CLEAVER-BROOKS MODEL CBL PACKAGED BOILER

Operation, Service, and Parts Manual

800 through 1500 hp
Fuel: Light Oil, Heavy Oil, Gas or Combination

Manual Part No. 750-158

06-24-03

SAFETY PRECAUTIONS AND ABBREVIATIONS

Safety Precautions

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

The following symbols are used throughout this manual:

⚠ WARNING

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

⚠ CAUTION

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

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

Abbreviations

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

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

MODEL CBL
PACKAGED BOILER
Operation, Service, and Parts Manual

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

NOTE: If you have a HAWK ICS Boiler Management Control System, refer also to HAWK ICS Installation, Operating and Service Manual No. 750-229.

Manual Part No. 750-158

Printed in U.S.A.

⚠ WARNING

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

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

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

TO: Owners, Operators and/or Maintenance Personnel

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

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

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

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

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

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

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

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

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

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

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

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

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CHAPTER 1

Basics of Firetube Operation

A. GENERAL

Firetube boilers are available for low or high pressure steam, or for hot water applications. Firetube boilers are typically used for applications ranging from 15 to 1500 horsepower. A firetube boiler is a cylindrical vessel, with horizontal tubes passing through and connected to the front and rear tube sheets. 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 gasses 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.

Note: If your boiler is equipped with a HAWK ICS boiler management control system, refer to HAWK ICS Installation, Operating and Servicing Manual No. 750-229 for information regarding controls discussed in Chapter 1.

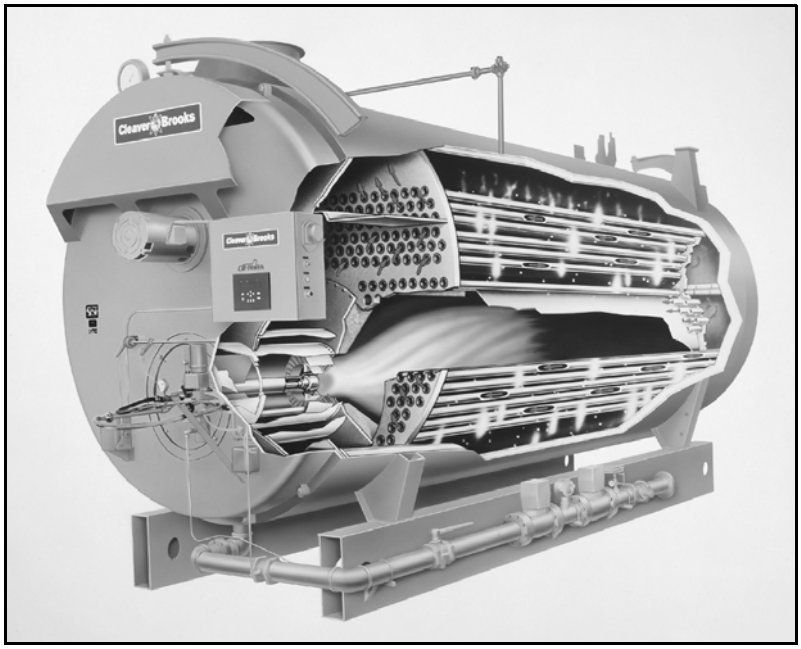


Figure 1-1: Firetube Cut Away

The general information in this manual applies directly to Cleaver-Brooks Model CBL Boilers in sizes ranging from 800 through1500 boiler horsepower for the following fuels:

Series 100 Light Oil (No. 2)
Series 200 Light Oil (No. 2) Or Gas
Series 700 Gas Only
Series 400 Heavy Oil (No. 6) or Gas
Series 600 Heavy Oil (No. 6)

Rated Capacity	800 through 1500 hp
Operating Pressure	Steam 15-225 psig. Hot Water 125 psig.
Fuel	Light Oil, Heavy Oil or Gas or Combination
Ignition	Automatic
Firing 800 1500 hp	Full Modulation
Burner (Oil)	No. 6 Oil: Air atomization No. 2 Oil: Air atomization
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.

B. THE BOILER

The Model CBL 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, CBL 700-1000 indicates a gas-fired 1000 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.

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

Steam 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 down-time, and prevention of costly

repairs. Care taken in placing the pressure vessel into initial service is vital. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove accumulations is described in Chapter 2.

The operator should be familiar with this manual 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, Power Boilers, of ASME Code.

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

D. STEAM CONTROLS (ALL FUELS)

1. Operating Limit Pressure Control: Breaks a circuit to stop burner operation on a rise of boiler pressure at a selected setting. It is adjusted to stop or start the burner at a preselected pressure setting.
2. High Limit Pressure Control: Breaks a circuit to stop burner operation on a rise of pressure above a selected

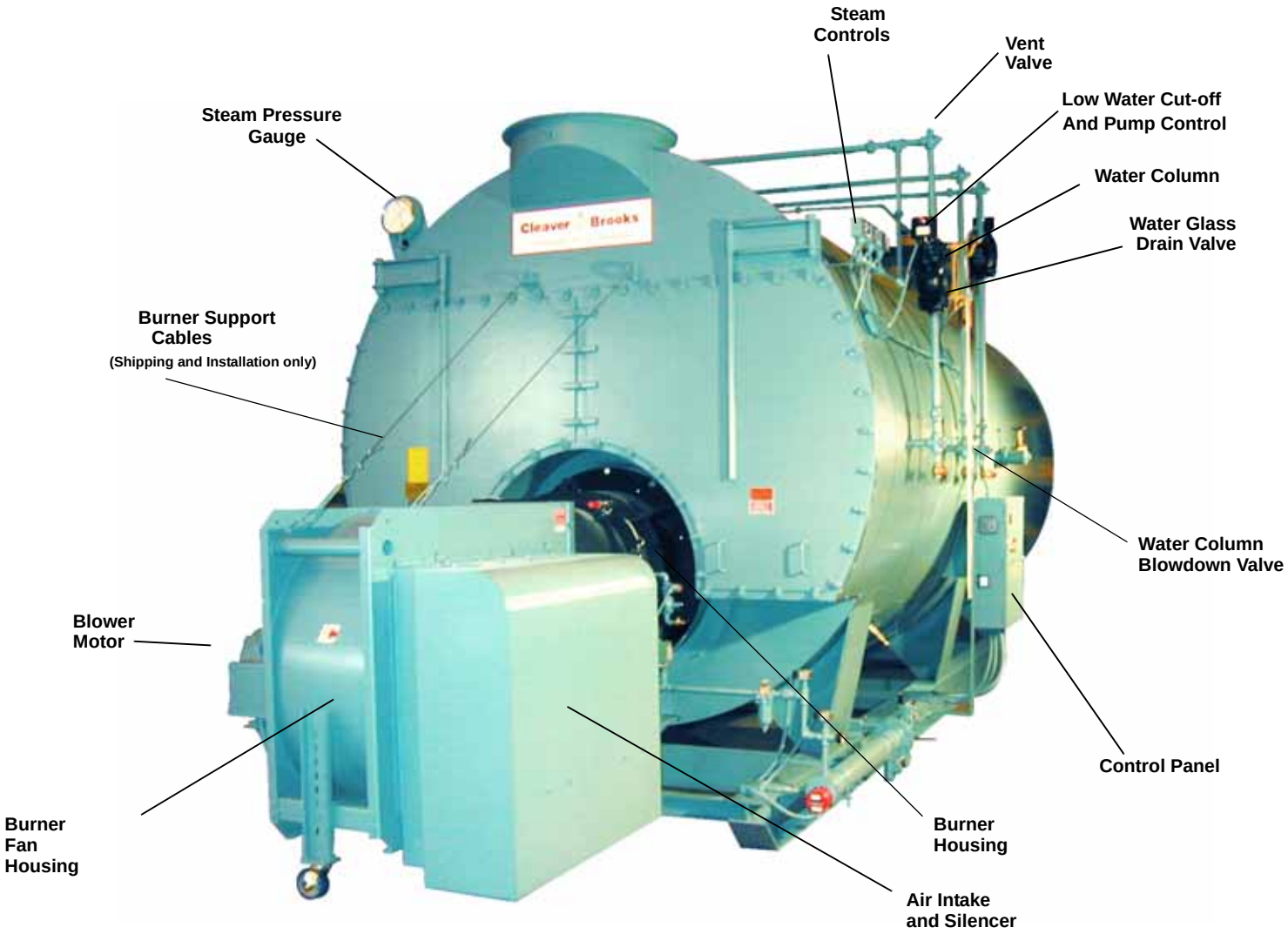


Figure 1-2: CBL Steam Boiler - Light Oil or Gas Fired

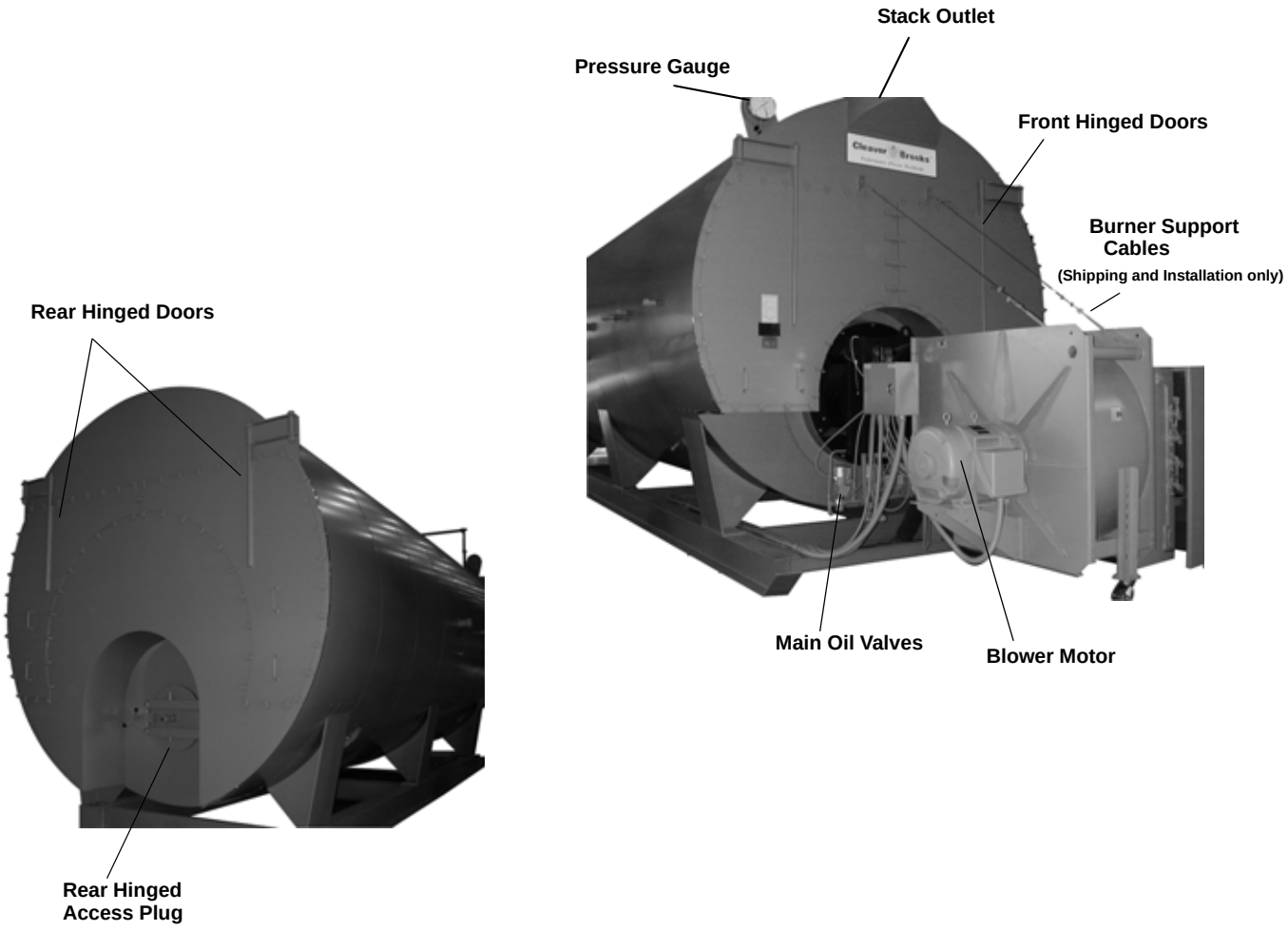


Figure 1-3: CBL Steam Boiler - Light Oil, Heavy Oil or Gas Fired

setting. It is adjusted to stop the burner at a preselected pressure above the operating limit control setting. The high limit pressure control is equipped with a manual reset.

3. Modulating Pressure Control: Senses changing boiler pressures and transmits the information to the modulating motor to change the burner firing rate when the manual-automatic switch is set on "automatic."

4. Low Water Cutoff and Pump Control: Float-operated control responds to the water level in the boiler. It performs two distinct functions:

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

   •Starts and stops the feedwater pump (if used) to maintain water at the proper operating level.

⚠ CAUTION

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

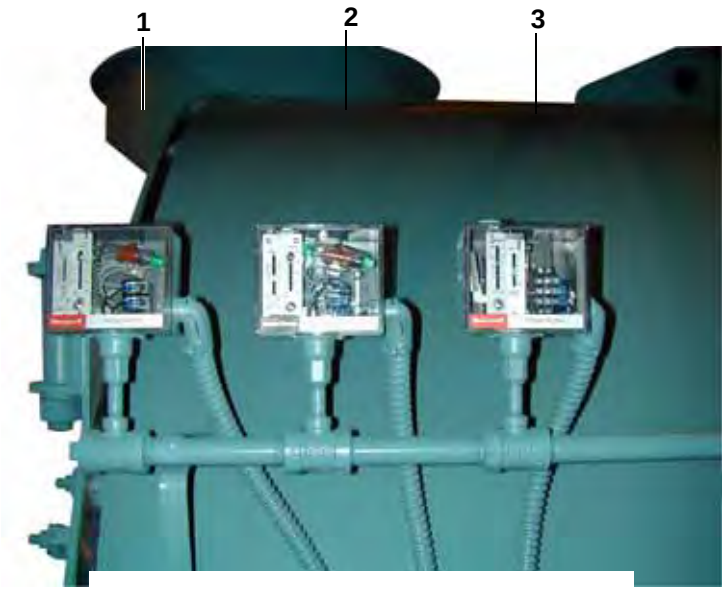


Figure 1-4: Steam Controls

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

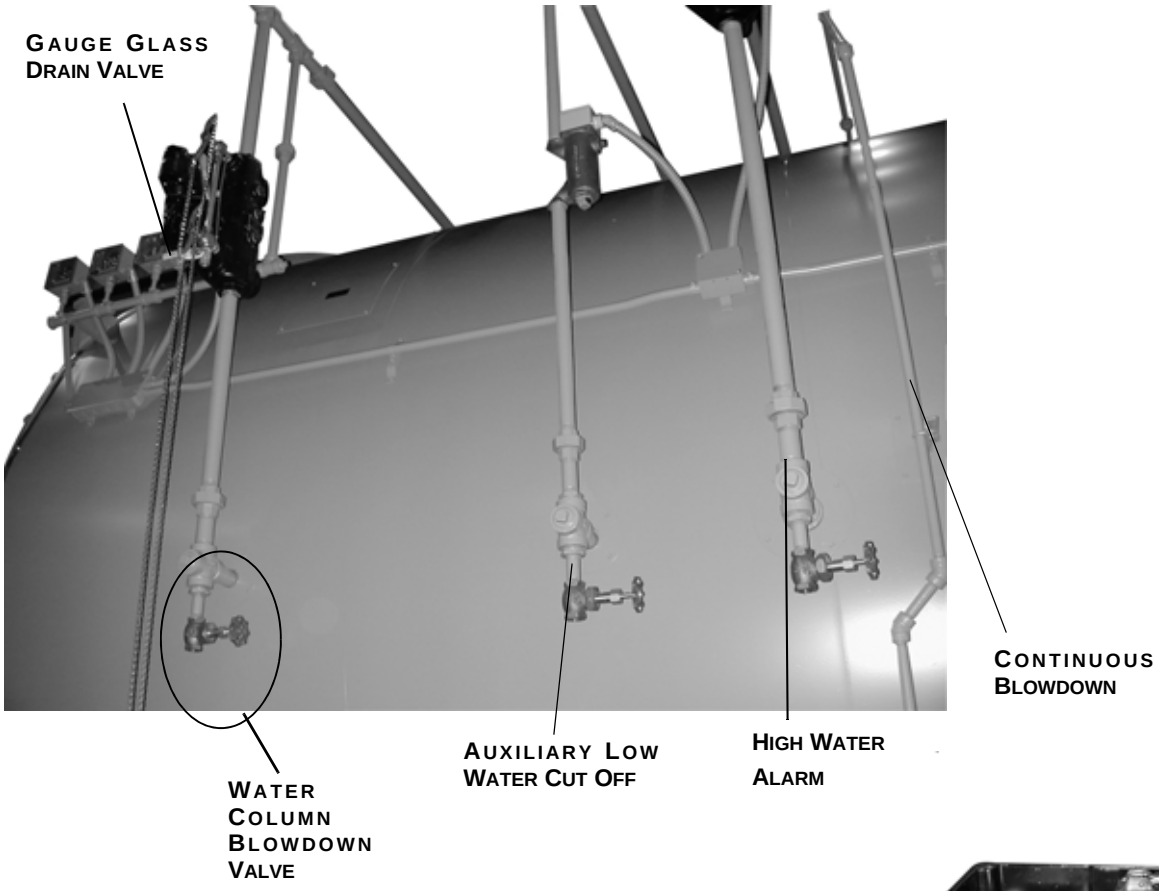


Figure 1-5: Water Column Assembly

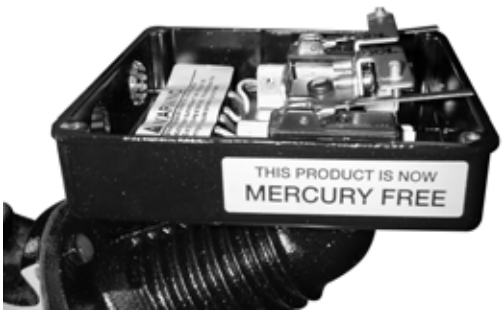


Figure 1-6: Low Water Cut Off Snap Switches

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

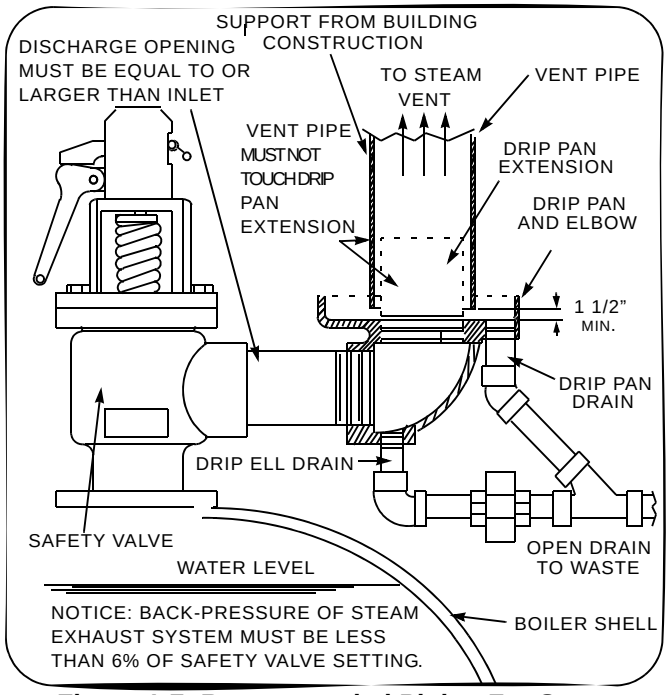


Figure 1-7: Recommended Piping For Steam

A drip pan elbow or a flexible connection between the valve and the escape pipe is recommended. The discharge piping must be properly arranged and supported so that its weight does not bear upon the valve.

Do not paint, oil, or otherwise cover any interior or working parts of the safety valve. A valve does not require any lubrication or protective coating to work properly.

