857-156
Oil Mtr. Vlv. Actr. Arm	1	Arm .76 (IC 2-184)	945-209	1	Arm .76 (IC 2-184)	945-209
Main Shaft Actr. Arm	1	Vly Tool, .500	945-206	1	Vly Tool, .500	945-206
Mod Linkage Ball Joint	2	Vly Tool, .25 - 20	945-207	2	Vly Tool, .25 - 20	945-207
Mod Linkage Drive Rod	1.2	.3125 Thd. Rod	971-137	1.5	.3125 Thd. Rod	971-137
Data Tag	1		118-3138	1		118-3138
Oil Strainer		(Note 6)	843-252		(Note 6)	843-252

Figure 10-16. Gas Fired (Std. Also: Remote Oil, Gas - Remote Oil), 3 Pass and 4 Pass

3 Pass Boiler						
Burner Size	Boiler Size	Motor HP	Impeller	Cone	Diffuser	Blast Tube
Size 3	100 HP	2	192-296	97-255	275-274	286-17
Size 3	125 HP	3	192-297	97-255	275-274	286-17
Size 3	150 HP	5	192-298	97-255	275-274	286-17
Size 4	200 HP	7.5	192-299	97-258	275-283	286-18
Size 4	250 HP	7.5	192-310	97-258	275-283	286-18
Size 4	300 HP	10	192-311	97-258	275-283	286-18
Size 4	350 HP	10	192-311	97-258	275-275	286-18

4 Pass Boiler						
Burner Size	Boiler Size	Motor HP	Impeller	Cone	Diffuser	Blast Tube
Size 3	100 HP	3	192-297	97-255	275-274	286-17
Size 3	125 HP	5	192-298	97-255	275-274	286-17
Size 3	150 HP	7.5	192-299	97-257	275-274	286-17
Size 4	200 HP	7.5	192-310	97-258	275-283	286-18
Size 4	250 HP	7.5	192-310	97-258	275-283	286-18

Figure 10-17. Motors & Mtg. Plate Selections

Size 3 TEFC (115/230-1-60, 110/220-1-50) **Size 3 TEFC (tri-3-60, 190/380-3-50)**

2	56C	894-3623	Size 3 (145 TC)	59-5402	56C	894-3613	Size 3 (145 TC)	59-5402
3	N/A	N/A	N/A	N/A	56C	894-3614	Size 3 (145 TC)	59-5402
5	N/A	N/A	N/A	N/A	145TC	894-3615	Size 3 (145 TC)	59-5402
					184/145TC	894-3616	Size 3 (145 TC)	59-5402

Size 4 TEFC (115/230-1-60, 110/220-1-50) **Size 4 TEFC (tri-3-60, 190/380-3-50)**

7.5	N/A	N/A	N/A	N/A	184/145TC	894-3616	Size 4 (145 TC)	59-5564
10	N/A	N/A	N/A	N/A	215TC	894-3696	Size 4 (213 TC)	59-5471

Size 3 TEFC (575/600-3-60) tefc3

56C	894-3631	Size 3 (145 TC)	59-5402
56C	894-3632	Size 3 (145 TC)	59-5402
145TC	894-3633	Size 3 (145 TC)	59-5402
184/145TC	894-3634	Size 3 (145 TC)	59-5402

Size 4 TEFC (575/600-3-60) tefc4

184/145TC	894-3634	Size 4 (145 TC)	59-5564
215TC	894-3700	Size 4 (213 TC)	59-5471

Figure 10-18. Pressure Atomized Light Oil, Delivery Components

All Sizes **Oil Metering Valves**

Input	Qty.	Oil Metering Vlv.	P/N
4185 MBH	1	Hauck S-3-9	940-5318
5231 MBH	1	Hauck S-3-13	940-5635
6280 MBH	1	Hauck S-3-9	940-5318

Figure 10-19. Oil Pump Selections

Pressure Atomization Systems

Oil Pumps (60 Hz)

Input	GPH (No. 2)	Qty.	Oil Pump	P/N
4185 MBH	29.9	1	Wbstr. 22R322C	901-1437
5231 MBH	37.4	1	Wbstr. 22R623C	901-1544
6280 MBH	44.9	1	Wbstr. 22R623C	901-1544

Figure 10-20. Remote Air Atomized Light Oil System Components

Size 3 Input	Qty.	Oil Metering Valves	P/N	Qty.	Pressure Regulators	P/N
5231 MBH	1	Hauck B-0.5-16	940-5690	1	Cash BBC .375	918-739
6280 MBH	1	Hauck B-0.5-16	940-5690	1	Cash BBC .375	918-739
Size 4						
8370 MBH	1	Hauck B-0.5-20	940-5691	1	Cash BBC .50	918-740
10460 MBH	1	Hauck B-0.5-20	940-5691	1	Cash BBC .50	918-740
12560 MBH	1	Hauck B-0.5-20	940-5691	1	Cash BBC .50	918-740
14650 MBH	1	Hauck B-0.5-20	940-5691	1	Cash BBC .50	918-740

Size 3 (Std. UL- All Inputs, FM, and IRI <12500MMbh

5231 MBH	1	ASCO .375 NPT	948-333	1	ASCO .375 NPT	948-335
6280 MBH	1	ASCO .375 NPT	948-333	1	ASCO .375 NPT	948-335

Size 4

8370 MBH	1	ASCO .50 NPT	948-334	1	ASCO .50 NPT	948-278
10460 MBH	1	ASCO .50 NPT	948-334	1	ASCO .50 NPT	948-278
12560 MBH	1	ASCO .50 NPT	948-334	1	ASCO .50 NPT	948-278
14650 MBH	1	ASCO .50 NPT	948-334	1	ASCO .50 NPT	948-278

Main Oil Valves w/POC (FM >= 12500 MMbh)

Size 4	Qty.	2-Way Valves	P/N	Qty.	3-Way Valves	P/N
8370 MBH	1	Gen. Con. .50 NPT	949-183	1	Gen. Con. .50 NPT	949-397
10460 MBH	1	Gen. Con. .50 NPT	949-183	1	Gen. Con. .50 NPT	949-397
12560 MBH	1	Gen. Con. .50 NPT	949-183	1	Gen. Con. .50 NPT	949-397
14650 MBH	1	Gen. Con. .50 NPT	949-183	1	Gen. Con. .50 NPT	949-397

Figure 10-21. Remote Air Atomized Light Oil System Components

Size 3 Oil Nozzle Assy, (Light Oil, Gas Light Oil Fired Units)

Input	Qty.	Oil Nozzle Tip	P/N	Qty.	Oil Swirler	P/N
5231 MBH	1	Nozl. Size 3, Air	48C618	1	Swirler	109-14
6280 MBH	1	Nozl. Size 3, Air	48C618	1	Swirler	109-14

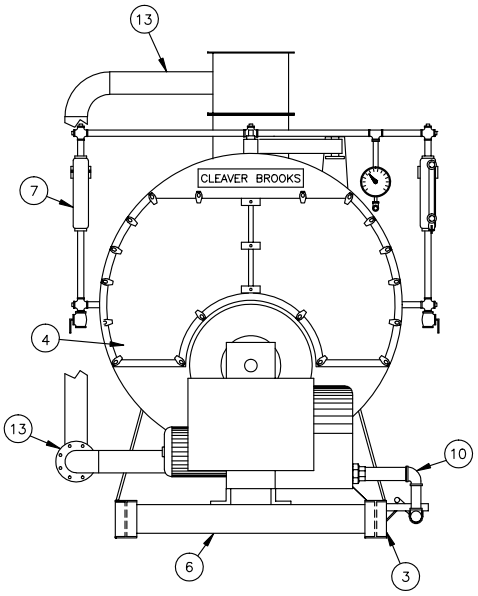
Size 4

8370 MBH	1	Nozl. Size 4, Air	48C605	1	Swrlr. HTD 250	109-73
10460 MBH	1	Nozl. Size 4, Air	48C605	1	Swrlr. HTD 250	109-73
12560 MBH	1	Nozl. Size 4, Air	48C605	1	Swrlr. HTD 250	109-73
14650 MBH	1	Nozl. Size 4, Air	48C605	1	Swrlr. HTD 250	109-73

Notes

Chapter 10B

Parts ICB Vessel and Trim



ITEM	DESCRIPTION
1	PRESSURE VESSEL
2	INSULATION & LAGGING
3	SKID ASSEMBLY
4	FRONT SMOKE BOX
5	REAR AREA & DOOR
6	BURNER SELECTION/INSTALLATION
7	WATER COLUMN PIPING
8	PRESSURE CONTROLS
9	TEMPERATURE CONTROLS
10	GAS TRAIN EQUIPMENT
11	AIR/OIL PIPING
12	INSTALLATION, TURNAROUND DOOR
13	FGR PIPING & INSTALLATION
14	SURFACE BLOWOFF
15	FEEDWATER PIPING
16	MOUNTED BLOWDOWN PIPING
17	SAFETY/RELIEF VALVES
18	MOUNTED S.B.O. – HYDAK
19	HEAT SHIELD

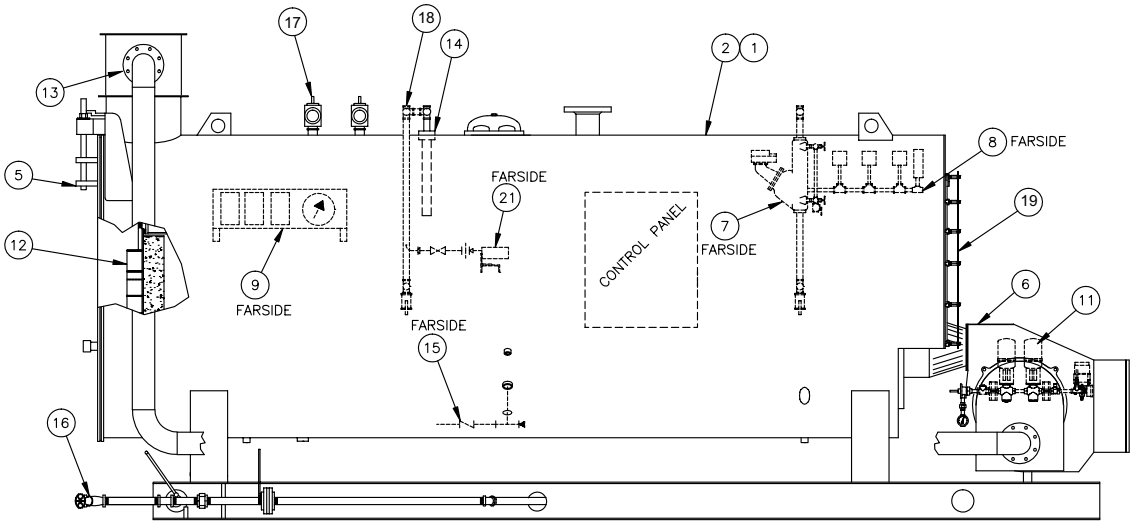
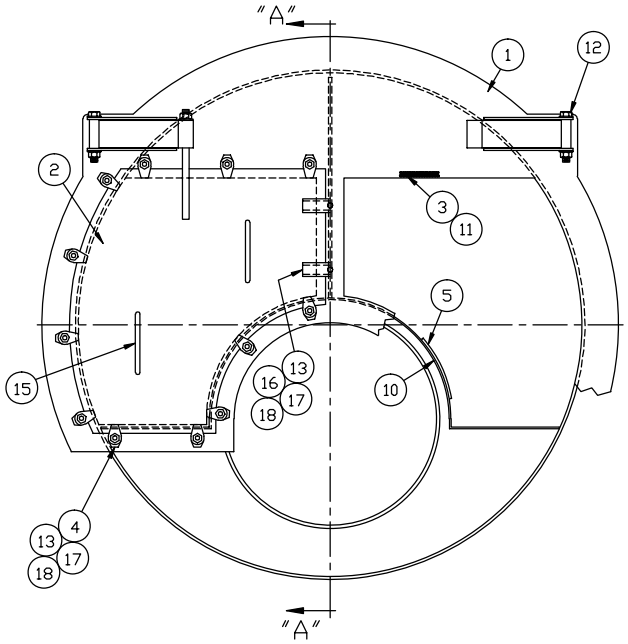
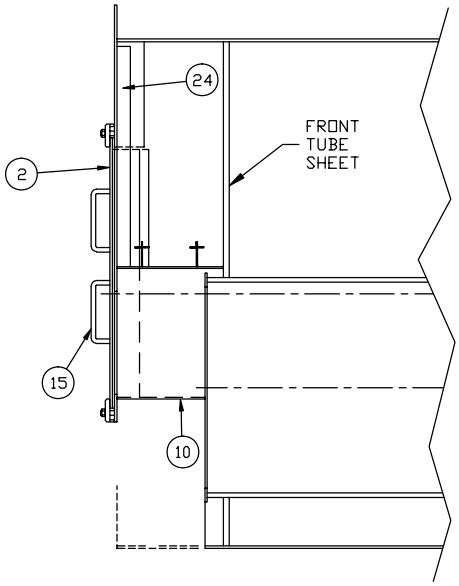


Table Of Contents
ICB Vessel and Trim

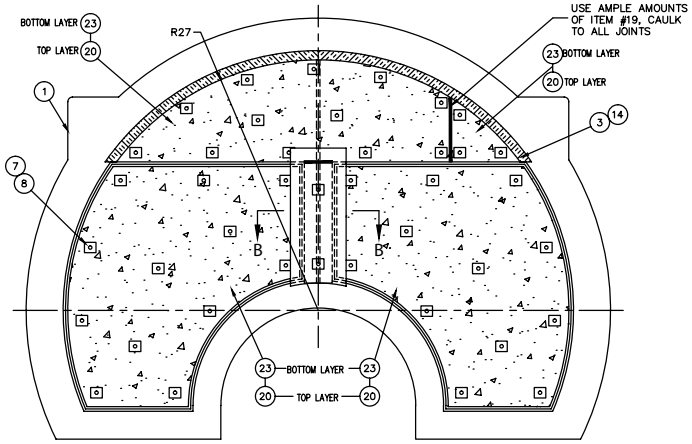
Figure 10-1. Smoke Box 55” 100-125 HP 3 Pass

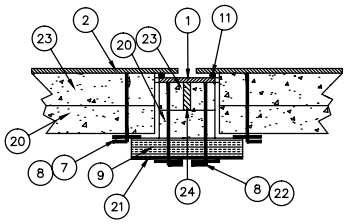
ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00842	PLATE, 1/4" x 63.00" x 44.625"	1
2	975 00842	PLATE, 1/4" x 28" x 28.625"	2
3	797 01813	ADHESIVE, SPAY, GENERAL PURPOSE, SUPER TAK	1
4	103 00375	LOCKING LUG	24
5	872 01081	WET FELT, 1/4", 11-5/8" x 66-3/4", SUPERWOOL 607	1
6	971 00059	FLAT BAR, 1/4" x 3" x 183" LG.	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	57
8	828 00034	CLIP, INSUL. RETAINER, 1 1/2" SQ., #10 GA. SST. (SEE SHEET #2)	62
9	872 01082	INSULATING BLANKET, 1" THK., 6" x 15", SUPERWOOL 607	1
10	975 00851	PLATE, 3/16" X 11.625" X 67-1/16"	1
11	872 00622	ROPE, FIBERFAX, 1/2"DIA., 2300°F. x 204" LG.	1
12	462 00024	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	26
14	872 01082	INSUL. BLANKET, 1" x 3" x 54", 8 LB. DEN. CU/FT., SUPERWOOL 607	1
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1-1/2"x 1/2"x 1/8"x 4.00"	2
17	869 00029	BRASS NUT,1/2"	26
18	952 00108	FLATWASHER,1/2"	26
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2" x 24" x 36", SUPERWOOL 607	3
21	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE, 6" x 15"	1
22	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	6
23	872 01008	INSULATNG BOARD, 1900°, 1-1/2", GEMINITE 19-SERIES	18 SF
24	971 00053	FLAT BAR, 1/4" x 1-1/2" x 24-1/16" LG.	1





SECTION A–A





SECTION B–B

Figure 10-2. Smoke Box 60” 150-200 HP 3 Pass

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00842	PLATE, 1/4"x 68.00"x 50.5"	1
2	975 00842	PLATE, 1/4"x 30.50"x 33"	2
3	797 01813	ADHESIVE, SPRAY, GENERAL PURPOSE, SUPER TAK	1
4	103 00375	LOCKING LUG	30
5	872 01081	WET FELT, 1/4", 11-5/8" x 74" SUPERWOOL 607	1
6	971 00059	FLAT BAR, 1/4"x 3"x 210"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	74
8	828 00034	CLIP, INSUL. RETAINER, 1-1/2" SQ., #10 GA. SST. (SEE SHEET #2)	80
9	872 01008	INSULATNG BOARD, 1-1/2"THK., 1900° , GEMINITE 19-SERIES	18SF
10	975 00851	PLATE, 3/16" X 11.625" X 73.125"	1
11	872 00622	ROPE, FIBERFAX, 1/2"DIA. 2300°F. x 240" LG.	1
12	462 00024	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	32
14	872 01082	INSUL. BLANKET, 1" x 3" x 60", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	2
17	869 00029	BRASS NUT,1/2"	32
18	952 00108	FLATWASHER,1/2"	32
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2"THK., 24" x 36" SUPERWOOL 607	3
21	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE, 6" x 15-5/8"	1
22	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	6
23	872 01082	INSULATING BLANKET, 1" THK., 6" x 15-5/8" SUPERWOOL 607	1
24	971 00053	FLAT BAR, 1/4" x 1-1/2" x 26-5/16"	1

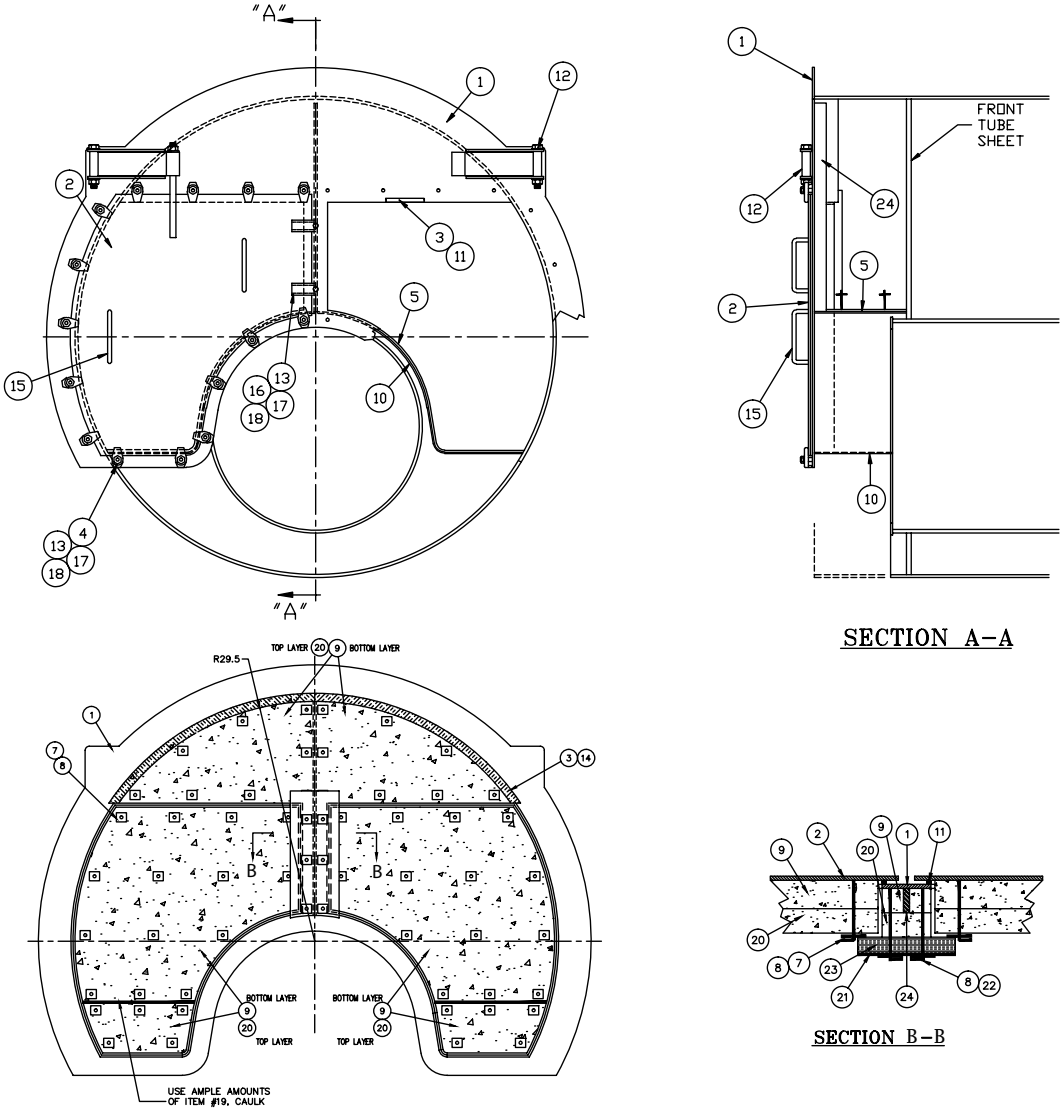


Figure 10-3. Smoke Box 72” 250-300 HP 3 Pass

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00842	PLATE,1/4"x 80.00"x 63.0625"	1
2	975 00842	PLATE,1/4"x 36.5"x 42.3125"	2
3	797-01813	SPRAY ADHESIVE, SUPER TAK	1
4	103 00375	LOCKING LUG	32
5	872 01081	WET FELT, 1/4" x 14-5/8" x 83.25" SUPERWOOL 607	1
6	971 00059	FLAT BAR,1/4"x 3"x 252"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	86
8	828 00034	CLIP, INSUL. RETAINER, 1 1/2" SQ., #10 GA. SST. (SEE SHEET #2)	92
9	872 01082	INSUL. BLANKET, 1" x 3" x72"LG., 8LB. CU.FT. DENSITY, SUPERWOOL 607	1
10	975 00851	PLATE, 3/16" X 14.625" X 83.25"	1
11	872 00622	ROPE,FIBERFAX,1/2"DIA. 2400°F. x 264"LG	1
12	462 00025	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	34
14	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	6
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	2
17	869 00029	BRASS NUT,1/2"	34
18	952 00108	FLATWASHER,1/2"	34
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2"THK., 24" x 36" SUPERWOOL 607	4
21	872-01082	INSULATNG BLANKET, 1"THK., 6" x 17-1/4" SUPERWOOL 607	1
22	930-00135	WIRE MESH, 1/2" MESH, .047"WIRE, 6" x 17-1/4"	1
23	872 01008	INSULATNG BOARD, 1-1/2"THK., 1900°F, GEMINITE 19-SERIES	24
24	971 00053	FLAT BAR, 1/4"x 1-1/2"x 19-13/16"	1
25	971 00053	FLAT BAR, 1/4"x 1-1/2"x 51-3/16"	1

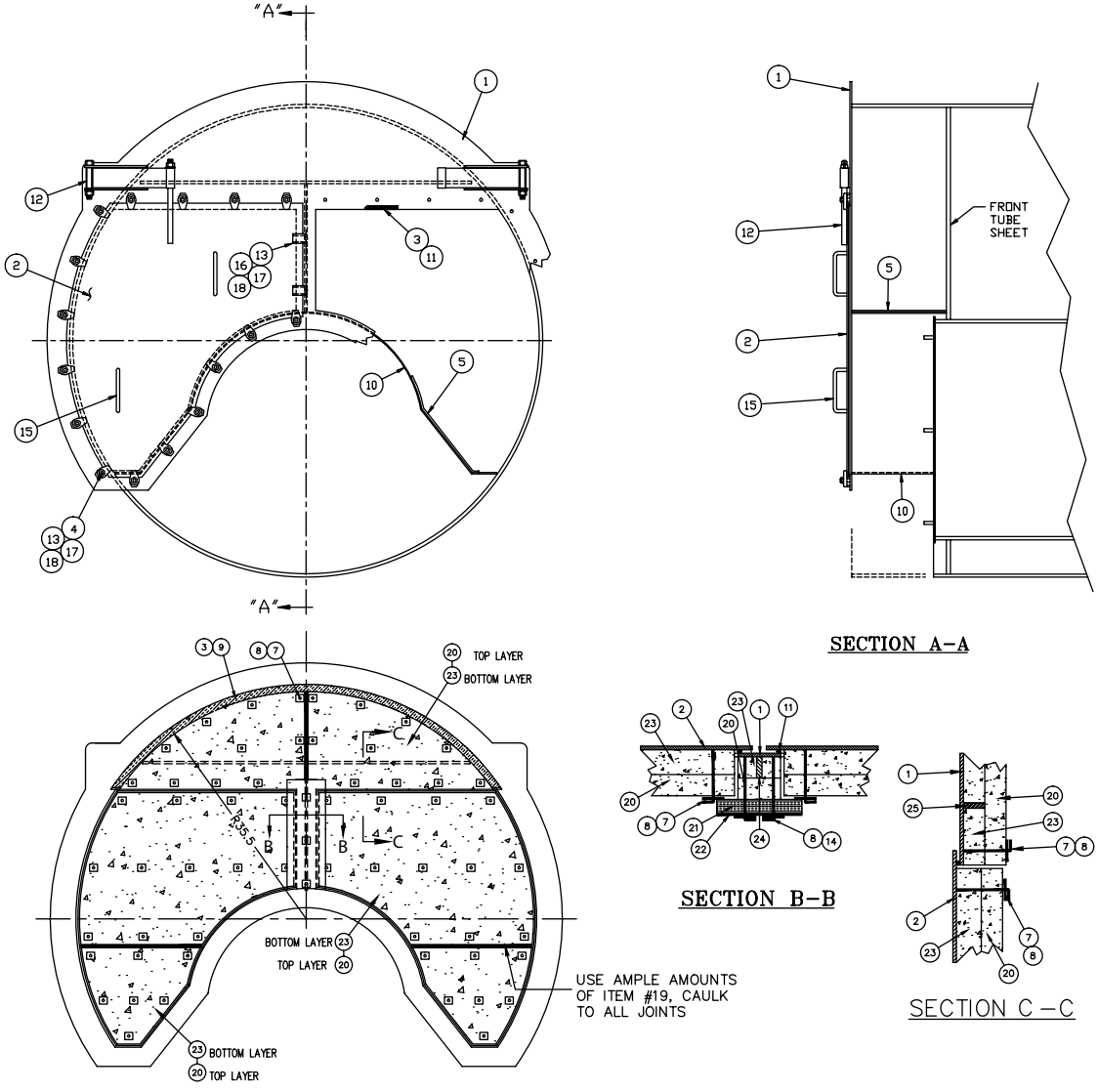


Figure 10-4. Smoke Box 78-350-400 HP 3 Pass

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00048	PLATE,1/4"x 49.50"x 49.8125"	1
2	975 00842	PLATE,1/4"x 39.50"x 49.8125"	2
3	797 01813	SPRAY ADHESIVE, SUPER TAK	1
4	103 00375	LOCKING LUG	38
5	872 01081	WET FELT, 1/4" x 14-5/8" x 96" SUPERWOOL 607	1
6	971 00059	FLAT BAR,1/4"x 3"x 288.00"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	84
8	828 00034	CLIP, INSUL. RETAINER, 1 1/2" SQ., #10 GA. SST. (SEE SHEET #2)	90
9	872 01008	INSULATNG BOARD, 1-1/2"THK., 1900°F, GEMINITE 19-SERIES	24SF
10	975 00851	PLATE, 3/16" X 14.625" X 94.125"	1
11	872 00622	ROPE,FIBERFAX,1/2"DIA., 2400°F x 300.00"	1
12	462 00025	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	40
14	872-01082	INSUL BLANKET, 1" x 3" x 80", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	2
17	869 00029	BRASS NUT,1/2"	40
18	952 00108	FLATWASHER,1/2"	40
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2"THK., 24" x 36" SUPERWOOL 607	4
21	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE, 6" x 18"	1
22	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	6
23	872 01082	INSULATING BLANKET, 1" THK., 6" x 18" SUPERWOOL 607	1
24	971 00053	FLAT BAR, 1/4"x 1-1/2" x 20-9/16"	1
25	971 00053	FLAT BAR, 1/4"x 1-1/2" x 57-7/8"	1