Figure 1-8: Safety Valves

⚠WARNING

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

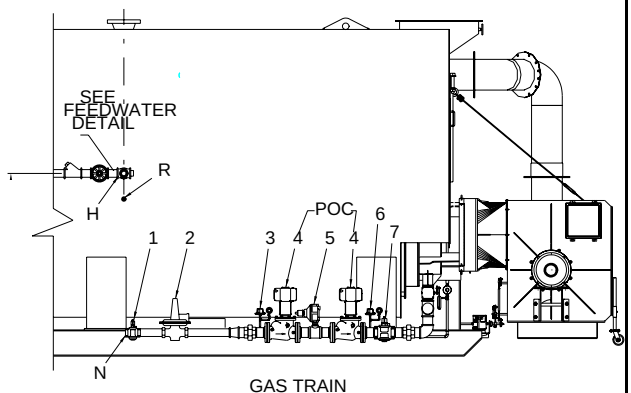
E. HOT WATER CONTROLS (ALL FUELS)

1. Water Temperature Gauge: Indicates the boiler internal water pressure.
2. Operating Limit Temperature Control: Breaks a circuit to stop burner operation on a rise of boiler temperature at a selected setting. It is adjusted to stop or start the burner at a preselected operating temperature.
3. High Limit Temperature Control: Breaks a circuit to stop burner operation on a rise of temperature at a selected setting. It is adjusted to stop burner at a preselected temperature above the operating control setting. The high limit temperature control normally is equipped with a manual reset.
4. Modulating Temperature Control : Senses changing boiler water temperature and transmits the information to the modulating motor to change the burner firing rate when the manual-automatic switch is set on “automatic.”
5. Low Water Cutoff: Breaks the circuit to stop burner operation if the water level in the boiler drops below safe operating point, activating low-water light and optional alarm bell if burner is so equipped.
6. Auxiliary Low Water Cutoff (Optional): Breaks the circuit to stop burner operation if the water level in the boiler drops below the master low-water cutoff point.
7. Safety Valve(s): Relieves the boiler of pressure higher than the design pressure or a lower pressure, if designated. Relief valves and their discharge piping are to be installed to conform to ASME Code requirements.

⚠WARNING

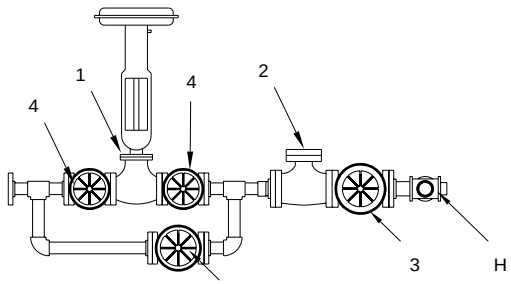
Only properly certified personnel such as the relief valve manufacturer’s certified representative can adjust or repair the boiler relief valves. Failure to follow these instructions could result in serious personal injury or death.

ITEM	REQ	DESCRIPTION
1	1	LUBRICATED PLUG VALVE - 2"
2	1	GAS PRESSURE REGULATOR - 2" NPT
3	1	LOW GAS PRESSURE SWITCH
4	2	MOTORIZED GAS VALVE
5	1	MAIN VENT VALVE - 2"
6	1	HIGH GAS PRESSURE SWITCH
7	1	LUBRICATED PLUG VALVE - 4"



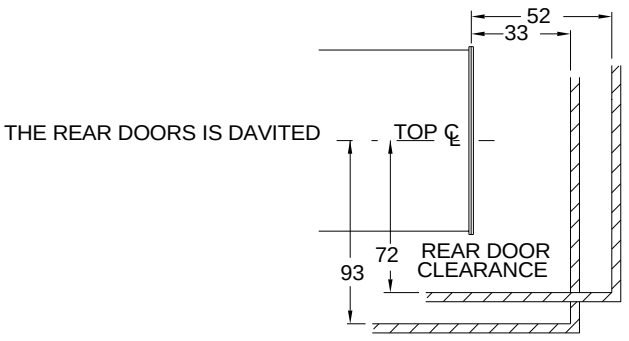
GAS TRAIN
PARTIAL LEFT SIDE VIEW

4	2	GATE VALVE, 2" 300 LB. FLG`D
5	1	GLOBE VALVE, 2" 300 LB. FLG`D



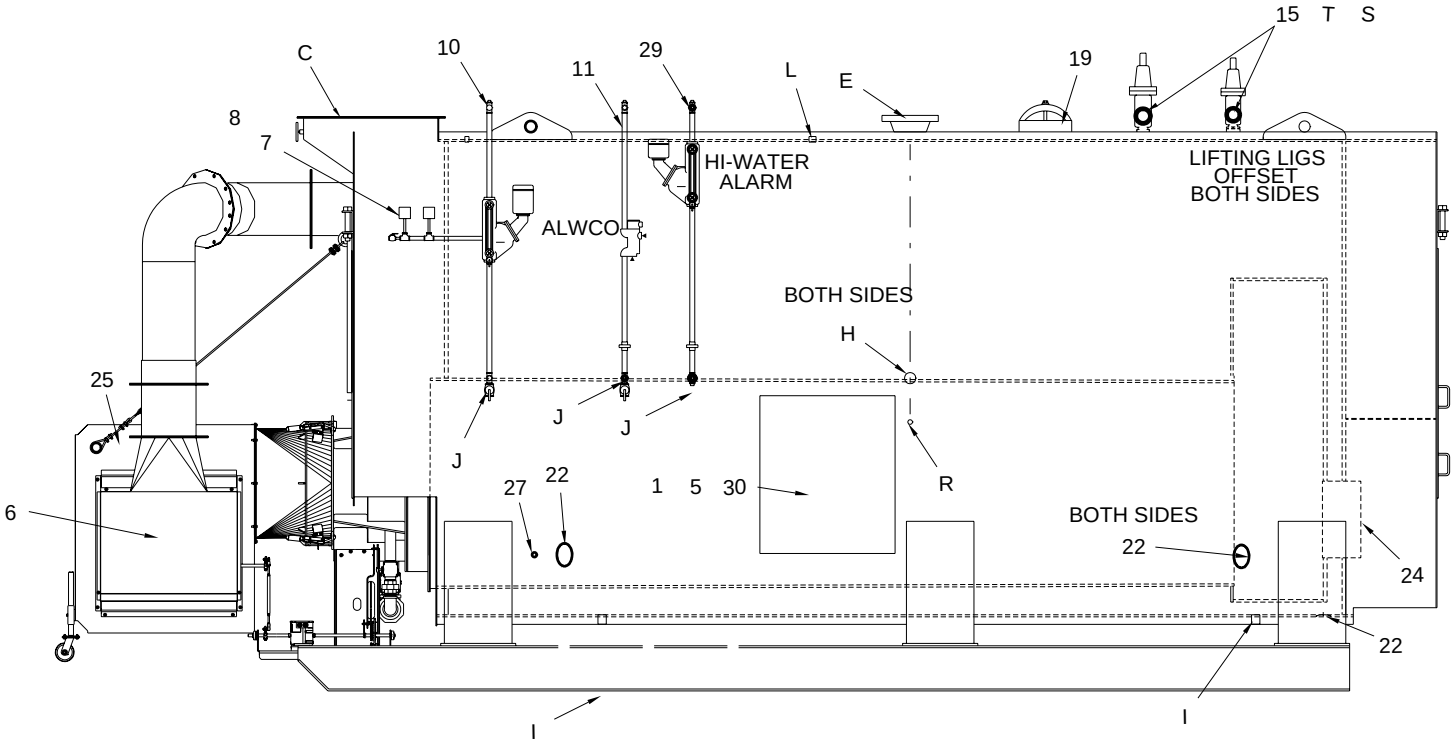
FEEDWATER PIPING (LH VIEW)

BOILER CLEARANCES

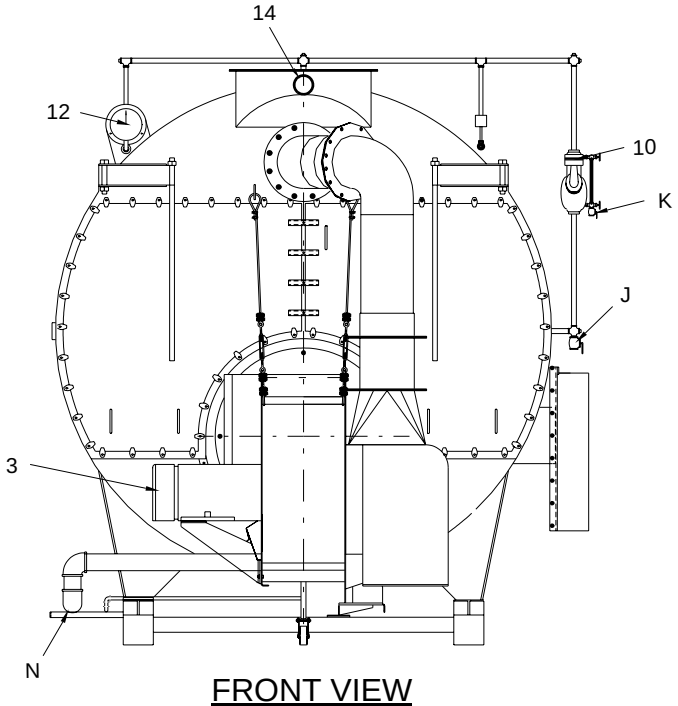


ITEM	MAJOR COMPONENTS
1	CONTROL PANEL
2	N/A
3	BLOWER MOTOR
4	N/A
5	COMBUSTION SAFEGUARD CONTROL- CB HAWK
6	FLAME SCANNER - ULTRAVIOLET
7	SENSOR
8	HI-LIMIT, HONEYWELL
9	N/A
10	WATER COLUMN - MCDONNEL & MILLER 194-7B
11	AUXILIARY LOW WATER CUTOFF / WARRICK C2
12	STEAM GAUGE
13	
14	STACK THERMOMETER (SHIPPED LOOSE)
15	SAFETY VALVE - (2) SET AT 250 PSI (SHIPPED LOOSE)
16	-
17	N/A
18	N/A
19	MANWAY
20	N/A
21	N/A
22	HANDHOLES
23	N/A
24	REAR SIGHT PORT
25	BURNER
26	N/A
27	N/A
28	N/A
29	HIGH WATER ALARM, MCDONNEL MILLER 94
30	ALARM BELL W/ SILENCING DEVICE

ITEM	SERVICE CONNECTIONS
A	ELECTRIC-MAIN POWER SUPPLY 460/3/60
B	N/A
C	EXHAUST VENT PIPE 36" OD
D	VENT FLANGE (SEE DETAIL)
E	STEAM OUTLET - 10" 300# R.F. FLANGE
F	N/A
G	N/A
H	FEED WATER (2) 3.0 NPS (EACH SIDE)
I	BLOWDOWN/DRAIN (2) 2.0 NPS
J	WATER COLUMN BLOWDOWN - .75 NPS
K	GAUGE GLASS BLOWDOWN - 0.25 NPS
L	
M	N/A
N	GAS TRAIN CONN.- 2-1/2 NPS
0	MIN GAS PRESSURE REQUIRED IS 200" ON THE INLET OF PRESSURE REGULATOR
P	N/A
Q	N/A
R	CHEMICAL FEED - 0.75 NPS (BOTH SIDES)
S	SAFETY VALVE - (1) 2.5" NPT OUTLET
T	SAFETY VALVE - (1) 3" NPT OUTLET



SIDE VIEW



FRONT VIEW

Notes

CHAPTER 2

Waterside Care And Requirements

A. GENERAL

The operator should be familiar with the complete manual before attempting to place the unit into operation.

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

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

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. It is vital that care be taken in placing the pressure vessel into initial service. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove the accumulations is described later in Chapter 2.

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

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

B. WATER REQUIREMENTS

1. HOT WATER BOILER

Air Removal

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 by-pass 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 by-passed. 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 2-1.

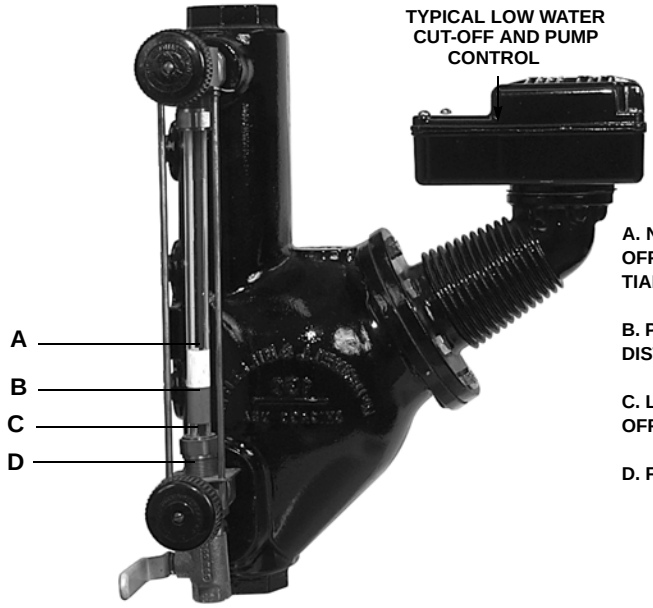
When initially firing a newly installed boiler, or when cutting an existing boiler into an operating system, the boiler or boilers to be cut into operation MUST be pressurized equal to the system and/or other boilers prior to opening the header valves.

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 over-emphasized that rapid changes in temperature within the boiler can, and sometimes do, cause damage.

MAXIMUM CIRCULATION RATE, GPM											
BHP	OUTPUT					TEMP DROP (F)					
	MMBTU/HR	10	20	30	40	50	60	70	80	90	100
800	26.78	5358	2679	1786	1340	1072	893	765	670	595	536
900	30.13	6028	3014	2009	1507	1206	1005	861	753	670	603
1000	33.48	6698	3349	2233	1674	1340	1116	957	837	744	670
1100	36.82	7367	3684	2456	1842	1473	1228	1052	921	819	737
1200	40.17	8037	4019	2679	2009	1607	1340	1148	1005	893	804
1300	43.52	8707	4353	2902	2177	1741	1451	1244	1088	967	871
1400	46.87	9377	4688	3126	2344	1875	1563	1340	1172	1042	938
1500	50.21	10047	5023	3349	2512	2009	1674	1435	1256	1116	1005

Table: 2-1 Maximum Circulating Rate in Gallons Per Hour For Hot Water Boilers



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 A-B IS APPROXIMATELY3/4 INCH.

C. LOW WATER CUT-OFF POINT BURNER WILL SHUT OFF IF WATER LEVEL LOWERS TO THIS POINT.

D. FIRST VISIBLE POINT IN THE GAUGE GLASS.

Figure 2-1: Low Water Cutoff Sight Gauge

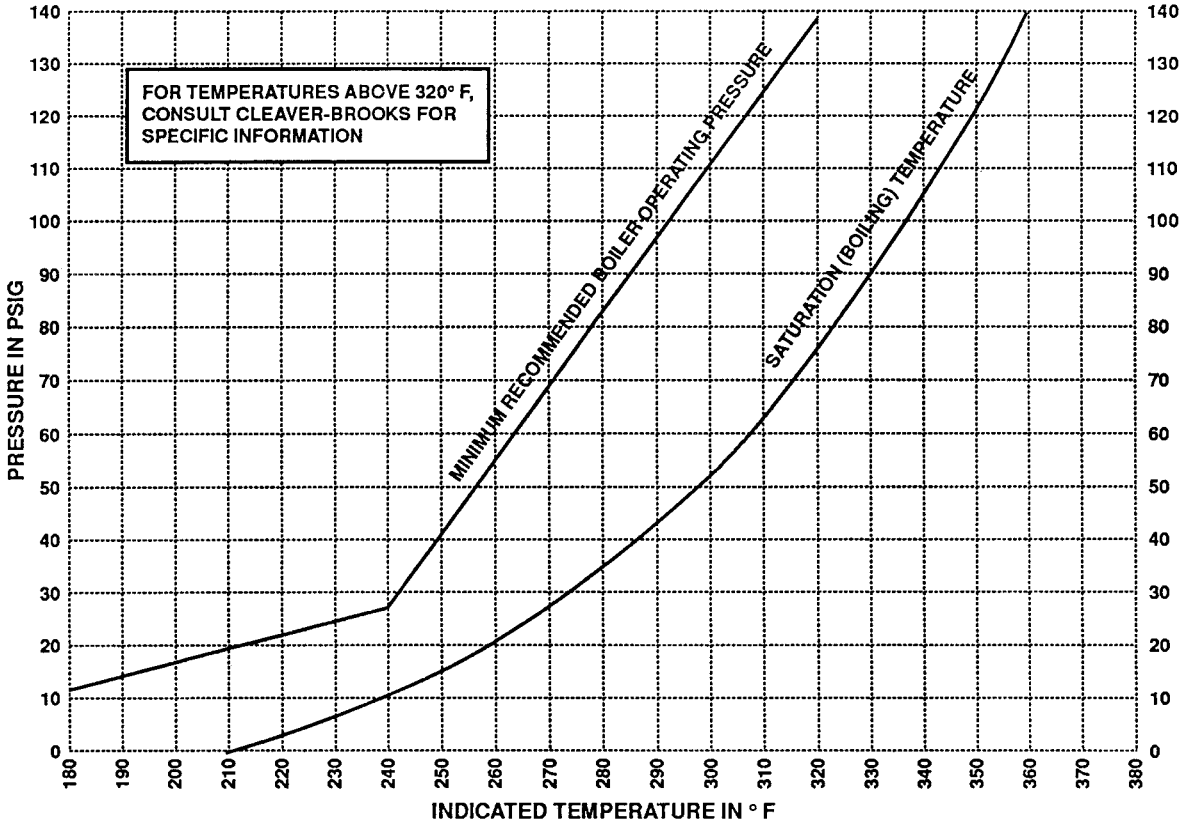


Figure 2-2: Internal Boiler Pressure

2. STEAM BOILER

Feed Pump Operation

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 shown in Figure 2-1.

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.

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, lead 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 the 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 down-time.

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.

E. 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.

Refer to Chapter 1, Section D-10 for valve installation instructions.

(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.

F. 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.

ITEM	REQ	DESCRIPTION
1	1	SLOW OPEN VALVE, EVERLASTING 4060-S 2" 300 LB FLG`D
2	2	QUICK OPEN VALVE, EVERLASTING 4000-S 2" 300 LB FLG`D

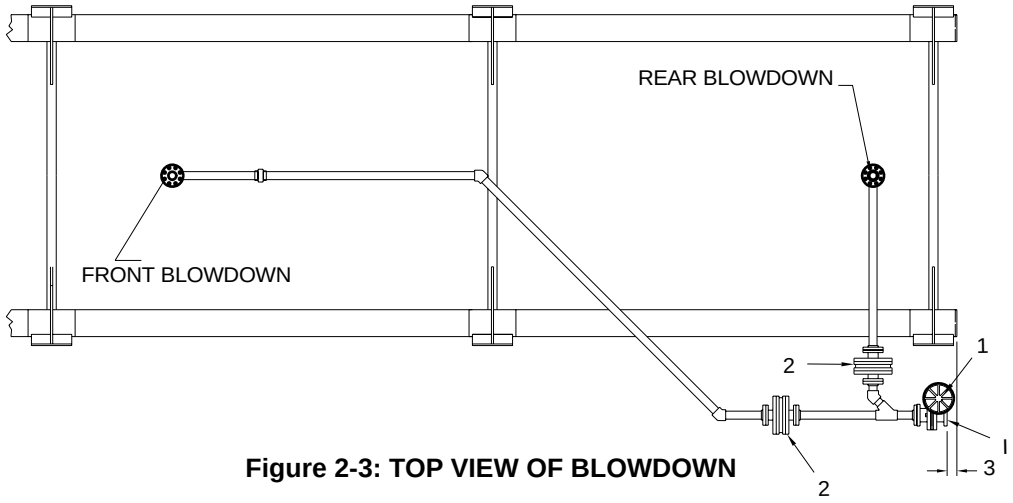


Figure 2-3: TOP VIEW OF BLOWDOWN

G. BLOWDOWN STEAM BOILER

Boiler water blowdown is the removal of some of the concentrated water from the pressure vessel and its replacement with feedwater so that the lowering of the concentration of solids in the boiler water occurs.

Solids are brought in by the feedwater even though the water is treated prior to use through external processes that are designed to remove unwanted substances which contribute to scale and deposit formations. However, none of the processes can remove all substances. Regardless of their high efficiency, some solids will be present in the boiler feedwater.

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

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

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

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

1. TYPES OF BLOWDOWN

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

Intermittent Manual Blowdown

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

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

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

Continuous Blowdown

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

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

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

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

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

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.

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 blow down 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.

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

Close the downstream (slow opening) valve first and as fast as possible. Then close the valve next to the boiler. Slightly crack the downstream valve and then close it tightly.

Under no circumstances should a blow-off valve be left open and the operator should never leave until the blowdown operation is completed and the valves are closed.

H. PERIODIC INSPECTION

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

⚠WARNING

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

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

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

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

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

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

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

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

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

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

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

I. PREPARATION FOR EXTENDED LAY-UP

Many boilers used for heating or seasonal loads or for stand-by 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 job-site 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 will 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 shut town. 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 anti-corrosive 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 stand-by 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

Installation, Operation and Adjustments

Model Designations, Sizes and Inputs

Model designations are based on the type of fuel(s) to be fired and the amount of furnace

pressure to be overcome. Burner size is based on firing rate (maximum input in BTU/HR)."

THE INSTALLATION OF A BURNER SHALL BE IN ACCORDANCE WITH THE REGULATIONS OF AUTHORITIES HAVING JURISDICTION. THE EQUIPMENT MUST BE INSTALLED IN ACCORDANCE WITH APPLICABLE LOCAL, STATE OR PROVINCIAL INSTALLATION REQUIREMENTS INCLUDING THE NATIONAL ELECTRICAL CODE (NEC) AND ASSOCIATED INSURANCE UNDERWRITERS. WHERE APPLICABLE, THE CANADIAN GAS ASSOCIATION (CGA) B149 AND CANADIAN STANDARD ASSOCIATION (CSA) B140 AND B139 (FOR OIL BURNERS) CODES SHALL PREVAIL.

OIL AND GAS BURNING EQUIPMENTS SHALL BE CONNECTED TO FLUES HAVING SUFFICIENT DRAFT AT ALL TIMES, TO ASSURE SAFE AND PROPER OPERATION OF THE BURNER.

THE BURNERS ARE DESIGNED TO BURN EITHER GAS OR LIGHT OIL No.1 OR 2 AS DEFINED BY ASTM D396-1978 SPECIFICATIONS.
DO NOT USE GASOLINE, CRANKASE OIL, OR ANY OIL CONTAINING GASOLINE.

BURNER H.P.	MAX.BURNER GAS INPUT BTU/HR.
800	33,600,000
900	37,800,000
1000	42,000,000
1100	46,200,000
1200	50,400,000
1300	54,600,000
1400	58,800,000
1500	63,000,000

Gas input based on natural gas at 1,000 Btu/cu.ft and 0.60 specific gravity.

BURNER H.P.	MAX.BURNER OIL INPUT U.S.G.P.H.
800	240
900	270
1000	300
1100	330
1200	360
1300	390
1400	420
1500	450

Oil input based on No.2 oil at 140,000Btu/gal.

INTRODUCTION

A. GENERAL INFORMATION

Cleaver-Brooks burners are assembled, wired and tested at the factory. They are constructed according to the Underwriters Laboratory code, NFPA-85, I.R.I., F.M., including the National Electrical Code (NEC) and associated insurance underwriters. Where applicable, the Canadian Gas Association (CGA) B149 and Canadian Standards Association (CSA) B140 codes shall prevail. Other regulatory agency control options are available.

The operator must be familiar with the individual functioning of all controls to understand the operations and procedures described in this manual. Identify and locate each item in the illustrations as they are described in the following sections.

B. DESCRIPTION

The Cleaver-Brooks 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.

The 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.

C. OPERATING CONTROLS

The burner is supplied with a remote control panel and with a burner mounted junction box.

CONTROL PANEL

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

1. ON-OFF BURNER SWITCH - (for gas or oil only)

2. FUEL SELECTOR SWITCH - Gas-Off-Oil
(for combination gas-oil burners only)
Gas position: Selects gas as the firing fuel .
Off position: Burner off.
Oil position: Selects oil as the firing fuel.

3. CONTROL CIRCUIT BREAKER
Supplementary low overcurrent protection only. No larger than 15 amps.

4. AUTO-MANUAL
MODULATION SELECTOR SWITCH.
Auto Position: Selects boiler modulation control.
Manual Position: Selects 135 ohm potentiometer for manual modulating control.

5. MANUAL MODULATING CONTROL (135 ohm)
Increases or decreases the burner firing rate manually.

6. SIGNAL LAMPS.
a. POWER ON (white) illuminates when the control circuit is energized (powered).

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

c. MAIN FUEL (green) illuminates when the main fuel valve or valves (gas or oil) are energized (open).

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

D. FLAME SAFEGUARD CONTROLS

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.

E. COMBUSTION AIR HANDLING SYSTEM

The combustion air handling system consists of two major components:

1. DAMPER ASSEMBLY.
A multi blade system regulates the combustion air volume and is positioned by a modulating motor. The dampers are 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 hertz or 60 hertz power and for firing against either moderate or high furnace pressure. For higher altitudes and higher furnace pressures, motor and impeller combinations are determined at the factory.

F. 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 valve and/or gas volume butterfly valves 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. Lever on the modulating motor shafts actuate the high fire position proving switch.

G. FIRING HEAD

Access to the firing head is provided by swinging open the impeller housing. 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.

H. OIL SYSTEM AIR ATOMIZING

The burner use compressed air for atomization. Atomizing air is independent of combustion air. The 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 (normally closed 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 normally closed port.

NOZZLE ASSEMBLY.

The nozzle assembly consists of four main parts: body, compression spring, swirler, and tip. The swirler 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 swirler. Oil is forced from the core of the swirler to the side ports where it meets with the atomizing air. Atomizing air enters and passes through the nozzle body to grooves in the swirler, 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.

OIL STRAINER.

Prevents foreign matter from entering the burner oil system.

ATOMIZING AIR PROVING SWITCH.

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

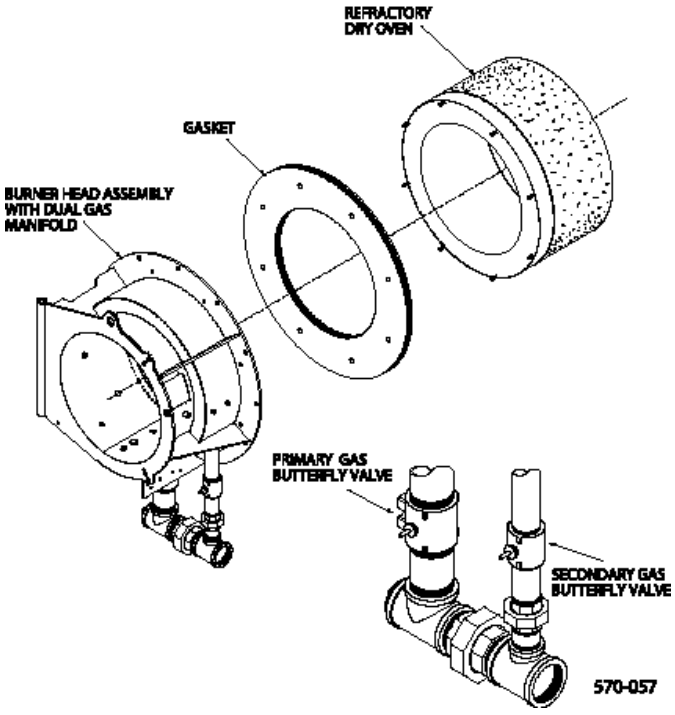


Figure 3-1: Firing Head Assembly

SEPARATE COMPRESSOR MODULE.

All burners have, a burner mounted oil metering unit and a separate compressor module. The system functions as follows:

AIR COMPRESSOR MODULE.

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.

The oil metering unit is a MAXON Synchro flow control valve. The multiple screw cam assembly provides mechanical adjustment capabilities to the fuel ratio at each valve position throughout the entire capacity range.

OPERATION

Fuel is delivered to the metering system at 50 to 70 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.

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 valve located on the compressor air breather. The valve allows air to be bled from the tank to the compressor inlet. Delivery rate of the fuel oil metering is controlled by the modulating motor through adjustable linkage.

I. GAS SYSTEM

Gas is introduced into the combustion zone from a circular manifold through multiple ports in the blast tube, and through a pre-mix zone. 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 valves. 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 3-4

GAS VOLUME VALVES.

Two butterfly type valves are 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 U.L. burners include:

One motorized gas valve w/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.

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.

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.

OPERATION

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

The butterfly gas valves modulates flow to burner input demand. The butterfly valves are positioned through mechanical linkage by the modulating motor. The air control damper is positioned simultaneously by the modulating motor. The automatic gas valve(s) cannot be energized unless the combustion air proving switch is closed. The low and high gas pressure switches must be closed to prove proper gas pressure.

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

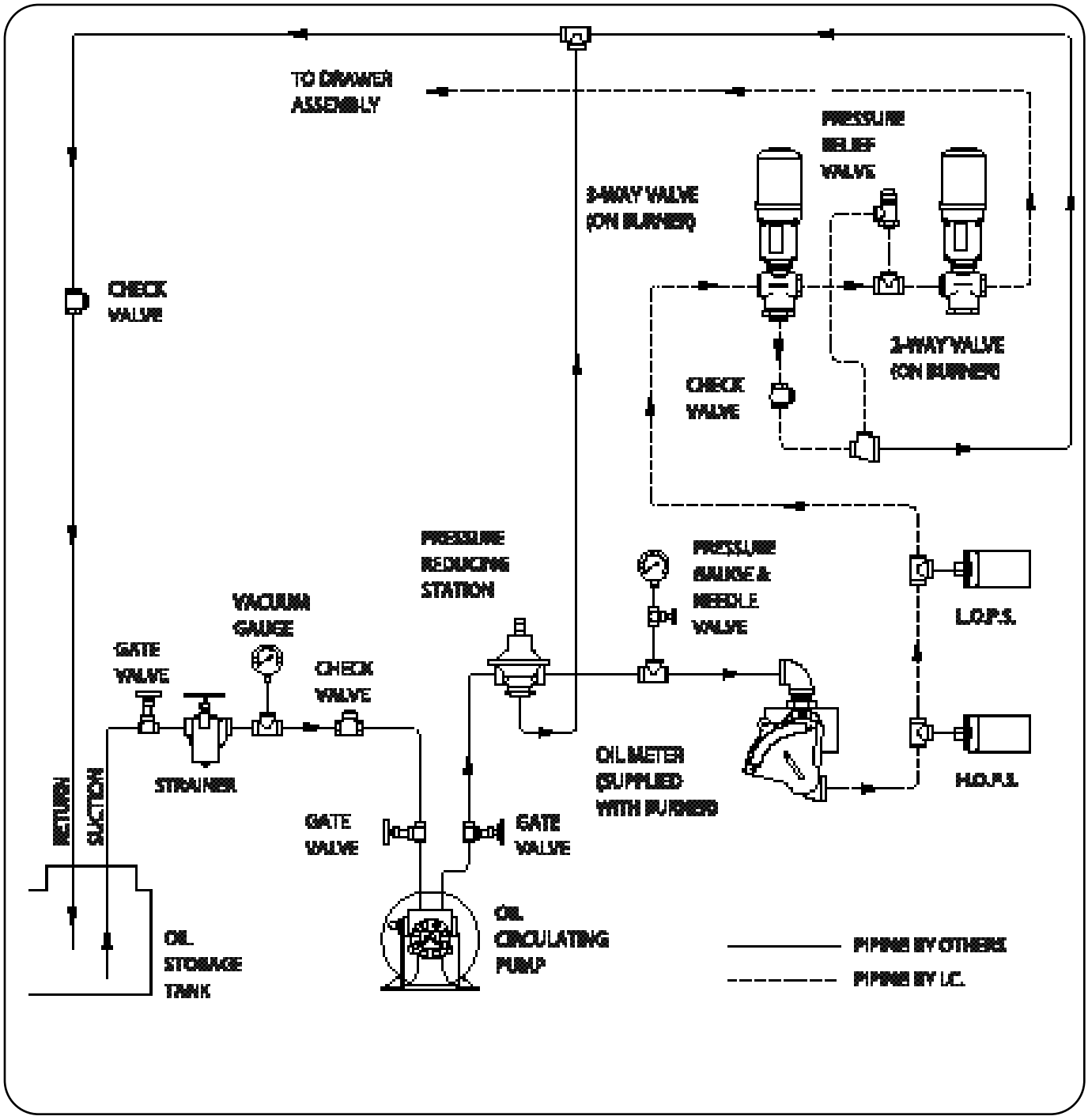


Figure 3-2: Oil Piping Arrangement

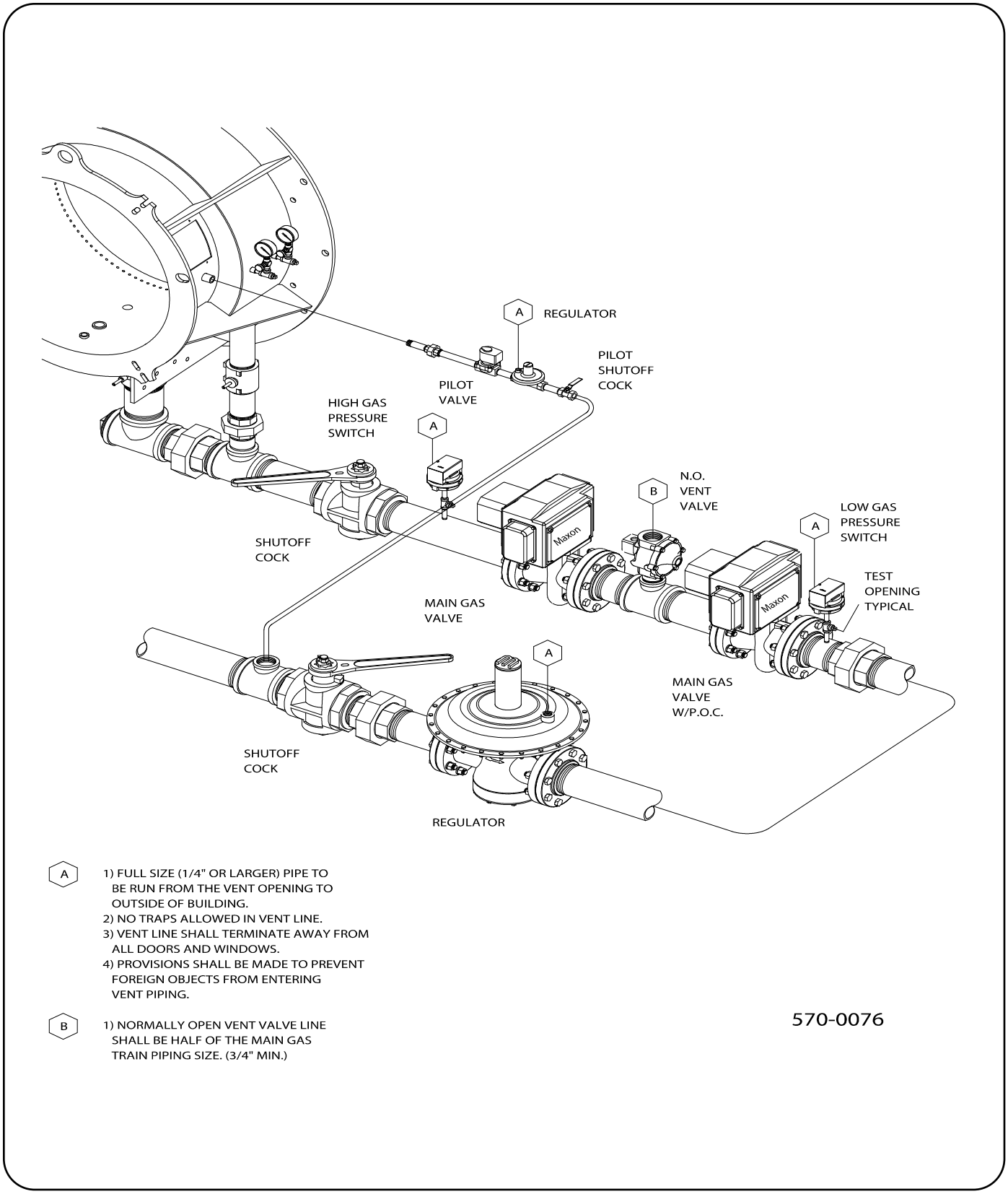


Figure 3-3: Typical Gas Train

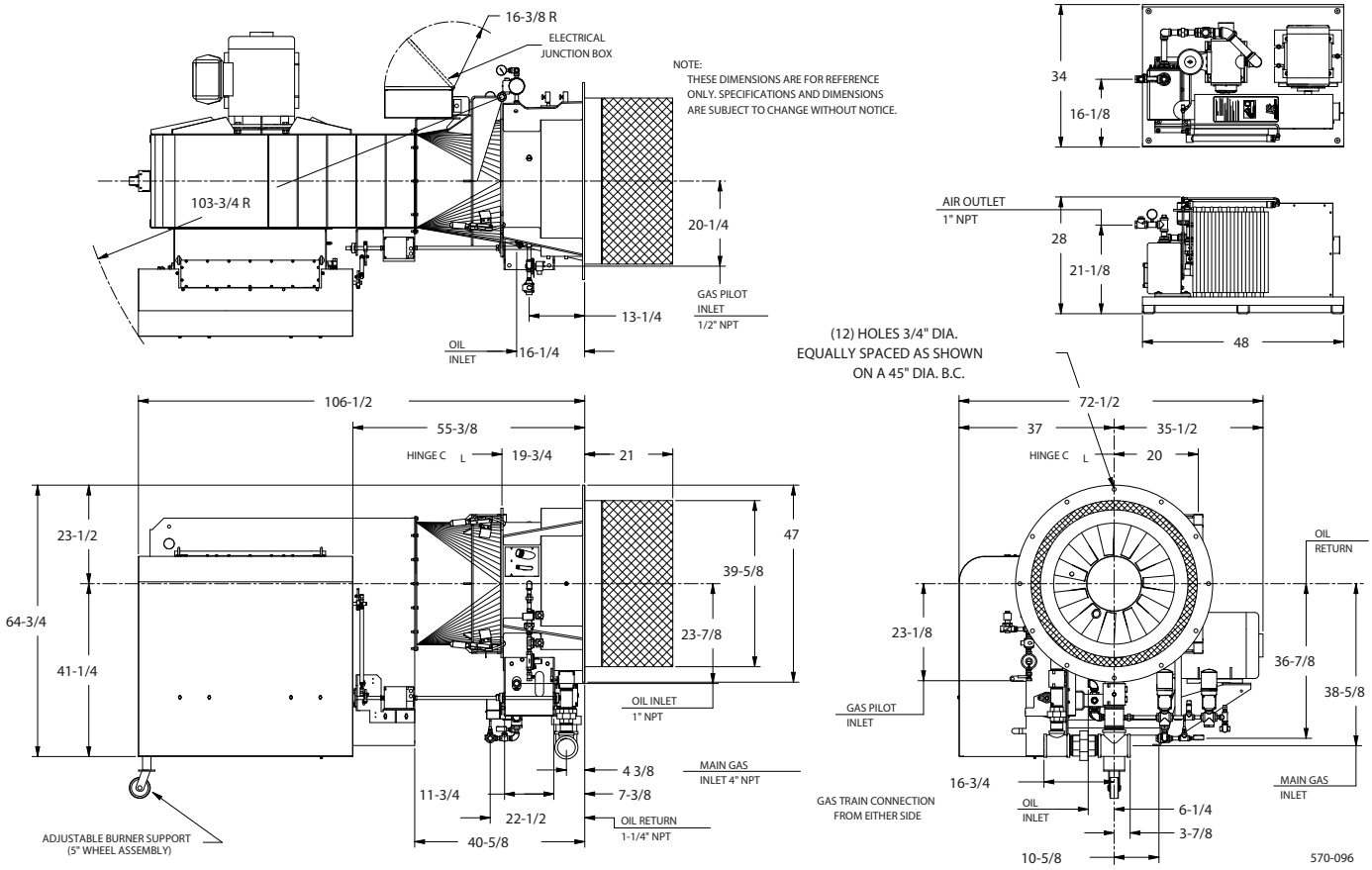


Figure 3-4: Burner Dimensions

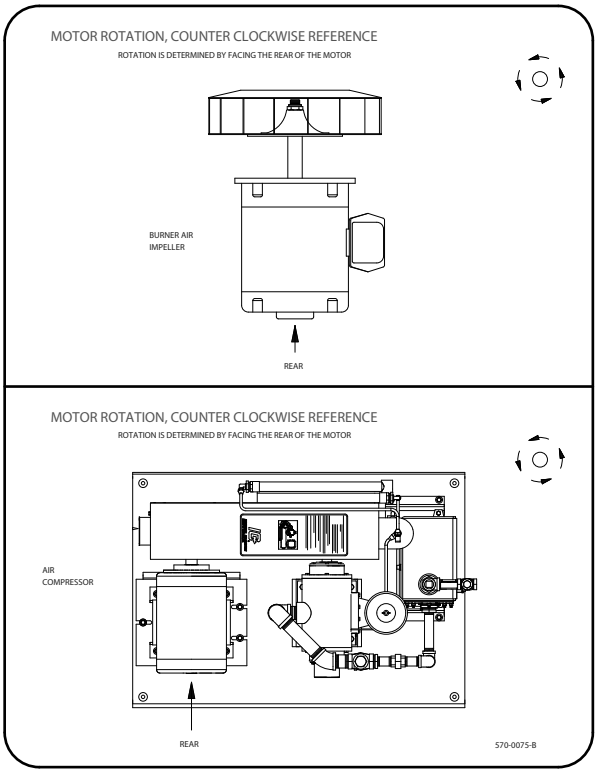


Figure 3-5: Motor Rotation

OPERATION

A. 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 Chapter 1 & 2. Adjustment procedures should be revised prior to firing. 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. Refer to Figure 3-8. Open the housing to check the electrode setting. Refer to Figure 3-14. Check the gas pilot pressure at the pilot gas regulator. Normal setting is 18" to 20" 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. Fill with non-detergent SAE30 oil.