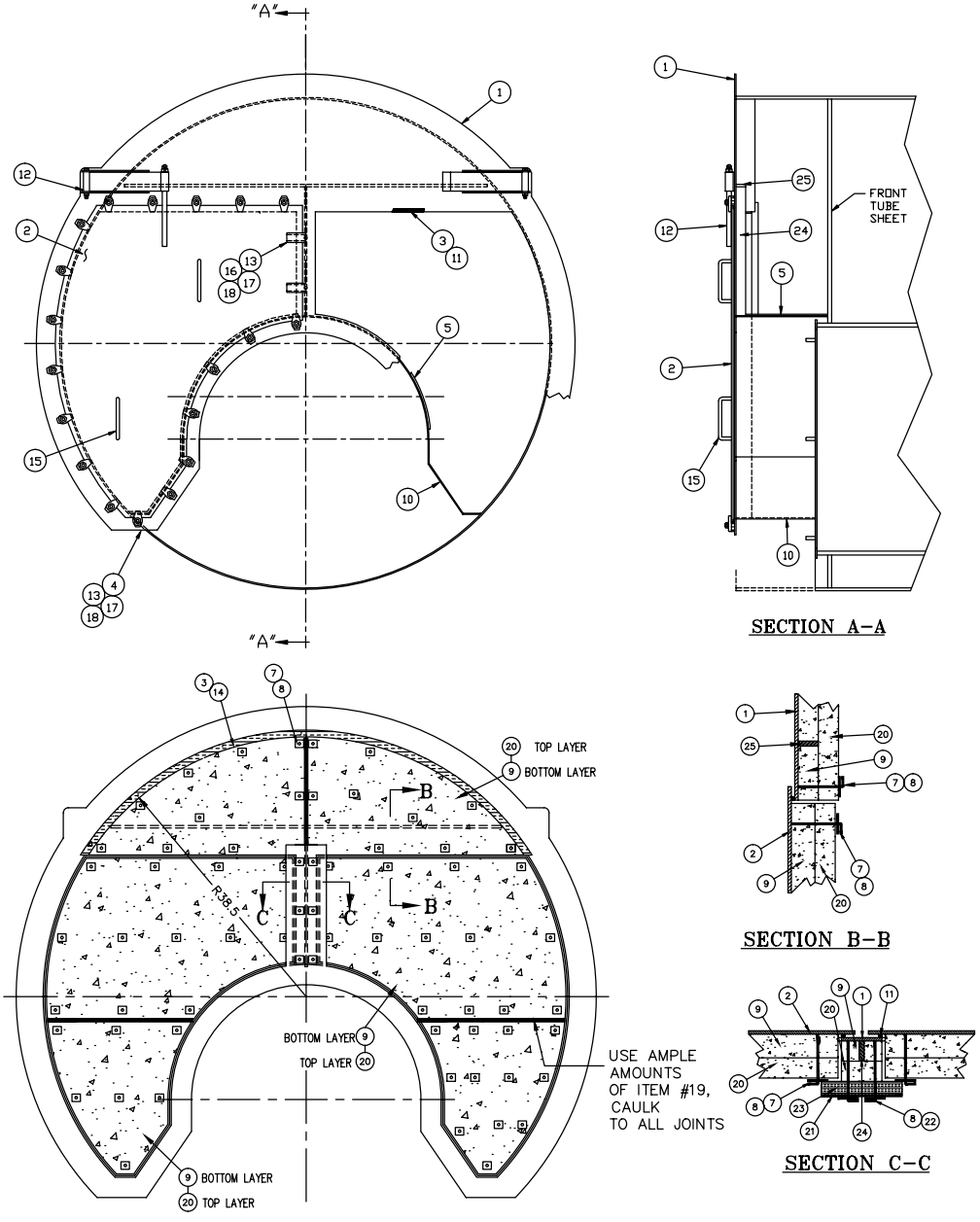


Figure 10-5. Smoke Box 92” 500-600 HP 3 Pass

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00842	PLATE,1/4"x 100"x 78"	1
2	975 00842	PLATE,1/4"x 46.5"x 51.5"	2
3	797-01813	ADHESIVE, GENERAL PURPOSE SPRAY - SUPER TAK	1
4	103 00375	LOCKING LUG	40
5	872 01081	WET FELT, 1/4" x 17.5" x 109.5625", SUPERWOOL 607	1
6	971 00059	FLAT BAR, 1/4" x 3" x 324"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	124
8	828 00034	CLIP, INSUL. RETAINER, 1-1/2" SQ., #10 GA. SST. (SEE SHEET #2)	130
9	971 00053	FLAT BAR,1/4"x 1-1/2"x 144"	1
10	975 00851	PLATE, 3/16" X 17.5" X 109.5625"	1
11	872 00622	ROPE,FIBERFAX, 2300°, 1/2"DIA.x 340"	1
12	462 00026	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	43
14	872 01082	INSUL. BLANKET, 1" x 3" x 96", 8 LB. DEN. CU/FT., SUPERWOOL 607	1
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	3
17	869 00029	BRASS NUT,1/2"	43
18	952 00108	FLATWASHER,1/2"	43
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2"THK., 24" x 36", SUPERWOOL 607	6
21	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE, 6" x 20"	1
22	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	6
23	872 01082	INSULATING BLANKET, 1" THK., 6" x 20", SUPERWOOL 607	1
24	872 01008	INSULATNG BOARD, 1-1/2"THK., 1900°F, GEMINITE 19-SERIES	36SF
25	971 00053	FLAT BAR, 1/4"x 1-1/2"x 22-7/16"	1
26	971 00053	FLAT BAR, 1/4"x 1-1/2"x 70-3/8"	1

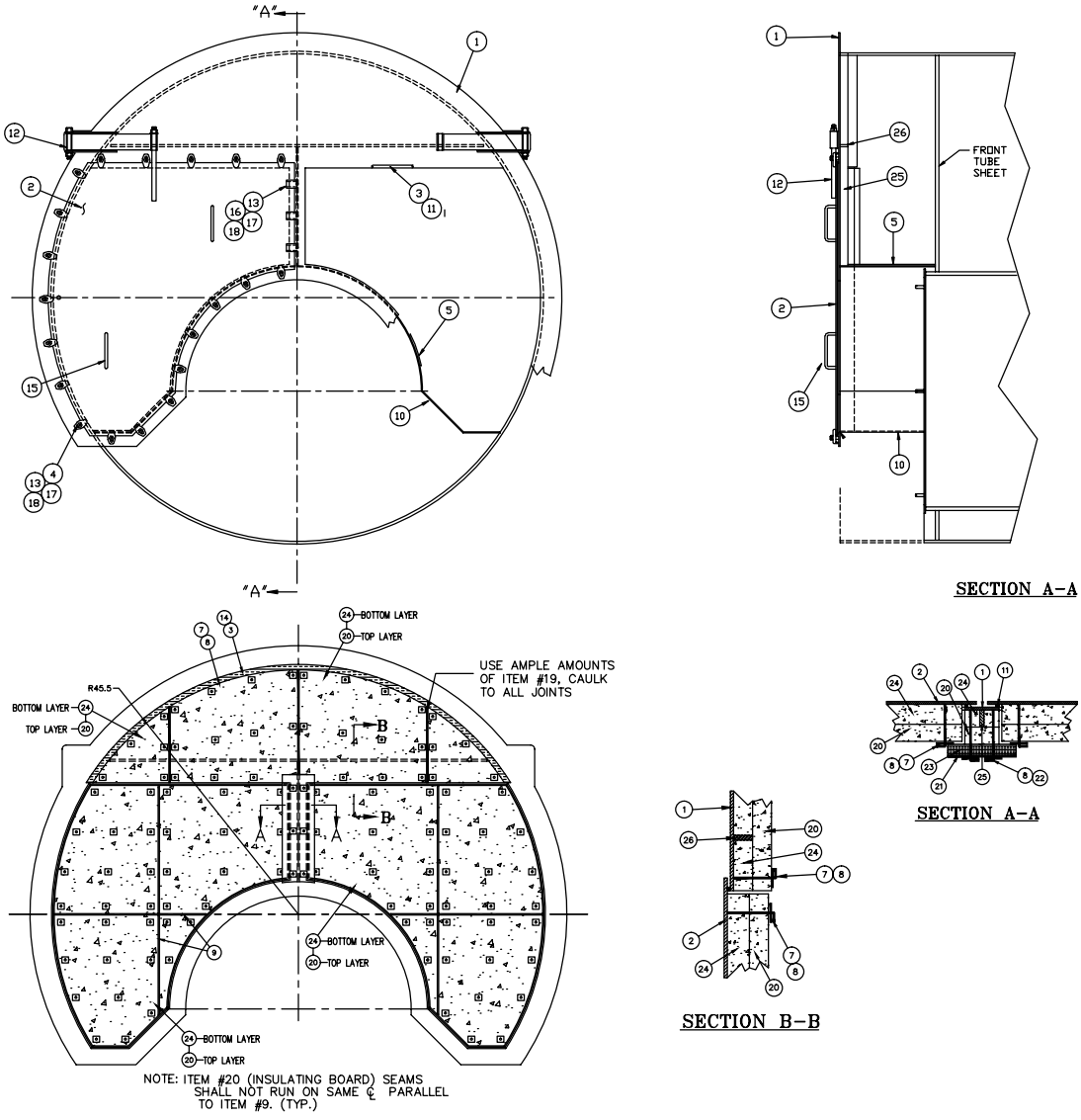


Figure 10-6. Smoke Box 106” 700-800 HP 3 Pass

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00832	PLATE, 3/8" x 114" x 87.1875"	1
2	975 00832	PLATE, 3/8" x 53.5" x 59.6875"	2
3	797 01813	ADHESIVE, SPAY, GENERAL PURPOSE, SUPER TAK	1
4	103 00375	LOCKING LUG	44
5	872 01081	WET FELT, 1/4" x 17-1/2" x 131", SUPERWOOL 607	1
6	971 00059	FLAT BAR, 1/4" x 3" x 384"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	155
8	828 00034	CLIP, INSUL. RETAINER, 1-1/2" SQ., #10 GA. SST. (SEE SHEET #2)	155
9	-	NOT USED	-
10	975 00851	PLATE, 3/16" X 17.5" X 131.125"	1
11	872 00622	ROPE,FIBERFAX, 2300°, 1/2"DIA.x 204"	2
12	462-C-58	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	48
14	872-00443	RIGIDIZER, COATING, 2300°F., THERMAL CERAMICS CERA-PREG	32
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	4
17	869 00029	BRASS NUT,1/2"	48
18	952 00108	FLATWASHER,1/2"	48
19	872 01084	INSUL. BLANKET, 1-1/2" x 8 LB. DEN. CU/FT. (DBL LAYER), SUPERWOOL 607	78
20	930-00135	WIRE MESH, 1/2" X 1/2". 19 GA., 304 S.S.	39
21	971 00059	FLAT BAR,1/4"x 3"x 100.0625"	1
22	971 00053	FLAT BAR,1/4"x 1-1/2"x 269"	1
23	971 00053	FLAT BAR,1/4"x 1-1/2"x 75"	1
24	971 00053	FLAT BAR,1/4"x 1-1/2"x 32.3125"	1
25	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE, 6' x 28'	1
26	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	8
27	872 01082	INSULATING BLANKET, 1" THK., 6' x 28", SUPERWOOL 607	1

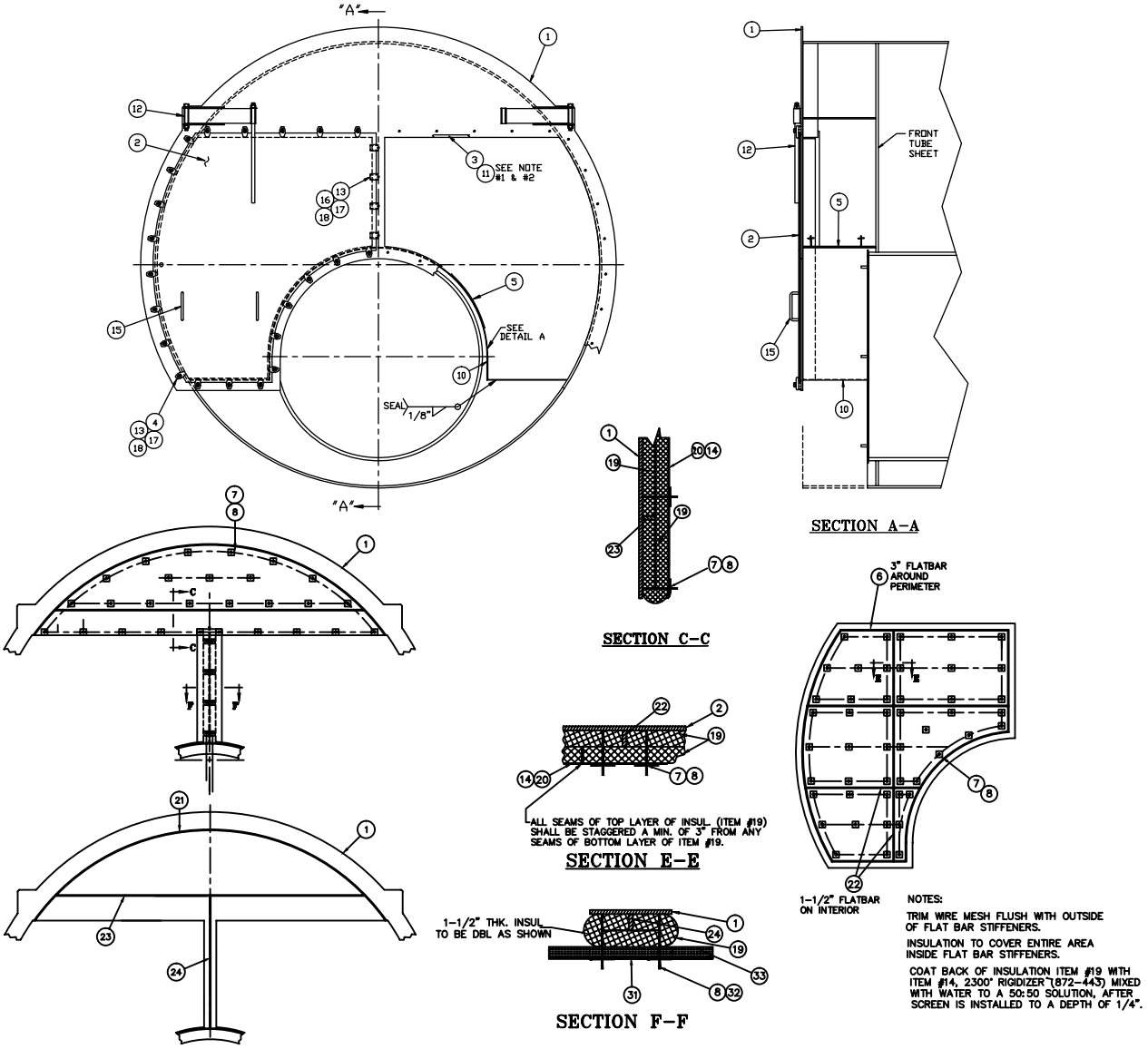


Figure 10-7. Smoke Box 55” 100-125 HP 4 Pass

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00842	PLATE, 1/4" x 63.00" x 44.625"	1
2	975 00842	PLATE, 1/4" x 28" x 28.625"	2
3	797 01813	ADHESIVE, SPAY, GENERAL PURPOSE, SUPER TAK	1
4	103 00375	LOCKING LUG	24
5	872 01081	WET FELT, 1/4", 11-5/8" x 66-3/4" SUPERWOOL 607	1
6	971 00059	FLAT BAR, 1/4" x 3" x 252" LG.	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	64
8	828 00034	CLIP, INSUL. RETAINER, 1 1/2" SQ., #10 GA. SST. (SEE SHEET #2)	66
9	261-B-322	BAFFLE DETAIL	1
10	975 00851	PLATE, 3/16" X 11.625" X 67-1/16"	1
11	872 00622	ROPE, FIBERFAX, 1/2"DIA., 2300°F. x 204" LG.	1
12	462 00024	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	26
14	872 01082	INSUL. BLANKET, 1" x 3" x 54", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1-1/2"x 1/2"x 1/8"x 4.00"	2
17	869 00029	BRASS NUT,1/2"	26
18	952 00108	FLATWASHER,1/2"	26
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2" x 24" x 36" SUPERWOOL 607	3
21	872 00558	THERMO CEMENT, HI TEMP	32
22	872 01082	INSUL. BLANKET, 1" x 2" x 38", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
23	029-B-1997	FLUE GAS INLET FLANGE	"A"
24	872 01007	INSULATNG BOARD, 1900°, 1" x 2" x 36", GEMINITE 19-SERIES	1
25	904 00012	TAPE,TEXTURED FIBERGLASS,1000° 1/8" x 2" x 38"	1
26	872 01082	INSUL. BLANKET, 1" x 6" x 15", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
27	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE x 6" x 15" 304 SS	1
28	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	2
29	872 01008	INSULATNG BOARD, 1900°, 1-1/2", GEMINITE 19-SERIES	18SF

ASSY NO.	DESCRIPTION	"A" QTY ITEM #23
132-C-2284	55" ICB W/ FGR	1
132-2285	55" ICB W/O FGR	N/A

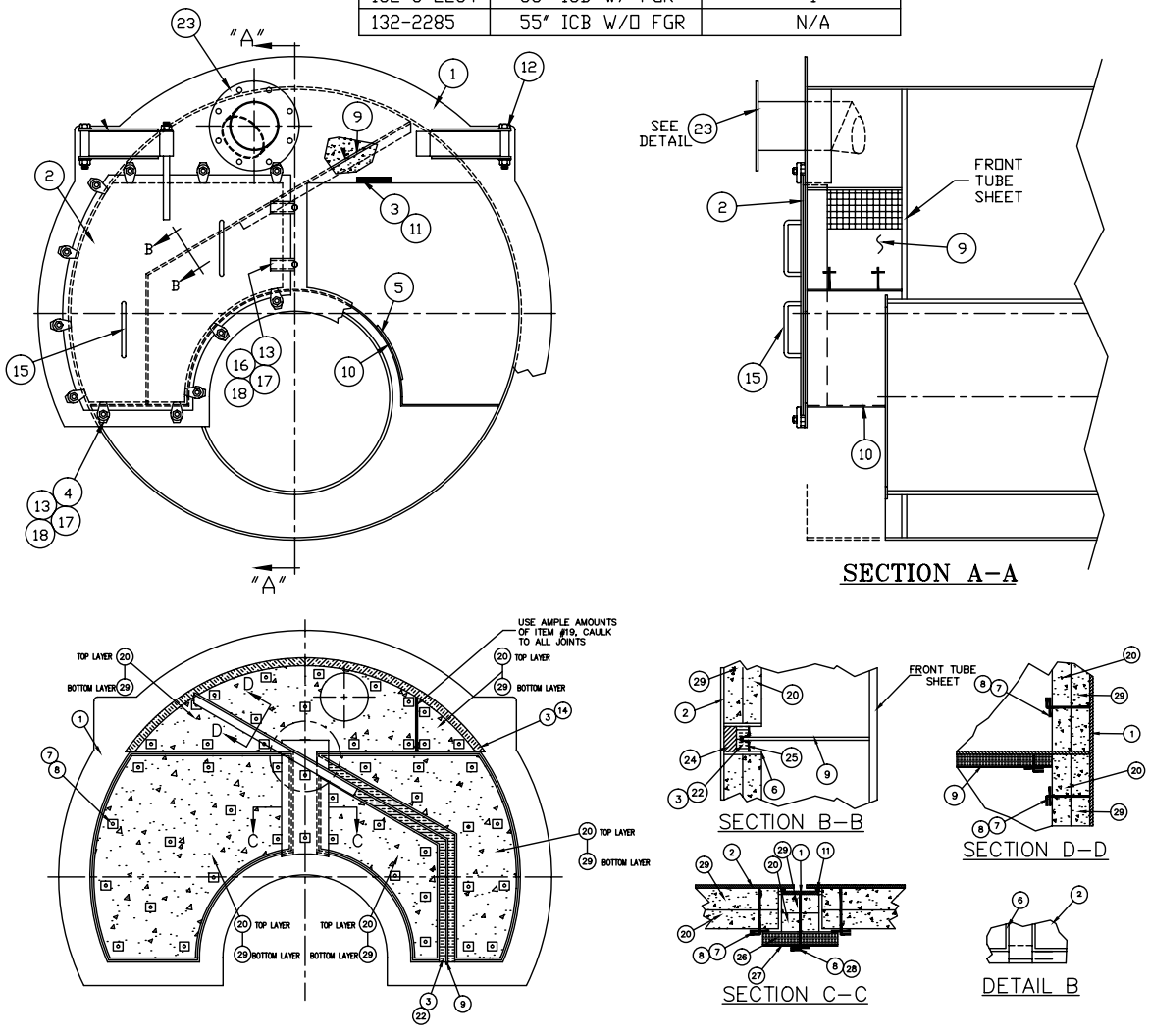
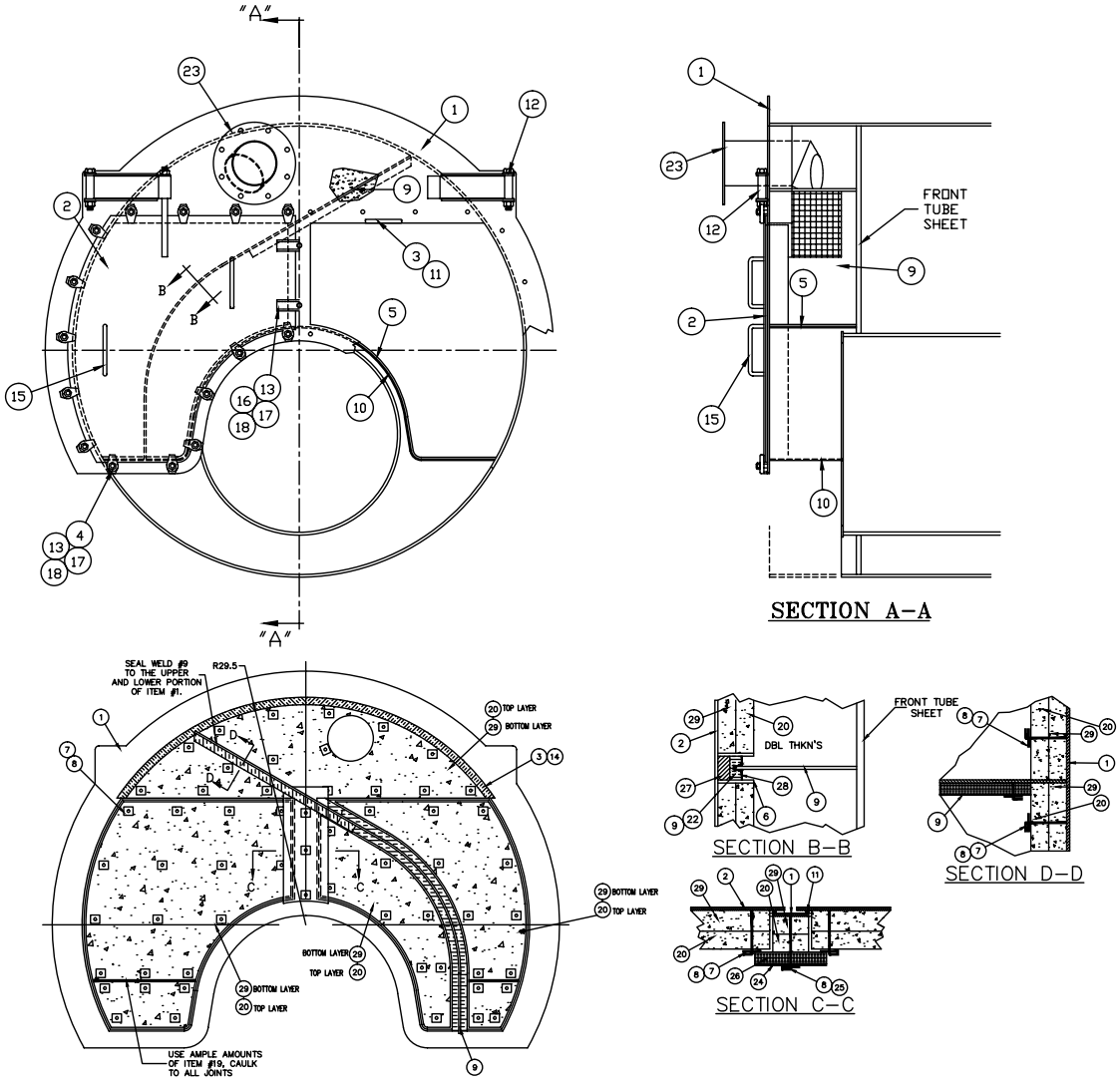


Figure 10-8 Smoke Box 60" 150-200 HP 4 Pass

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00841	PLATE, 1/4"x 60.00"x 33"	1
2	975 00842	PLATE, 1/4"x 30.50"x 33"	2
3	797 01813	ADHESIVE, SPRAY, GENERAL PURPOSE, SUPER TAK	1
4	103 00375	LOCKING LUG	30
5	872 01081	WET FELT, 1/4", 11-5/8" x 74" SUPERWOOL 607	1
6	971 00059	FLAT BAR, 1/4"x 3"x 279"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	76
8	828 00034	CLIP, INSUL. RETAINER, 1-1/2" SQ., #10 GA. SST. (SEE SHEET #2)	79
9	261-B-00313	BAFFLE DETAIL	1
10	975 00851	PLATE, 3/16" X 11.625" X 73.125"	1
11	872 00622	ROPE, FIBERFAX, 1/2"DIA. 2300°F. x 240" LG.	1
12	462 00024	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	32
14	872 01082	INSUL. BLANKET, 1" x 3" x 60", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	2
17	869 00029	BRASS NUT,1/2"	32
18	952 00108	FLATWASHER,1/2"	32
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2"THK., 24" x 36" SUPERWOOL 607	3
21	872 00558	THERMO CEMENT, HI TEMP	32
22	872 01082	INSUL. BLANKET, 1" x 2" x 42", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
23	029-B-1997	INLET FLANGE ASS'Y, 6" FGR DUCT	"A"
24	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE, 6" x 15-5/8"	1
25	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	3
26	872 01082	INSULATING BLANKET, 1" THK., 6" x 15-5/8" SUPERWOOL 607	1
27	872 01007	INSULATING BOARD,1" THK., 1900°,2" x 40", GEMINITE 19-SERIES	1
28	904 00012	TAPE, TEXTURED FIBERGLASS, 1/8" x 2" x 42"	1
29	872 01008	INSULATING BOARD,1-1/2" THK., 1900°, GEMINITE 19-SERIES	18SF

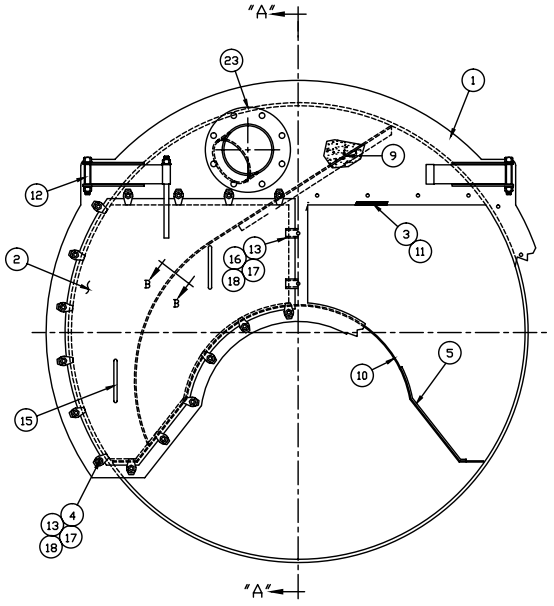
ASSY NO.	DESCRIPTION	"A" QTY ITEM #23
132-C-2293	60" ICB W/ FGR	1
132-2294	60" ICB W/O FGR	N/A



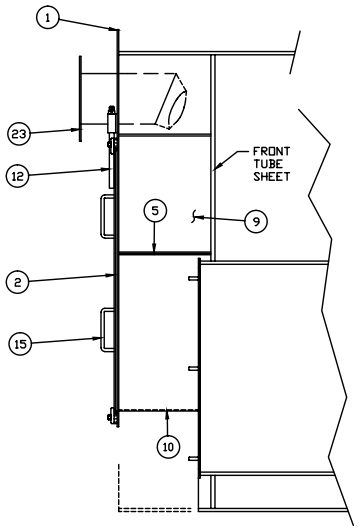
ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00842	PLATE,1/4"x 80.00"x 63.0625"	1
2	975 00843	PL,5/16"x 36.50"x 42.3125"	1
3	797-01813	SPRAY ADHESIVE, SUPER TAK	1
4	103 00375	LOCKING LUG	32
5	872 01081	WET FELT, 1/4" x 14-5/8" x 83.25", SUPERWOOL 607	1
6	971 00059	FLAT BAR,1/4"x 3"x 336"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	90
8	828 00034	CLIP, INSUL. RETAINER, 1 1/2" SQ., #10 GA. SST. (SEE SHEET #2)	93
9	261B324	BAFFLE DETAIL	1
10	975 00851	PLATE, 3/16" X 14.625" X 83.25"	1
11	872 00622	ROPE,FIBERFAX,1/2"DIA. 2400°F. x 264"LG.	1
12	462 00025	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	34
14	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	3
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	2
17	869 00029	BRASS NUT,1/2"	34
18	952 00108	FLATWASHER,1/2"	34
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2"THK., 24" x 36" SUPERWOOL 607	4
21	872 00558	THERMO CEMENT, HI TEMP	32
22	872 01082	INSUL. BLANKET, 1" x 2" x 48"LG., 8LB. CU.FT. DENSITY, SUPERWOOL 607	1
23	029B1998	FLUE GAS INLET FLANGE	"A"
24	872 01082	INSUL. BLANKET, 1" x 3" x 72"LG., 8LB. CU.FT. DENSITY, SUPERWOOL 607	1
25	872 01007	INSULATNG BOARD, 1"THK., 1900°F, 2" x 48" ,GEMINITE 19-SERIES	1
26	904 00012	TAPE,TEXTURED FIBERGLASS, 1000°, 1/8" x 2" x 48"	1
27	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE, 6" x 17-1/4"	1
28	872 01082	INSULATING BLANKET, 1" THK., 6" x 17-1/4" SUPERWOOL 607	1
29	872 01008	INSULATNG BOARD, 1-1/2"THK., 1900°F, GEMINITE 19-SERIES	24

ASSY NO.	DESCRIPTION	"A" QTY ITEM #23
132C2300	72" ICB W/ FGR	1
132-2301	72" ICB W/O FGR	N/A

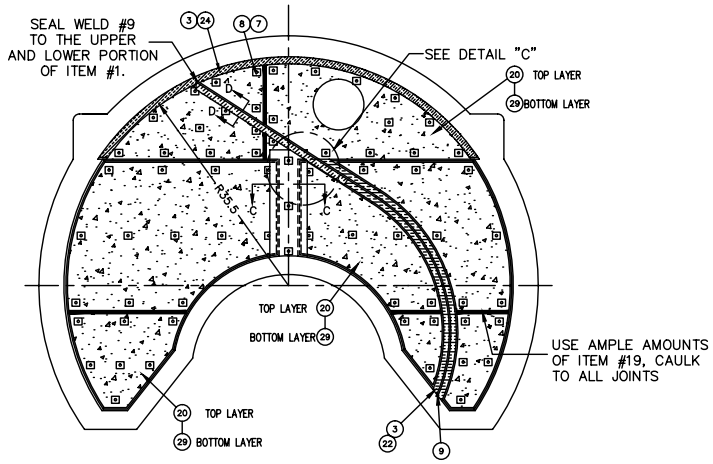
Figure 10-9. Smoke Box 72" 250-300 HP 4 Pass



FRONT VIEW



SECTION A-A



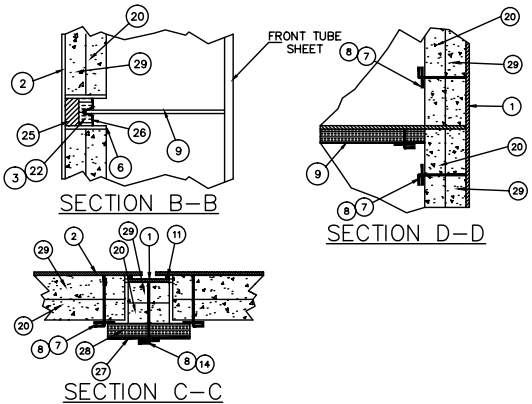


Figure 10-10. Smoke Box 78” 350-400 HP 4 Pass

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00842	PLATE,1/4"x 86.00"x 72.8125"	1
2	975 00842	PLATE,1/4"x 39.50"x 49.8125"	2
3	797 01813	SPRAY ADHESIVE, SUPER TAK	1
4	103 00375	LOCKING LUG	38
5	872 01081	WET FELT, 1/4" x 14-5/8" x 96" SUPERWOOL 607	1
6	971 00059	FLAT BAR,1/4"x 3"x 391.00"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	98
8	828 00034	CLIP, INSUL. RETAINER, 1 1/2" SQ., #10 GA. SST. (SEE SHEET #2)	95
9	261B323	BAFFLE DETAIL	1
10	975 00851	PLATE, 3/16" X 14.625" X 94.125"	1
11	872 00622	ROPE,FIBERFAX,1/2"DIA. 2400"F x 300.00"	1
12	462 00025	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	40
14	872-01082	INSUL BLANKET, 1" x 3' x 80", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	2
17	869 00029	BRASS NUT,1/2"	40
18	952 00108	FLATWASHER,1/2"	40
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2"THK., 24" x 36" SUPERWOOL 607	5
21	872 00558	THERMO CEMENT, HI TEMP	32
22	872 01082	INSUL BLANKET, 1" x 2" x 48", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
23	029B1998	FLUE GAS INLET FLANGE	"A"
24	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE, 6" x 18"	1
25	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	3
26	872 01082	INSULATING BLANKET, 1" THK., 6" x 18" SUPERWOOL 607	1
27	872 01007	INSULATING BOARD,1" THK., 1900°,2" x 48",GEMINITE 19-SERIES	1
28	904 00012	TAPE, TEXTURED FIBERGLASS, 1/8" x 2" x 48"	1
29	872 01008	INSULATING BOARD,1-1/2" THK., 1900°,15 PCF,GEMINITE 19-SERIES	30SF

ASSY NO.	DESCRIPTION	"A" QTY ITEM #23
132C2296	78" ICB W/ FGR	1
132-2297	78" ICB W/O FGR	N/A

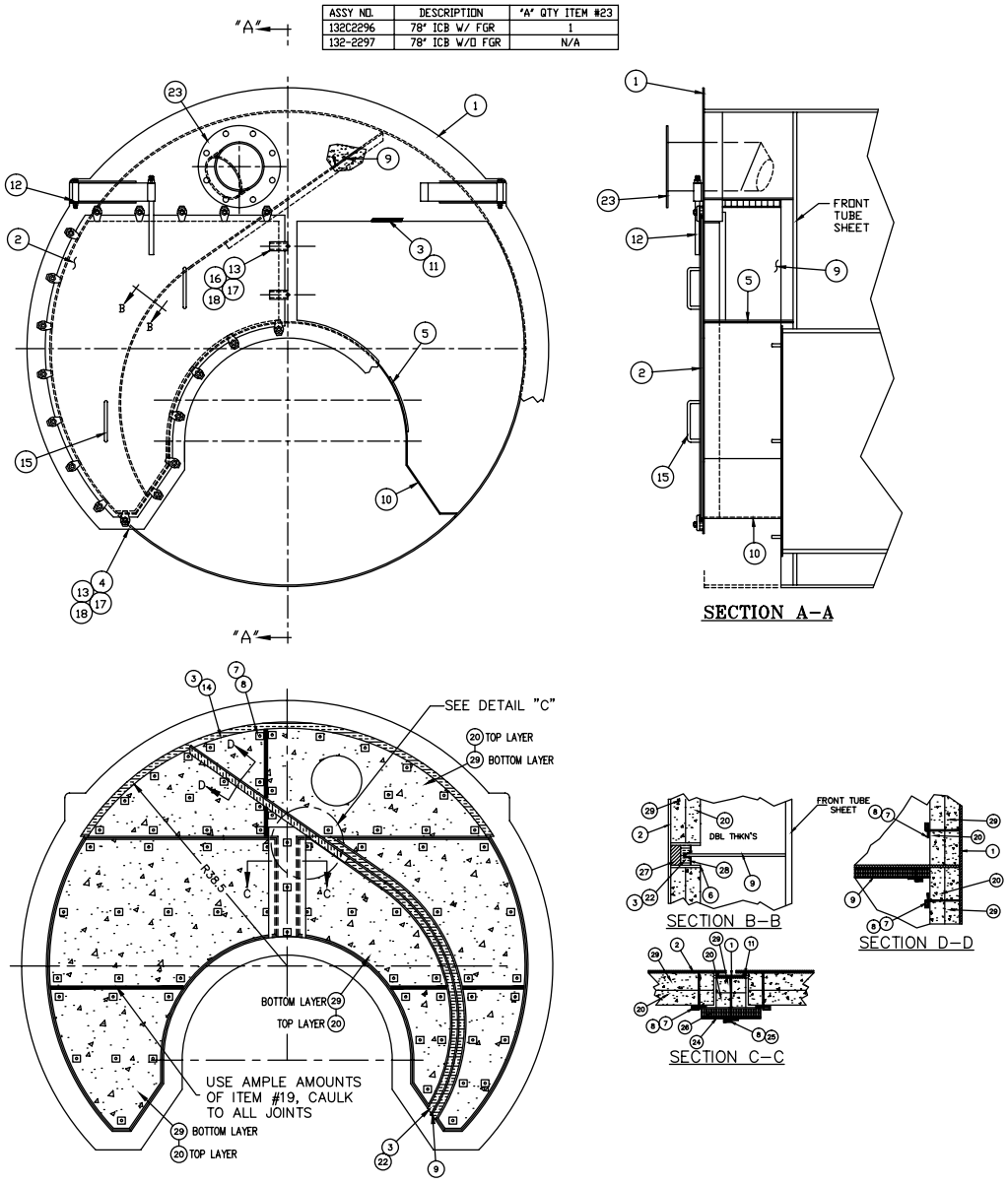


Figure 10-11. Smoke Box 92” 500-600 HP 4 Pass

MATERIAL LIST

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00842	PLATE,1/4"x 100"x 78"	1
2	975 00842	PLATE,1/4"x 46.5"x 51.5"	2
3	797-01813	ADHESIVE, GENERAL PURPOSE SPRAY - SUPER TAK	1
4	103 00375	LOCKING LUG	40
5	872 01081	WET FELT, 1/4" x 17.5" x 109.5625" SUPERWOOL 607	1
6	971 00059	FLAT BAR, 1/4" x 3" x 432"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	124
8	828 00034	CLIP, INSUL. RETAINER, 1-1/2" SQ., #10 GA. SST. (SEE SHEET #2)	127
9	261B316	BAFFLE DETAIL	1
10	975 00851	PLATE, 3/16" X 17.5" X 109.5625"	1
11	872 00622	ROPE,FIBERFAX, 2300°, 1/2"DIA.x 340"	1
12	462 00026	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	43
14	872 01082	INSUL. BLANKET, 1" x 3" x 96", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	3
17	869 00029	BRASS NUT,1/2"	43
18	952 00108	FLATWASHER,1/2"	43
19	872 00757	INSULATION, FIBREFRAX CAULK- TUBE (SEE SHEET #2)	1
20	872 01086	INSULATNG BOARD, 1-1/2"THK.,, 24" x 36" SUPERWOOL 607	6
21	872 00558	THERMO CEMENT, HI TEMP	32
22	872 01082	INSUL. BLANKET, 1" x 2" x 60", 8 LB. DEN. CU/FT. SUPERWOOL 607	1
23	029B1999	FLUE GAS INLET FLANGE	"A"
24	872 01007	INSULATNG BOARD, 1"THK.,1900°F, 2" x 96",GEMINITE 19-SERIES	1
25	971 00053	FLAT BAR,1/4"x 1-1/2"x 72"	1
26	872 01082	INSUL. BLANKET, 1" x 6" x 20", 8 LB. DEN. CU/FT., SUPERWOOL 607	1
27	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	3
28	904 00012	TAPE, TEXTURED FIBERGLASS, 1000°,1/8" x 2" x 96"	1
29	930 00135	WIRE MESH, 1/2" MESH, .047"WIRE, 304 SS, 6"x 20"	1
30	872 01008	INSULATNG BOARD, 1-1/2"THK.,1900°F,GEMINITE 19-SERIES	36SF

ASSY NO.	DESCRIPTION	"A" QTY ITEM #23
132C2269	92" ICB W/ FGR	1
132-2270	92" ICB W/O FGR	N/A

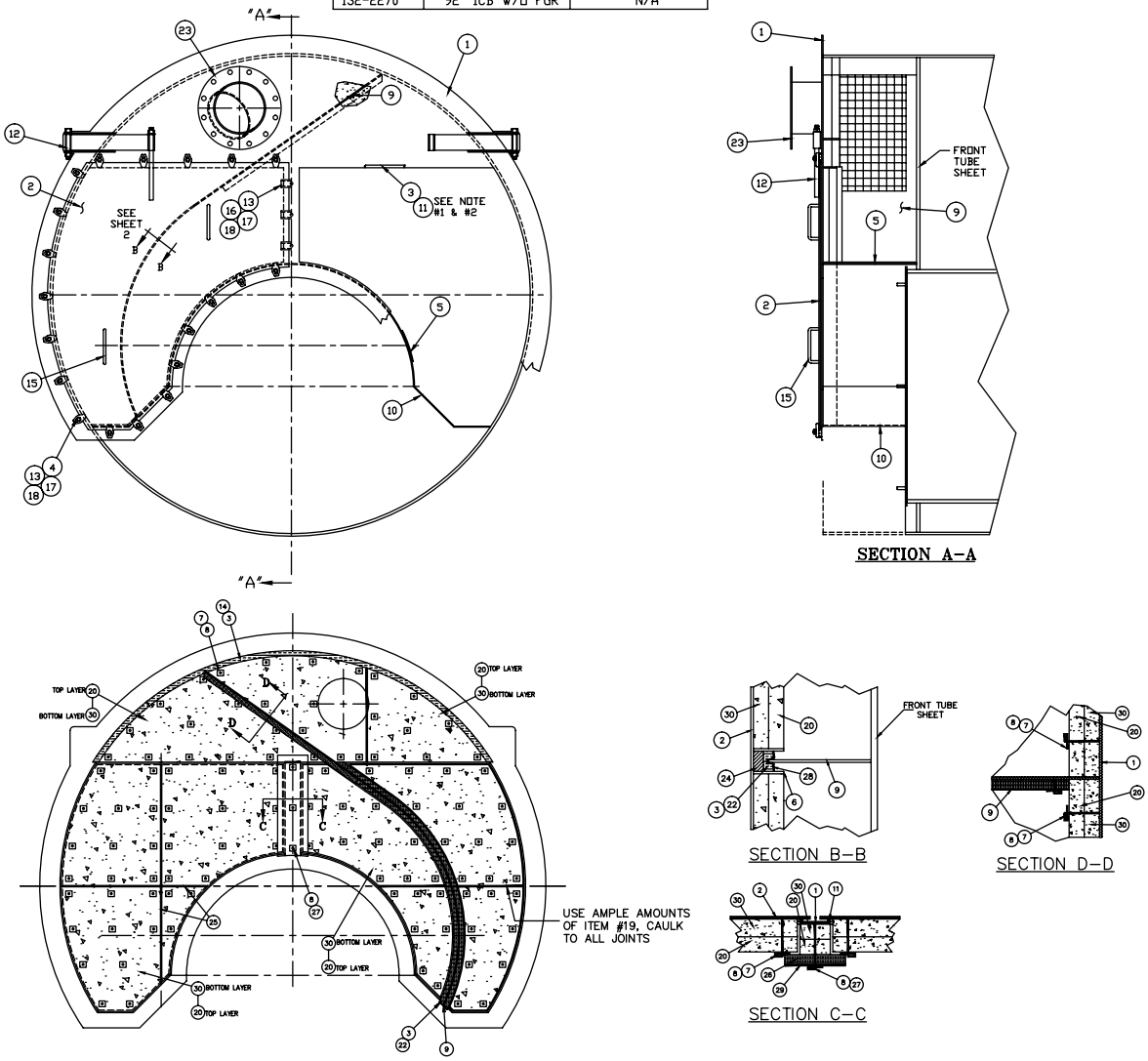
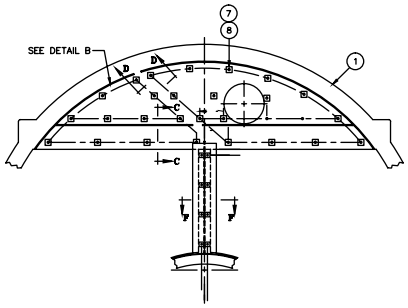
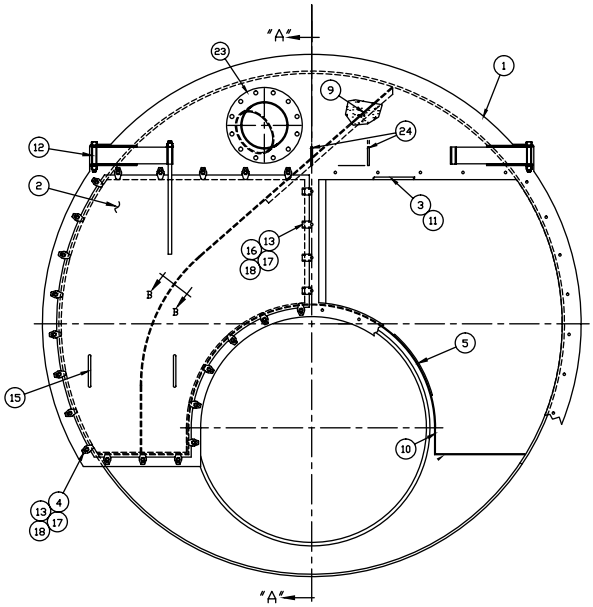


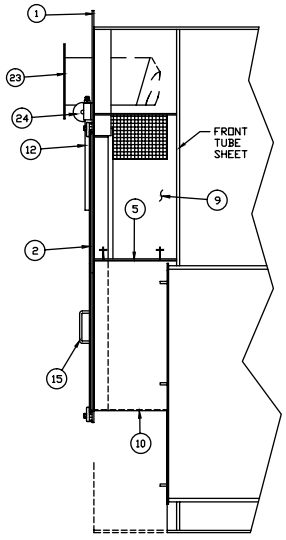
Figure 10-12. Smoke Box 106” 700-800 HP 4 Pass

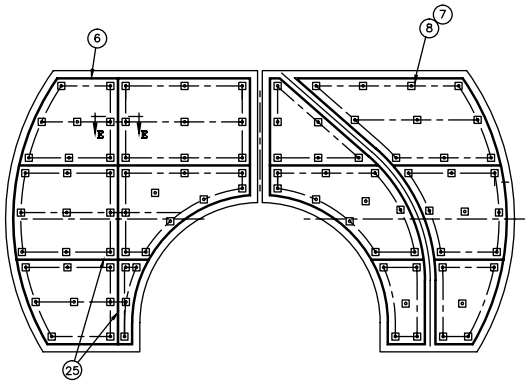
ITEM	PART NUMBER	DESCRIPTION	QTY.
1	975 00832	PLATE, 3/8"x 114"x 87.1875"	1
2	975 00832	PLATE, 3/8"x 53.5" x 59.6875"	2
3	797 01813	ADHESIVE, SPAY, GENERAL PURPOSE, SUPER TAK	1
4	103 00375	LOCKING LUG	44
5	872 01081	WET FELT, 1/4" x 17-1/2" x 131", SUPERWOOL 607	1
6	971 00059	FLAT BAR,1/4"x 3"x 516.00"	1
7	903 00299	PIN WELDING, #10 GA x 4" LG. SST. (SEE SHEET #2)	153
8	828 00034	CLIP, INSUL. RETAINER, 1-1/2" SQ., #10 GA. SST. (SEE SHEET #2)	151
9	261-B-317	BAFFLE DETAIL	1
10	975 00851	PLATE, 3/16" X 17.5" X 131.125"	1
11	872 00622	ROPE,FIBERFAX, 2300°, 1/2"DIA.x 204"	2
12	462-C-58	HINGE DETAIL	2
13	841 00331	STUD,1/2"x 2"	48
14	872-00443	RIGIDIZER, COATING, 2300°F., THERMAL CERAMICS CERA-PREG	32
15	037-A-52	DOOR HANDLE	4
16	149 00917	CHANNEL,1 1/2"x 1/2"x 1/8"x 4.00"	4
17	869 00029	BRASS NUT,1/2"	48
18	952 00108	FLATWASHER,1/2"	48
19	872 01084	INSUL. BLANKET, 1-1/2" x 8 LB. DEN. CU/FT. (DBL LAYER), SUPERWOOL 607	78
20	930-00135	WIRE MESH, 1/2" X 1/2". 19 GA., 304 S.S.	39
21	872 00558	THERMO CEMENT, HI TEMP	32
22	872 01082	INSUL. BLANKET, 1" x 2" x 72", 8 LB. DEN. CU/FT., SUPERWOOL 607	1
23	"C"	FLUE GAS INLET FLANGE	"A"
24	971 00083	FLAT BAR,3/8"x 4"x 4"	"E"
25	971 00053	FLAT BAR,1/4"x 1-1/2"x 204"	1
26	971 00059	FLAT BAR,1/4"x 3"x 66.375"	1
27	971 00059	FLAT BAR,1/4"x 3"x 31.875"	1
28	971 00053	FLAT BAR,1/4"x 1-1/2"x 34.5"	1
29	971 00053	FLAT BAR,1/4"x 1-1/2"x 38"	1
30	971 00053	FLAT BAR,1/4"x 1-1/2"x 28.3125"	1
31	930 00135	WIRE MESH, 1/2"MESH, .047" WIRE, 6' x 28"	1
32	903 00298	PIN WELDING, #10 GA x 5" LG. SST. (SEE SHEET #2)	8
33	872 01082	INSULATING BLANKET, 1" THK., 6' x 28', SUPERWOOL 607	1
34	872 01007	INSULATING BOARD,1" THK., 1900°,2' x 72', GEMINITE 19-SERIES	1
35	904 00012	TAPE, TEXTURED FIBERGLASS, 1/8" x 2" x 72"	1

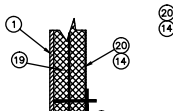
ASSY NO.	DESCRIPTION	"A" QTY ITEM #23	"B" DIMN.	"C" P/N ITEM #23	"D"	"E" QTY ITEM #24
132-C-2327	106" ICB W/ FGR	1	42"	029-A-1999	10.125"	N/A
132-2328	106" ICB W/O FGR	N/A	N/A	N/A	N/A	N/A
132-2545	106" ICB W/14" FGR	1	44"	029-A-2075	14.125"	2

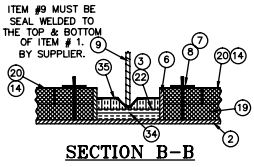


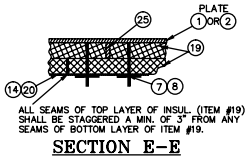


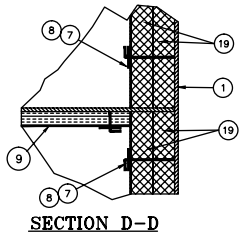












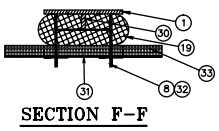


Figure 10-13. Rear Area and Door

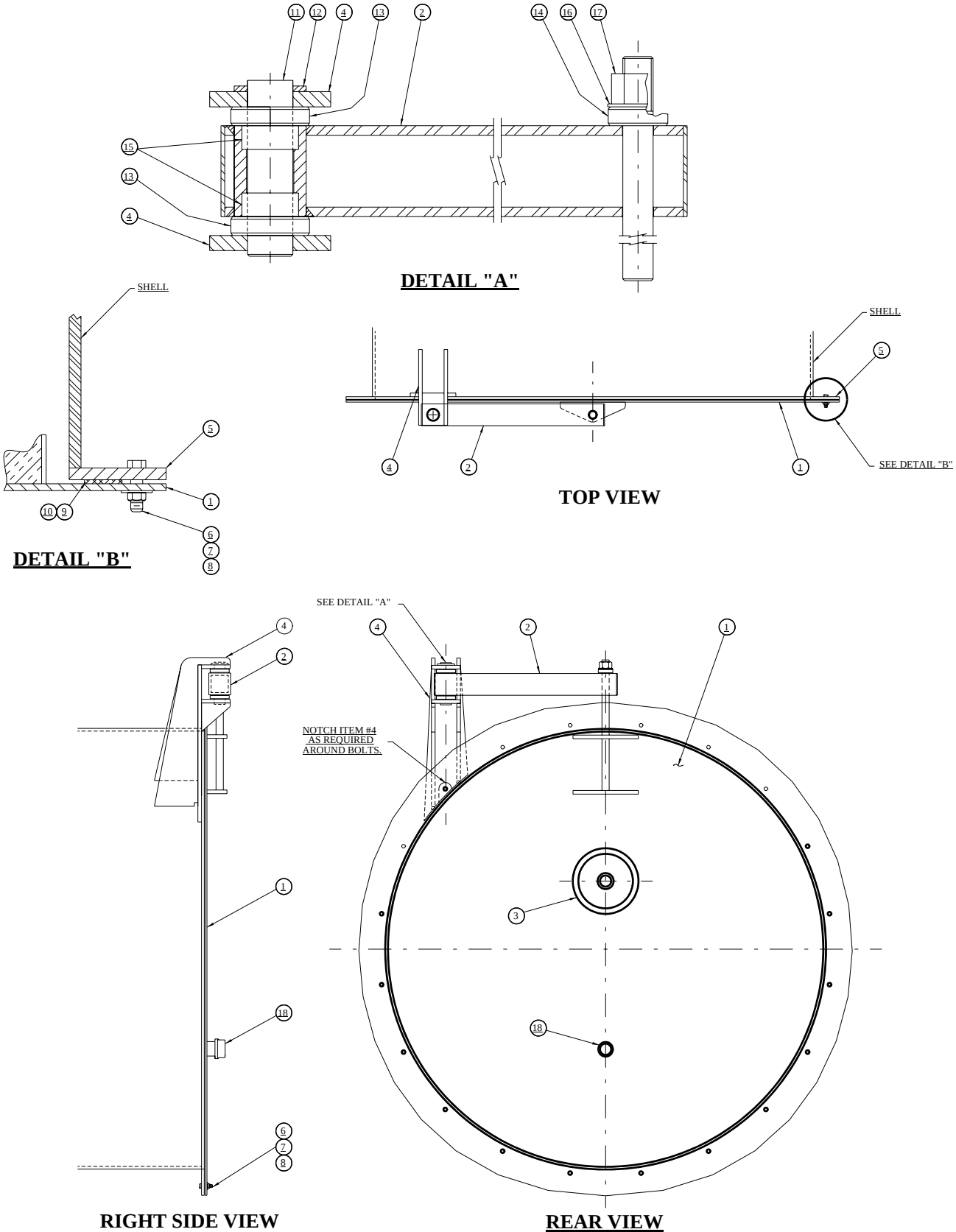


Figure 10-14. Rear Area and Door

	ITEM	PART NO.	DESCRIPTION	USED ON	QTY	OPTION
W/O RELIEF DOOR	①	457C3443	REAR DOOR, INSULATED	106" ICB	1	43
		457C3428	REAR DOOR, INSULATED	92" ICB		
		457C3422	REAR DOOR, INSULATED	78" ICB		
		457C3435	REAR DOOR, INSULATED	72" ICB		
		457C3419	REAR DOOR, INSULATED	60" ICB		
		457C3432	REAR DOOR, INSULATED	55" ICB		
W/ 12" RELIEF DOOR	①	457-03444	REAR DOOR, INSULATED	106" ICB	1	46
		457-03429	REAR DOOR, INSULATED	92" ICB		
		457-03423	REAR DOOR, INSULATED	78" ICB		
		457-03436	REAR DOOR, INSULATED	72" ICB		
		457-03421	REAR DOOR, INSULATED	60" ICB	1	47
W/ 7" RELIEF DOOR	①	457-03420	REAR DOOR, INSULATED	60" ICB	1	46
		457-03433	REAR DOOR, INSULATED	55" ICB		
	②	287-00090	DAVIT ARM DETAILS	106" ICB	1	A2
		287-00076	DAVIT ARM DETAILS	92" ICB		
		287-00075	DAVIT ARM DETAILS	78" ICB		
		287-00081	DAVIT ARM DETAILS	72" ICB		
		287-00073	DAVIT ARM DETAILS	60" ICB		
		287-00072	DAVIT ARM DETAILS	55" ICB		
	③	428-A-17	COMBUSTION RELIEF DOOR, 7"	55" & 60" ICB	1	46
		428-A-37	COMBUSTION RELIEF DOOR 12"	60" THRU 106" ICB	1	46,47
	④	085-03275	PEDESTAL ASS'Y	55" ICB	1	A2
		085-03276	PEDESTAL ASS'Y	60" ICB		
		085-03288	PEDESTAL ASS'Y	72" ICB		
		085-03278	PEDESTAL ASS'Y	78" ICB		
		085-03279	PEDESTAL ASS'Y	92" ICB		
		085-03307	PEDESTAL ASS'Y	106" ICB		
	⑤	080-00921	REAR SHELL FLANGE	55" ICB	1	
		080-00840	REAR SHELL FLANGE	60" ICB		
		080-00934	REAR SHELL FLANGE	72" ICB		
		080-00846	REAR SHELL FLANGE	78" ICB		
		080-00913	REAR SHELL FLANGE	92" ICB		
		080-00958	REAR SHELL FLANGE	106" ICB		
	⑥	868-00102	BOLT, HEX, 1/2"-13 UNC x 1-1/2"	55" ICB	18	
				60" ICB	20	
				72" & 78" ICB	24	
				92" & 106" ICB	30	
	⑦	869-00029	NUT, HEX, 1/2"-13 UNC, BRASS	55" ICB	18	
				60" ICB	20	
				72" & 78" ICB	24	
				92" & 106" ICB	30	
	⑧	952-00108	WASHER, FLAT, PLAIN,	55" ICB	18	
				60" ICB	20	
				72" & 78" ICB	24	
				92" & 106" ICB	30	
	⑨	872-00622	ROPE, 1/2"DIA., 2300°F x 180"	55" ICB	1	
			ROPE, 1/2"DIA., 2300°F x 194"	60" ICB	1	
			ROPE, 1/2"DIA., 2300°F x 240"	72" ICB	1	
			ROPE, 1/2"DIA., 2300°F x 252"	78" ICB	1	
			ROPE, 1/2"DIA., 2300°F x 312"	92" ICB	1	
			ROPE, 1/2"DIA., 2300°F x 336"	106" ICB	1	
	⑩	797-01813	ADHESIVE, SUPERTAK	ALL	1	
	⑪	135-03633	SIZED ROD, 1-1/2" OD x 5.8125"	55",60",72",78",92" CBX	1	
		135-03634	SIZED ROD, 1-1/2" OD x 6.8125"	106" CBX	1	
	⑫	066-00573	RING, RETAINER, REAR DOOR	ALL	1	
	⑬	807-00439	BEARING, BALL THRUST	ALL	2	
	⑭	807-00438	BEARING, BALL THRUST	ALL	1	
	⑮	807-00440	BEARING, NEEDLE ROLLER,	ALL	2	
	⑯	952-00132	WASHER, FLAT, 1"	ALL	1	
	⑰	869-00157	NUT, SELF LOCKING HEX- 1"-8	ALL	1	
	⑱	550-00042	MICA SIGHT PORT ASSEMBLY	ALL	1	

BOILER DIA.	"C"	"D"
55" ICB	18-3/4"	31-5/16"
60" ICB	22"	33-13/16"
72" ICB	23"	40-5/16"
78" ICB	24-1/2"	42-13/16"
92" ICB	27-5/8"	49-13/16"
106" ICB	31-9/16"	56-7/8"

NOTES:
1.) ITEM 3 IS OPTIONAL, USED ONLY WHEN REQUIRED BY CUSTOMER.
2.) REMOVE VENDOR SUPPLIED PIPE CAP ON DOOR AND REPLACE WITH ITEM #18.