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

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 50 to 70 psi pressure by a circulating supply pump.

A vacuum (or compound pressure-vacuum) gauge should be installed in the oil suction line, and its reading noted. This gauge indicates the tightness of the suction system.

4. OIL- AIR TANK (LUBE OIL).

Check the lube oil level in the air-oil tank. Inspect oil level regularly. Loss of oil will damage the compressor. Fill the tank with non detergent SAE30 oil to a level midway up the sight glass. Do not overfill the tank.

For normal environment use SAE30 oil. For a 32 degree F. and below environment use SAE10 oil. Change oil every 2000 hours of operation.

5. FIRING PREPARATIONS FOR GAS BURNERS

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

On combination fuel models, set the selector switch to gas. On initial start-up it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through pre-purge and pilot sequences 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.

B. 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.

C. GAS PILOT FLAME ADJUSTMENT

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 18" to 20" 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.

D. 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 lamplights.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.

E. 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

F. 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

G. SAFETY SHUTDOWN

1. 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.

   A. The lockout switch on the flame safeguard control must be manually reset after a waiting period of two minutes, before the burner will fire again.

2. If a low water condition occurs, the burner shuts down as in Automatic Shutdown.
3. If a high or low gas pressure condition occurs while firing on gas, the burner shuts down as in Automatic Shutdown.

   A. Condition must be corrected and the respective gas pressure switch manually reset before the burner will fire again on gas.

H. START-UP AND OPERATING

GAS BURNERS

Close the main and pilot gas cocks. Make sure the "ON-OFF" switch is in the "OFF" position and the fuel selector switch on "GAS". Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.

Set the "MANUAL-AUTO" switch in the "MANUAL" position. Set The manual potentiometer in low fire position.

Open the gas pilot cock.

Set the "ON-OFF" switch to "ON". The burner will start and pre-purge. After pre-purge, the ignition transformer and the gas pilot solenoid are energized. Before proceeding conduct electrical interference and pilot turndown tests if not previously done.

On initial start-up it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through prepurge and pilot sequence. Then determine that main gas valve opens. When this is confirmed, turn the burner switch "OFF" and let programmer finish its cycle.Check to see that gas valve has closed tightly. If ignition does not occur, turn the burner switch "OFF" and allow programmer to recycle for a new ignition trial.

Turn burner "ON" and after pilot ignition when the flame relay pulls in, the slow opening, motorized, main gas valve is energized. Slowly open the downstream manual shutoff gas cock. Main flame should ignite at this time. The gas valve and air damper continue advancing until high fire is reached.

Do not repeat unsuccessful light off attempts without rechecking burner and pilot adjustment. Vent fuel vapors from the combustion chamber after each unsuccessful light off attempt. Set the gas low fire rate by adjusting butterfly valve and air linkage. When low fire is adjusted, shut down burner. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start the burner with fuel vapor in the furnace. In case of emergency, open main power switches and close all fuel valves. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normal operating pressure or temperature.

Turn the potentiometer switch to the high fire position. Check high fire at this point using combustion instruments.

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

High fire combustion analysis typically is 9 to 10.5 percent CO2. When conditions covered above are assured, refer to Sections I and J.

OIL BURNERS

The fuel selector switch should be set to "OIL". On initial start-up of a combination burner, it is recommended that oil firing be adjusted before gas firing. Gas low firing rate is set to match oil low fire rate.

Be sure the "ON-OFF" switch is in the "OFF" position and the fuel selector switch is on "OIL". Actuate the manual reset button of the flame safeguard control to close the safety switch contacts. Be sure the "MANUAL-AUTO" switch in "MANUAL" position. Set manual modulating control potentiometer in "LO" fire position.Open the pilot gas valve.

Set the "ON-OFF" switch to "ON". The burner will start and pre-purge. After pre-purge, the ignition transformer and the gas pilot are energized. Before proceeding conduct electrical interference and pilot turndown tests if not previously done.

Observe the primary atomizing air pressure gauge on the air/oil tank. The gauge reading should be approximately 10 psi during pre-purge.

When the pilot flame is proven, the programmer will proceed to the main flame position. Allow the burner to operate in low fire, to warm the boiler before moving to high fire.

Typically, for No. 2 oil, CO2 is 8 to 11 percent at low fire.

Turn the manual potentiometer switch to the high fire position. Check high fire combustion at this point. Do not disturb previously established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate settings. The primary atomizing air pressure will increase automatically with the oil flow rate.

Typically, for No. 2 oil, CO2 is 10 to 13 percent at high fire.

When conditions covered above are assured, refer to section I and J

I. NORMAL OPERATION

Normal operation must be with the “MANUAL-AUTO” switch selector at “AUTO”.

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

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

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

Refer to adjustments procedures and maintenance instructions.

J. SHUTDOWN

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

The fuel valve(s) de-energize and flame extinguishes. The blower motor continues running during post-purge.

At the end of the post-purge the blower motor is de-energized. The programmer returns to its starting position and stops. Unit is ready to restart.

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

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

ADJUSTMENTS

A. GENERAL

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

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

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

B.COMBUSTION ADJUSTMENT ON GAS AND OIL

Efficient combustion cannot be properly judged by flame appearance, although it may help in making preliminary settings.

The proper settings of air-fuel ratios must be determined

by flue gas analysis. Combustion gas analysis indicates

the air to fuel ratio and the degree of complete combustion.

Instruments are available to measure carbon dioxide (CO_2), oxygen (O_2) and carbon monoxide (CO).

STACK TEMPERATURE

Net stack temperature is obtained by subtracting the ambient temperature from the flue gas temperature. A high

net stack temperature indicates wasted heat. Stack temperature should be as low as possible without causing flue gas condensation.

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

SMOKE MEASUREMENT

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

Smoky combustion can result from: Improper air delivery, insufficient draft, improper fuel viscosity, improper fuel-air ratio, excessive air leaks in the combustion chamber, or improper fuel oil temperature.

GAS ADJUSTMENTS

Low fire combustion analysis typically is 7 to 9 percent CO_2 and less than .04 percent CO (400 ppm). High fire reading typically is 9 to 10.5 percent CO_2 and less than .04 percent CO. Typically these burners are capable of operating at CO levels less than 50 ppm.

FUEL OIL ADJUSTMENTS

Adjust for a “clean fire”. Typically for No. 2 oil, CO_2 is 8 to 11 percent at low fire and 10 to 13 percent at high fire, with a maximum of #1 spot (ASTM D2156 Shell-Bacharach scale).

C. ELECTRICAL INTERFERENCE TEST

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

GAS FIRED

Close the pilot and main line manual gas valves.

Start the burner and at time of pilot trial with just the electrical ignition system energized, the flame relay should not pull in (i.e. be energized).

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

OIL FIRED

Disconnect the electrical power to the burner.

Disconnect the electric oil safety shutoff valve.

Reconnect electric power. Close the pilot line manual gas valve, if used. Start burner and at the time of pilot trial, with just the electrical ignition system energized, the flame relay should not pull in.

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

D. 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 18" to 20" 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 manufacturer's literature for regulator adjustment.

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.

GAS COMBUSTION ADJUSTMENT

After operating for a sufficient period of time to assure a warm boiler, make adjustments for most efficient combustion.The butterfly gas valve directly controls the rate of flow. The low fire light-off setting should be regarded as preliminary until proper gas pressure for high fire operation is established. Determine the actual gas flow from a meter reading at high fire. With the butterfly valve open and with regulated gas pressure set, the actual flow rate should be quite close to the required input. If corrections are necessary, increase or decrease the gas pressure by adjusting the gas pressure regulator, following manufacturer's directions for regulator adjustment. When proper gas flow is obtained take a flue gas analysis reading.With the high fire air-fuel ratio established the gas pressure regulator needs no further adjusting.Recheck low fire and adjust if necessary.

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

SECONDARY VALVE ADJUSTMENT

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.

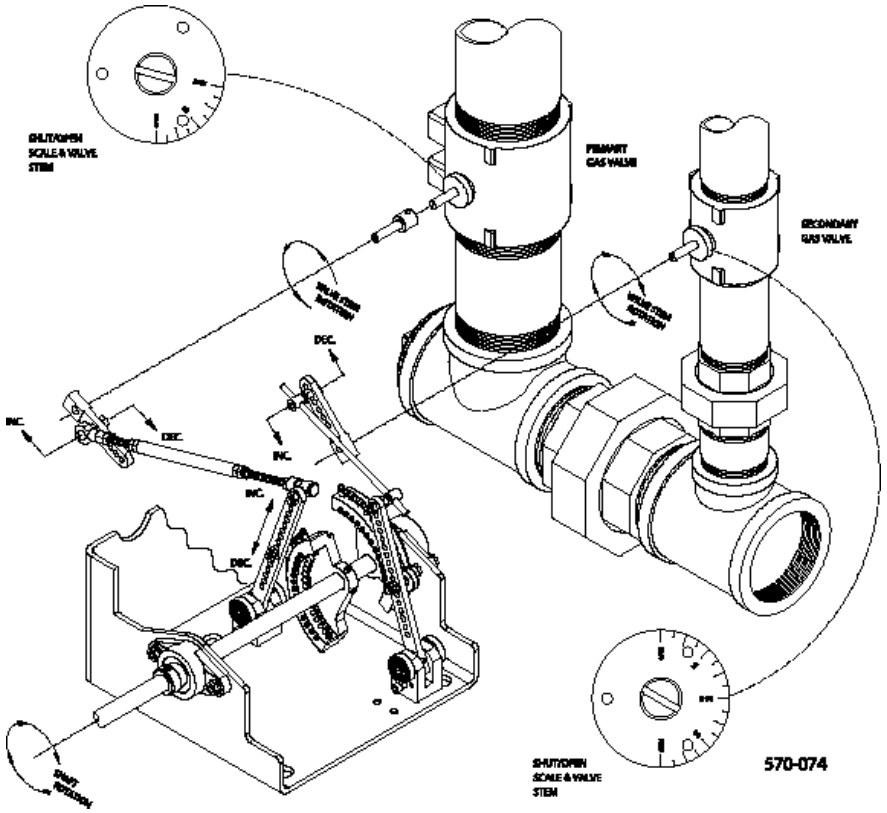


Figure 3-6: Butterfly shaft slot indicated valve angle

Fine tuning the modulating cam.

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

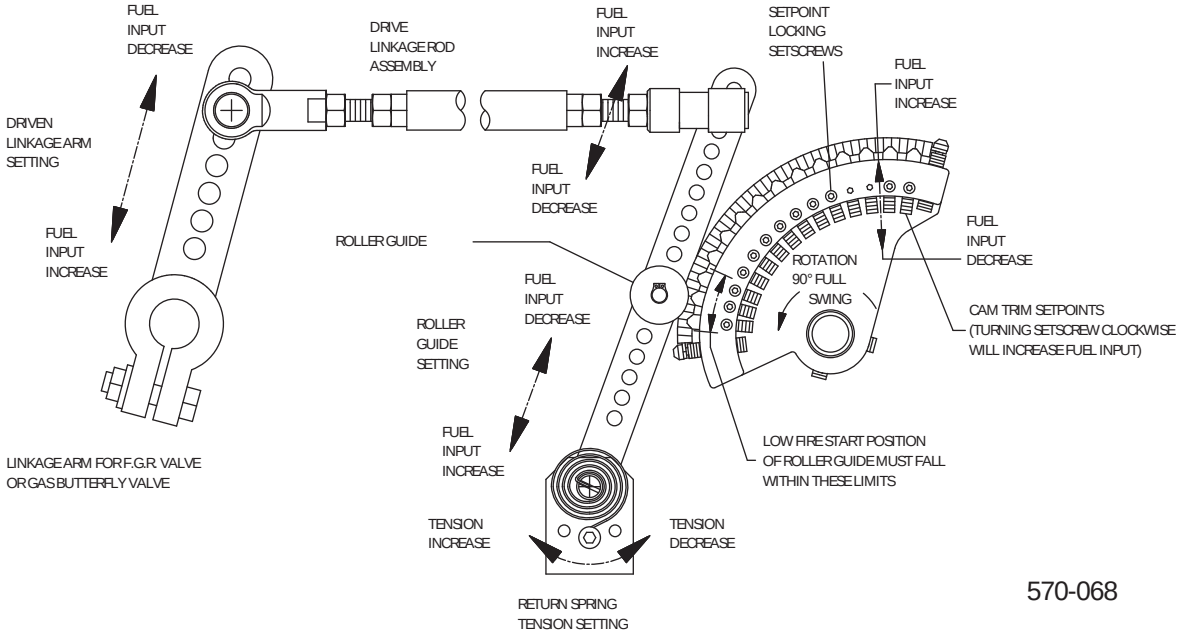


Figure 3-7: Fuel Cam and Linkage Components

burner then operate the automatic modulating cycle to assure satisfactory results. Tighten the locking set screws.

E. OIL SYSTEM

OIL METERING SYSTEM

Fuel oil supply to the metering unit must be 50 to 70 psi. The oil spray should ignite as soon as the oil solenoid valve opens. If a burner failure occurs, 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 metering unit but not to exceed 80 psi

6.That the circulating 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.

To adjust the metering valve, proceed as follow:

1. Check that the air dampers are closed.

2. During pre-purge, check that the valve travels its full quadrant range from minimum to maximum.

3. The oil flow is adjusted by screwing "in" the locking allen screws located on the side of the valve. With SYNCHRO valve at minimum position, screw down (clockwise) to permit fuel flow to the burner. Once your flame is established and refined at this position, screw all remaining screws down at least the same level as your first adjusting screw.

4. A preliminary setting can be established with all the remainings screws. Generally each succeeding screw needs to be screwed in approximately one full turn deeper than its preceding screw. A smooth "stair-step" gradient pre-set at this point from low to high will simplify the remaining adjustment steps.

5. Adjust each screw to match the air supply and obtain a clean fire. Take combustion analysis as refered in section B.

6. Advance valve to the #2 screw position and adjust.

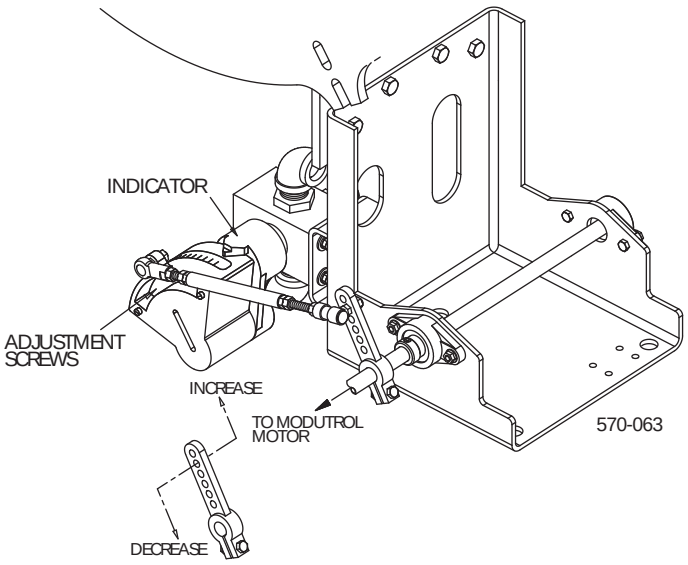


Figure 3-8: Cam Linkage

7. Progressively work your way up through each adjusting screw position, developing a smooth progression slope from your first screw to the maximum position. Take combustion readings at each point. To adjust the flame at any position, you must move the flow control valve to the number you desire to adjust. This aligns the adjusting screw directly on top of the fuel valve plunger. A resulting adjustment of the screw is directly applied to the fuel valve plunger and its interconnected valve body linkage.

8. Refine adjustments as needed, always turning valve so that position indicator matches screw being adjusted. To avoid possible damage to cam strips, always turn all higher numbured screws in as far as the last one adjusted. For more fuel, turn screw in (clockwise). For less fuel, turn screw out (counter-clockwise). If screw must be turned in flush with carrier casting, increase fuel pressure and re-adjust

9. Cycle burner from minimum to maximum and refine adjustments if necessary. Always set flow control valve to the numbered position you wish to adjust.

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.

F. LINKAGE-MODULATING MOTOR

The linkage consists of adjustable cams, levers, rods and ball joints that transmit motion from the modulating motor to the air damper, gas butterfly valves, and oil metering unit.

When properly adjusted, coordinated movement of the air and fuel control devices provide proper fuel/air ratios through the firing range. In linkage adjustments, several important factors serve as guides:

1. The modulating motor must be able to complete its full travel range. Restrictions will damage the motor and/or the linkage.

2. Lever and rod adjustments should be made with the motor in the low fire position.

The modulating motor will be stopped at the end of its stroke by an internal limit switch. Combustion gas analysis indicates the air to fuel ratio and the degree of complete combustion. The closer the rod comes to parallel with the lever, the slower the rod moves.The angles of the driven levers on the jackshaft can be adjusted to vary the rate of good air/fuel ratio throughout the entire firing range.The input of combustion air is fixed at any given point in the modulating cycle. The fuel input may be varied to obtain correct flue gas readings. The adjustment is made to the metering cam by means of the 14 adjusting screws which are turned in (clockwise from the hex-socket end) to increase the flow of fuel, and out (counterclockwise from the hex-socket end) to decrease it. A 3/32" hex key is required. It will be necessary to cut off the short end of a hex key to approximately 3/8" to adjust the first two socket head setscrews at the low fire position. Take a combustion analysis at various points of the cam profile. Adjustment can be made without cycling the burner then operate the automatic modulating cycle to assure satisfactory results. Tighten the locking set screws.

G. FIRING RATE CONTROLS

Firing rate adjustments are made at the modulating motor linkages to the combustion air inlet dampers, oil metering valve 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 occurs 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 dampers must be in low fire position (closed) for reliable ignition.