Figure 10-15. Burner Selection / Installation

BURNER MODEL FORMAT

X	XXX	XXXX	XXXX
BURNER SERIES (D,LND OR FP)	I.C. OR CB FUEL CODE (I.C. CODE FOR D/LND) (CB CODE FOR FP)	BURNER SIZE	INPUT RATE (FP ONLY)

FUEL SERIES DESIGNATION

CB CODE	DESCRIPTION	IC CODE
100 =	LIGHT OIL	= L
200 =	LIGHT OIL & GAS	= LG
400 =	HEAVY OIL & GAS	= EG
600 =	HEAVY OIL	= E
700 =	GAS ONLY	= G

USED ON	ITEM	QTY.	PART NUMBER	DESCRIPTION	OPTION CODE
	1	1	SEE TABLE	DRY OVEN	–
55"–92"ø	2	1	872–1075	SUPERWOOL 607 MAX, BLANKET,INSULATION,1–1/2" X 8" x 132"	
106"ø				SUPERWOOL 607 MAX, BLANKET,INSULATION,1–1/2" X 5" x 132"	
	3	1	872–00622	ROPE, FIBERFRAX, 2300°F. 1/2" DIA X 144" LG.	
	4	1	SEE TABLE	BURNER SUPPORT	
	5	2	869–00021	NUT,1/4"	FP BURNER
		"A"	869–00030	NUT,3/8"	–
	6	2	952–00082	LOCKWASHER,1/4"	FP BURNER
		"A"	952–00093	LOCKWASHER,3/8"	–
	7	2	868–00137	CAPSCREW,1/4" x 1" LG.	FP BURNER
		"A"	868–00158	CAPSCREW,3/8" x 1–1/2" LG.	–
	8	"B"	869–00015	NUT,HEX., 1/2" – 13UNC	–
	9	"B"	952–00094	LOCKWASHER,1/2"	
	10	"C"	869–00017	NUT, HEX. 5/8"– 11 UNC	
	11	"C"	952–00084	LOCK WASHER, 5/8"	
92"ø	12	40 LBS	872–00225	REFRACTORY, COATING, 3300°F	
106"ø		45 LBS			
	13	1	SEE TABLE	GASKET, BURNER TO DRY OVEN	

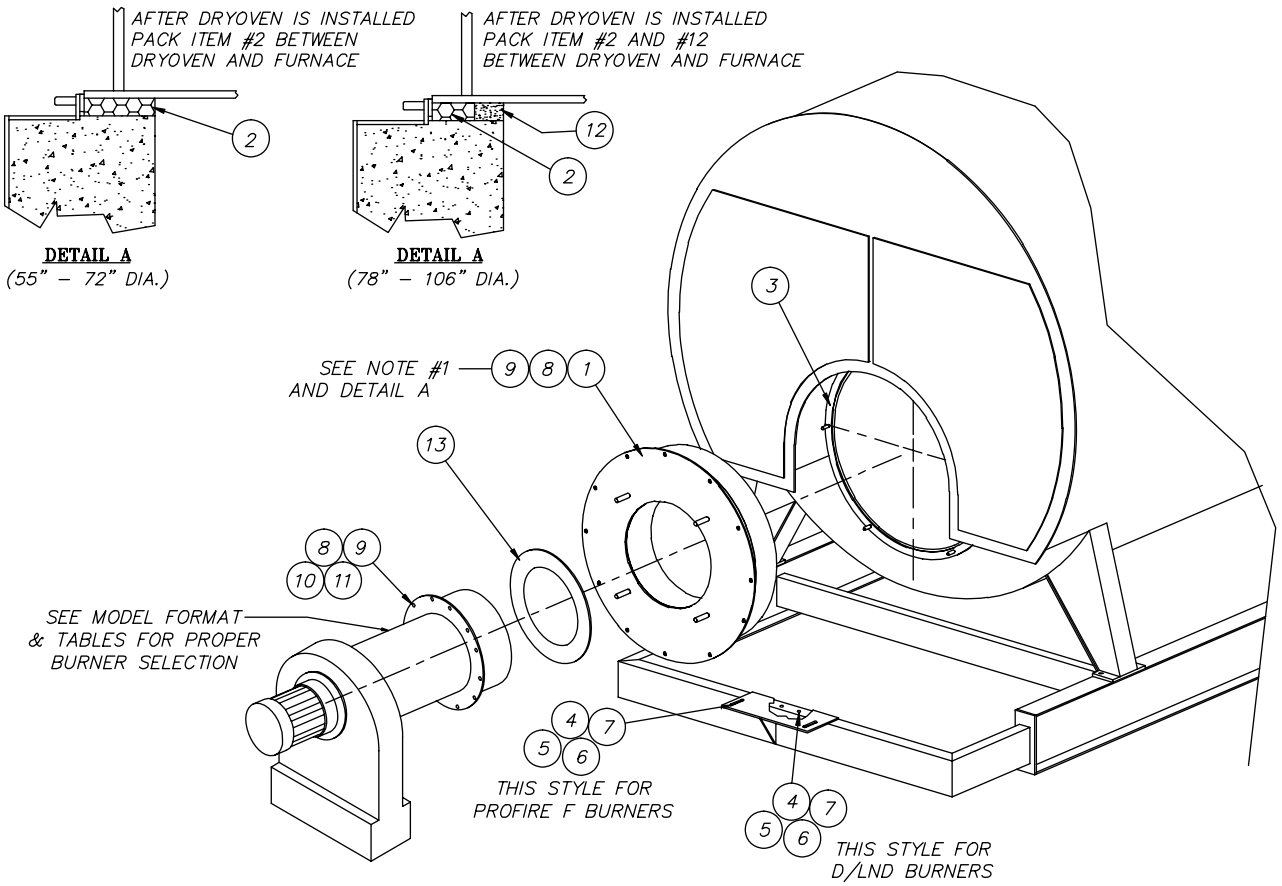


Figure 10-16. Burner Selection / Installation

BOILER / BURNER CHART						ITEM #1				ITEM #4 (SEE NOTE #4)				ITEM #13			
BOILER DIA.	BOILER (HP)	BURNER MODEL-SIZE				DRY OVEN				BURNER SUPPORT				DRY OVEN GASKET			
		STANDARD		30 PPM		STANDARD		30 PPM		STANDARD		30 PPM		STANDARD		30 PPM	
		3 PASS	4 PASS	3 PASS	4 PASS	3 PASS	4 PASS	3 PASS	4 PASS	3 PASS	4 PASS	3 PASS	4 PASS	3 PASS	4 PASS	3 PASS	4 PASS
55"	100	VG-42-PF		-	-	059-08112		-		530-658		-		032-2664		BY I.C.	
		FP-3-4200		LND-54P	LND-54P	059-7706		059-7711		530-599		530-591					
	125	FP-3-5400		LND-63P	LND-84P			059-7711	059-7712								
60"	150	FP-3-6300		LND-84P	LND-105P	059-7707		059-7713		530-594		530-567		032-2664		BY I.C.	
	200	FP-4-8400		LND-105P	LND-125P	059-7708				530-593				032-2665			
72"	250	FP-4-10500		LND-145S	LND-145P	059-7709		059-7715		530-598		530-597		032-2665		BY I.C.	
	300	FP-4-12600	D145P	LND-145P	LND-175P	059-7709	059-7715	059-7715	059-7716	530-598	530-597			032-2665	BY I.C.		
78"	350	FP-4-14700	D175P	LND-175P	LND-210P	059-7710	059-7718	059-7718	059-7718	530-596	530-559	530-559	530-561	032-2665	BY I.C.	BY I.C.	
	400	D175P	D210P	LND-210P	LND-252P	059-7718			059-7717	530-559	530-561	530-561		BY I.C.			
92"	500	D210P	D252P	LND-252P	LND-300P	059-7719	059-7720	059-7720	059-7721	530-589		530-589		BY I.C.		BY I.C.	
	600	D252P	D300P	LND-300P	LND-315P	059-7720	059-7721	059-7721									
106"	700	D300P	D336P	LND-315P	LND-378P	059-7722	059-7723	059-7722	059-7723	530-600		530-600		BY I.C.		BY I.C	
	800	D336P	D378P	LND-378P	LND-420P	059-7723		059-7723									
	800	-	-	-	LNS1G-462	-		059-7934		-		530-646					

BOILER / BURNER CHART						"A"				"B"				"C"			
BOILER DIA.	BOILER (HP)	BURNER MODEL-SIZE				STD		30 PPM		STD		30 PPM		STD		30 PPM	
		STANDARD		30 PPM													
		3 PASS	4 PASS	3 PASS	4 PASS	3-P	4-P	3-P	4-P	3-P	4-P	3-P	4-P	3-P	4-P	3-P	4-P
55"	100	VG-42-PF		-	-	4				12		-		-		-	
		FP-3-4200		LND-54P	LND-54P	2						20		-		-	
	125	FP-3-5400		LND-63P	LND-84P												
60"	150	FP-3-6300		LND-84P	LND-105P	2											
	200	FP-4-8400		LND-105P	LND-125P												
72"	250	FP-4-10500		LND-145S	LND-145P	2				16		24		-		-	
	300	FP-4-12600	D145P	LND-145P	LND-175P					16	24						
78"	350	FP-4-14700	D175P	LND-175P	LND-210P	2	2	2	4	16	24	24	24	-		-	-
	400	D175P	D210P	LND-210P	LND-252P		4	4		24	24	24	12	-		-	12
92"	500	D210P	D252P	LND-252P	LND-300P	4				28	16	16		-	12	12	
	600	D252P	D300P	LND-300P	LND-315P					16	16			12	12		
106"	700	D300P	D336P	LND-315P	LND-378P	4				16		16		12		12	
	800	D336P	D378P	LND-378P	LND-420P												
	800	-	-	-	LNS1G-462	3				-				-			

Figure 10-17. Water Column Piping 100-200 HP (55” & 60”)

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	193 817–4604	817–4230	LOW WATER CUT–OFF	15# ST
	1	157S–RL 817–2405	817–4230	LOW WATER CUT–OFF	15# ST
	1	157S–RL 817–2405	817–4230	LOW WATER CUT–OFF	150# ST
	1	194 817–303	817–4230	LOW WATER CUT–OFF	200# ST
	1	194 817–303	817–4230	LOW WATER CUT–OFF	250# ST
	1	W29 817–1062	817–4233	LOW WATER CUT–OFF	300# ST
	1	–	————	–	
	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	941–170		VALVE, GATE 3/4"	15–300# ST
4		–		–	–
	2	941–55		BALL VALVE, 1/4" M x F	0–200# ST
		941–2656		BALL VALVE, 1/4" F x F	201–250# 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	851–34	————	GAUGE GLASS	194
	1	851–190	851–38	GAUGE GLASS	157S–RL
	1	————	851–391	GAUGE GLASS	300# ST
7	2	912–34	————	ROD, GAUGE GLASS	157S–RL
	4	912–85	————	ROD, GAUGE GLASS	194
	2	————	912–38	ROD, GAUGE GLASS	15–250# ST
8	1	825–203		SET, GAUGE GLASS	15# FOR 36"&48" CBH
	1	825–203		SET, GAUGE GLASS	15–200# ST
	1	825–394		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	□ CB/CBH
	1	971–13		FLAT BAR, 1/8" x 1" x 36"	CBE/CEW/ICB
12	*	830–28		CHAIN SASH	250–300 ST
13	1	869–234		NUT & LOCKWASHER	–

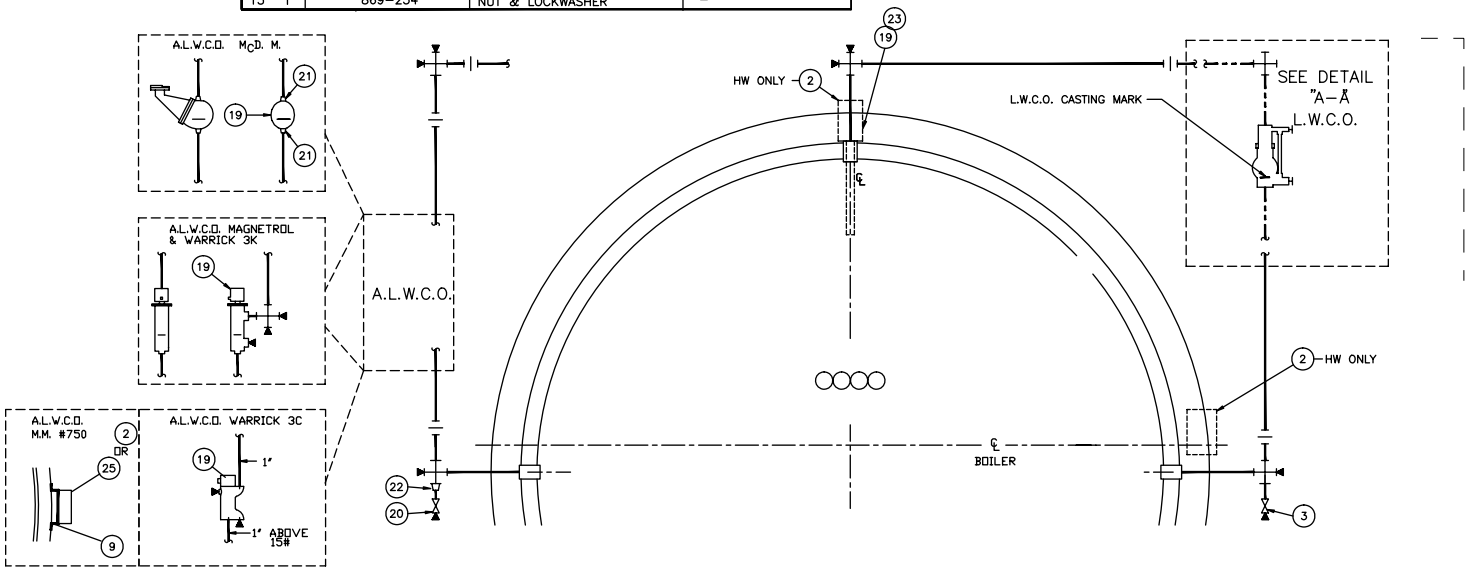


Figure 10-18. Water Column Piping 100-200HP (55” & 60”)

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 X 3/4" LG	
16	1	847–424	847–467		BUSHING, RED. 1" X 1/4"	ALL ST
17	–	–	–		–	–
18	1	–		847–612	BUSHING, RED. 1/2" X 1/4"	MAGNETROL
(19)	1	SEE TABLE			CONTROL, AUX. L.W.C.O.	
(20)	1	941–1790			VALVE, BALL, 3/4"	0–200# (PROBE TYPE)
		941–170			VALVE, GATE 3/4"	ALL OTHERS
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"	(PROBE TYPE)
		847–431	847–471		BUSHING 1–1/4" x 3/4"	(FLOAT TYPE)
28	–	–			–	–

* – 6 FT ON 250#, 12 FT ON 300#.

EXTERNAL A.L.W.C.O.

MCD. M. (19)	1	817–2407	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	817–4231	CONTROL, AUX. L.W.C.O.	15–250#
	1	817–4232	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	LMC 289–154	LOW WATER CUTOFF	15–250#
3	1	941–1790	VALVE, BALL, 3/4" NPT	15#–200#
	1	941–170	VALVE, GATE, 3/4" NPT	250#
6	1	851–34	GAUGE GLASS	15#–250#
7	1	912–34	ROD, GAUGE GLASS	15#–250#
17	1	847–471	BUSHING, 1–1/4" X 3/4"	15#–250#
24	1	623–197	LEVEL MASTER CONTROL PANEL	15#–250# A.R.
	1	623–198		15#–250# M.R.
25	1	623–172	LEVEL MASTER PROBE	15#–250#
26	1	8–3267	BRACKET	15#–250#
27	1	847–269	RDCR. TEE, 3/4" x 3/4" x 1/2"	15#–150#
	1	847–319		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

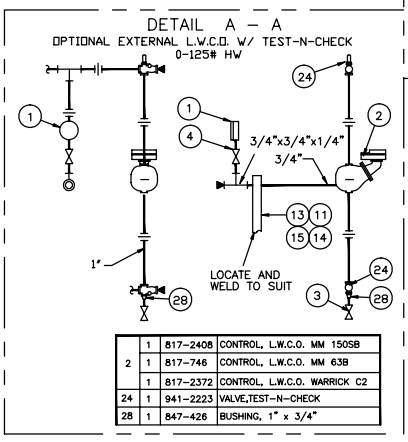
OPTIONAL REPLACEMENT FOR ITEM (2)

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

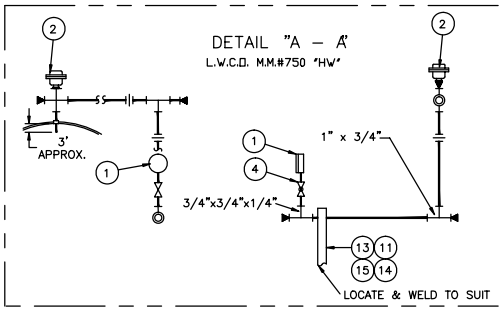
15–150# ST	817–1100
200–250# ST	817–1211

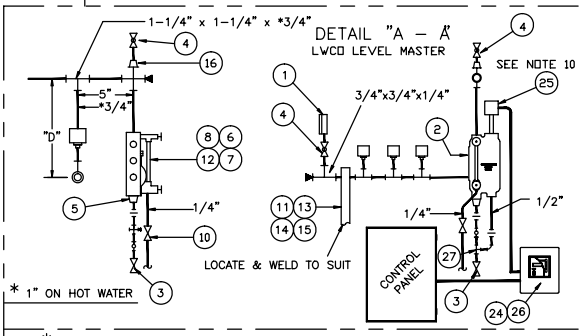
LWCO W/ SWITCH FOR MOTORIZED FEED VALVE 158, 193, & 194

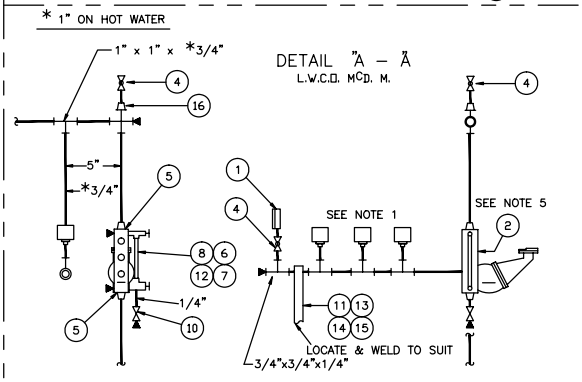
15# ST	817–781
150# ST	817–733
200–250# ST	817–304

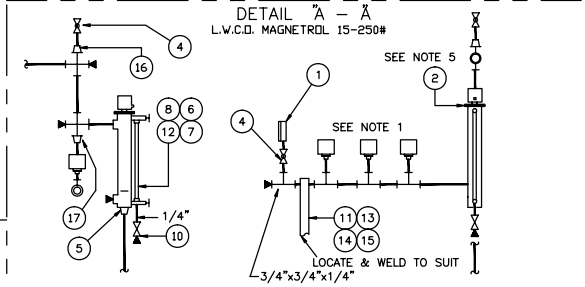


2	1	817–2408	CONTROL, L.W.C.O. MM 150SB
	1	817–746	CONTROL, L.W.C.O. MM 63B
	1	817–2372	CONTROL, L.W.C.O. WARRICK C2
24	1	941–2223	VALVE,TEST–N–CHECK
28	1	847–426	BUSHING, 1" x 3/4"









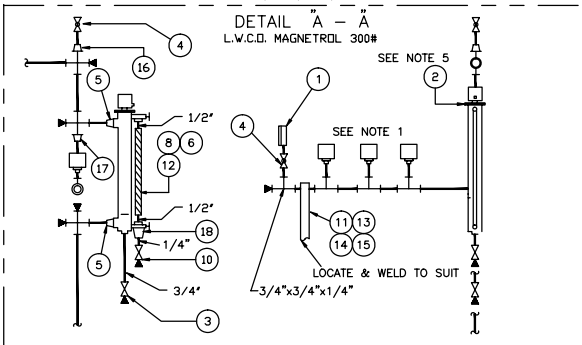


Figure 10-19. Water Column Piping 72" and 78" ICB

ITEM	QTY	PART NO. McD. 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	193B 817–621	817–4230	LOW WATER CUT–OFF	15 ST
	1	157S–RL 817–2405	817–4230	LOW WATER CUT–OFF	150 ST
	1	194 817–303	817–4230	LOW WATER CUT–OFF	200 – 250ST
	1	194A 817–2374	817–4233	LOW WATER CUT–OFF	200 – 250ST
	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	941–170		VALVE, GATE, 3/4"	15–250 ST
	2	941–170		VALVE, GATE, 3/4"	300 ST
4	–	–	———	–	–
	2	941–55	———	BALL VALVE, 1/4", M x F	0–200 ST
	2	941–2656	———	BALL VALVE, 1/4", F x F	201–250 ST
	2	941–318	———	GLOBE,VALVE	300 ST.
5					
6	1	851–34	851–195	GAUGE, GLASS	193B 157S–RL 194A
	1	851–190	851–195	GAUGE, GLASS	194
	1	---	851–391	GAUGE, GLASS	300 ST
7	4	912–34	912–34	ROD, GAUGE GLASS	157S–RL 193B 194A
	4	912–85	912–34	ROD, GAUGE GLASS	194
8	1	825–203		SET, GAUGE GLASS	15–200 ST
	1	825–394		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
12	9FT	830–28		CHAIN SASH	15–300 ST

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

LEVEL MASTER EQUIPMENT				
2	1	LMB 289–155	LOW WATER CUTOFF	15#–250#
	1	LMC 289–235	LOW WATER CUTOFF	15–250#
3	1	941–1790	VALVE, BALL, 3/4" NPT	15#–200#
	1	941–170	VALVE, GATE, 3/4" NPT	250#
6	1	851–34	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	623–197	LEVEL MASTER CONTROL PANEL	15#–250# AUTO RESET
	1	623–198		15#–250# MANUAL RESET
31	1	623–172	LEVEL MASTER PROBE	15#–250#
32	1	8–3267	BRACKET	15#–250#
33	1	847–269	RDCR. TEE, 3/4" x 3/4" x 1/2"	15–150#
		847–319		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

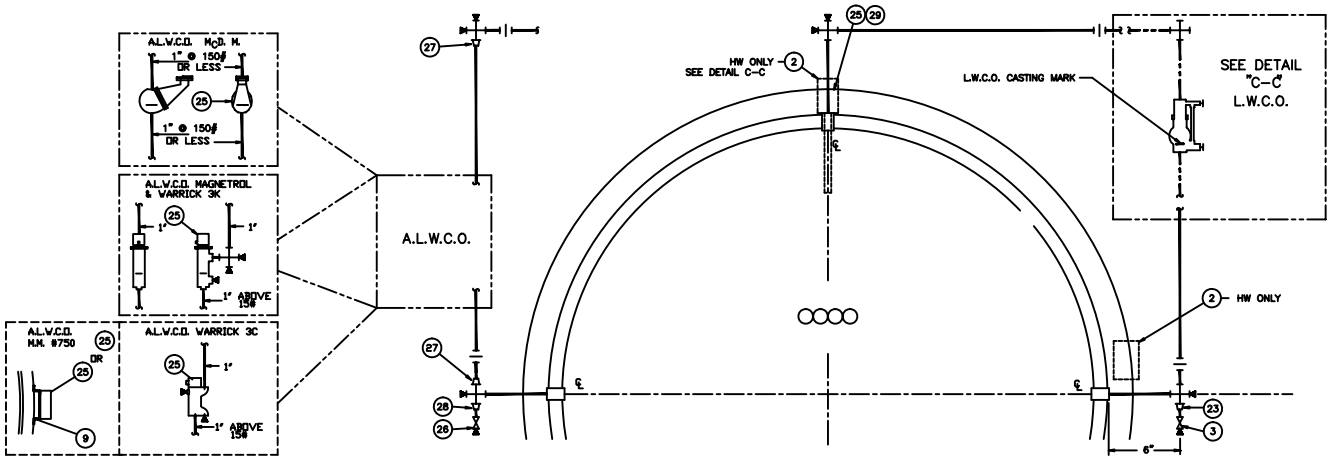


Figure 10-20. Water Column Piping 72" and 78" ICB

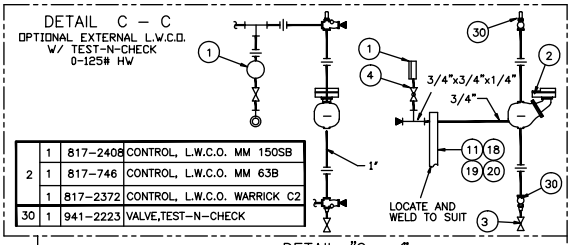
ITEM	QTY	PART NO. 15–150#	PART NO. 200–300#	DESCRIPTION	USED ON
13	–	–	–	–	–
14	–	–		–	–
15	–	–		–	–
16	–	–		–	–
17	–	–		–	–
18	1	869–234		NUT & LOCKWASHER 1/4"	–
19	1	928–44		ONE–HOLE CLAMP	–
20	1	868–136		CAPSCREW HEX. HD. 1/4–20 x 3/4"	–
21	1	847–428	847–470	BUSHING 1–1/4" x 1/4"	ALL ST
22	1	847–432	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"	300# ONLY
(25)	1	SEE TABLE		CONTROL, AUX. L.W.C.O.	
(26)	1	941–1790		VALVE, BALL 3/4"	15–200# (PROBE ALWCO)
	1	941–170		VALVE, GATE, 3/4"	ALL OTHERS
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	847–471		BUSHING 1–1/4" x 3/4"	15–200# (PROBE ALWCO)
	1	847–471		BUSHING 1–1/4" x 3/4"	15–300# (FLOAT ALWCO)
30	–	–		–	–

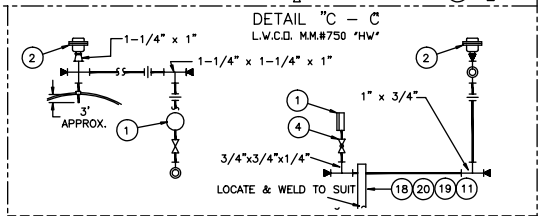
EXTERNAL A.L.W.C.O.