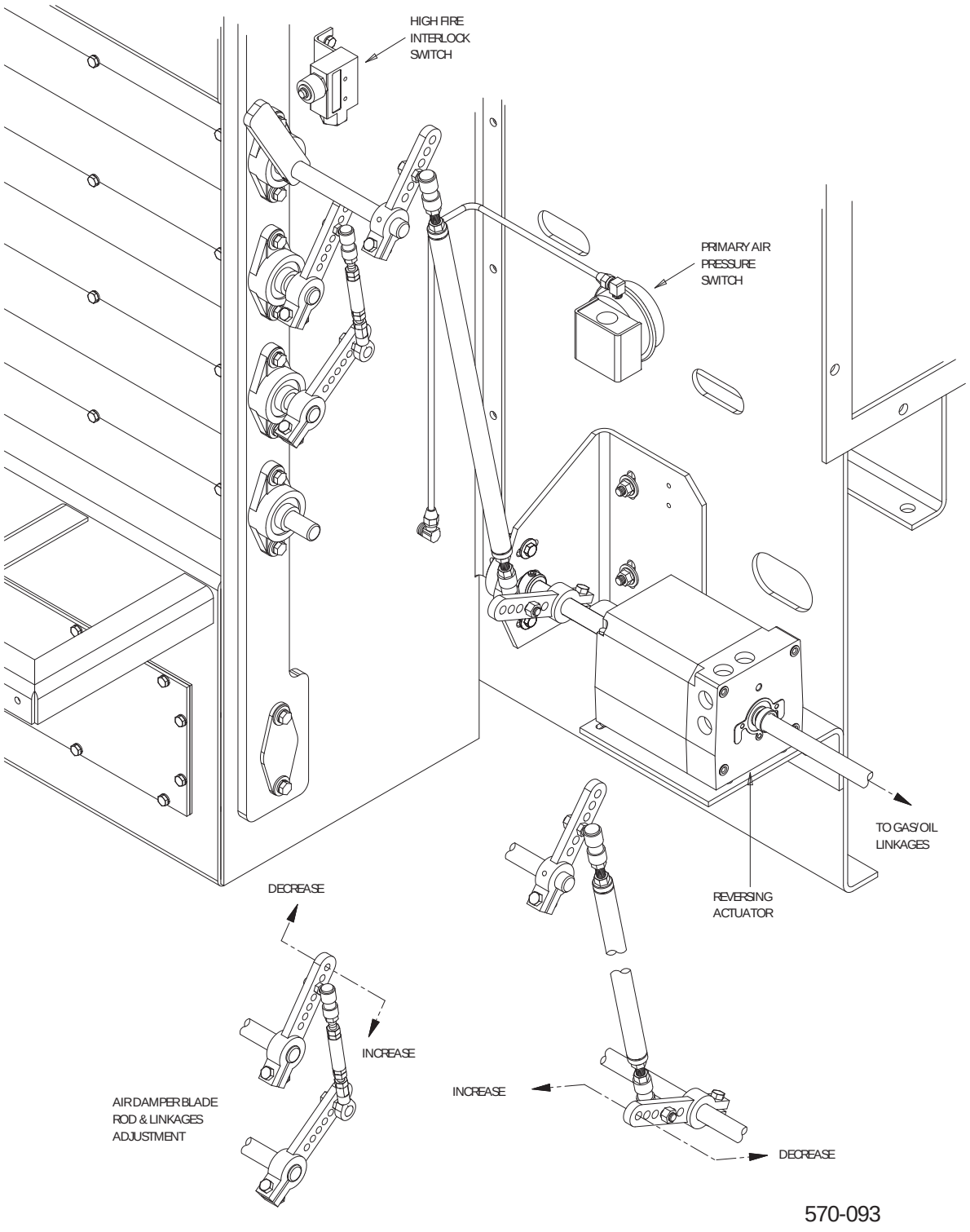


Figure 3-9: Air Damper Linkage

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.

A. 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.

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.

B. 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.

C. PROGRAMMING CONTROL

This control requires no adjustment, nor should any attempt be made to alter contact settings or timing logic. Those programmers with contacts may require occasional cleaning. If so, follow instructions given in the manufacturer's bulletin. Never use abrasive materials. The manufacturer's bulletin also contains troubleshooting information. The flame detector lens should be cleaned as often as conditions demand. A periodic safety check procedure should be established to test the complete safeguard system. Tests should verify safety shutdown with a safety lock out upon failure to ignite the pilot or the main flame, and upon loss of flame. Each of these conditions should be checked on a scheduled basis. The safety check procedures are contained in the manufacturer's bulletin.

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 3-14, for electrode gap setting and position. 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.

F. 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.

G. 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. 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. Refer to Figure 3-10. To clean the nozzle tip and swirler, 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 swirler seating spring pressing the swirler tight against the nozzle 2 tip. Turn the swirler a few times to be sure it fits snugly in the nozzle and the spring is pressing the two parts firmly together. When reinstalling, be sure the nozzle is centered with the proper distance from the diffuser.

⚠ 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.

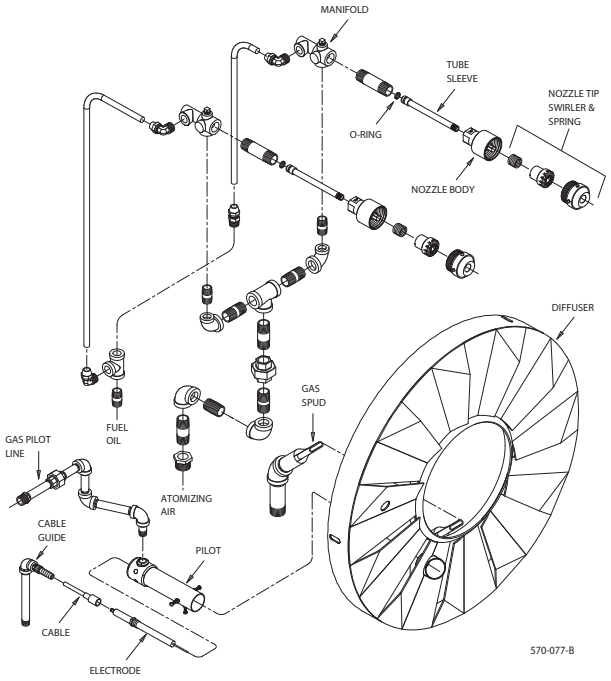


Figure 3-10: Oil Nozzles

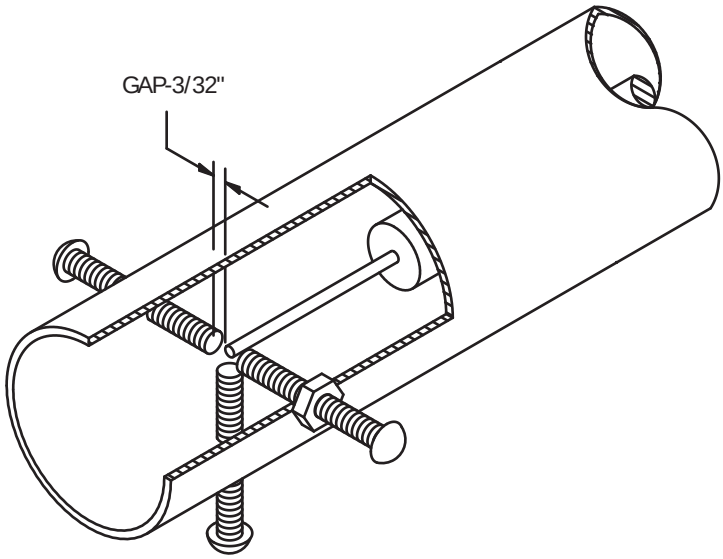


Figure 3-11: Ignition Pilot Electrode Setting

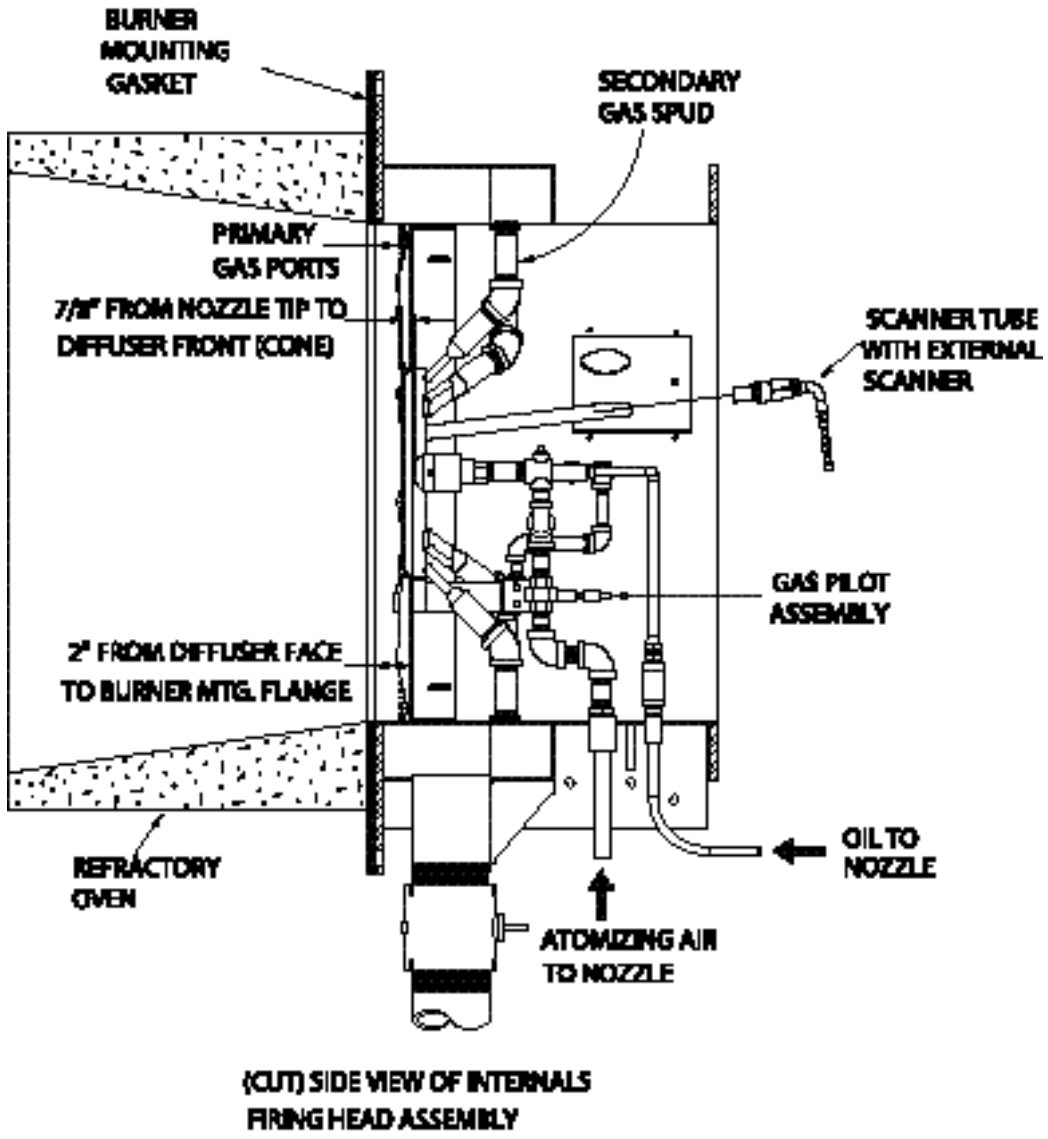


Figure 3-12: Diffuser Settings

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

H. 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.

I. FIRING RATE CONTROLS

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

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.

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.

6.Pump rotating in wrong direction.

7.Three phase pump motor operating on single phase because of fuse failure.

8.Low voltage applied to pump motor.

PRIMARY AIR 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.

Alignment of the compressor and motor sheaves and proper belt tension are important.

Belt tension is adjusted according to the displacement on the belt with thumb pressure. The displacement should be 3/8 to 1/2 inch.

To adjust, loosen the two bolts on the compressor mounting flange and the three set screws which hold the compressor in place.

The mounting flange is slotted at the top, which permits belt tightening. If the slot in the mounting flange is insufficient for obtaining proper belt tension, the modular base has two extra holes for this purpose.

Move the top bolt to the next hole and adjust. Tighten bolts and setscrews. Replace belt guards. If belt becomes frayed or cracked, replace it.

DO NOT attempt field repair of the compressor. Installation of a new compressor is mandatory. Send the old compressor in for repair or exchange (where allowed).ithe cam

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.

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.

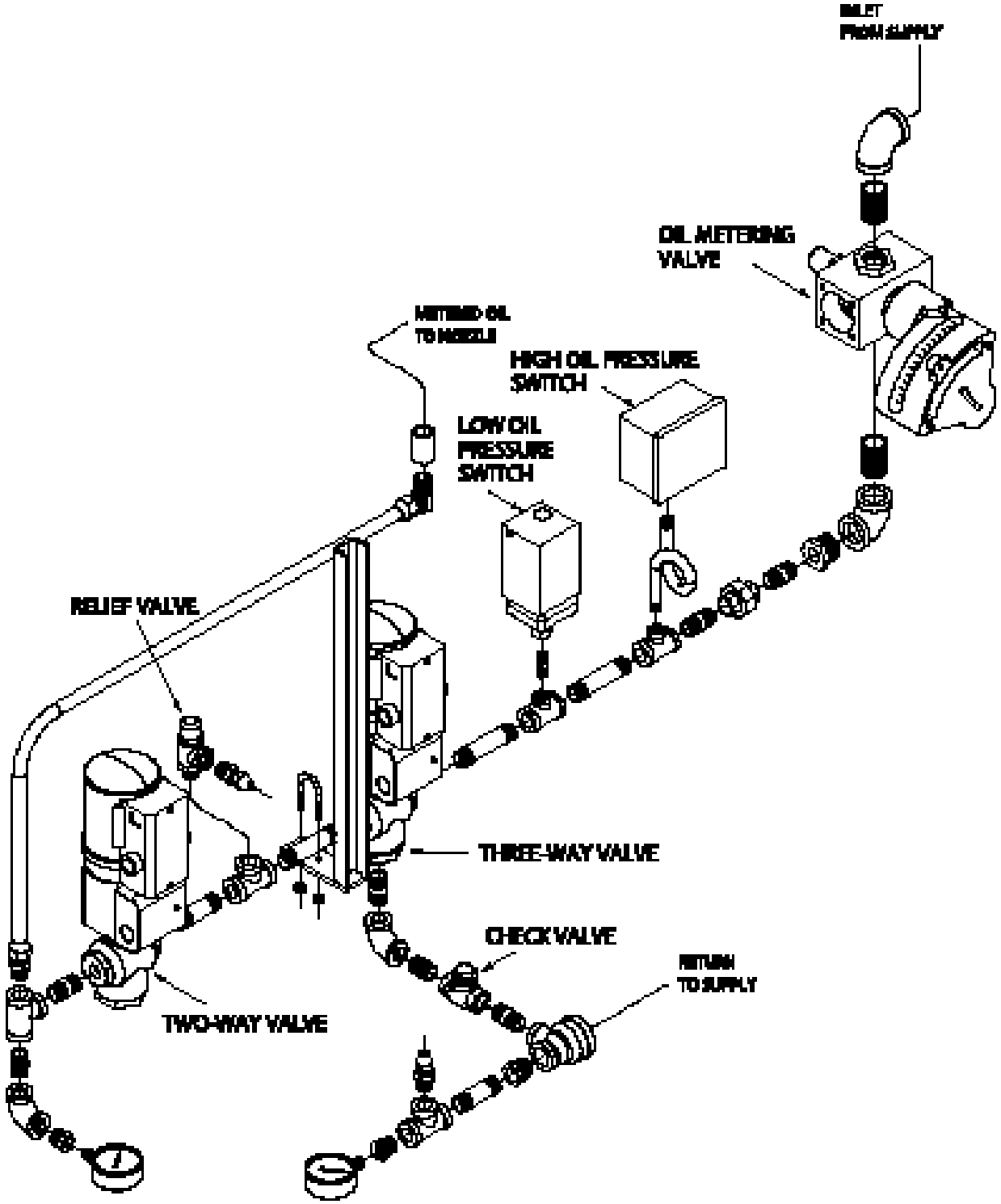


Figure 3-13: Fuel Oil System

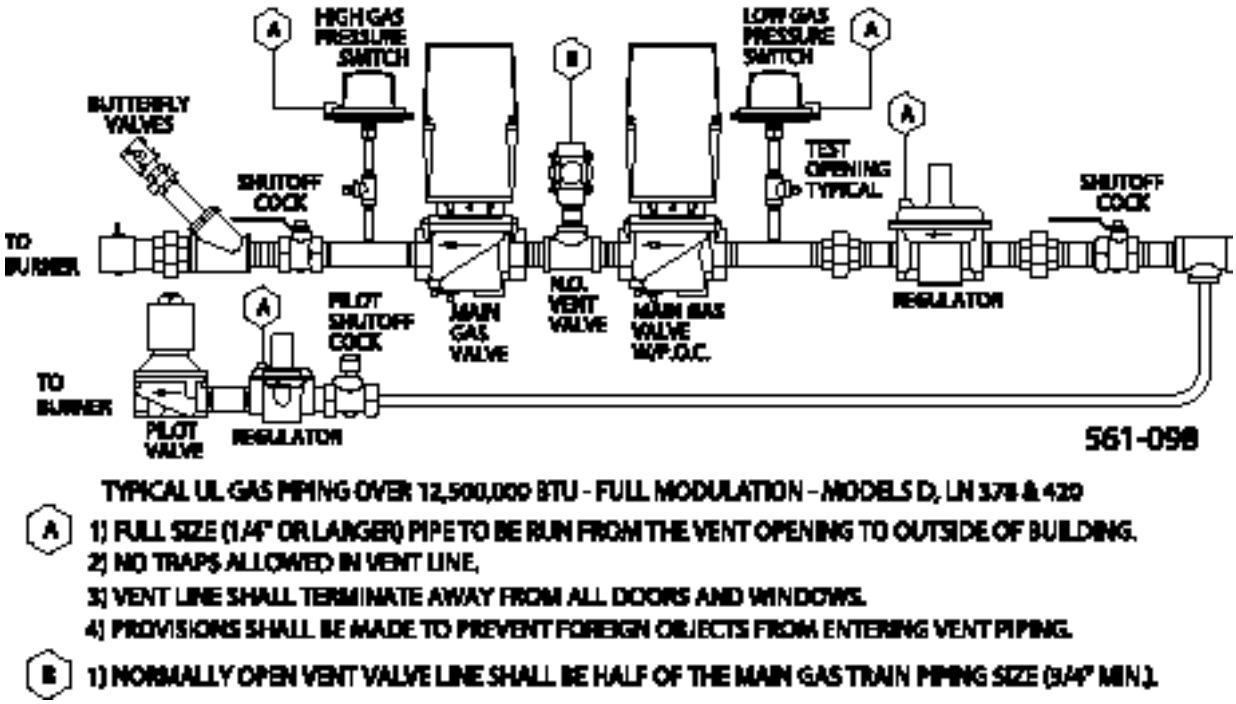


Figure 3-14: Typical Gas Train

L. 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 manufacturer's bulletin for correct procedure in coil replacement.

Should it become necessary to replace the complete valve, be sure that the flow is in the drection 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.

⚠ CAUTION

ALL POWER MUST BE DISCONNECTED BEFORE SERVICING THE VALVES

M. ELECTRICAL SYSTEM

Because of the many types of flame safeguard systems applicable to this equipment, complete descriptions of all 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 manufacturer's instructions.

N. 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.

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.

⚠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 ATTEMPS 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.

O. AWARENESS

Assumes that:

1. The unit in question has been properly installed and that it has been running for some time.

2. The operator has become thoroughly familiar with both the burner and the manual by this time.

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.

NEVER ATTEMPT TO CIRCUMVENT ANY OF THE SAFETY FEATURES.

P. 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. Follow instruction in Section H of the Installation Operation and Adjustments section.

Problem	Solution
BURNER DOES NOT START	1.No voltage at program relay power input terminals. a. Main disconnect switch open. b. Blown control circuit fuse. c. Loose or broken electrical connection.
	2.Program relay safety switch requires resetting.
	3.Limit circuit not completed - no voltage at end of limit circuit program relay terminal. a. Pressure or temperature is above setting of operation control. b. Water below required level. Low-water light (and alarm horn) should indicate this condition. Check manual reset button, if provided, on low -water control. c. Fuel pressure must be within settings of low pressure and high pressure switches. d. Check burner air proving switch and high fire limit switch.
	4.Fuel valve interlock circuit not completed. a. Fuel valve auxiliary switch not closed. a.
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 IsoConverter.
	2.Spark but no flame. a. Lack of fuel - no gas pressure, closed valve, empty tank, broken line, etc.
	3.Low fire switch open in low fire proving circuit. a. Damper motor not closed, slipped cam, defective switch. b. Damper jammed or linkage binding.
	4.Running interlock circuit not completed. a. Combustion 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.dtw0
PILOT FLAME, BUT NO MAIN FLAME	1.Insufficient pilot flame.
	2.Manual-automatic switch in wrong position.
	3.Inoperative modulating motor.
	4.Scanner lens dirty or sight tube obstructed.

	5.If the programmer lockout switch has not tripped, check the limit circuit for an opened safety control.
BURNER STAYS IN LOW FIRE:	1.Pressure or temperature above modulating control setting.
	2.Manual-automatic switch in wrong position._
	3.Inoperative modulating motor.
	4.Defective modulating control.
	5.Binding or loose linkages, cams, setscrews etc.
SHUTDOWN OCCURS DURING FIRING	1.Loss or stoppage of fuel supply.
	2.Defective fuel valve; loose electrical connection.J
	3.Flame detector weak or defective.
	4.Scanner lens dirty or sight tube obstructed.
	5.If the programmer lockout switch has not tripped, check the limit circuit for an opened safety control.x743ÿ
SHUTDOWN OCCURS DURING FIRING (cont).	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. Temporary obstruction in the fuel line. Temporary drop in gas pressure. Orifice gate valve accidentally opened (heavy oil).
	8.Interlock device inoperative or defective.
	9. Air in the oil lines. Bleed lines.

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[Preferences]
	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.

LOW NOx SYSTEM

This section covers the adjustments for the Low NOx burners. The Low NOx burners are equipped with a Flue Gas Recirculation system (F.G.R.). The flue gases are duct to the air housing and the burner combustion air fan is used to pull flue gases from the stack. The F.G.R. rate is controlled by a damper blade linked to the modutrol motor. Top or bottom connection is used with a flanged adaptor to the damper box. Fresh air and F.G.R. is mixed and injected in the combustion zone. All FGR duct piping should be covered with a minimum of 2" of insulation, and supported as required. The burner is designed to operate with < 30 ppm NOx corrected @ 3% O2 throughout the firing range, when firing natural gas. The following controls are used for a safe operation of the system.

A. F.G.R. SHUTOFF VALVE.

The FGR shutoff valve is located as close to the stack as possible. A modutrol motor with a 90 degree stroke opens and closes the FGR shut off valve in 15 seconds. Proof of closure for the shutoff valve is provided by an auxiliary switch in the modutrol motor. The modutrol motor has a maximum temperature rating of 150 degrees F. This valve should never be mounted with the motor shaft in a vertical position. Damage to the modutrol motor will result. During pre purge and post purge the FGR shutoff valve is closed to prevent any unused gas fumes from returning to the combustion zone.

B. F.G.R. DAMPER ASSEMBLY.

The FGR control is mounted to a FGR damper on the burner. A burner mounted modutrol motor with linkage connections, coordinates the air, fuel and NOx control devices to provide proper fuel/air/NOx ratios through the firing range. The modutrol motor must be able to complete it's full travel range. Restrictions will damage the motor and/or the linkage. Linkage consists of adjustable levers, rods and ball joints that transmits motion from the modutrol motor to the FGR control valve. Lever and rod adjustments should be made with the motor in the low fire position. The angles of the driven levers on the modutrol motor jackshaft can be adjusted to vary the rate of change. The closer the rod is to the lever hub, the less distance the rod and control blade will travel.

The FGR damper regulates the volume of combustion air. Position of the damper blade is control by a modutrol motor. The damper blade in the low fire position is normally almost closed. The FGR damper and FGR control valve blades open as the modutrol motor drives toward the high fire position where flue gas is pulled into the regulated combustion air flow above the damper blade as controlled by the FGR control valve. Combustion air mixed with flue gas is passed on through the blast tube to the combustion zone. .

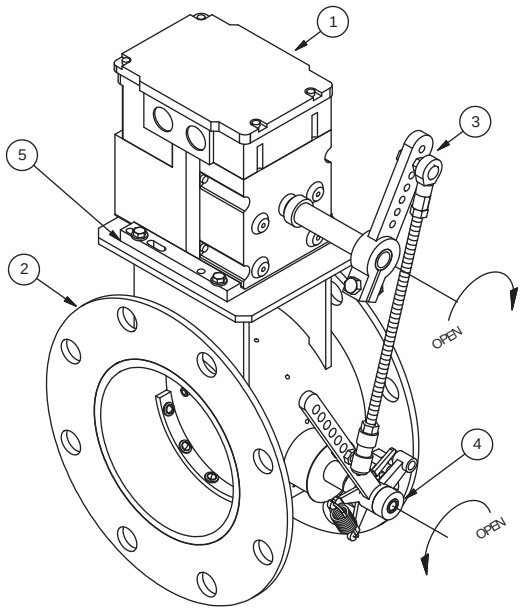
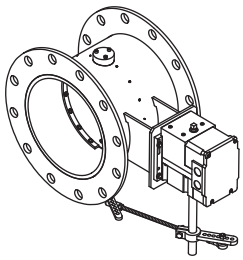


Figure 3-15: Mod Motor Orientation



WARNING:
THE F.G.R. SHUTOFF VALVE SHOULD NEVER BE MOUNTED IN THIS POSITION! THE MODUTROL MOTOR CAN NOT BE MOUNTED VERTICALLY, (VERTICAL IS DEFINED BY THE AXIS OF THE MOD. MOTOR SHAFT) DAMAGE TO THE MODUTROL MOTOR WILL RESULT.

Figure 3-16: Do Not Mount Mod Motors Sideways

ADDITIONAL CONTROLS FOR HEAVY OIL

The oil heater is provided to heat heavy oil to the point where it can be effectively atomized and burned. Most heavy oil heaters utilize an electric heater to reduce the viscosity of the heavy oil until the point where either steam or hot water is available. Heavy oil heaters operating with hot water will have additional controls not represented in this section.

Heater Switch (Not Shown): Manually provides power to the oil heater system.

1. Oil Heater (Electric): Used for heating sufficient fuel oil for low-fire flow during cold starts before steam or hot water is available for heating. The heater must be turned off during extended boiler lay-up, or at any time the fuel oil transfer pump is stopped.
2. Electric Oil Heater Thermostat: Senses fuel oil temperature and energizes or deenergizes the electric oil heater to maintain required temperature of the fuel oil.
3. Steam Oil Heater Thermostat: Senses fuel oil temperature and controls the opening and closing of the steam heater valve to maintain the required temperature of the fuel oil.
4. Oil Heater Shell (Steam/Hot Water): Heats fuel oil through medium of steam or hot water. Electric heater is housed in the steam heater, but is housed separately on a hot water heater. Steam oil heaters on 15 psi boilers operate at boiler pressure. Steam oil heaters furnished on high pressure boilers are to be operated at less than 15 psi. Operation is accomplished with a steam pressure regulator valve.
5. Oil Return To Tank: Excess oil returned to the heavy oils supply tank.
6. Oil Inlet From Supply Tank: Heavy oil inlet from the supply tank.
7. Steam Heater Check Valve: Prevents oil contamination of the waterside of pressure vessel should any leakage occur in the oil heater.
8. Steam Trap: Drains condensate and prevents loss of steam from the steam oil heater. Condensate must be piped to a safe point of discharge.
9. Check Valve (Steam Heater Discharge): Prevents air entry during shutdown periods when cooling action may create vacuum within steam heater.
10. Steam Heater Pressure Regulator: Adjust to provide reduced (usually less than 15 psi) steam pressure to the heater to properly maintain the required fuel oil temperature. The regulator and the pressure gauge are not furnished on 15 psi units.
11. Steam Heater Solenoid Valve: A normally open solenoid valve opened by the steam oil heater thermostat to allow
12. flow of steam to the steam heater to maintain temperature of fuel oil.
13. Steam Pressure Gauge: Indicates steam pressure entering the heater.
14. Oil Relief Valve: Allows release of excessive pressure to the return side of the oil line piped to the tank.
15. Low-Oil-Temperature Switch: Thermostatic switch that prevents burner from starting, or stops burner firing if fuel oil temperature is lower than required for oil burner operation.
16. Oil Supply Pressure Gauge: Indicates fuel oil pressure in the oil heater and supply pressure to the fuel oil controller's pressure regulator.

In addition to the components of the fuel oil controller mentioned. The following are used with a heavy oil fired burner.

A. High-Oil-Temperature Switch (Optional): Switch contacts open when fuel oil temperature raises above a selected temperature. Switch will interrupt the limit circuit in the event fuel oil temperature rises above the selected point.

B. Hot Water Oil Heater Thermostat: Used on a hot water boiler to sense fuel oil temperature and control the starting and stopping of the booster water pump.

C. Booster Water Pump: Started and stopped by the hot water thermostat to regulate the flow of hot water through the hot water oil heater to maintain temperature of fuel oil.

D. Fuel Oil Thermometer: Indicates temperature of fuel oil being supplied to the fuel oil controller.

E. Back Pressure Valve: For adjustment of oil pressure on the downstream side of the metering valve. Also regulates rate of return oil flow.

F. Oil Return Pressure Gauge: Indicates oil pressure on the return side of the fuel oil controller.

G. Manual By-Pass Valve: Provided as a time saver in establishing oil flow. When open, it permits circulation of oil through the supply and return lines. The valve must be closed prior to initial light off.

H. Orifice Oil Control Valve: Valve may be opened prior to start-up to aid in establishing fuel oil flow through the controller. The valve must be closed prior to initial

light off. Its disc has an orifice to permit a continuous circulation of hot fuel oil through the controller.

I. Air Purge Valve: Solenoid valve opens simultaneously with closing of oil solenoid valve at burner shutdown, allowing compressed air to purge oil from the burner nozzle and adjacent piping. The oil is burned by the diminishing flame, which continues burning for approximately 4 seconds after the oil solenoid valve closes.

J. Air Purge Orifice Nozzle: Limits purging air to proper quantity for expelling unburned oil at normal delivery rate.

K. Air Purge Orifice Nozzle Filter: Filters the purging air of any particles that might plug the air purge orifice nozzle.

L. Air Purge Check Valve: Valve check prevents fuel oil from entering the atomizing air line.

M. Air Purge Relay: When energized, controls operation of air purge valve.

OIL FUEL FLOW - HEAVY OIL

The oil fuel flow and circulating system is shown in schematic diagram form in Figures 3-20. The pertinent controls are called out and the oil flow is indicated by arrows.

Fuel oil is delivered into the system by the fuel oil supply pump which delivers part of its discharge to the oil heater. The remainder of the fuel oil returns to the oil storage tank through a fuel oil relief valve and oil return line.

The combination electric and steam oil preheater is controlled by thermostats. The electric oil heater thermostat energizes the electric heater, which is provided to supply heated oil on cold starts. The steam heater thermostat controls operation of the steam solenoid valve to permit a flow of steam to the heater when steam is available.

A hot water boiler is equipped to heat the oil with hot water from the boiler, unless other preheating equipment is utilized. The electric heater, which is housed separately, is sized to provide heated oil on a cold start. The hot water thermostat controls the operation of a pump that supplies hot water to the oil heater when hot water is available.

The heated oil flows through a fuel oil strainer to prevent any foreign matter from entering the control valves and nozzle.

The fuel oil controller contains, in a single unit, the necessary valves, regulators and gauges to regulate the pressure and flow of oil to the burner.

The program relay energizes or deenergizes the solenoid oil valve to permit or cut off oil flow to the burner. The oil solenoid is closed when deenergized. It cannot be opened (energized) unless the combustion air proving switch, the atomizing air proving switch, and the low oil-temperature and any pressure switches are closed. They are satisfied, respectively, by sufficient combustion air pressure from the forced draft fan, pressurized air from the air pump and sufficient oil temperature and pressure.

Oil flow to the burner is controlled by the movement of the metering stem of the oil metering valve, which varies the flow to meet load demands. The metering valve and the air damper are controlled simultaneously at all times by the modulating motor to proportion combustion air and fuel for changes in load demand.

Oil is purged from the burner gun upon each burner shutdown. The air purge solenoid valve opens as the fuel valve closes, diverting atomizing air through the oil line. The air assures a clean nozzle and line for subsequent restart.

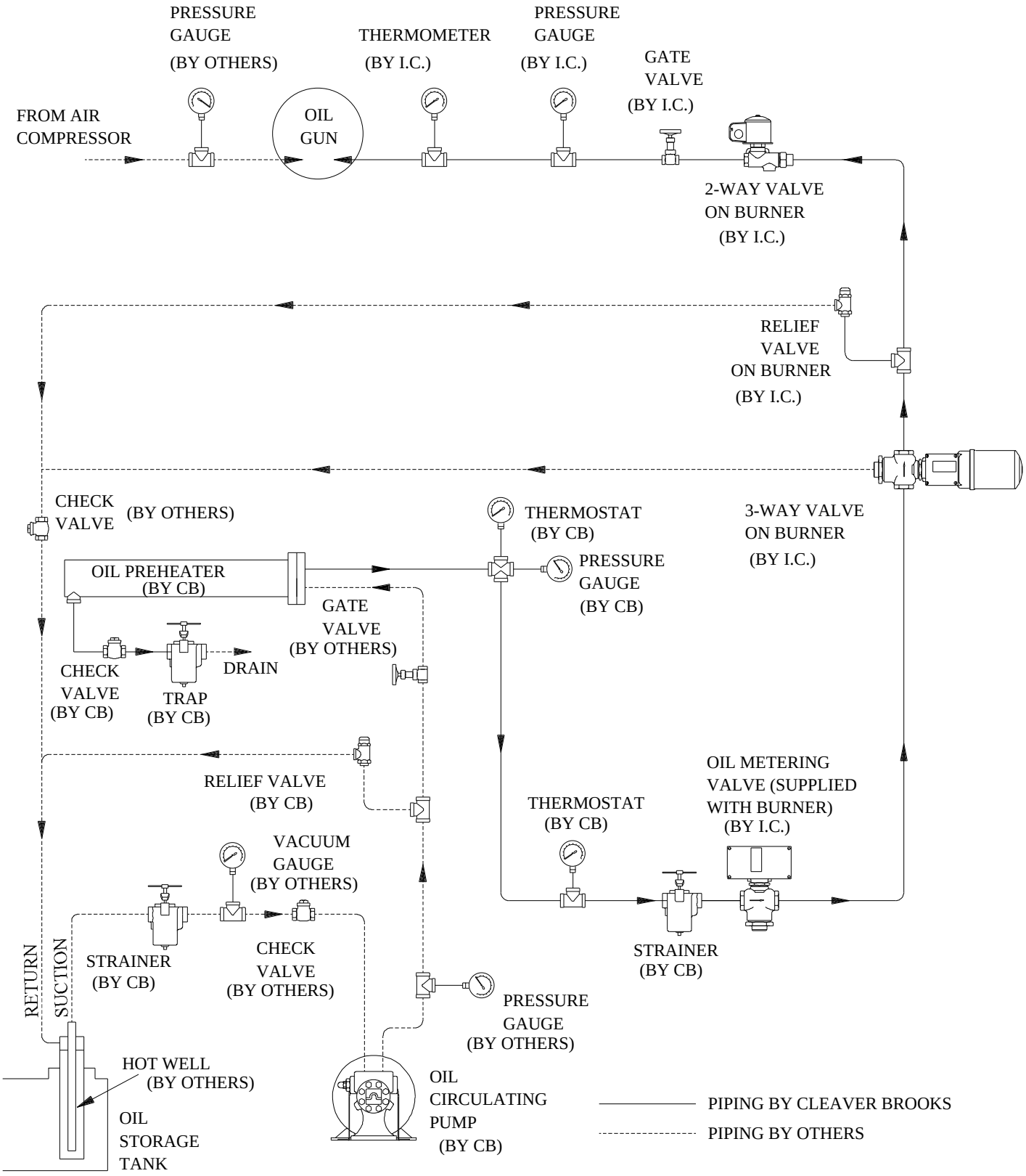


Figure 3-17: Schematic Diagram For No. 6 Heavy Oil Flow
(W/ S1 BURNER) (STEAM-ELECTRIC HEATER)

CHAPTER 4

Operational Controls

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.

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.

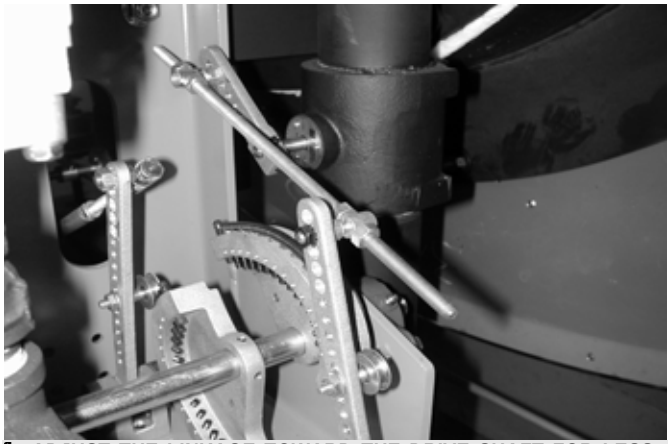
2. Initial adjustment should be made with the motor in full closed position, that is with the shaft on the power end of the motor in its most counterclockwise position.
3. The closer the connector is to the drive shaft, the less the arm will travel; the closer the connector is to the driven shaft, the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

C. MODULATING MOTOR

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



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

Figure 4-1: Linkage Assembly - Combination Gas and Oil

D. MODULATING MOTOR SWITCHES - LOW FIRE AND HIGH FIRE

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

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

E. BURNER OPERATING CONTROLS - GENERAL

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

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

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

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

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

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

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

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

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

Separate and independent controls affect modulated firing and burner on-off cycling. Figure 4-4 depicts a typical setting relationship of the operating limit control, modulating control and the high limit control.