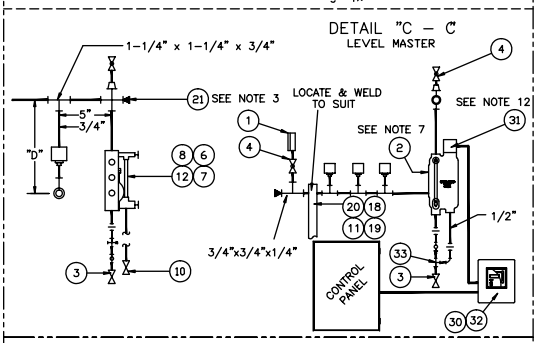
M D. M. C MAGNETROL	(25)	1	817–2408	CONTROL, AUX. L.W.C.O. (AUTO RESET)	15#
		1	817–2407	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	150#
		1	817–306	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	200–250#
WARRICK	(25)	1	817–4231	CONTROL, AUX. L.W.C.O.	15–250#
		1	817–4232	CONTROL, AUX. L.W.C.O.	300#
WARRICK	(25)	1	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#
WARRICK		1	817–2259	CONTROL, AUX. L.W.C.O. WARRICK 3K3A	15–250#

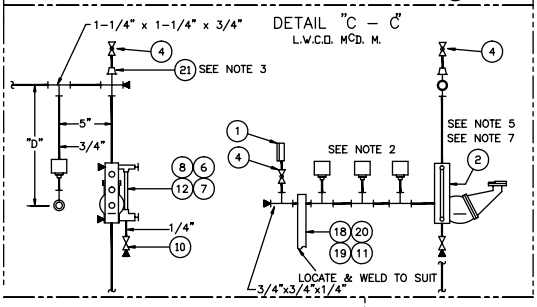
INTERNAL A.L.W.C.O.
(ABOVE 15# ONLY)

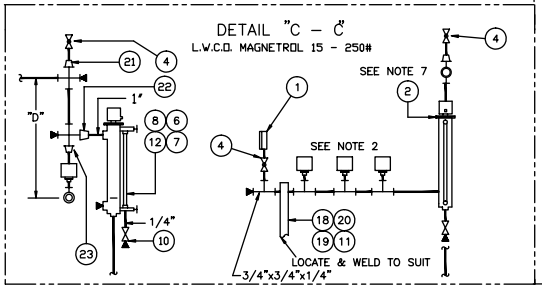
M D. M. C	(25)	1	817–740	CONTROL, AUX. L.W.C.O. WARRICK 3E2B	✱30#–200#
		1	817–1020	CONTROL, AUX. L.W.C.O. WARRICK 3E3B	✱30#–200#
		1	817–2305	CONTROL, AUX. L.W.C.O. MM 750MT–120	✱15#–250#
	(29)	2	67–873	ROD,ELECTRODE, 1/4" DIA X 24" LG.	✱3E2B
		3	67–873	ROD,ELECTRODE, 1/4" DIA X 24" LG.	✱3E3B











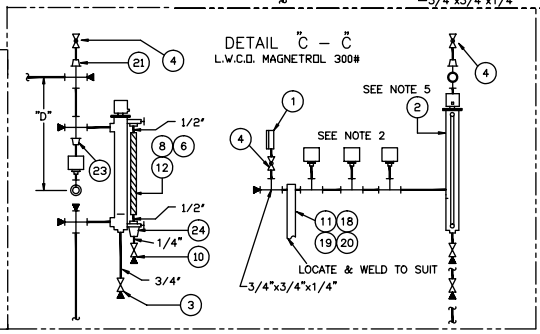
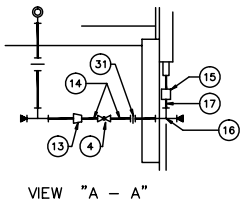


Figure 10-21. Water Column Piping 92” & 106” ICB Steam

		McD. M.	MAGNETROL				
1	1	850–264		PRESSURE GAUGE– 8–1/2"		15 ST	A9
	1	850–230		PRESSURE GAUGE– 6"		15 ST 67"	
	1	850–104		PRESSURE GAUGE– 8–1/2"		150–200 ST	
		850–222		PRESSURE GAUGE– 6"		150–200 ST 67"	
	1	850–150		PRESSURE GAUGE– 8–1/2"		250 ST	
		850–320		PRESSURE GAUGE– 6"		250 ST 67"	
	1	850–172		PRESSURE GAUGE– 8–1/2"		300 ST	
		850–400		PRESSURE GAUGE– 6"		300 ST 67"	
2	1	193B 817–621		817–4230	LOW WATER CUT–OFF	15 ST	
	1	157S–RL 817–2405		817–4230	LOW WATER CUT–OFF	15 ST	
	1	W–25–CLA 817–163		817–4230	LOW WATER CUT–OFF	15 ST	
	1	157S–RL 817–2405		817–4230	LOW WATER CUT–OFF	150 ST	
	1	194 817–303		817–4230	LOW WATER CUT–OFF	200 ST	
	1	194A 817–2374		817–4230	LOW WATER CUT–OFF	200 ST	
	1	194 817–303		817–4230	LOW WATER CUT–OFF	250 ST	
	1	194A 817–2374		817–4230	LOW WATER CUT–OFF	250 ST	
	1	W29 817–1962			LOW WATER CUT–OFF	300 ST	
3	1	941–170		VALVE, GATE 3/4"		15–250 ST	A9
	2	941–170		VALVE, GATE 3/4"		300 ST	
4	–	–	———	–		–	A9
	2	941–55	———	BALL VALVE, 1/4", M x F		0–200 ST	
	2	941–2656	———	BALL VALVE, 1/4", F x F		201–250 ST	
	2	———	941–318	VALVE, GLOBE 1/4", BRASS		300 ST	
5	1	8–A–3172		BRACKET, STEAM GAUGE		78" CB/LE/CBW ALL 4W/CBR/CBSOS	A9
	1	8–3252		BRACKET, STEAM GAUGE		96" CB/LE/CBW	
	1	8–3340		BRACKET, STEAM GAUGE		96"CEW/92–106"CB/96"–106"4WC	
6	1	851–34	851–195	GAUGE, GLASS	193B 194A 157S–RL	MAG.	A9
	1	851–190	851–195	GAUGE, GLASS	194	MAG.	
	1	———	851–391	GAUGE, GLASS	300 ST		
7	4	912–34	912–34	ROD, GAUGE GLASS	193B 194A 157S–RL	MAG.	A9
	4	912–85	912–34	ROD, GAUGE GLASS	194	MAG.	
8	1	825–394		SET, GAUGE GLASS		0–250 ST	A9
	1	———	825–370	SET, GAUGE GLASS		300 ST	
10	1	941–55		VALVE, BALL 1/4"		15–200 ST	A9
	1	941–318		VALVE, GLOBE, 1/4"		250–300 ST	



VIEW "A – A"

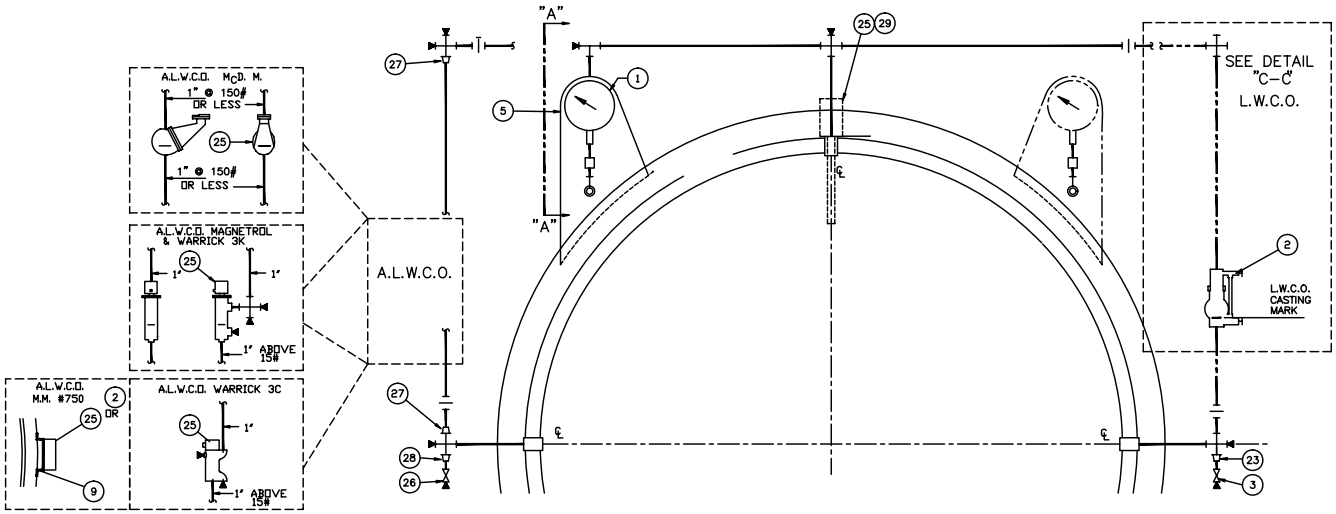


Figure 10-22. Water Column Piping 92” & 106” ICB Steam

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
(11)	1	8–A–868	BRACKET, PRESS. CONTROL	□15–300 ST
	1	971–13	FLAT BAR, 1/8" x 1" x 36"	CEW/ICB/4WG
(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	3	857–448		857–726	BRASS NIPPLE, 1/4" x 1–1/2"	–
15	1	858–856		858–768	COUPLING 1/4" R.H. THREAD	67" DIA. ONLY
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"	67" DIA. ONLY
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	941–1790			VALVE, BALL 3/4"	15–200# (PROBE TYPE)
	1	941–170			VALVE, GATE 3/4"	ALL OTHERSS
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	847–471			BUSHING 1–1/4" x 3/4"	15–200# (PROBE TYPE)
	1	847–471			BUSHING 1–1/4" x 3/4"	ALL OTHERS
30	–	–			–	–
31	1	858–193		858–172	UNION, FEMALE, 1/4"	ALL

EXTERNAL A.L.W.C.O.

M C.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	817–4231	CONTROL, AUX. L.W.C.O.	15–250#
	1	817–4232	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#

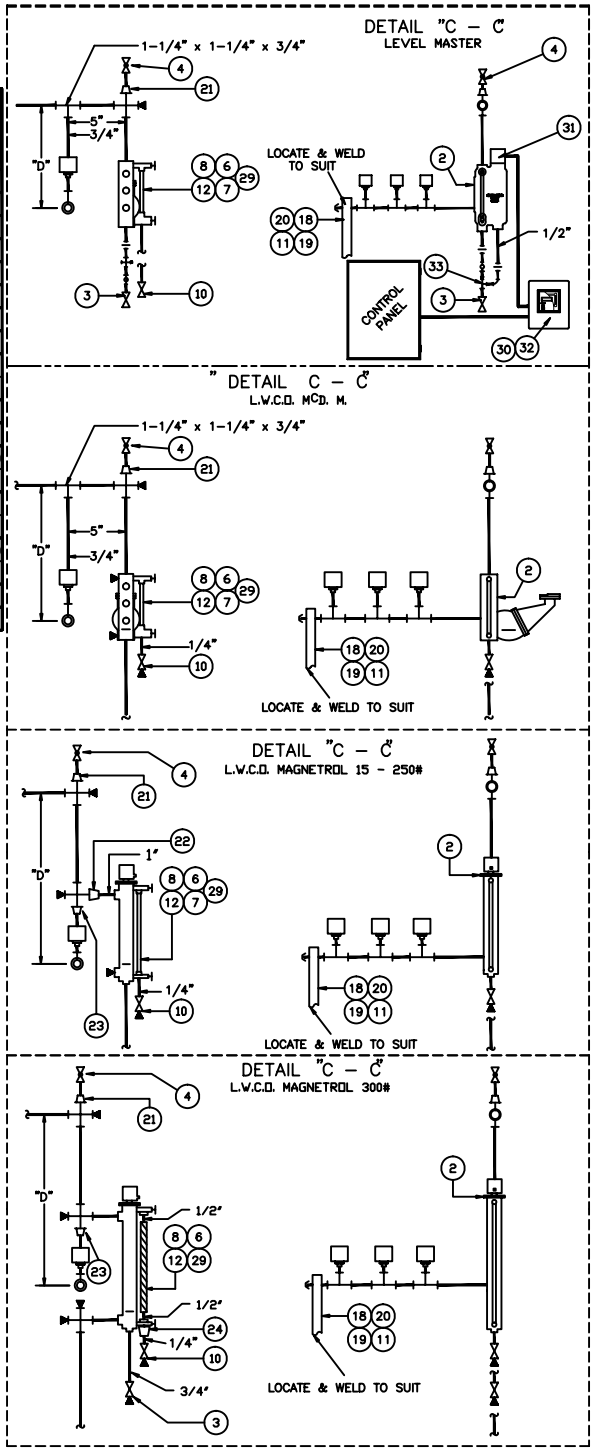
INTERNAL A.L.W.C.O.
(ABOVE 15# ONLY)

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 C.D. 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 EXCEPT 83" CBR
	3	67–873	ROD,ELECTRODE, 1/4" DIA X 24" LG.	*3E3B EXCEPT 83" CBR
	2	67–708	ROD,ELECTRODE, 1/4" DIA X 27" LG.	*3E2B 83" CBR
	3	67–708	ROD,ELECTRODE, 1/4" DIA X 27" LG.	*3E3B 83" CBR
	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 CB/LE/CBW/4WI/CBR

2	1	LML 289–154	LOW WATER CUTOFF	15–250# 67" 4WI/CBR/CBSOS
	1	LMB 289–155	LOW WATER CUTOFF	15–250#
	1	LMC 289–235	LOW WATER CUTOFF	15–250#
3	1	941–1790	VALVE, BALL, 3/4" NPT	15#–200#
	1	941–170	VALVE, GATE, 3/4" NPT	250#
6	1	851–34	GAUGE GLASS	LMB LMC
7	1	912–34	ROD, GAUGE GLASS	LMB LMC
23	1	847–472	BUSHING, 1–1/4" X 1"	15#–250#
30	1	623–197	LEVEL MASTER CONTROL PANEL	15#–250# AUTO RESET
	1	623–198		15#–250# MANUAL RESET
31	1	623–172	LEVEL MASTER PROBE	15#–250#
32	1	8–3267	BRACKET	15#–250#
33	1	847–269	RDCR. TEE, 3/4" x 3/4" x 1/2"	15#–150#
	1	847–319		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

Figure 10-23. Water Column Piping 92” & 106” ICB Hot Water

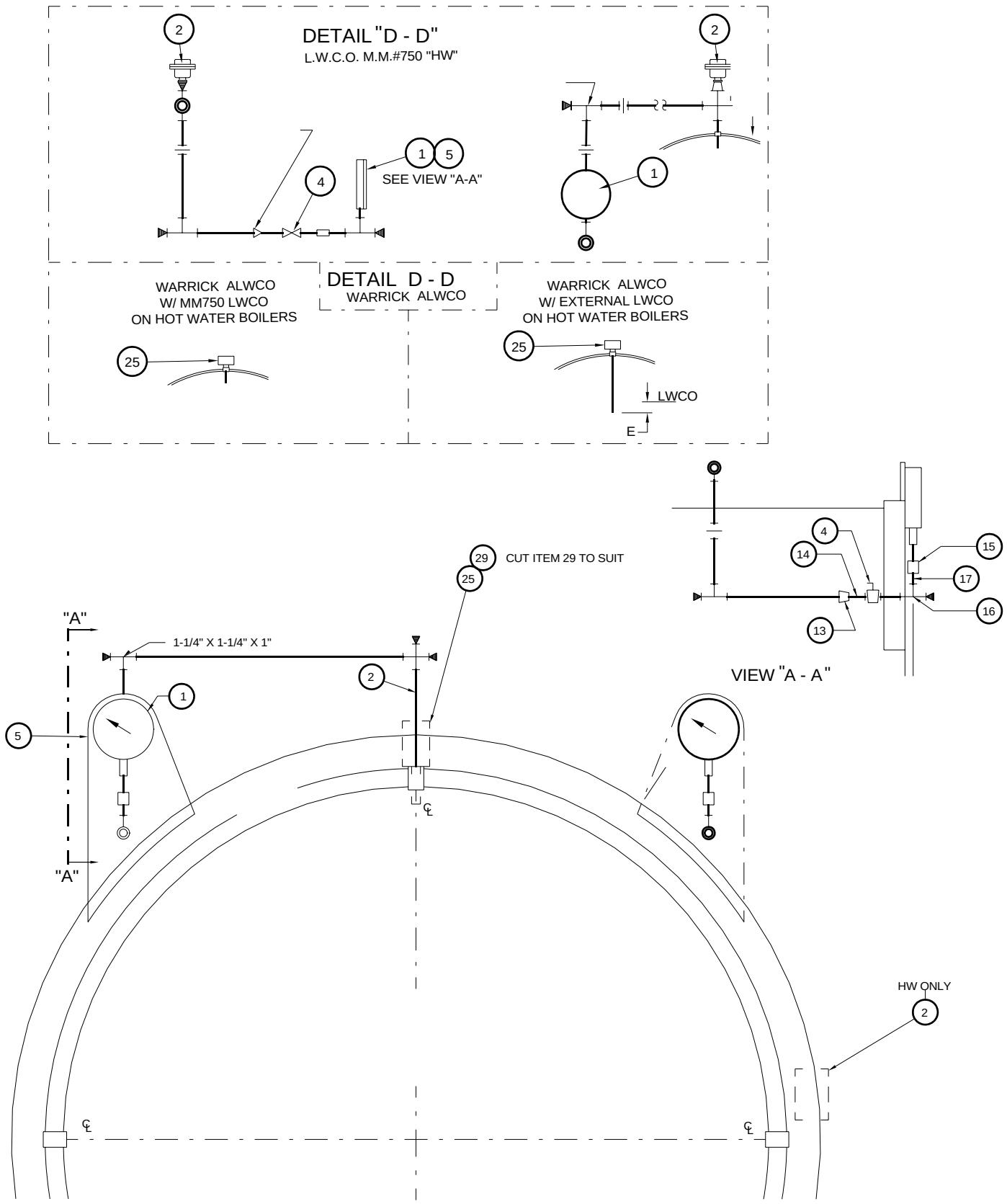


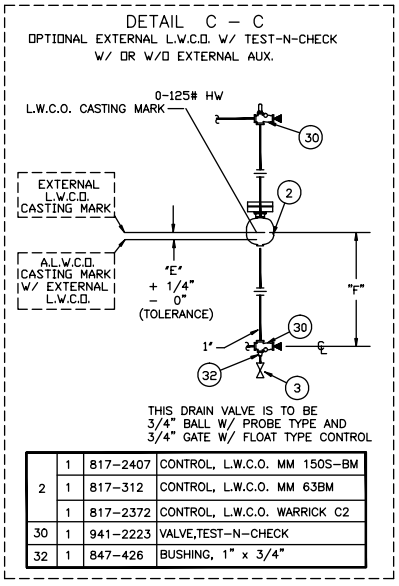
Figure 10-24. Water Column Piping 92” & 106” ICB Hot Water

ITEM	QTY	PART NO. McD. M.	PART NO. MAGNETROL	DESCRIPTION	USED ON	OPTION
1	1	850–101		PRESSURE GAUGE– 8–1/2”	30 HW	A9
		850–223		PRESSURE GAUGE–6”	30 HW 67”	
		850–103		PRESSURE GAUGE– 8–1/2”	125 HW	
		850–821		PRESSURE GAUGE– 6”	125 HW 67”	
		850–104		PRESSURE GAUGE– 8–1/2”	150 HTHW	
		850–222		PRESSURE GAUGE– 6”	150 HTHW 67”	
2	1	817–2305		CONTROL, WATER LEVEL PROBE TYPE, MDL. 750	ALL HW	33
		817–2306		REMOTE SENSOR, PROBE HOLDER, MDL. 750		
		067–871		ROD,ELECTRODE 12”LG, FOR REMOTE SENSOR		
3	1	941–1790		VALVE, BALL 3/4”	15–200 (PROBE)	A9
		941–170		VALVE, GATE 3/4”	0–300 (FLOAT)	
4	1	941–55		VALVE, BALL, 1/4”	0–150#	A9
5	1	8–A–3172		BRACKET, STEAM GAUGE	78” CB/LE/CBW, ALL 4WI	A9
	1	8–3252		BRACKET, STEAM GAUGE	96” CB/LE/CBW	
	1	8–3340		BRACKET, STEAM GAUGE	96”CEW/92–106”CB/96”–106”4WG	
	1	8–A–3172		BRACKET, STEAM GAUGE	67”	
	1	8–A–3172		BRACKET, STEAM GAUGE	83” CBR	
6	N/A			–		
7	N/A			–		
8	N/A			–		
9	2	8–1152		BRACKET	M.M. #750	
10	N/A			–		
11	N/A			–		
11	N/A			–		

ITEM	QTY	PART NO. 15–150#	DESCRIPTION	USED ON
13	1	847–1687	COUPLING 1” X 1/4”	–
14	3	857–448	BRASS NIPPLE, 1/4” x 1–1/2”	–
15	1	858–856	COUPLING 1/4” R.H. THREAD	67” DIA. ONLY
16	1	859–54	BRASS TEE 1/4”	–
17	1	857–452	BRASS NPL. (X–HEAVY) 1/4” x 1–1/2”	67” DIA. ONLY
18	N/A		–	–
19	N/A		–	–
20	N/A		–	–
21	N/A		–	–
22	N/A		–	–
23	N/A		–	–
24	1		BUSHING 1/2” X 1/4”	–
25	1	SEE TABLE	CONTROL, AUX. L.W.C.O.	
26	1	–	–	–
	1	–	–	–
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#
29		SEE TABLE	SEE TABLE	–
30	N/A		–	–
31	1	858–193	UNION, FEMALE, 250#, BRONZE, 1/4”	15–250#
	1	858–172	UNION, FEMALE, 300#, MI, BLK, 1/4”	251–300#

INTERNAL A.L.W.C.O.

						OPTION
WARRICK	25	1	817–740	CONTROL, AUX. L.W.C.O. WARRICK 3E2B	★30#–200#	DA
WARRICK		1	817–1020	CONTROL, AUX. L.W.C.O. WARRICK 3E3B	★30#–200#	DB
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 EXCEPT 83” CBR	DA
		3	67–873	ROD,ELECTRODE, 1/4” DIA X 24” LG.	★3E3B EXCEPT 83” CBR	DB
		2	67–708	ROD,ELECTRODE, 1/4” DIA X 27” LG.	★3E2B 83” CBR	
		3	67–708	ROD,ELECTRODE, 1/4” DIA X 27” LG.	★3E3B 83” CBR	
		1	817–2306	REMOTE SENSOR, PROBE HOLDER,	MDL. 750	
		1	817–2383	PROBE EXT., 36”LG, FOR REMOTE SENSOR,	MDL. 750	



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
30	1	941–2223	VALVE,TEST–N–CHECK
32	1	847–426	BUSHING, 1” x 3/4”

Figure 10-25. Pressure Controls

15#	16#–150#	151#–200#	201#–250#	300#	BILL OF MATERIAL				
PART NO.	PART NO.	PART NO.	PART NO.	PART NO.	ITEM	QTY	PART NO.	DESCRIPTION	USED ON
817–4095	817–4093	817–4146	817–4147	817–4091	①	1	SEE TABLE	CONTROL PRESSURE (OLC)	CB780/CB100/E100
817–4094	817–4092	817–4148	817–4149	817–4073	②	1	SEE TABLE	CONTROL PRESSURE (HLC)	–
817–251	817–204	817–234	817–234	817–234	③	1	SEE TABLE	CONTROL PRESSURE (MC)	48"– 106" CB780/CB100/E100
817–4150	817–120	817–137**	817–137**	–		1	SEE TABLE	CONTROL PRESSURE (HLFC)	30 & 40 HP. CB780/CB100/E100
857–448	857–448	857–448	857–448	857–726	4	*3	SEE TABLE	NIPPLE – 1/4" x 1–1/2"	–
–	–	–	–	–	5	–	–	–	–
–	–	–	–	–	6	–	–	–	–
–	–	880–605	880–605	–	⑦	2	SEE TABLE	LIMIT STOP ASSY SEE NOTE 7	UL & CSD–1

* ITEM #4 QTY OF 2
FOR 15 & 20 H.P. CB780/E100.

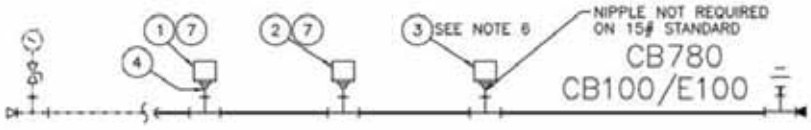


Figure 10-26. Temperature Controls

CB780/CB100/E100 281–360 DEG F. HTHW	CB780/CB100/E100 240–280 DEG F. HTHW	CB780/CB100/E100 30–125# HW 170–240 DEG F.	BILL OF MATERIAL ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OPTION
832–2091 **	832–2091 **	817–1244	1	1	SEE TABLE	TEMPERATURE CONTROL, MODULATING (MC)	–	D3
937–772	937–772	817–378	2	1	SEE TABLE	WELL, SEPARABLE		
817–4289	817–4291	817–2402	3	1	SEE TABLE	TEMPERATURE CONTROL, HIGH LIMIT (HLC)	–	D3
817–699	817–399 (5)(8)	817–399 (5)(8)	4	1	SEE TABLE	WELL, SEPARABLE		
817–4292	817–4290	817–400	5	1	SEE TABLE	TEMPERATURE CONTROL, OPERATING LIMIT (OLC)	–	D3
817–699	817–399 (5)(8)	817–399 (5)(8)	6	1	SEE TABLE	WELL, SEPARABLE		
937–710	937–710	937–787	7	1	SEE TABLE	THERMOMETER	15–200HP	D3
937–673	937–673	937–27			SEE TABLE	THERMOMETER	250–800HP	
937–658	937–658	817–3103	8	1	SEE TABLE	WELL, SEPARABLE	15–200HP	
		817–641			SEE TABLE	WELL, SEPARABLE	250–800HP	
008–995	008–995	008–967	9	1	SEE TABLE	BRACKET, LIMIT CONTROLS (DWG. 008–B–937)	15–200HP	D3
008–995	008–995	008–995			SEE TABLE	BRACKET, LIMIT CONTROLS (DWG. 008–B–937)	250–800HP	
008–1317	008–1317	–	10	2	SEE TABLE	MOUNTING BRACKET, MERCOID CONTROLS	–	
–	–	5	11	SEE TABLE	847–466	BUSHING, REDUCING, 3/4" x 1/2", F.S.	–	–
			12	9	860–4	MACH. SCR. #10–32 x 3/4"		
			13	9	869–9	NUT, MACH. SCR. #10–32		
			14	4	841–571	SHT. MTL. SCR. #10–32 x 5/8"		
			15	1	928–39	STRAP, PIPE		
			16	NOTE #4	950–414	WIRE, THERMOCOUPLE, TYPE–J	–	D3
			17	1	817–491	TEMPERATURE CONTROL, (LFHC) (9)	30/125# ICB	X8
			18	1	817–399	WELL, SEPARABLE (9)	30/125# ICB	X8

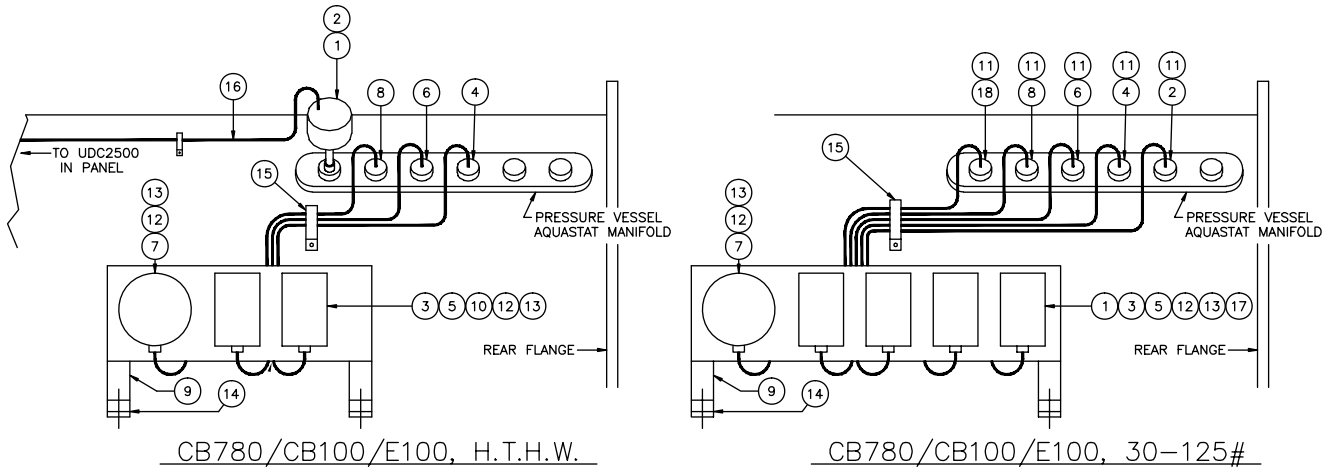
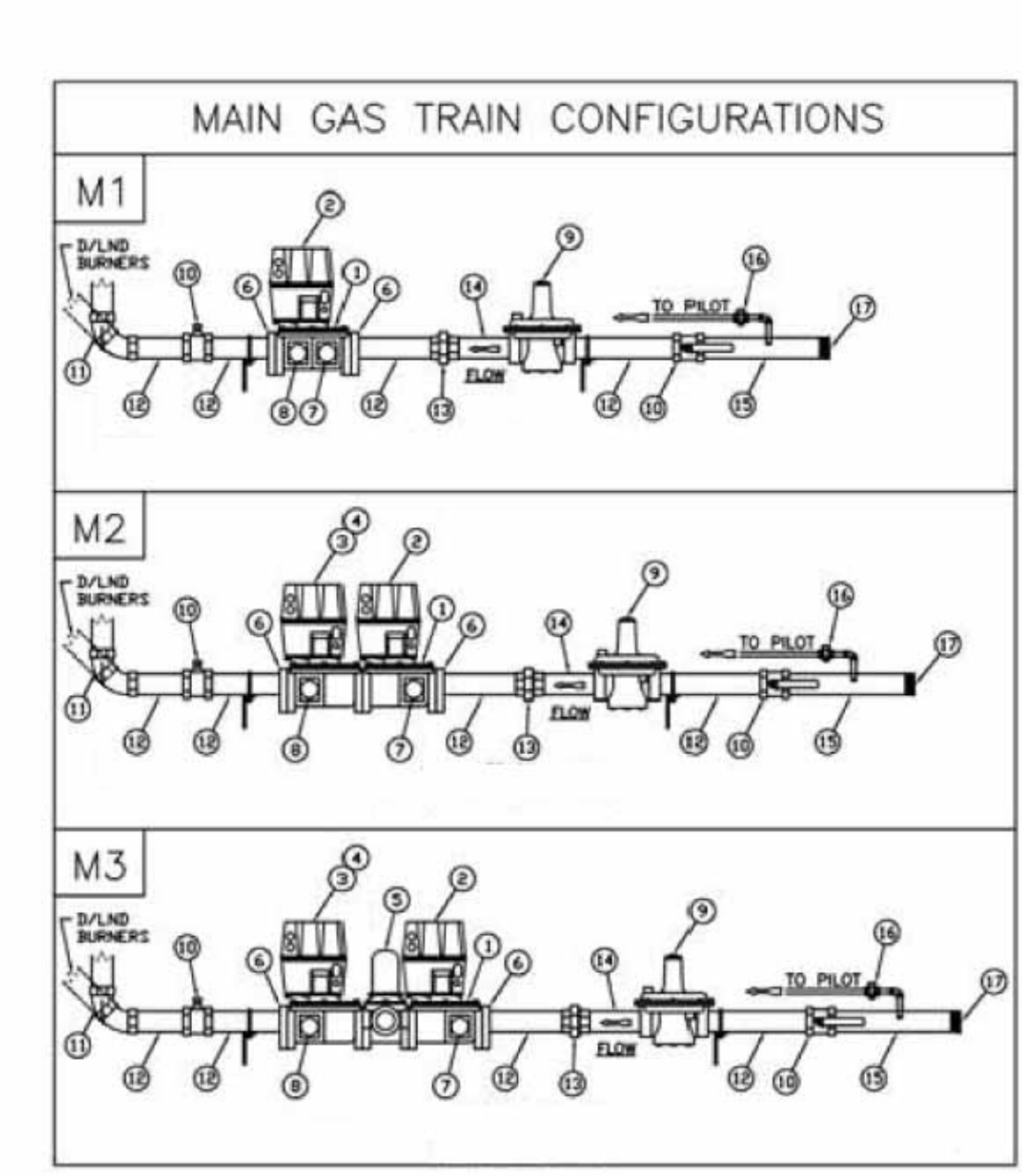


Figure 10-27. Main Gas Train 100-350 HP

Boiler HP		100	125	150	200	250	300	350
Main Gas Train	3 Pass	M1	M2	M2	M2	M2	M3	M3
	4 Pass	M1	M2	M2	M2	M2	M2	M3

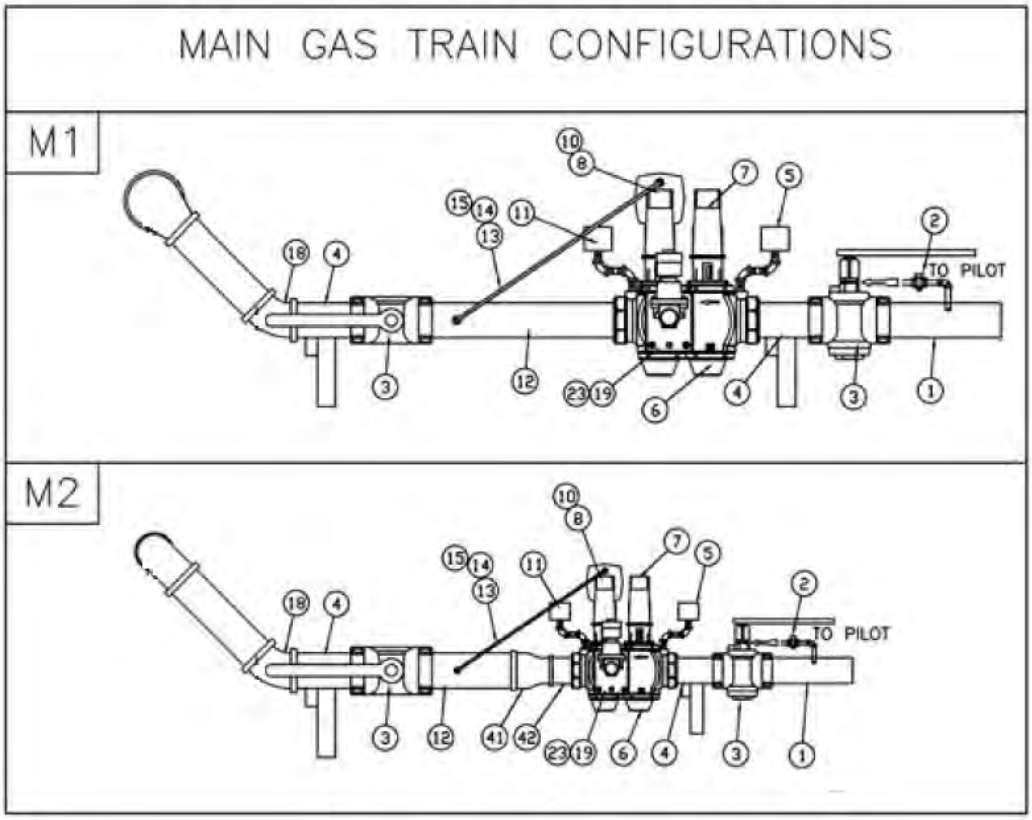


Main Gas Train 100-350 HP continued

ITEM	QTY	P/N	DESCRIPTION	USED ON
1	1	940-5812	VALVE, MOTORIZED, IVT, V5097, NO PDC	125-250 FM/GE-GAP 125-350HP UL
		940-5813	VALVE, MOTORIZED, IVT, V5097, W/ PDC	300-350HP FM/GE-GAP/NFPA-85 100 FM/GE-GAP/UL
2	1	945-139	ACTUATOR, GAS VALVE, NO PDC	125-250 FM/GE-GAP 125-350HP UL
		945-143	ACTUATOR, GAS VALVE, W/ PDC	100HP FM/GE-GAP 300-350HP FM/GE-GAP/NFPA-85
3	1	940-5813	VALVE, MOTORIZED, IVT, V5097, W/ PDC	125-250HP FM/GE-GAP/UL 300-350HP FM/GE-GAP/NFPA-85/UL
4	1	945-143	ACTUATOR, GAS VALVE, W/ PDC	125-250HP FM/GE-GAP/UL 300-350HP FM/GE-GAP/NFPA-85/UL
5	1	948-345	VALVE, SOLENOID, VENT, N.O. 1-1/4" NPT	300HP(3 PASS) & 350HP
6	2	800-83	ADAPTER, PIPE, 2"	100-150 HP
		800-84	ADAPTER, PIPE, 2-1/2"	200-300 HP
		800-85	ADAPTER, PIPE, 3"	350 HP
7	1	817-2414	PRESSURE SWITCH, LOW GAS	100-250HP
	1	817-2419	PRESSURE SWITCH, LOW GAS	300-350HP
8	1	817-2421	PRESSURE SWITCH, HIGH GAS	100-150HP
	1	817-2415	PRESSURE SWITCH, HIGH GAS	200-350HP
9	1	918-650	REGULATOR, PRESS., 2" NPT, MAXITROL RV91	100-STD, 125-3P-STD, 100-3P-LN
		918-705	REGULATOR, PRESS., 2" NPT, MAXITROL RV91	125-4P-STD, 150-STD 100-4P-LN, 125-150-LN
		918-59	REGULATOR, PRESS., 2-1/2" NPT, MAXITROL RV111	200-3P-STD.
		918-283	REGULATOR, PRESS., 2-1/2" NPT, MAXITROL 210G	200-4P-STD, 200-3P-LN 250-3P-LN
		918-682	REGULATOR, PRESS., 2-1/2" NPT, MAXITROL 210G	250-300-STD, 200-4P-LN 250-4P-LN, 300-LN
		918-521	REGULATOR, PRESS., 3" NPT, MAXITROL 210G	350 HP
10	2	941-1947	VALVE, BUTTERBALL, 2" NPT	100-150 HP
		941-129	LUBRICATED PLUG VALVE, 2-1/2" NPT	200-300 HP
		941-130	LUBRICATED PLUG VALVE, 3" NPT	350 HP
11	1	859-85	ELBOW, FEMALE, 90°, 2" NPT - 150# M.I.	100-150 HP FP BRNR
	1	859-99	ELBOW, FEMALE, 45°, 2" NPT - 150# M.I.	100-150 HP L/LND BRNR
		859-86	ELBOW, FEMALE, 90°, 2-1/2" NPT - 150# M.I.	200-300 HP FP BRNR
		859-100	ELBOW, FEMALE, 45°, 2-1/2" NPT - 150# M.I.	200-300 HP L/LND BRNR
		859-87	ELBOW, FEMALE, 90°, 3" NPT - 150# M.I.	350 HP FP BRNR
		859-101	ELBOW, FEMALE, 45°, 3" NPT - 150# M.I.	350 HP L/LND BRNR
12	4	857-1105	NIPPLE, PIPE, 2" x 10"	100-150 HP
		857-1556	NIPPLE, PIPE, 2-1/2" x 10"	200-300 HP
		857-1486	NIPPLE, PIPE, 3" x 10"	350 HP
13	1	858-169	UNION, FEMALE, 150#, 2" NPT	100-150 HP
		858-170	UNION, FEMALE, 150#, 2-1/2" NPT	200-300 HP
		858-171	UNION, FEMALE, 150#, 3" NPT	350 HP
14	1	857-1105	NIPPLE, PIPE, 2" x 10"	100-150 HP
		857-1556	NIPPLE, PIPE, 2-1/2" x 10"	200-300 HP
		857-1486	NIPPLE, PIPE, 3" x 10"	350 HP
15	1	157-606	NIPPLE, SIDE OUTLET, 2" x 10" x 1/2"	100-150 HP
		157-1038	NIPPLE, SIDE OUTLET, 2-1/2" x 10" x 1/2"	200-300 HP
		157-1039	NIPPLE, SIDE OUTLET, 3" x 10" x 1/2"	350 HP
16	1	825-30	GAS COCK, 1/2" NPT	ALL HP
17	1	919-104	PLASTIC CAPLUG, 2" PIPE	100-150 HP
		919-105	PLASTIC CAPLUG, 2-1/2" PIPE	200-300 HP
		919-99	PLASTIC CAPLUG, 3" PIPE	350 HP

Figure 10-28. Main Gas Train 400-800 HP

Boiler HP		400	500	600	700	800
Main Gas Train	3 Pass	M1	M1	M1	M2	M1
	4 Pass	M1	M1	M1	M2	M1



Main Gas Train 400-800 HP continued

ITEM	QTY	P/N	DESCRIPTION	USED ON
1	1	157-1038	NIPPLE, SIDE OUTLET, 2-1/2" x 1/2" x 10" LG	400-700HP
		157-1039	NIPPLE, SIDE OUTLET, 3" x 1/2" x 10" LG	800HP
2	1	825-30	GAS COCK, 1/2"NPT	ALL HP
3	2	941-129	LUBRICATED PLUG VALVE, 2-1/2"NPT	400-600HP
	1			700HP
	1	941-130	LUBRICATED PLUG VALVE, 3"NPT	700HP
	2			800HP
4	2	857-687	NIPPLE, 2-1/2" x 6" LG	400-600HP
	1	857-687	NIPPLE, 2-1/2" x 6" LG	700HP
	1	857-1422	NIPPLE, 3" x 6" LG	700HP
	2	857-1422	NIPPLE, 3" x 6" LG	800HP
5	1	817-3483	PRESSURE SWITCH, LOW GAS, ANTUNES	ALL
6	1	949-445	DOUBLE VALVE BODY, SEIMENS, 2-1/2" THD.	400-700HP
		949-446	DOUBLE VALVE BODY, SEIMENS, 3" THD.	800HP
7	1	-	-	-
		945-236	SEIMENS ACTUATOR W/ POC.	ALL HP
8	1	945-234	SEIMENS REGULATING ACTUATOR W/ POC	ALL HP
9	-	-	-	-
10	1	924-175	SPRING, YELLOW, 6"-48"	400HP
		924-174	SPRING, RED, 40"-100"	500-800HP
11	1	817-3481	HIGH GAS PRESSURE SWITCH	ALL HP
12	1	157-2201	NIPPLE, SIDE OUTLET, 2-1/2" x 1/2" x 18" LG	400-600HP
		157-2204	NIPPLE, SIDE OUTLET, 3" x 1/2" x 21" LG	700-800HP
13	2	845-7	CONNECTOR, MALE, 1/4" ODT x 1/4" NPT	ALL HP
14	2	845-8	NUT, FLARED, 1/4" ODC	ALL HP
15	1	939-642	ALUMINUM TUBING, 1/4" x 36" (CUT TO FIT)	ALL HP
16	1	850-412	PRESSURE GAUGE, 2-1/2", 0-15PSI	400-800HP NFPA-85 &GE-GAP
17	-	-	-	-
		-	-	-
18	1	859-100	ELBOW, FEMALE, 45°, 2-1/2"NPT - 150# M. I.	400-600HP
		859-101	ELBOW, FEMALE, 45°, 3"NPT - 150# M. I.	700-800HP
19	1	948-54	VENT VALVE, 1-1/4"	400-800HP
23	1	542-1242	VENT VALVE PLATE, SEIMENS	400-800HP
41	1	847-1692	REDUCER, COUPLING, 3" x 2-1/2", 150#, M. I.	700 HP
42	1	857-686	NIPPLE, 2-1/2" x 4" LG	700 HP

Figure 10-29. Air Oil Piping (55”-78” ICB)

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
①	1	615–23	COMPRESSOR ASSY 182T/184T MTR FRAME	60 HZ
		505–D–139	COMPRESSOR ASSY BELT DRIVEN	50 HZ
2	1	941–613	VALVE, GATE, 1/2"	–
3	1	940–135	VALVE, SWING CHECK, 1/2"	–
4	1	843–252	STRAINER	ICB/4WG 200
		843–34	STRAINER	CBE250–350; CEW/ICB 250–400 4WG 250–300
5	1	940–3898	RELIEF VALVE	ICB/4WG 200
		940–2296	RELIEF VALVE	CBE250–350; CEW/ICB 250–400 4WG 250–300
6	1	847–614	BUSHING, RED. 1–1/2" X 1/2"	
⑦	1	940–2470	VALVE, HORIZONTAL LIFT CHECK, 1/2"	CEW 200S–225S
8	2	939–70	BULK TUBING, 3/8" ODC x .03" WALL x 36"LG	–
9	4	845–43	NUT, SHORT, FLARED, BRASS, 3/8" ODT	–
10	4	845–46	CONNECTOR, MALE, 3/8" ODT x 1/2" NPT	–
⑪	1	SEE TABLE	MOTOR, 2 HP, 1200 SRPM, 60Hz (SEE NOTE 3)	SEE TABLE
	1	SEE TABLE	MOTOR, 3 HP, 1800 SRPM, 60Hz	SEE TABLE
	1	SEE TABLE	MOTOR, 2 HP, 1000 SRPM, 50Hz (SEE NOTE 3)	SEE TABLE
	1	SEE TABLE	MOTOR, 3 HP, 1800 SRPM, 50Hz	SEE TABLE
⑫	1	819–158	COUPLING, HALF	60Hz ONLY
	1	921–619	SHEAVE, 1–1/8" BORE, 6.35" O.D., 5.6 P.D.	50Hz ONLY
13	1	841–522	KEY, 1/4" x 1–1/4" LG	50Hz ONLY

ITEM ⑪

60Hz					
ICB 100–150HP			ICB 200–250HP, ICB 300–350HP (3–PASS STD)		
200V	208–230/460V	600V NOTE 6	200V	208–230/460V	600V NOTE 6
894–3661	894–3662	894–2788	894–3430	894–4443	894–4657

50Hz							
ICB 100–150HP				ICB 200–250HP, ICB 300HP (3–PASS STD)			
346V	380V	400V	415V	346V	380V	400V	415V
–	894–3502	–	–	–	894–2291	–	–

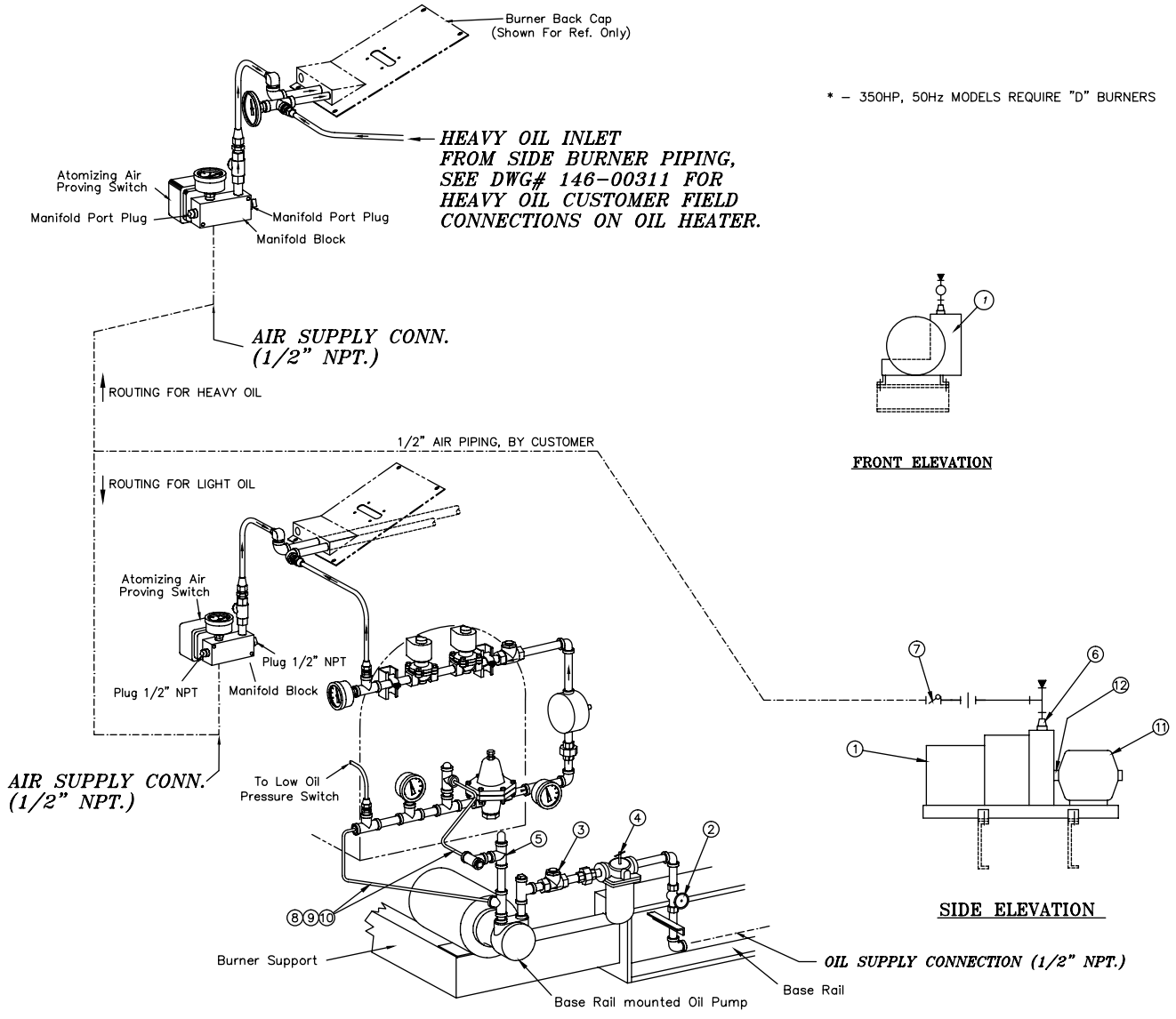
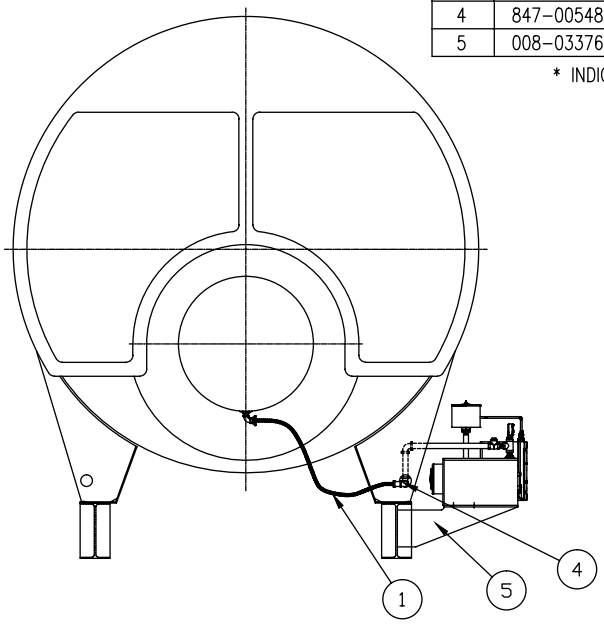


Figure 10-30. Air Compressor Piping (“D” Series Burner)

ITEM	D042-00336-000*	D378-00420-000*	DESCRIPTION	QTY.
1	861-00439-000	861-00374-000	FLEX HOSE, FEMALE UNION END x MALE NIPPLE END	1
2	008-00753-000		BRACKET, AIR LINE	2
3	928-00105-000		CLAMP	1
4	847-00548-000	859-00081-000	ELBOW	1
5	008-03376-000	008-03377-000	COPMPRESSOR BRACKET	2

* INDICATES BURNER MODEL



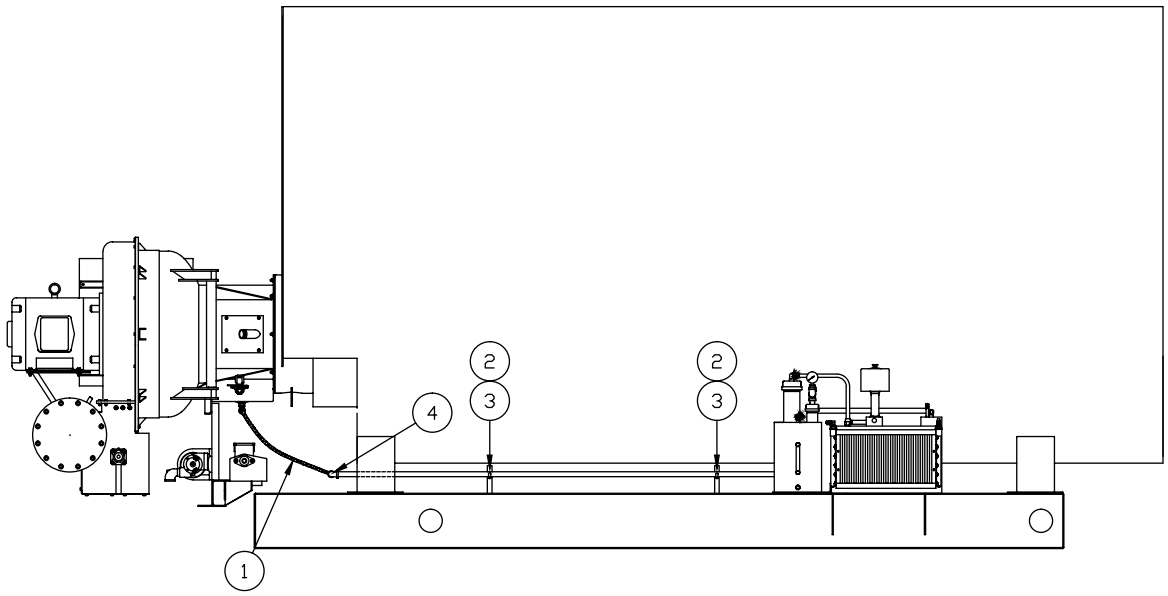


Figure 10-31. Air Compressor Piping (“F” Series Burner)

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	615–D–23	COMPRESSOR ASSEMBLY182T/184T MTR FRAME	60Hz
		505–D–139	COMPRESSOR ASSEMBLY BELT DRIVEN	50Hz
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	847–279	TEE, RED., 1"x1"x1/2"	–
7	1	940–2470	VALVE, HORIZONTAL LIFT CHECK, 1/2"	–
8	2	008–01159	BRACKET, COMPRESSOR (8–B–1002)	60Hz
	1	008–B–03624	BRACKET, COMPRESSOR, RH	50Hz
	1	008–03625	BRACKET, COMPRESSOR, LH (8–B–3624)	50Hz
9	3	928–44	CLAMP, PIPE, 1/2"	–

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
10	1	841–1407	SCREW, SELF TAP, 1/4"–20 X 5/8" LG.	–
11	1	SEE TABLE	MOTOR, 2 HP , 1200 SRPM, 60Hz	FP–3
	1	SEE TABLE	MOTOR, 3 HP , 1800 SRPM, 60Hz	FP–4
	1	SEE TABLE	MOTOR, 2 HP , 1000 SRPM, 50Hz	
	1	SEE TABLE	MOTOR, 3 HP , 1500 SRPM, 50Hz	
12	1	819–00158	COUPLING, HALF	60Hz ONLY
13	1	008–00753	BRACKET, AIR PIPING CBE/CEW	100–200HP
	0	–	N/A	250–350HP
14	1	861–00439	FLEX HOSE, 1/2", FEMALE UNION END x MALE NIPPLE END	–
15	1	921–619	SHEAVE, 1–1/8" BORE, 6.35" OD, 5.6" PD	50Hz ONLY
16	1	841–522	KEY, 1/4" X 1–1/4" LG.	50Hz ONLY
17	1	847–475	BUSHING, 1–1/2" x 1"	

		100–200HP CEW; 125–200HP CBE 100–150HP ICB; 100–150HP 4WG (***)			200–250HP ICB (3 PASS STD) 250–350HP CEW/CBE; 200–300HP 4WG			
60Hz	ITEM	200V	208–230/460V	600V (NOTE 4)	200V	208–230/460V	600V (NOTE 4)	
	(11)	894–3661	894–3662	894–02788	894–3430	894–4443	894–4657	
		CEW 100–200HP, CBE 125–200HP(***) ICB 100–150HP, 4WG 100–150HP			ICB 200–250HP, ICB 300HP (3–PASS STD) CEW/CBE 250–300HP; 4WG 200–300HP *			
50Hz	ITEM	346V	380V	400V	415V	346V	380V	400V	415V
	(11)	–	894–3502	–	–	–	894–2291	–	–