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

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

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

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

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

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

Figure 4-2: Steam Operating Controls

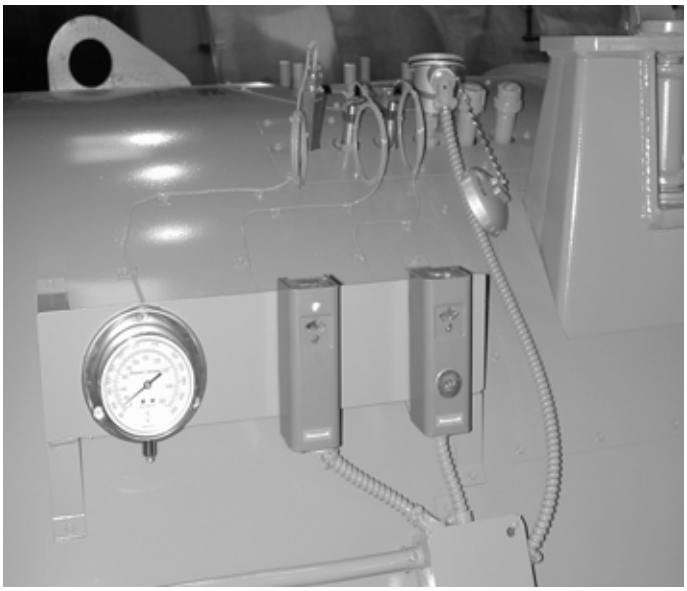


Figure 4-3: Hot Water Operating Controls

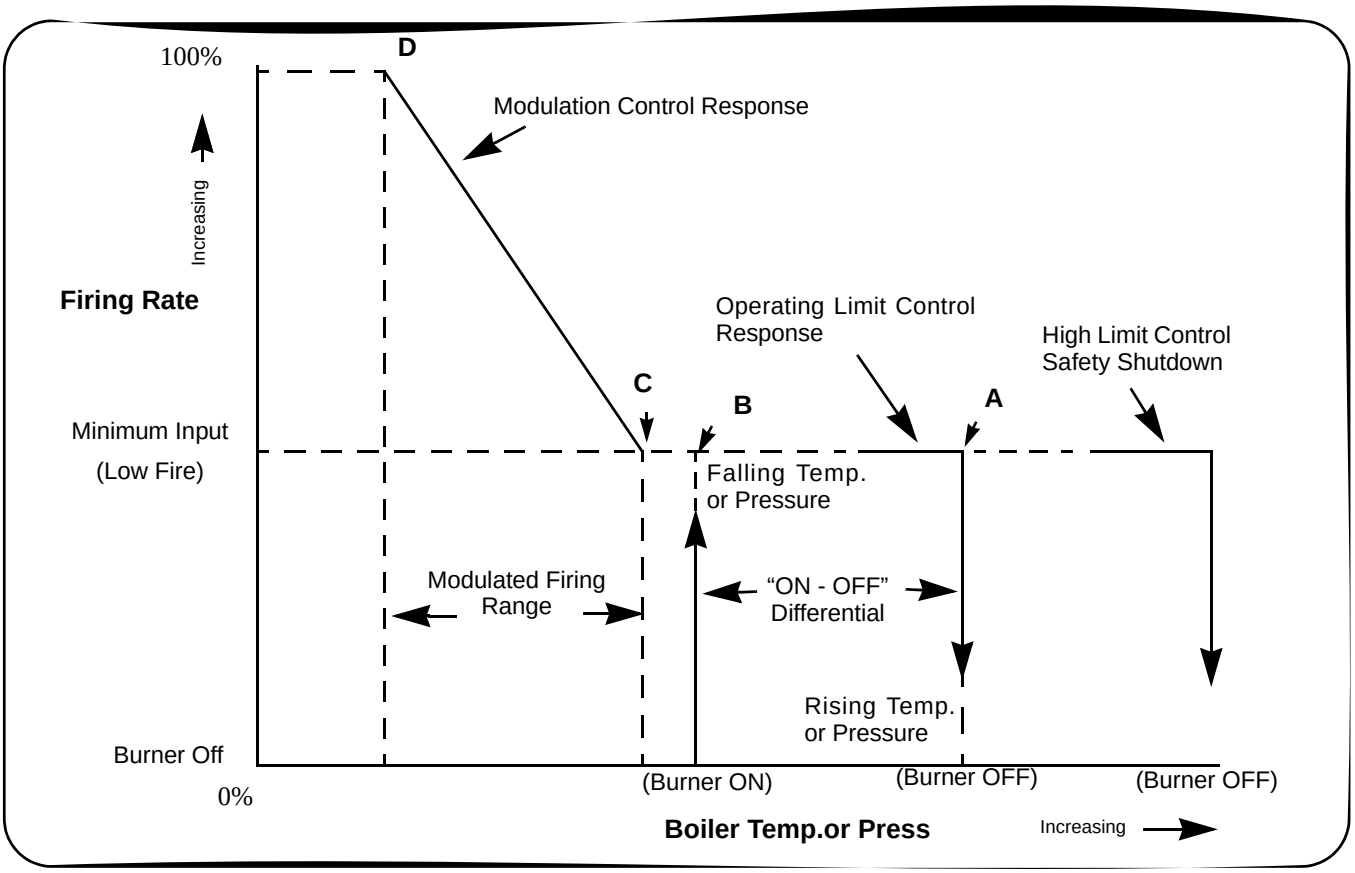


Figure 4-4: Firing Graph

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 4-4 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 prepurge period, plus the fixed time required for proving the pilot and main flame. In addition, approximately one-half minute is required for the damper motor to travel from low to high fire. The time lag may allow pressure or temperature to drop below desirable limits.

F. MODULATING PRESSURE CONTROL (Steam)

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

⚠ CAUTION

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

G. OPERATING LIMIT PRESSURE CONTROL (Steam)

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

Figure 4-5: Steam Operating Controls

H. HIGH LIMIT PRESSURE CONTROL (Steam)

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

I. MODULATING TEMPERATURE CONTROL (Hot Water)

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

⚠ CAUTION

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

J. OPERATING LIMIT TEMPERATURE CONTROL (Hot Water)

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

K. HIGH LIMIT TEMPERATURE CONTROL (Hot Water)

Set the "cut-out" (burner off) temperature on scale using the adjusting screw. The control will break the circuit and lock out on a rise in water temperature above the setting. The setting should be sufficiently above the operating limit temperature to avoid unnecessary shutdowns. 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.

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

No adjustment is required since LWCO controls are preset by the original manufacturer. However, if the water level is not maintained as shown in Figure 2-1, inspect the devices immediately and replace as required.

M. COMBUSTION AIR PROVING SWITCH

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

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

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.

N. 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 prepurge period of operation by stopping the programmer during the prepurge 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 prepurge, 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 M.

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

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 Table 4-1 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 4-1 for standard pressure require-ments.

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 4-2.

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 Glow = Ft^3/Hr

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

$$\text{GAS FLOW} = \frac{\text{INPUT}}{\text{GAS BTU's/Ft}^3}$$

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

Pressure Correction

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

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

To express the volume obtained from an actual meter reading into cubic feet at base pressure, it is necessary to multiply the meter index reading by the proper pressure factor obtained from Table 4-2

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 (Table 4-1). Table 4-2 indicates a correction factor of 1.07 for 2,000 feet. Multiplying the 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 (Table 4-2).

$\frac{\text{Btu/hr Input}}{\text{Btu/cu-ft}}$ = CFH (Cubic feet/hour)

OR

$\frac{12{,}550{,}000}{1{,}000}$ = 12,550 CFH (At 14.7 Ib-atmospheric base pressure)

THEN

$\frac{12{,}550}{1.18}$ = 10,635 CFH

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.

Table: 4-1 Standard Gas Train Data

GAS TRAIN DATA

BHP	Pipe size	Maximum inlet pressure (psi)			MAX GAS @ 80% (MMBtuh)	MAX #2 OIL @ 80% (gals)	MAX #6 OIL* @ 80% (gals)
		UL	FM	IRI			
800	2	10	10	10	33.48	239.11	223.17
900	2	10	10	10	37.66	269.00	251.06
1000	2	10	10	10	41.84	298.88	278.96
1100	2	10	10	10	46.03	328.77	306.85
1200	2	10	10	10	50.21	358.66	334.75
1300	2	10	10	10	54.40	388.55	362.65
1400	3	10	10	10	58.58	418.44	390.54
1500	3	10	10	10	62.77	448.33	418.44

*140,000 Btu/gal
** 150,000 Btu/gal

Final adjustment of the gas fuel is carried out by means of the adjusting rods and linkage arms, while performing a combustion efficiency analysis. See Section Q for details.

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

P. GAS FUEL COMBUSTION ADJUSTMENT

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

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

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

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

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

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

It's important to understand what the readings shown on an instrument refer to when setting combustion in a boiler. To assist with this understanding Figure 4-6 shows the relationship between O_2 levels (excess air) and the products of combustion for a typical flue gas analysis (natural gas).

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

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

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

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

Using information from Section P, 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.

Table: 4-2 Pressure Correction Factors

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

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 highfire air damper may need to be adjusted.

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

After being certain that the air control damper and its linkage are correctly adjusted to provide the proper amount of secondary air, and after adjusting the gas pressure regulator, final adjustment can be made using the adjustable linkage 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 jackshaft.

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 AND TEMPERATURE - GENERAL

Variations in burning characteristics of the fuel oil may occasionally require adjustments to assure highest

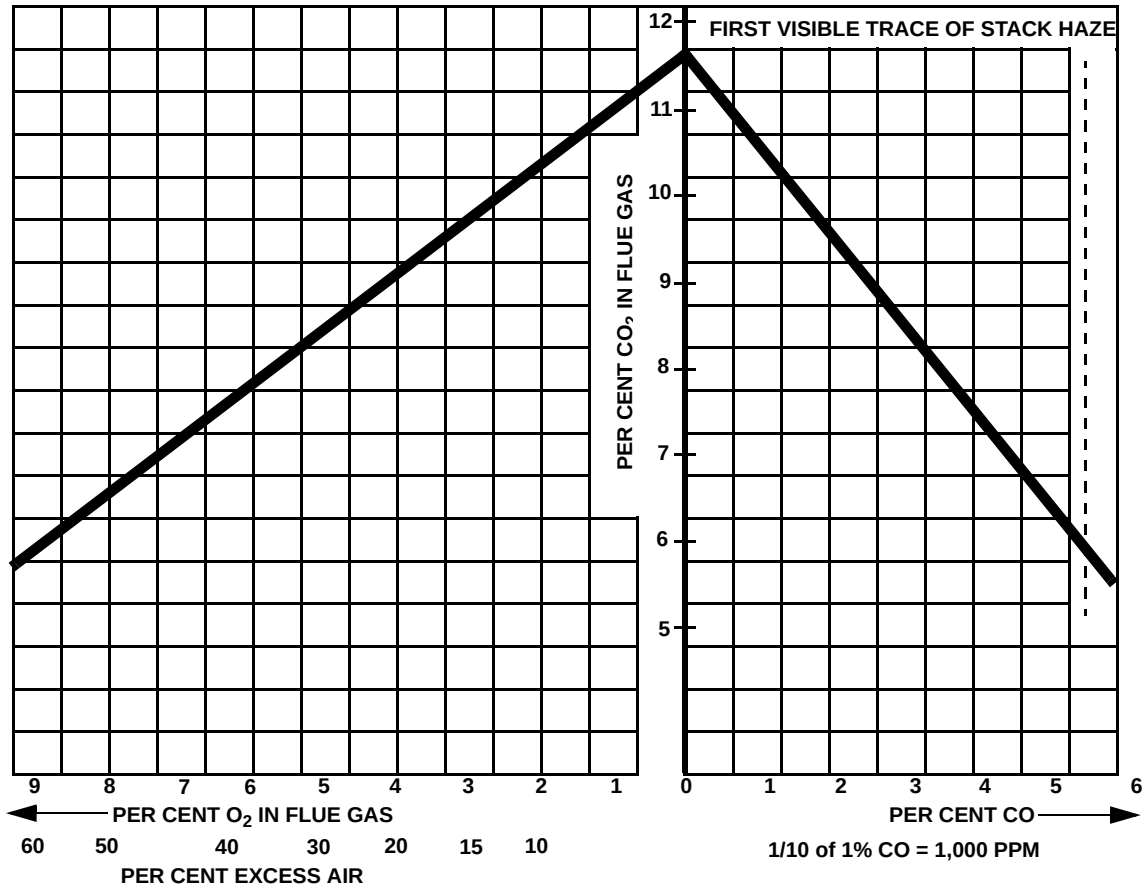


Figure 4-6: Flue Gas Analysis Chart for Natural Gas

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.

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 manufactures 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 5

INSPECTION AND MAINTENANCE

A. General

A well-planned maintenance program will help avoid unnecessary down-time 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 Figure 5-3. 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. Section H of Chapter 2 contains information relative to the inspection.

Inspections are usually, though not necessarily, scheduled for periods of normal boiler down time, 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 boilers 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.

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

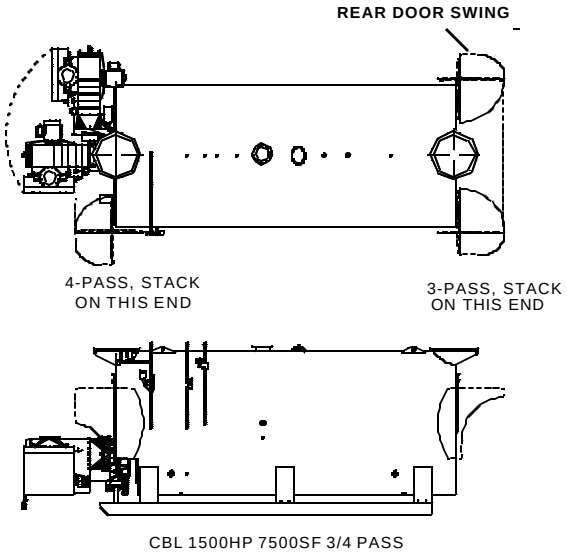


Figure: 5-1 Door Swing Profile

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. See Section I in Chapter 2.

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.

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. Refer to Sections G and H in Chapter 2 for blowdown instructions and internal inspection procedures.

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.

Steam Boiler

Figure 5-2 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.

On a steam boiler, the head mechanism of the low-water cutoff device(s) should be removed from the bowl at least

Figure: 5-2 LWCO

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

DAILY	WEEKLY	MONTHLY	SEMI ANNUALLY	ANNUALY
•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	•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.	•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	•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	•Clean fireside surfaces •Clean breeching •Inspect waterside surfaces •Check operation of safety valves

Figure: 5-3 Recommended Boiler Inspection Schedule

Hot Water Boiler.

It is impractical to blowdown the low-water cutoff devices on a hot water boiler since the entire water content of the system would become involved. Many hot water systems are fully closed and any loss of water will require 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 manufactures instructions on the regulator

D. Water 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

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 a 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.

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.

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.

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.

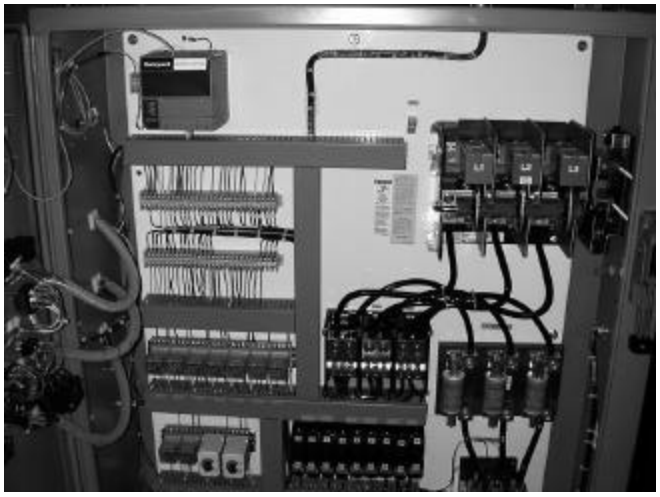


Figure: 5-4 Entry Box

⚠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.

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 deenergize 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.

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) deenergize within 4 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.

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 deenergized and the relay will signal the condition within 4 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. See Chapter 3.

Oil Strainers

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

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 counter-clockwise to remove the basket. Reassemble in reverse order.

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

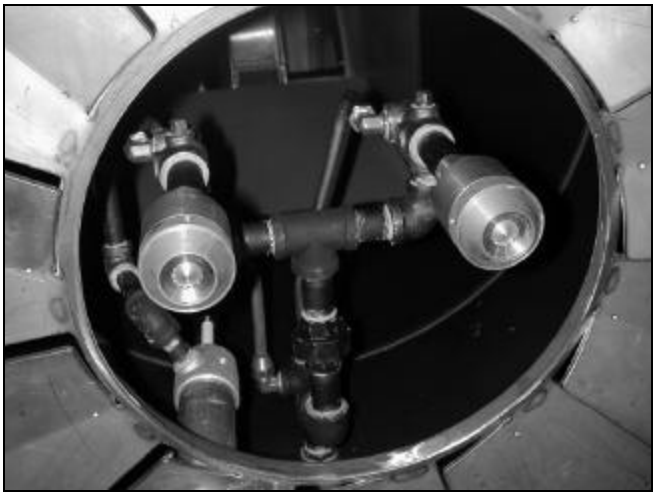


Figure: 5-5 Oil Nozzles and Pilot

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.

Ignition System

For best results, maintain the proper gap and dimensions of the ignition electrode(s). Figure 3-13 and 3-14 shows the proper settings.

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.

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. See Chapter 3.

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.

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. See Figure 3-14 for electrode settings.

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

J. Motorized Gas Valve

The motorized gas valve (Hydramotor) operating mechanism is completely immersed in oil and little maintenance is required because of the sealed design. However, proper operation should be checked on a routine periodic basis.

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

The packing gland is of the O-ring type. If oil is noticed around the operator base or if leakage occurs, repair by replacing any leaking O-rings and refilling the actuator with oil.

If the actuator is sluggish or fails to operate, even after the oil level is checked, replace the entire operator portion.

K. 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.

L. 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.

Figure: 5-6 Damper Linkage

⚠ 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.

M. 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 down time of the boiler for valve repair or replacement. Repair of a valve must be done only by the manufacturer or his authorized representative.

Figure: 5-7 Safety Valves

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.

N. Refractory

The boiler is shipped with completely installed refractory. The refractory consists of the dry oven, the rear access plug, blanket insulation, wetpack and sealing rope. 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.

O. Opening And Closing Doors

1. Opening Front or Rear Door

Before opening the doors, tighten the nut on the davit arm to create slight tension (See Figure 5-8.) This will prevent sagging and facilitate opening of the door. After opening either door, check the gaskets and seating surfaces. Replace the door gaskets if they are hard or brittle. Clean the sealing surfaces of the door and tube sheet. If the blanket insulation is torn away or decorated The insulation will require replacing.

Figure: 5-8 Tighten the nut on the davit arm before opening door

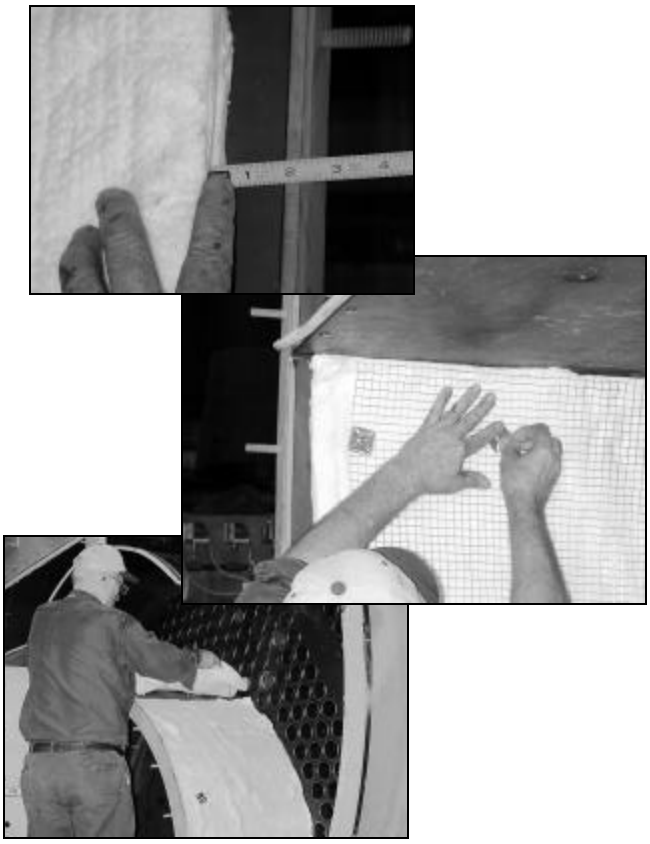


Figure: 5-9 Cut insulation, wire mesh and fit to place

2. Insulating the Smoke Box.

When replacing the insulation in the front smoke box area, be sure to clean the installation area. Be sure all firetubes are clean and free of old insulation material. If necessary replace the retainer pins. Cut the blanket insulation 1-1/2" to 2" back from the door mounting flange. The space is required for the doors to close and compress into the inner lining of insulation with out causing distortion to the blanket insulation. Use spray adhesive to hold the insulation in place prior to placing the wire mesh over the blanket insulation. Install the retainers and bend the pins parallel to the blanket insulation and retainers. WetPack insulation should be used on the base of the smoke box and around the furnace area.

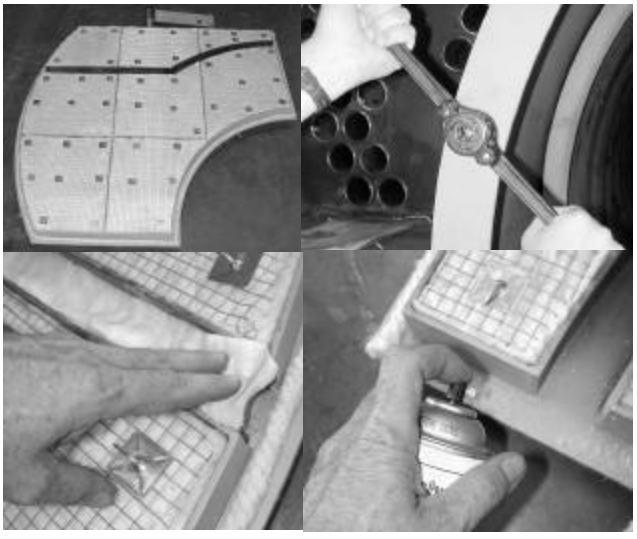


Figure: 5-10 Prepare Doors for Closing and Sealing

Preparing to Close Doors

The doors are insulated with 2" blanket insulation and held in place with wire mesh, retainer pins and clips.