* – 350HP, 50Hz MODELS REQUIRE "D" BURNERS

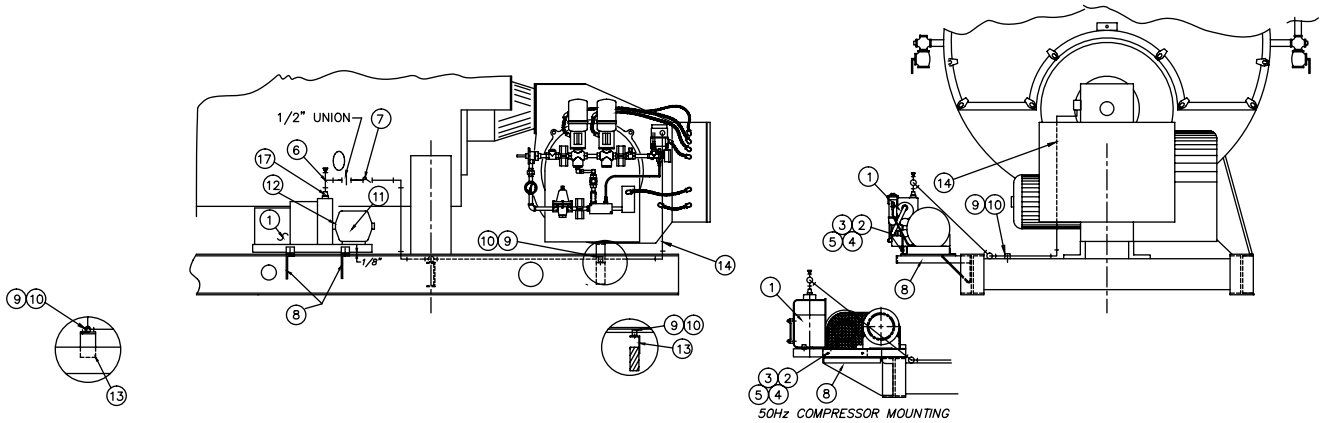
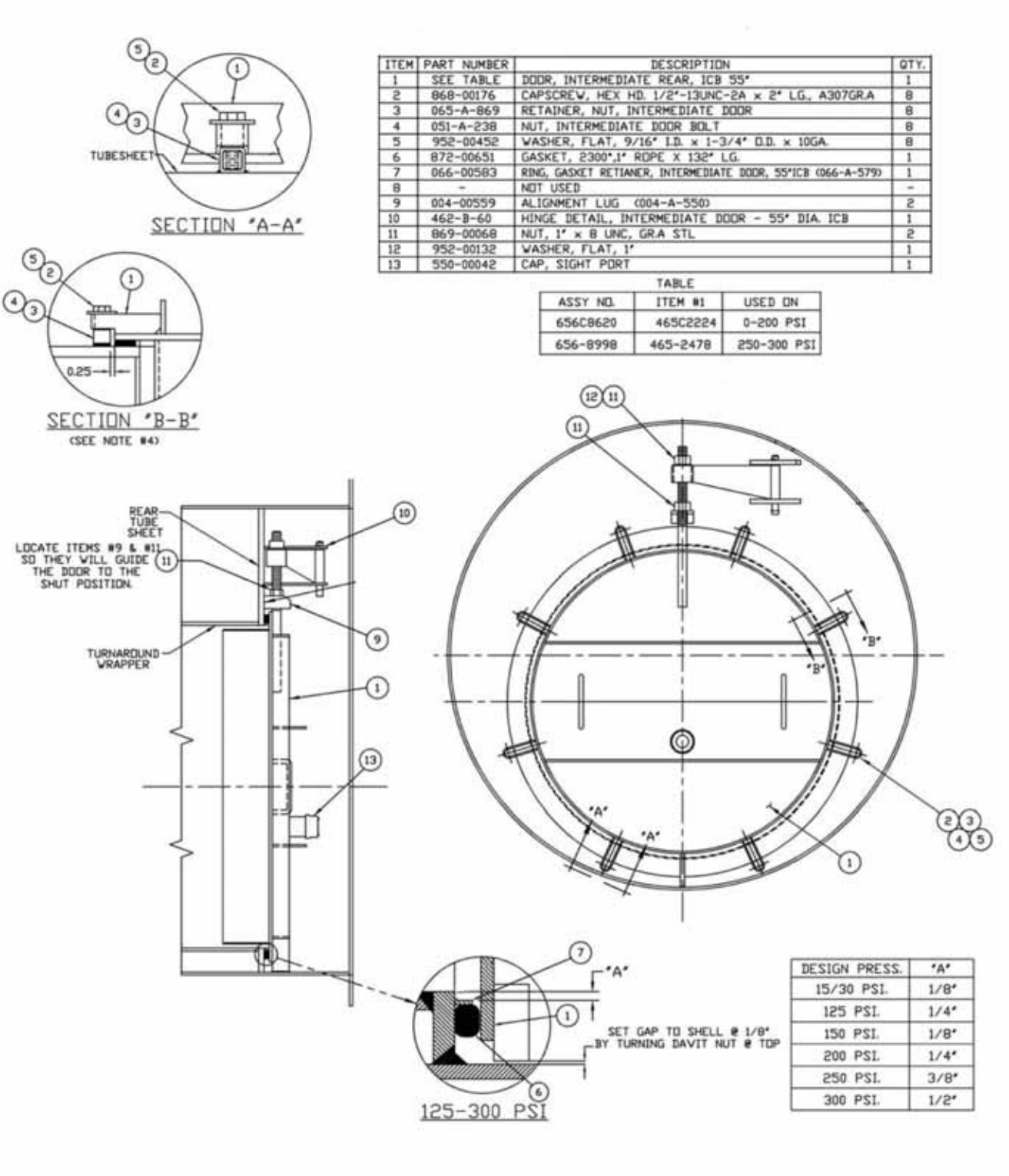


Figure 10-32. Rear Door Turnaround - 55” ICB



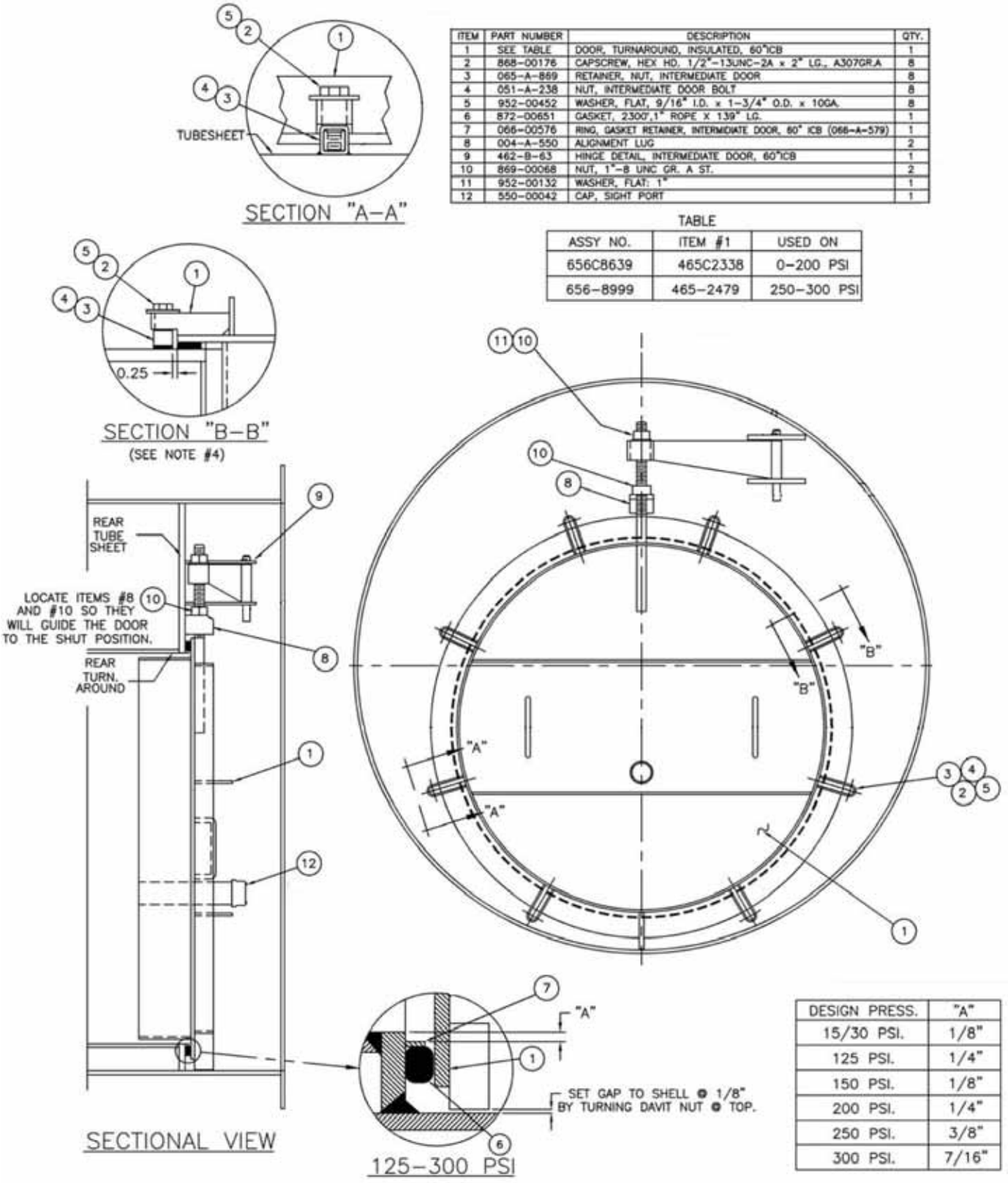
ITEM	PART NUMBER	DESCRIPTION	QTY.
1	SEE TABLE	DOOR, INTERMEDIATE REAR, ICB 55"	1
2	868-00176	CAPSCREW, HEX HD. 1/2"-13UNC-2A x 2" LG., A307GR.A	8
3	065-A-869	RETAINER, NUT, INTERMEDIATE DOOR	8
4	051-A-238	NUT, INTERMEDIATE DOOR BOLT	8
5	952-00452	WASHER, FLAT, 9/16" I.D. x 1-3/4" O.D. x 10GA.	8
6	872-00651	GASKET, 2300",1" ROPE X 132" LG.	1
7	066-00583	RING, GASKET RETIANER, INTERMEDIATE DOOR, 55"ICB (066-A-579)	1
8	-	NOT USED	-
9	004-00559	ALIGNMENT LUG (004-A-550)	2
10	462-B-60	HINGE DETAIL, INTERMEDIATE DOOR - 55" DIA. ICB	1
11	869-00068	NUT, 1" x 8 UNC, GR.A STL	2
12	952-00132	WASHER, FLAT, 1"	1
13	550-00042	CAP, SIGHT PORT	1

TABLE

ASSY NO.	ITEM #1	USED ON
656C8620	465C2224	0-200 PSI
656-8998	465-2478	250-300 PSI

DESIGN PRESS.	"A"
15/30 PSI.	1/8"
125 PSI.	1/4"
150 PSI.	1/8"
200 PSI.	1/4"
250 PSI.	3/8"
300 PSI.	1/2"

Figure 10-33. Rear Door Turnaround - 60”



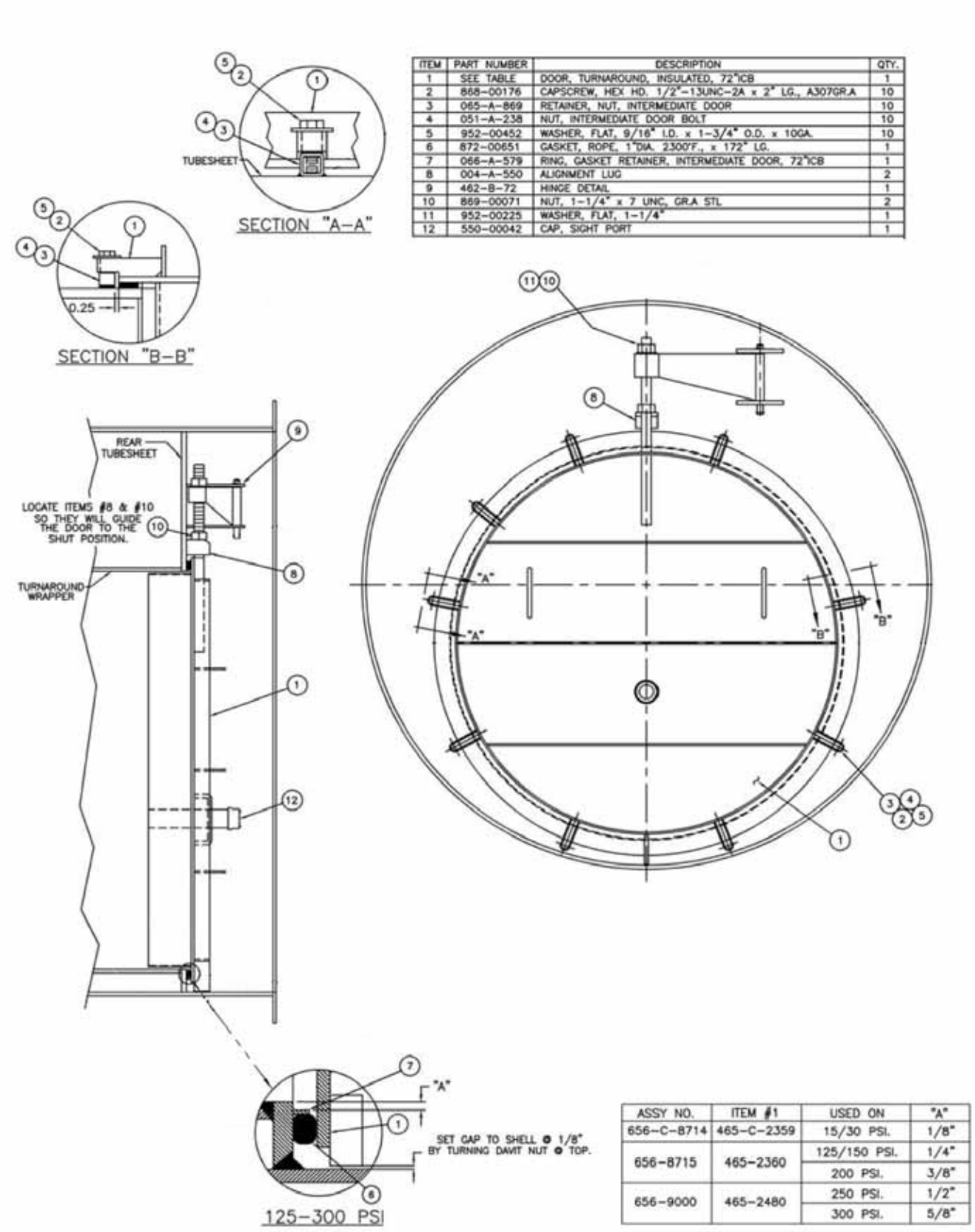
ITEM	PART NUMBER	DESCRIPTION	QTY.
1	SEE TABLE	DOOR, TURNAROUND, INSULATED, 60"ICB	1
2	868–00176	CAPSCREW, HEX HD. 1/2"–13UNC–2A x 2" LG., A307GR.A	8
3	065–A–869	RETAINER, NUT, INTERMEDIATE DOOR	8
4	051–A–238	NUT, INTERMEDIATE DOOR BOLT	8
5	952–00452	WASHER, FLAT, 9/16" I.D. x 1–3/4" O.D. x 10GA.	8
6	872–00651	GASKET, 2300",1" ROPE X 139" LG.	1
7	066–00576	RING, GASKET RETAINER, INTERMEDIATE DOOR, 60" ICB (066–A–579)	1
8	004–A–550	ALIGNMENT LUG	2
9	462–B–63	HINGE DETAIL, INTERMEDIATE DOOR, 60"ICB	1
10	869–00068	NUT, 1"–8 UNC GR. A ST.	2
11	952–00132	WASHER, FLAT: 1"	1
12	550–00042	CAP, SIGHT PORT	1

TABLE

ASSY NO.	ITEM #1	USED ON
656C8639	465C2338	0–200 PSI
656–8999	465–2479	250–300 PSI

DESIGN PRESS.	"A"
15/30 PSI.	1/8"
125 PSI.	1/4"
150 PSI.	1/8"
200 PSI.	1/4"
250 PSI.	3/8"
300 PSI.	7/16"

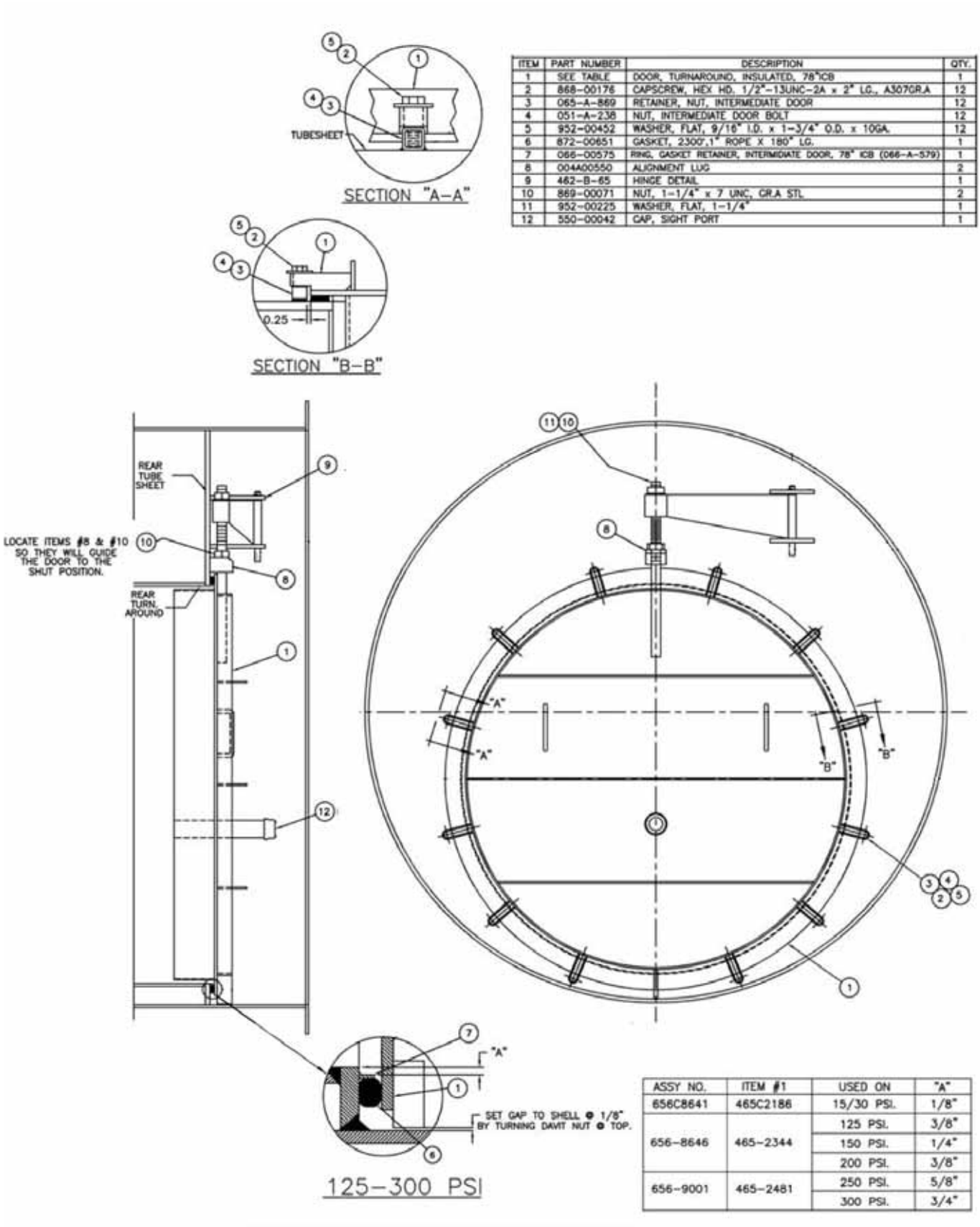
Figure 10-34. Rear Door Turnaround - 72”



ITEM	PART NUMBER	DESCRIPTION	QTY.
1	SEE TABLE	DOOR, TURNAROUND, INSULATED, 72"ICB	1
2	868–00176	CAPSCREW, HEX HD. 1/2"–13UNC–2A x 2" LG., A307GR.A	10
3	065–A–869	RETAINER, NUT, INTERMEDIATE DOOR	10
4	051–A–238	NUT, INTERMEDIATE DOOR BOLT	10
5	952–00452	WASHER, FLAT, 9/16" I.D. x 1–3/4" O.D. x 10GA.	10
6	872–00651	GASKET, ROPE, 1"DIA. 2300°F., x 172" LG.	1
7	066–A–579	RING, GASKET RETAINER, INTERMEDIATE DOOR, 72"ICB	1
8	004–A–550	ALIGNMENT LUG	2
9	462–B–72	HINGE DETAIL	1
10	869–00071	NUT, 1–1/4" x 7 UNC, GR.A STL	2
11	952–00225	WASHER, FLAT, 1–1/4"	1
12	550–00042	CAP, SIGHT PORT	1

ASSY NO.	ITEM #1	USED ON	"A"
656–C–8714	465–C–2359	15/30 PSI.	1/8"
656–8715	465–2360	125/150 PSI.	1/4"
		200 PSI.	3/8"
656–9000	465–2480	250 PSI.	1/2"
		300 PSI.	5/8"

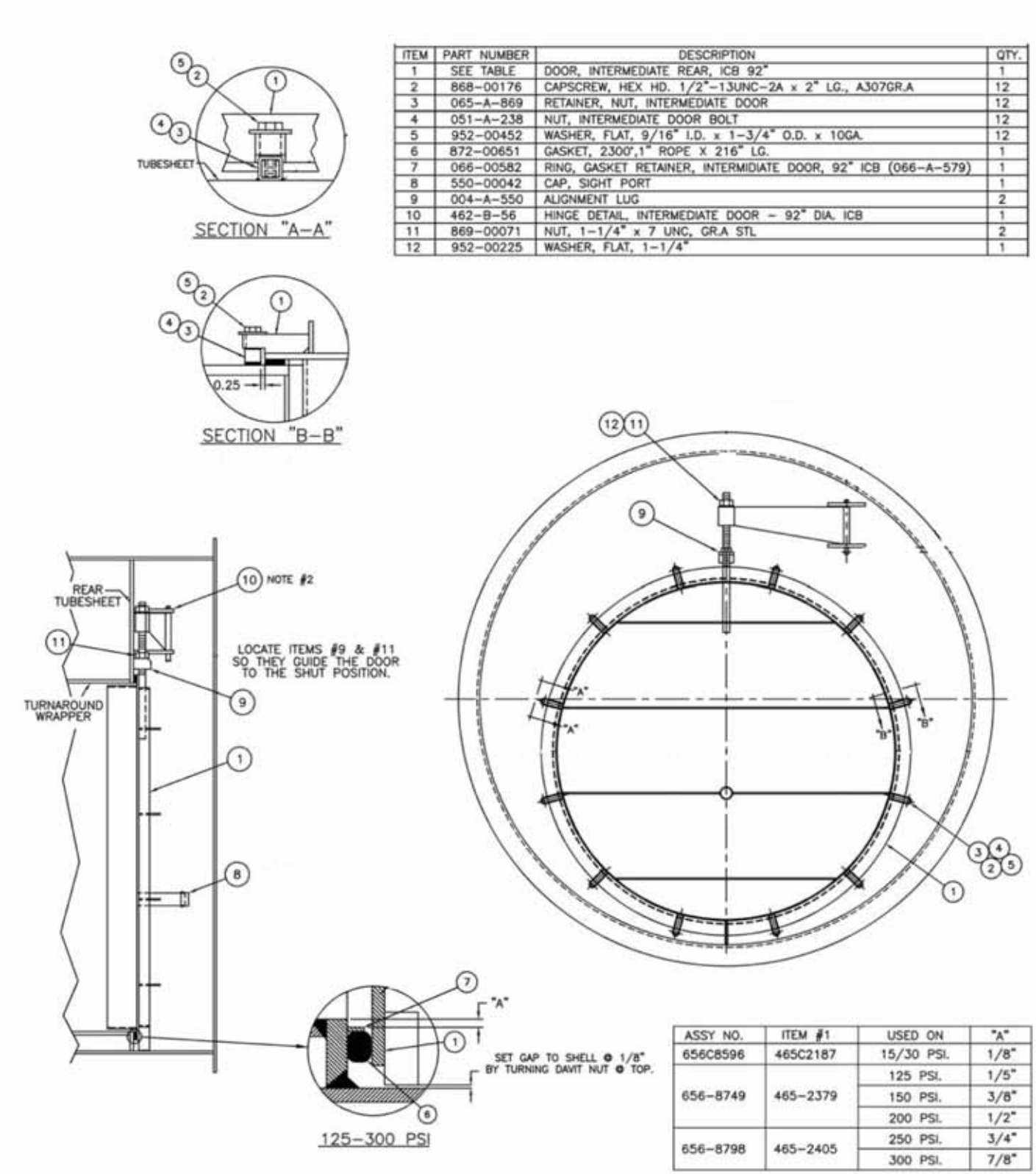
Figure 10-35. Rear Turnaround - 78”



ITEM	PART NUMBER	DESCRIPTION	QTY.
1	SEE TABLE	DOOR, TURNAROUND, INSULATED, 78"ICB	1
2	868-00176	CAPSCREW, HEX HD. 1/2"-13UNC-2A x 2" LG., A307GR.A	12
3	065-A-869	RETAINER, NUT, INTERMEDIATE DOOR	12
4	051-A-236	NUT, INTERMEDIATE DOOR BOLT	12
5	952-00452	WASHER, FLAT, 9/16" I.D. x 1-3/4" O.D. x 10GA.	12
6	872-00651	GASKET, 2300",1" ROPE X 180" LG.	1
7	066-00575	RING, GASKET RETAINER, INTERMEDIATE DOOR, 78" ICB (066-A-579)	1
8	004A00550	ALIGNMENT LUG	2
9	462-B-65	HINGE DETAIL	1
10	869-00071	NUT, 1-1/4" x 7 UNC, GR.A STL	2
11	952-00225	WASHER, FLAT, 1-1/4"	1
12	550-00042	CAP, SIGHT PORT	1

ASSY NO.	ITEM #1	USED ON	"A"
656C8641	465C2186	15/30 PSI.	1/8"
656-8646	465-2344	125 PSI.	3/8"
		150 PSI.	1/4"
		200 PSI.	3/8"
656-9001	465-2481	250 PSI.	5/8"
		300 PSI.	3/4"

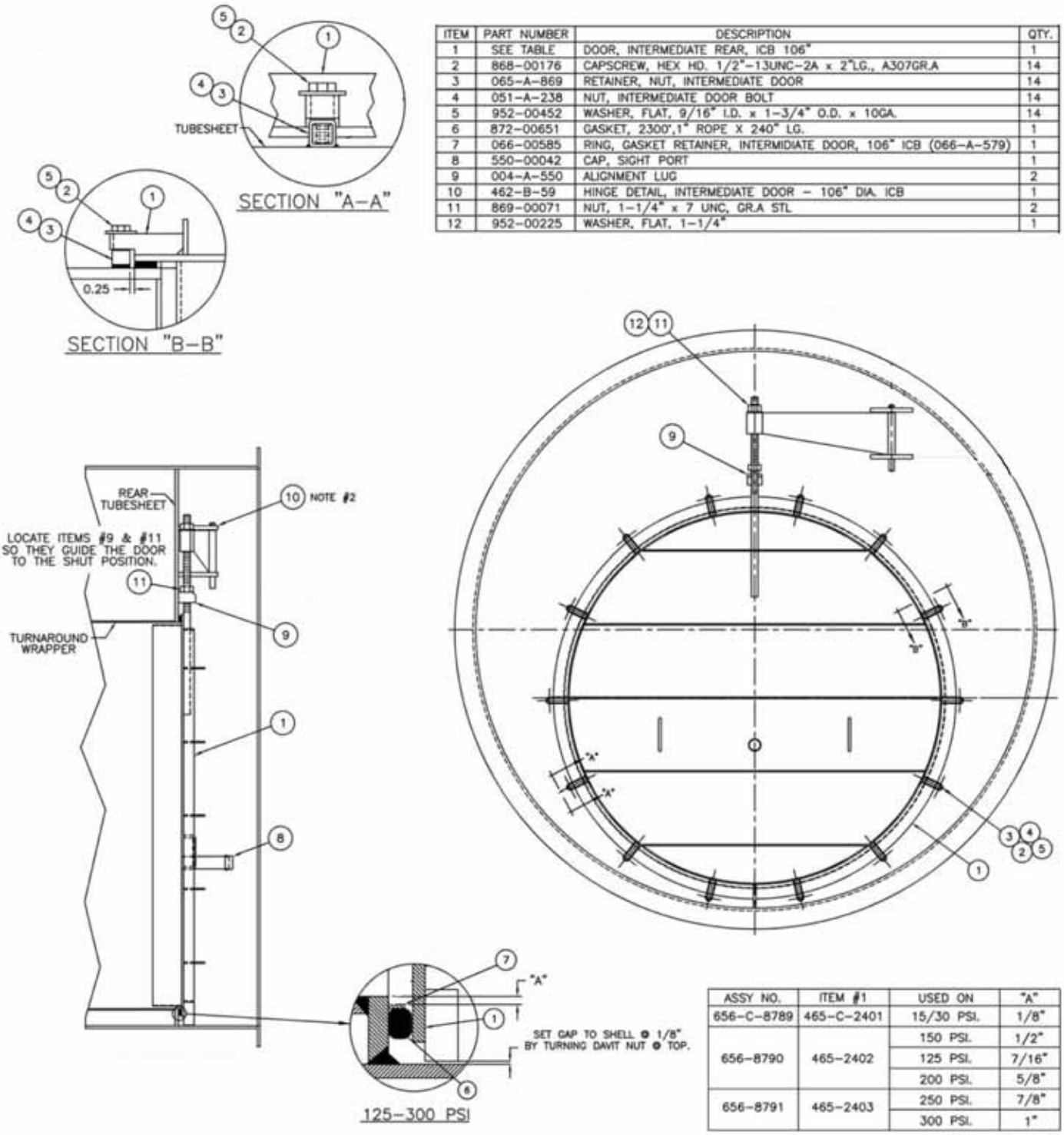
Figure 10-36. Rear Turnaround - 92”



ITEM	PART NUMBER	DESCRIPTION	QTY.
1	SEE TABLE	DOOR, INTERMEDIATE REAR, ICB 92"	1
2	868–00176	CAPSCREW, HEX HD. 1/2"–13UNC–2A x 2" LG., A307GR.A	12
3	065–A–869	RETAINER, NUT, INTERMEDIATE DOOR	12
4	051–A–238	NUT, INTERMEDIATE DOOR BOLT	12
5	952–00452	WASHER, FLAT, 9/16" I.D. x 1–3/4" O.D. x 10GA.	12
6	872–00651	GASKET, 2300",1" ROPE X 216" LG.	1
7	066–00582	RING, GASKET RETAINER, INTERMIDIATE DOOR, 92" ICB (066–A–579)	1
8	550–00042	CAP, SIGHT PORT	1
9	004–A–550	ALIGNMENT LUG	2
10	462–B–56	HINGE DETAIL, INTERMEDIATE DOOR – 92" DIA. ICB	1
11	869–00071	NUT, 1–1/4" x 7 UNC, GR.A STL	2
12	952–00225	WASHER, FLAT, 1–1/4"	1

ASSY NO.	ITEM #1	USED ON	"A"
656C8596	465C2187	15/30 PSI.	1/8"
656–8749	465–2379	125 PSI.	1/5"
		150 PSI.	3/8"
		200 PSI.	1/2"
656–8798	465–2405	250 PSI.	3/4"
		300 PSI.	7/8"

Figure 10-37. Rear Turnaround - 106”

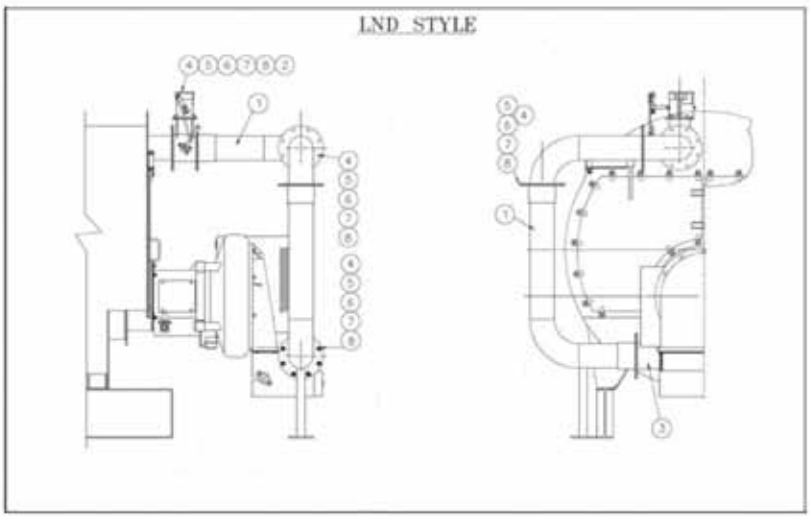


ITEM	PART NUMBER	DESCRIPTION	QTY.
1	SEE TABLE	DOOR, INTERMEDIATE REAR, ICB 106"	1
2	868–00176	CAPSCREW, HEX HD. 1/2"–13UNC–2A x 2"LG., A307GR.A	14
3	065–A–869	RETAINER, NUT, INTERMEDIATE DOOR	14
4	051–A–238	NUT, INTERMEDIATE DOOR BOLT	14
5	952–00452	WASHER, FLAT, 9/16" I.D. x 1–3/4" O.D. x 10GA.	14
6	872–00651	GASKET, 2300',1" ROPE X 240" LG.	1
7	066–00585	RING, GASKET RETAINER, INTERMIDIATE DOOR, 106" ICB (066–A–579)	1
8	550–00042	CAP, SIGHT PORT	1
9	004–A–550	ALIGNMENT LUG	2
10	462–B–59	HINGE DETAIL, INTERMEDIATE DOOR – 106" DIA. ICB	1
11	869–00071	NUT, 1–1/4" x 7 UNC, GR.A STL	2
12	952–00225	WASHER, FLAT, 1–1/4"	1

ASSY NO.	ITEM #1	USED ON	"A"
656–C–8789	465–C–2401	15/30 PSI.	1/8"
656–8790	465–2402	150 PSI.	1/2"
		125 PSI.	7/16"
		200 PSI.	5/8"
656–8791	465–2403	250 PSI.	7/8"
		300 PSI.	1"

Figure 10-38. FGR Piping - 4 Pass

BOILER DIA	BOILER HP	BURNER MODEL	ITEM #1 ASS'Y NO.	DESCRIPTION	DUCT I.D.	QTY "A"	ITEM #6 PART NO.	QTY "C"	QTY "E"	BOILER HP
55"	100 HP	LND 54P	0198712	INCLUDES FGR SHUTOFF VALVE	6"	40	853-550	5	1	100 HP
	125 HP	LND 84P								125 HP
60"	150 HP	LND 105P	0198713	INCLUDES FGR SHUTOFF VALVE	6"	40	853-550	5	1	150 HP
	200 HP	LND 125P								200 HP
72"	250 HP	LND 145P	0198714	INCLUDES FGR SHUTOFF VALVE	8"	40	853-868	5	1	250 HP
	300 HP	LND 175P								300 HP
78"	350 HP	LND 210P	0198715	INCLUDES FGR SHUTOFF VALVE	8"	40	853-868	5	1	350 HP
	400 HP	LND 252P								400 HP
92"	500 HP	LND 300P	0198716	INCLUDES FGR SHUTOFF VALVE	10"	60	853-869	5	1	500 HP
	600 HP	LND 315P								600 HP
106"	700 HP	LND 378P	0198717	INCLUDES FGR SHUTOFF VALVE	10"	60	853-869	5	1	700 HP
	800 HP	LND 420P								800 HP
	700 HP	LND 378P	019-773	WITHOUT FGR SHUTOFF VALVE	10"	48	853-869	4	0	700 HP
	800 HP	LND 420P								800 HP
		LNS1-462	019-807		14"	36	853-871	3	0	



ITEM	QTY	PART NO.	DESCRIPTION	OPTION
1	1	"M"	FGR DUCT ASSEMBLY	-
2	"B"	BY I.C.	FGR SHUTOFF VALVE	-
3	1	BY I.C.	FGR CONTROL VALVE	-
4	"N"	868-107	CAPSCREW, 3/4" - 10UNC x 2"	-
5	"N"	869-18	NUT, 3/4" - 10UNC	-
6	"N"	952-124	FLAT WASHER, 3/4"	-
7	"N"	952-95	LOCK WASHER, 3/4"	-
8	"Q"	"P"	GASKET, FGR FLANGE	-

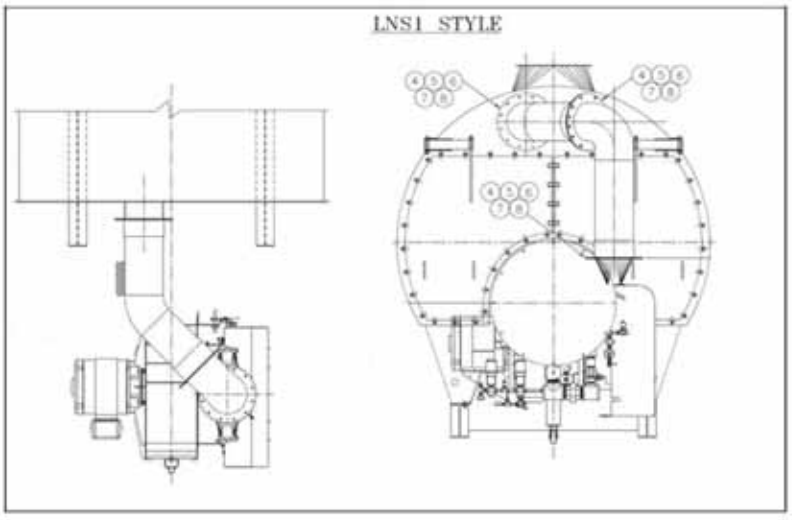


Figure 10-39. FGR Piping - 3 Pass

BOILER DIA	BOILER HP	BURNER MODEL	ITEM #1 ASS'Y NO. "N"	QTY "J"	QTY "K"	ITEM #15 PART NO. "L"	ITEM #10 PART NO. "M"	BOILER HP
55"	100 HP	LNB 54P	619B718	40	12	32-512	853-550	100 HP
	125 HP	LNB 63P	619-719					125 HP
60"	150 HP	LNB 84P	619-720	40	12	32-512	853-550	150 HP
	200 HP	LNB 105P	619-721					200 HP
72"	250 HP	LNB 143S	619-722	40	12	32-514	853-550	250 HP
		LNB 145P	619-829					
	300 HP	LNB 145P	619B723				853-868	300 HP
78"	350 HP	LNB 175P	619-724	40	12	32-514	853-868	350 HP
	400 HP	LNB 210P	619-725					400 HP
92"	500 HP	LNB 252P	619-726	40	12	32-515	853-868	500 HP
	600 HP	LNB 300P	619B727	60			853-869	600 HP
106"	700 HP	LNB 315P	619-728	60	12	32-515	853-869	700 HP
	800 HP	LNB 378P	619-729					800 HP

ITEM	QTY	PART NO	DESCRIPTION	OPTION
1	1	"N"	FGR DUCT ASSEMBLY	-
2	1	BY I.C.	FGR SHUTOFF VALVE	-
3	1	BY I.C.	FGR CONTROL VALVE	-
4	1	BY I.C.	FGR SPOOL ASSEMBLY	-
5	-	-	NOT USED	-
6	"J"	868-197	CAPSCREW, 3/4" - 10UNC x 2"	-
7	"J"	869-18	NUT, 3/4" - 10UNC	-
8	"J"	952-124	FLAT WASHER, 3/4"	-
9	"J"	952-95	LOCK WASHER, 3/4"	-
10	5	"M"	GASKET, FGR FLANGE	-
11	"K"	868-56	CAPSCREW, 3/8" - 16UNC x 1"	-
12	"K"	869-30	NUT, 3/8" - 16UNC	-
13	"K"	952-106	FLAT WASHER, 3/8"	-
14	"K"	952-93	LOCK WASHER, 3/8"	-
15	2	"L"	GASKET, RING, FLANGE FOR VENT PIPE	-

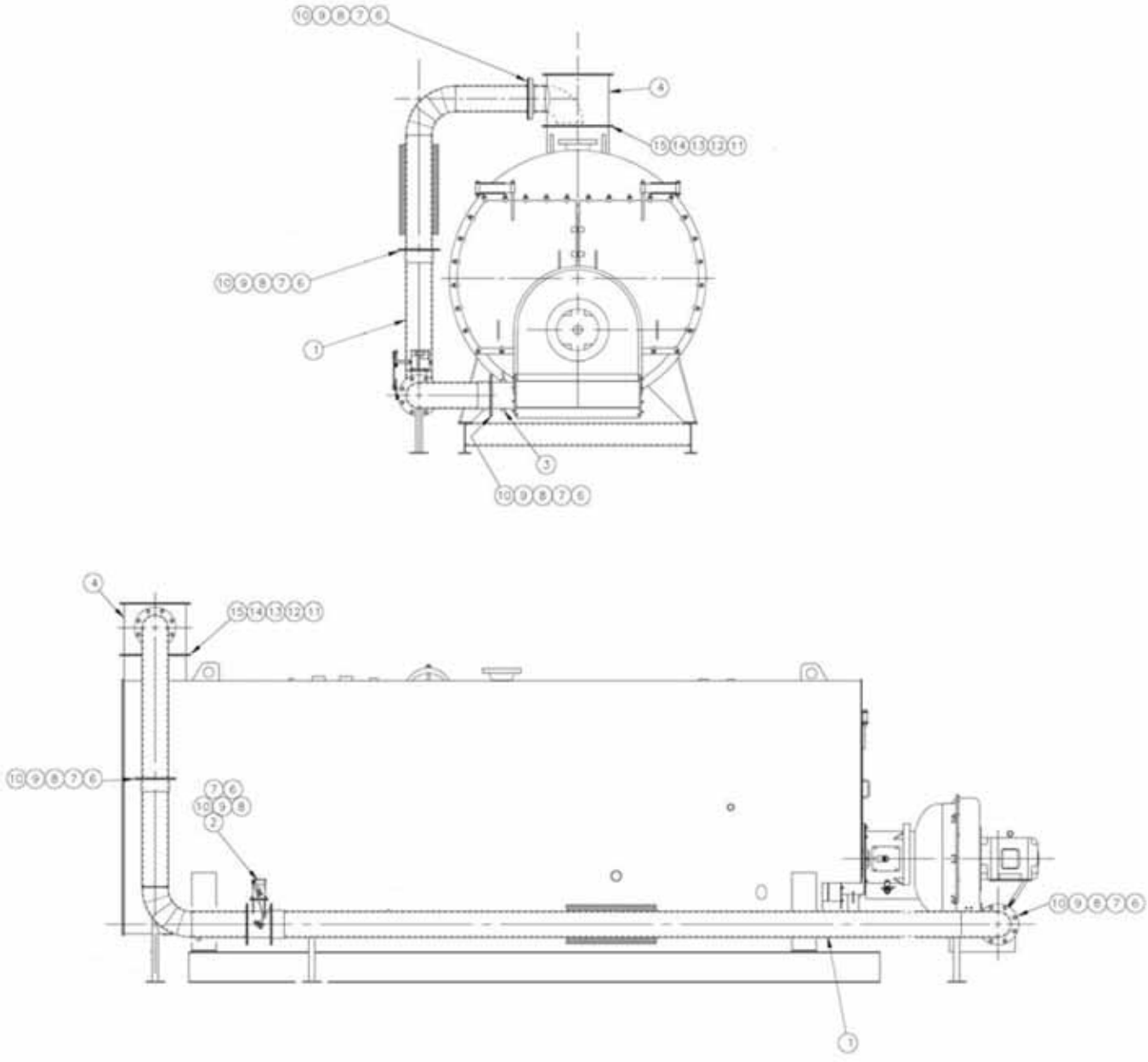


Figure 10-40. Feedwater Piping w/3 Valve Bypass

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"	50–125A H.P.
	2	941–333	941–693	VALVE, GATE, 1–1/2"	125–150 / 100S–225S 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"	50–125A H.P.
	1	941–144	941–404	VALVE, GLOBE, 1–1/2"	125–150 / 100S–225S 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 SEE NOTE 2	350–800 H.P.
4	1	SEE TABLE		VALVE, GLOBE SEE NOTE 3	350–800 H.P.
5	1	SEE TABLE		VALVE, CHECK SEE NOTE 3	50–125A H.P.
6	1	883306		BRACKET	ALL
7	1	SEE TABLE		STRAINER	SEIMENS FEEDWATER VALVE

TABLE–BOILER FEED VALVES ITEMS 4 & 5 (SEE NOTE 3)

HORSEPOWER	STEAM PRESS.	ITEM 4 PART NO.	ITEM 5 PART NO.
50–125A	150#	941–143	940–144
	200#	941–403	940–456
	250#–300#	941–1872	940–1380
125–150 100S–225S	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–"SIEMENS" FEEDWATER VALVES ITEM 3.

15# ST. BLR. HP.	15# ST. PROPORTIONAL	15# ST. BLR. HP.	15# ST. ON/OFF	150–250# ST. BLR. HP.	150–250# ST. PROPORTIONAL	150–250# ST. BLR. HP.	150–250# ST. ON/OFF
50–60	949–435	50	949–436	50–80	949–435	50	949–435
70–80	949–436	60–80	949–437	100–125	949–436	60–70	949–436
100–150	949–437	100–125	949–438	150–200	949–437	80–125	949–437
200	949–438	150–200	949–439	250–350	949–438	150	949–438
250–350	949–439	250–350	949–440	400–500	949–443	200–300	949–443
400–600	949–440	400–500	949–462	600–800	949–444	350–500	949–444
700–800	949–462	600–800	949–463			*600–800	949–441

*600–800HP: NOT AVAILABLE FOR 250#

TABLE–ITEM 7.

15–250# ST. BLR. HP.	15–250# ST. PART NO.
50–125A	923–439
125–150	923–440
100S–225S	923–440
200–300	923–441
*350–800	923–441
**350–800	923–442

*350–800HP 250#
**350–800 15–200#

NON–FLOOR STK. ITEMS 350–800 H.P. 15–200# 2–1/2" NPT. PIPING

FITTINGS	P/N	SIZE	QTY
PLUG	858–97	2–1/2"	1
UNION	858–180	2–1/2"	2
ELBOW	859–140	2–1/2"	1
TEE	859–40	2–1/2"	3
BULK PIPE	900–343	2–1/2"	

BUSHING (STL)	SIZE
847–481	2–1/2" X 3/4"
847–482	2–1/2" X 1"
847–483	2–1/2" X 1–1/4"
847–484	2–1/2" X 1–1/2"
847–485	2–1/2" X 2"

TABLE–FEEDWATER VALVE ITEM 3 (SEE NOTE 2)

	VENDOR NAME: JORDAN 15–300# MARK 33 SERIES PART NO.	OPT.	BARBER–COLMAN 15–250# PROPORTIONAL VP–SERIES PART NO.	OPT.	BARBER–COLMAN 15–250# ON–OFF VC–SERIES PART NO.	OPT.	HONEYWELL 15# STEAM PART NO.	OPT.	HONEYWELL 150–250# STEAM PART NO.	OPT.	SVF 4–20mA PART NO.	SVF 0–130 OHM PART NO.	BALLENGER 4–20mA PART NO.	BALLENGER 0–135 OHM PART NO.
VALVE SIZE														
3/4"	940–4908	6W	949–320	6S	949–311	6I	949–358	6N	949–83	6R	949–420	949–408	940–6723	940–6513
1"	940–4909	6X	949–321	6T	949–312	6J	949–359	6O	949–359	6O	949–421	949–409	940–6724	940–6514
1–1/4"	940–4910	6Y	949–322	6U	949–313	6K	949–360	6P	–		949–422	949–413	940–6725	940–6515
1–1/2"	940–4911	6Z	949–323	6V	949–314	6L	949–361	6Q	–		949–423	949–414	940–6726	940–6516
2"	940–4912	70	–		949–315	6M	–		–		949–424	949–415	940–6727	940–6517

NOTES:

1. UNLESS OTHERWISE NOTED ALL PIPE & NIPPLES TO BE SCH. 80 SMLS. STEEL AND ALL FITTINGS TO BE 300# M.I. WITH PIPE SIZES AS FOLLOWS– 50–125A H.P. 1–1/4" NPT.; 125–150 H.P., 1–1/2" NPT., 200–300 H.P., 2" NPT., 350–800 H.P. FOR 250#–300# ST, 2" NPT. FOR 350–800 H.P. FOR 15–200# ST 2–1/2" NPT. PIPING (NON–FLOOR STOCK) REFER TO FITTING TABLE.
2. SEE WORK ORDER FOR SPECIFIC FEEDWATER VALVE ITEM 3 REQUIRED BY CUSTOMER & REDUCE PIPE SIZE IN THIS AREA TO MATCH VALVE SIZE (IF NECESSARY) AS SHOWN.
3. ITEMS 4 & 5 ARE NOT COMPONENTS OF THE FEEDWATER 3 VALVE BY–PASS AND MAY NOT ALWAYS BE SUPPIED BY CLEAVER BROOKS. SEE WORK ORDER FOR REQUIREMENTS.
4. ITEM 6 IS REQUIRED FOR SHOP MOUNTED PIPING ONLY.
5. LOCATION OF HORIZONTAL & VERTICAL CENTERLINES AND TERMINATING POINT MAY BE A CUSTOMER REQUIRMENT. CHECK EMS AND DIMENSIONAL DIAGRAM FOR SPECIFIC REQUIREMENTS, ALSO ALL PIPING MUST CLEAR REAR FLANGE BY 12".
6. WHEN THREE VALVE BY PASS OPTION IS USED, THE OIL HEATER STEAM LINE (IF APPLICABLE) MUST BE REROUTED UP TO BOILER CENTERLINE AND THEN UP TO BOILER STEAM LINE CONNECTION.
7. USE ON 400HP LE WHEN GAS TRAIN AND FEEDWATER ON SAME SIDE.
8. ALTHOUGH PIPING IS PICTORIALLY INDICATED ON THE RIGHT HAND SIDE OF THE BOILER, INSTALLER SHOULD FOLLOW THE D.D. AND MIRROR IMAGE TO THE LEFT SIDE IF REQUIRED.

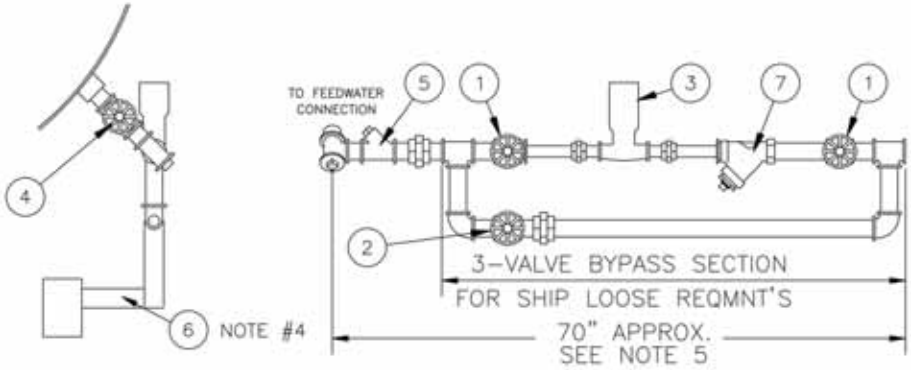


Figure 10-41. Surface Blowoff w/ & w/o Hydac and Sample Cooler

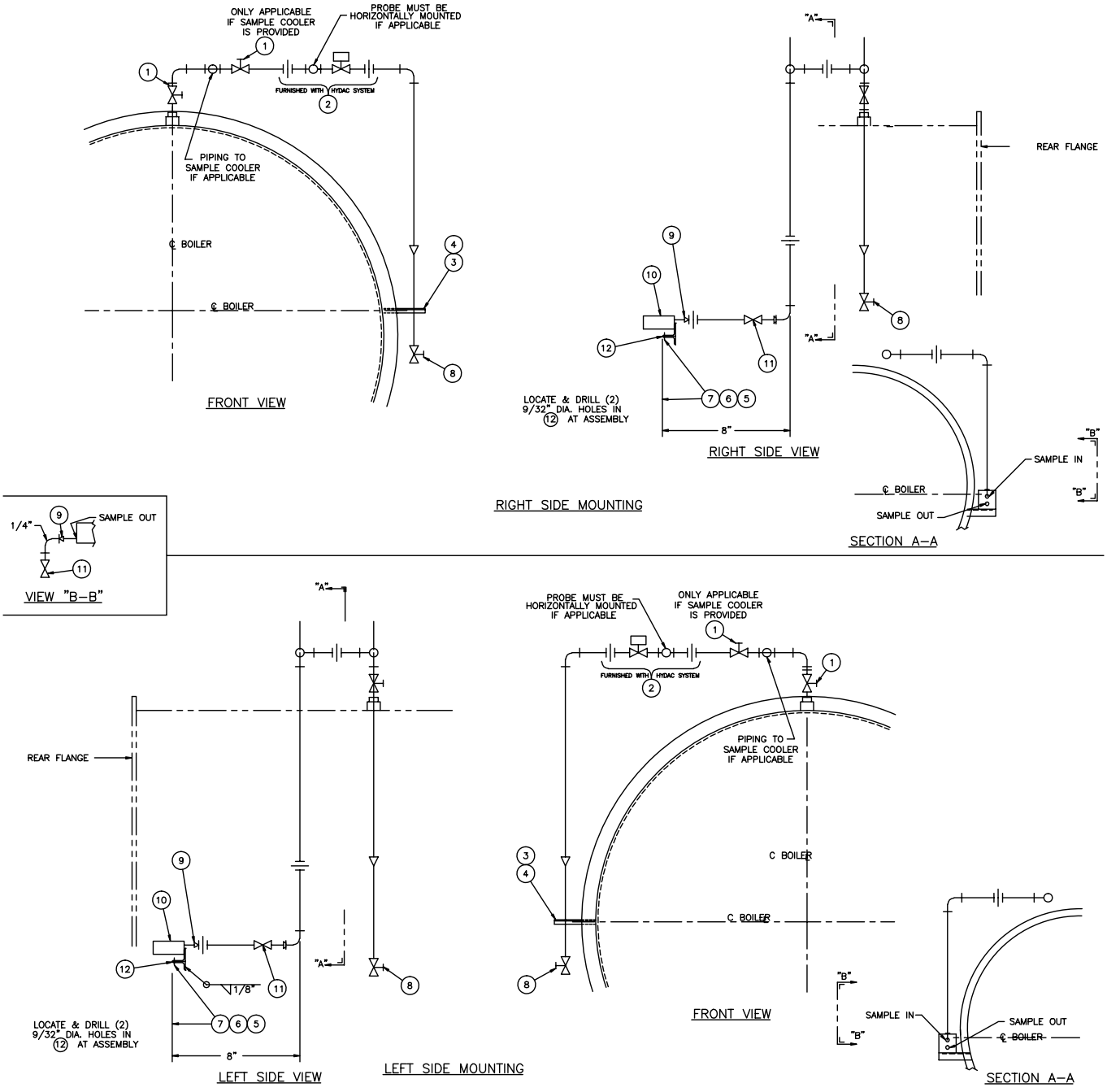


Figure 10-42. Surface Blowoff w/ & w/o Hydac and Sample Cooler

CONTINOUS SURFACE BLOWOFF					
ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OPT.
1	1	941-170	VALVE, GATE, 3/4" NPT	15-100HP	7A
				125-250 HP	7B
				300-800 HP & CBL	7C
2	–	–	NOT USED		
3	1	8-753	BRACKET	ALL	7A,7B,7C
4	1	841-1119	U-BOLT, 1/2" P.S.	15-250HP	
		841-1120	U-BOLT, 3/4" P.S.	300-800 HP & CBL	
6	–	–	–		
7	–	–	–		
8	1	941-1900	VALVE, FLOW CONTROL, 1/4" NPT	15-100HP	7A
		941-558	VALVE, FLOW CONTROL, 1/2" NPT	125-250 HP	7B
		941-1244	VALVE, FLOW CONTROL, 3/4" NPT	300-800 HP & CBL	7C

AUTOMATIC CONTINOUS SURFACE BLOWOFF					
ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OPT.
1	1	941-170	VALVE, GATE, 3/4" NPT	15-100HP	7A
				125-250 HP	7B
				300-800 HP & CBL	7C
2	1	817-2378	HYDAC VALVE AND ORFICE ASSY (SEE NOTE #5)	15-800 HP	7F
3	1	8-753	BRACKET	ALL	7A,7B,7C
4	1	841-1119	U-BOLT, 1/2" P.S.	15-250HP	
		841-1120	U-BOLT, 3/4" P.S.	300-800 HP & CBL	
6	–	–	–		
7	–	–	–		
8	1	941-1900	VALVE, FLOW CONTROL, 1/4" NPT	15-100HP	7A
		941-558	VALVE, FLOW CONTROL, 1/2" NPT	125-250 HP	7B
		941-1244	VALVE, FLOW CONTROL, 3/4" NPT	300-800 HP & CBL	7C

CONTINOUS SURFACE BLOWOFF W/ SAMPLE COOLER					
ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OPT.
1	2	941-170	VALVE, GATE, 3/4" NPT	15-100HP	7A
				125-250 HP	7B
				300-800 HP & CBL	7C
2	–	–	NOT USED		
3	2	8-753	BRACKET	ALL	7A,7B,7C,7D
4	2	841-1119	U-BOLT, 1/2" P.S.	15-250HP	
		841-1120	U-BOLT, 3/4" P.S.	300-800 HP & CBL	
6	–	–	–		
7	–	–	–		
8		941-1900	VALVE, FLOW CONTROL, 1/4" NPT	15-100HP	7A
	1	941-558	VALVE, FLOW CONTROL, 1/2" NPT	125-250 HP	7B
		941-1244	VALVE, FLOW CONTROL, 3/4" NPT	300-800 HP & CBL	7C
9	2	845-457	CONNECTOR, MALE, 1/4" ODT x 1/4" MPT	ALL	
10	1	863-510	SAMPLE COOLER		7D
11	2	941-2113	VALVE, GATE, 1/4"		7D
12	1	USE DROP	SIZED ANGLE, 3/8" x 2" x 2" x 10" LG.		7D

AUTOMATIC CONTINOUS SURFACE BLOWOFF W/ SAMPLE COOLER					
ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OPT.
1	2	941-170	VALVE, GATE, 3/4" NPT	15-100HP	7A
				125-250 HP	7B
				300-800 HP & CBL	7C
2	1	817-2378	HYDAC VALVE AND ORFICE ASSY (SEE NOTE 5)	15-800 HP & CBL	7F
3	2	8-753	BRACKET	ALL	7A,7B,7C,7D
4	2	841-1119	U-BOLT, 1/2" P.S.	15-250HP	
		841-1120	U-BOLT, 3/4" P.S.	300-800 HP & CBL	
6	–	–	–		
7	–	–	–		
8	1	941-1900	VALVE, FLOW CONTROL, 1/4" NPT	15-100HP	7A
		941-558	VALVE, FLOW CONTROL, 1/2" NPT	125-250 HP	7B
		941-1244	VALVE, FLOW CONTROL, 3/4" NPT	300-800 HP & CBL	7C
9	2	845-457	CONNECTOR, MALE, 1/4" ODT x 1/4" MPT	ALL	
10	1	863-510	SAMPLE COOLER		7D
11	2	941-2113	VALVE, GATE, 1/4"		7D
12	1	USE DROP	SIZED ANGLE, 3/8" x 2" x 2" x 10" LG.		7D

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