Before closing the doors check all the mounting studs by running a mounting nut down the threads to check for burs or flat spots. Checking the mounting studs before trying to close the door will greatly facilitate the closing process. If a flat spot or bur is found, remove the nut and chase the thread with the appropriate sized Thread die.

> **Note: When closing the doors, 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.**

Use spray adhesive to secure the 1/2" rope (872-622) to the sealing area of the doors.

Cut 2" blanket insulation to fit in the door baffle seal area. Use a spray adhesive to hold the baffle seal in place.

3. Closing and Sealing Doors

Swing the door to the closed position, adjusting the davit bolt to align the door. Be sure the gasket is positioned correctly prior to tightening the door. 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.

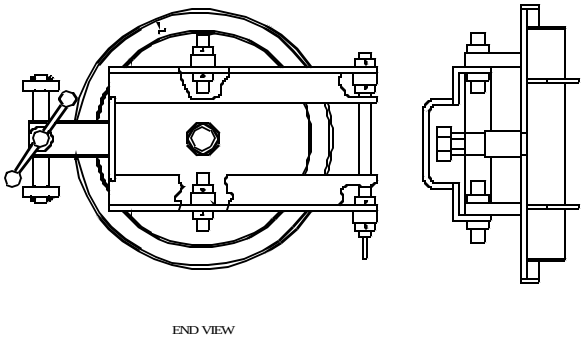
After closing the door, loosen the nut on the davit arm stud to release tension on the davit arm. Failure to do so may result in damage to the boiler due to thermal stresses during boiler operation.

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: 5-11 Closing Doors

P. Sealing and Closing the Access Plug

The access plug is hinged to allow easy access to the first and second pass turnaround area. The access plug is 20" in diameter. Secured with a locking bolt and latch.



END VIEW

Sealing the rear access plug requires cleaning the seal area. Spray adhesive into the sealing area and insert the 2" rope gasket.

Q. Lubrication

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 motors in CB applications require an *aluminum complex high temperature* grease. Do not mix with any other type of grease.

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.

Solenoid and Motorized Valves

Solenoid valves and motorized valves require no lubrication.

R. Combustion

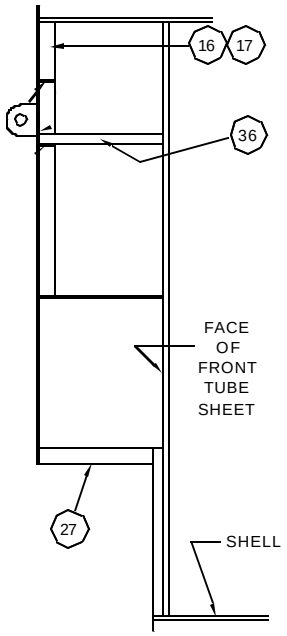
The frequency of burner adjustments depends upon several factor, including; type of burner, type of fuel, load conditions, ambient temperature, climatic variables, and general maintenance practices.

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.

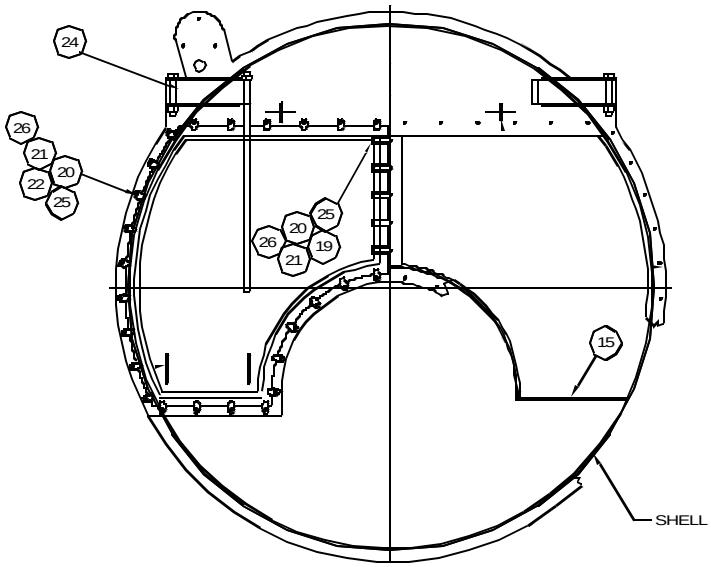
Section 6

CBL Vessel Parts

MATERIAL LIST			114"-3	126"-3(3"tube)	138"-3(3"tubes)	126"-4	136"-4(3" tubes)
ITEM	PART NUMBER	DESCRIPTION					
15	872-00412	INSUL.WET FIBER 1/4"x 24"x 138"	1	150	165	150	165
16	930-00135	WIRE MESH	70	116	80	116	80
17	872-00549	BLANKET INS. 2",8 LB.DEN	70	110	80	116	80
19	103A510	LOCKING LUG	5	6	6	5	5
20	841-00331	STUD,1/2"x 2"	55	59	62	59	61
21	869-00029	NUT,1/2"BRASS	55	59	62	59	61
22	103-00375	LOCKING LUG	50	54	56	54	56
24	462-00032	HINGE DETAIL	2				
25	872-00622	FIBERFRAX RD BRAID,1/2"x 212"	2	230	252	230	252
26	872-00660	SEALANT,ADHESIVE	4	4	4	4	4
28	828-00034	INSULATING SPEED CLIPS, S.S.	141	165	201	181	241
31	872-00362	INSULATION BLANKET, 1" THK. 2400°	10	15	20	120	120
37	903-00297	INSULATION PIN 10 GA. x 2.50" S.S.	141	165	201	181	241



SECTIONAL SIDE VIEW
SHOWN W/O DOORS



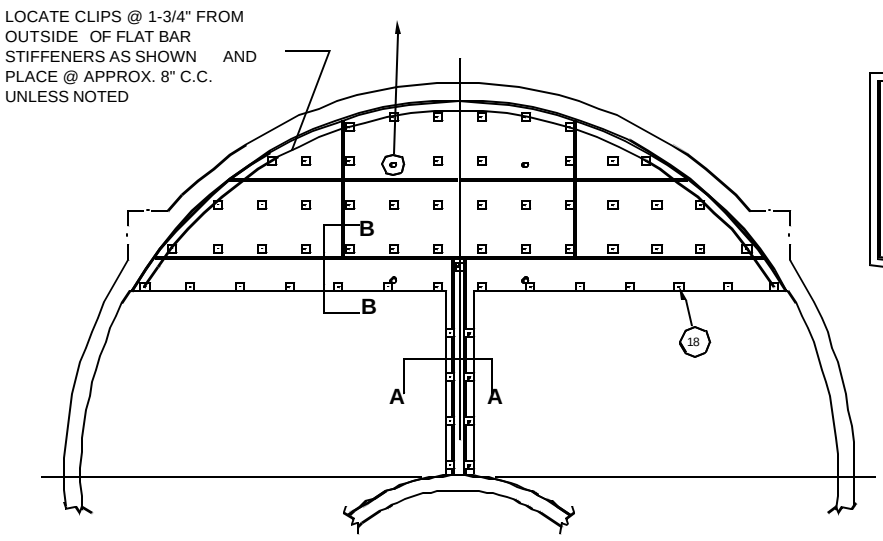
FRONT VIEW

FRONT SMOKE BOX DETAIL

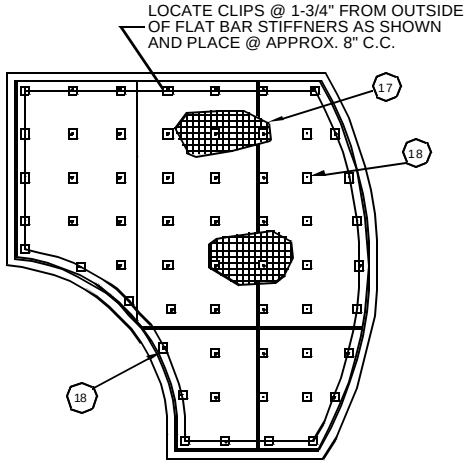
FOR A 114"DIA CBL 3-PASS

13202169

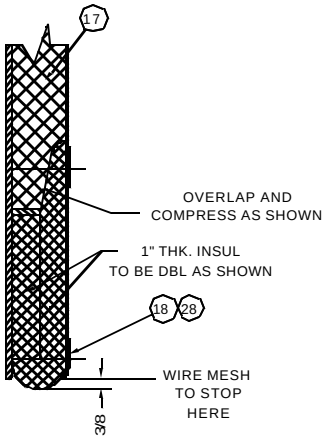
NOTES:
1) SEE SHEET 1 FOR MAT`L LIST.
2) TRIM WIRE MESH FLUSH WITH OUTSIDE OF FLAT BAR STIFFENERS.
3) INSULATION TO COVER ENTIRE AREA INSIDE FLAT BAR STIFFENERS.
4) COAT BACK OF INSULATION W/ A 2300° RIGIDIZER (872-443) MIXED W/ WATER TO A 50:50 SOLUTION, AFTER SCREEN IS INSTALLED TO A DEPTH OF 1/4".



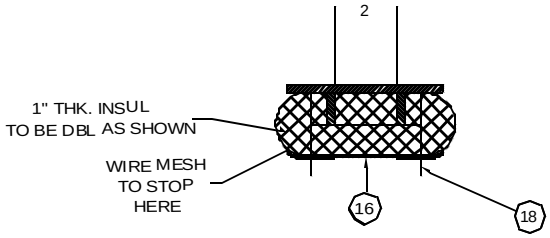
REAR VIEW ITEM #1



REAR VIEW ITEM #2



SECTION B-B



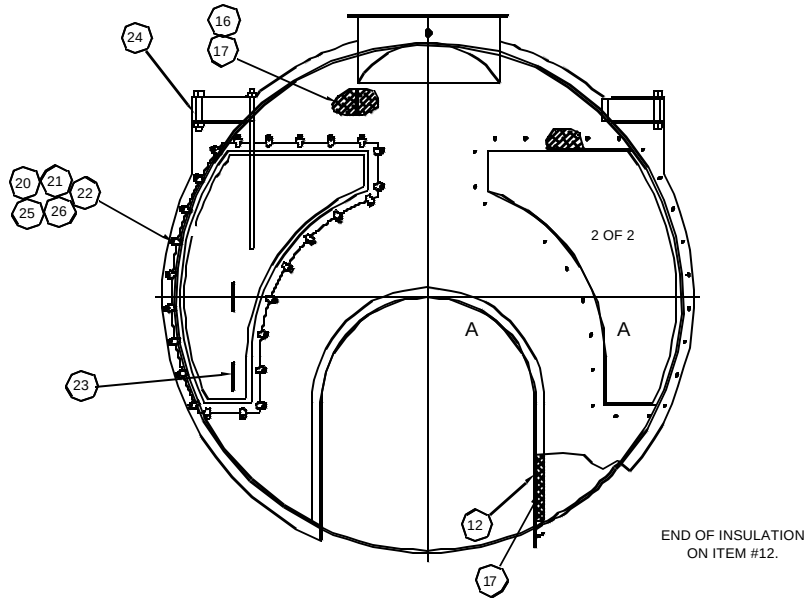
SECTION A-A

FRONT SMOKE BOX FOR A
138" CBL-3 W/ 3" TUBES

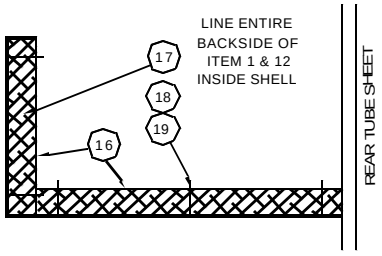
132 02232

MATERIAL LIST

ITEM	PART NUMBER	DESCRIPTION	QTY.	114"DIA.CBL-3 W/ 3"TUBES	126"DIA.CBL-3 W/ 3"TUBES	138"DIA.CBL-3 W/ 3"TUBES	114"DIA.CBL-4 W/ 3"TUBES	126"DIA.CBL-4 W/ 3"TUBES	138"DIA.CBL-4 W/ 3"TUBES
16	930-00135	WIRE MESH	100	80	110	100	80	110
17	872-00549	INSULATION BLANKET,2" THK. 8 LB. DEN	100	80	110	100	80	110
18	903-00044	INSULATION PIN	125	203	256	128	201	201
19	828-00034	SPEED CLIPS	125	203	256	128	201	263
20	841-00331	STUD,1/2"x 2"	52	63	63	52	63	63
21	869-00029	NUT,1/2"BRASS	52	63	63	52	63	63
22	103-00375	LOCKING LUG	52	62	62	52	62	62
24	462-00029	HINGE DETAIL	2					
25	872-00622	FIBERFRAX RD BRAID,1/2"x 256"	2	240	240	256	240	240
26	872-00660	SEALANT,ADHESIVE	1	4	4	4	4	4



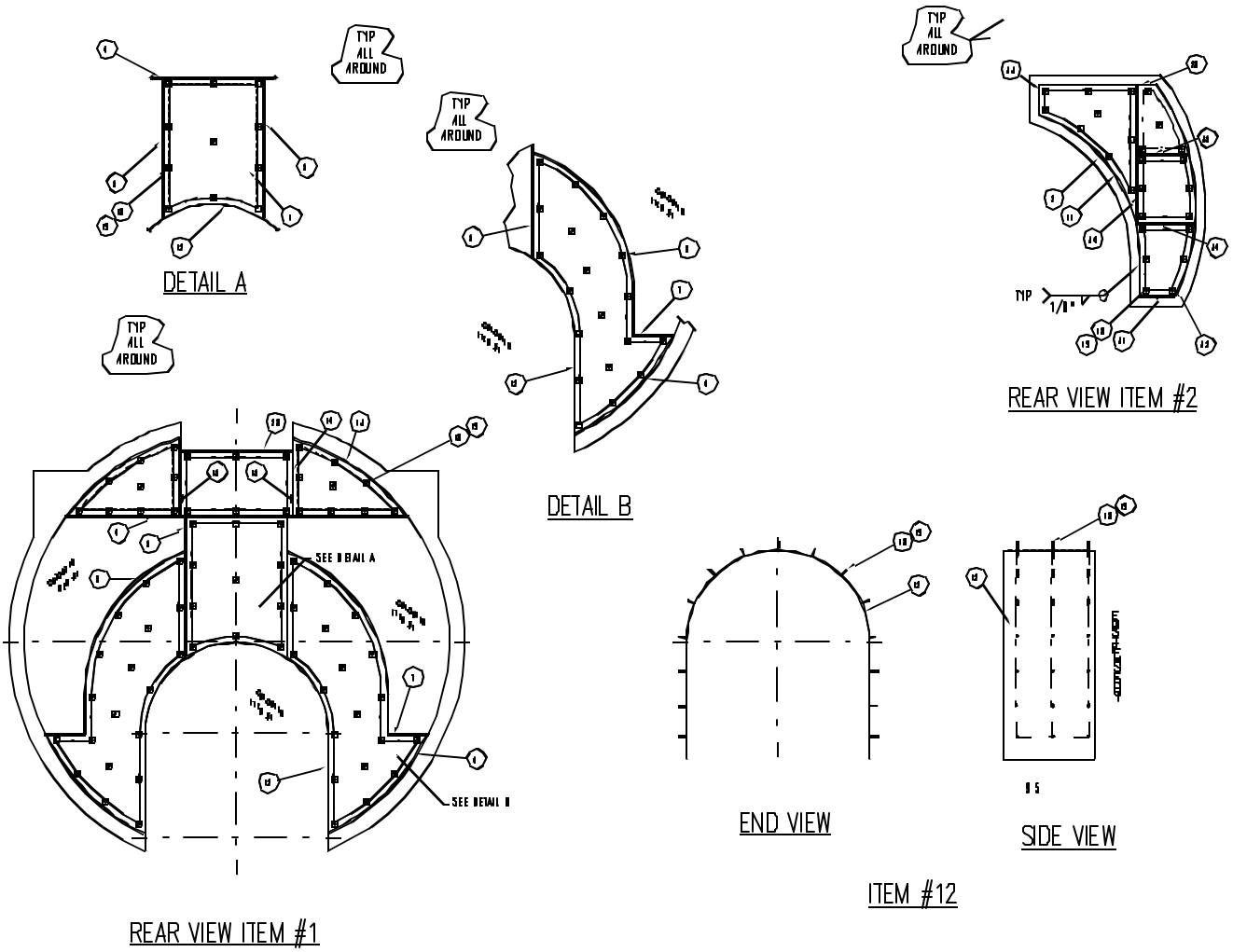
REAR VIEW



SECTION A-A

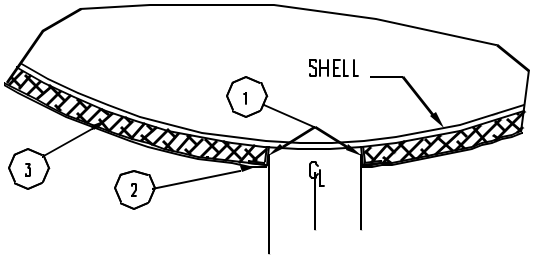
REAR SMOKE BOX FOR A
114"DIA.CBL-3 W/ 3"TUBES

132 02170

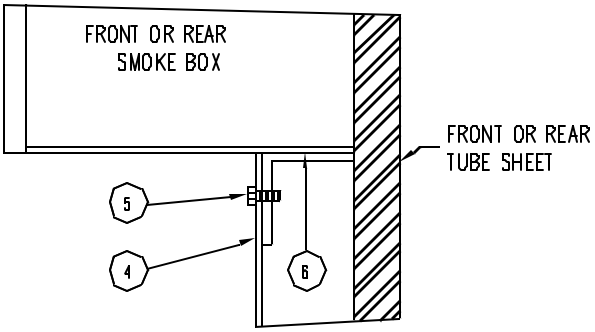


REAR SMOKE BOX STIFFNER AND CLIP
LOCATION, CBL-3

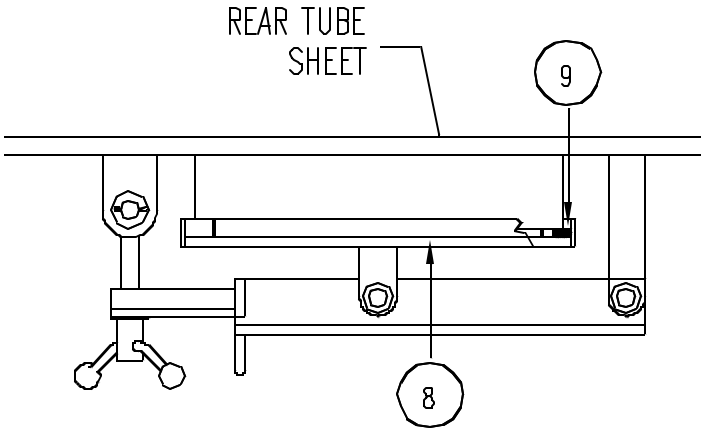
132 02170



SHELL INSULATING DETAIL



DETAIL A



ACCESS PLUG INSTALLATION

MATERIAL LIST			
ITEM	PART NUMBER	DESCRIPTION	QTY
1	972-00021	ANGLE,1/4"x 2"x 2" x "A"	6
2	974-00394	SHEET,16 GA. x "B"	1
3	872-00737	ROCKWOOL BLANKET INS., 2",8 LB.DEN x "C"	1
4	310-00847	COVER PLATE, REAR, 11 GA.	1
5	841-01596	SCREW,SHEET METAL,8 x 1/2"STP	150
6	030-00449	FRAME, REAR INSULATION COVER PLATE	1
7	310-00848	COVER PLATE, FRONT, 11 GA.	1
8	465-02022	REAR ACCESS DOOR	1
9	872-00724	FIBERFRAX ROPE, 1-1/2" DIA. x 61.25"	1
10	828-00034	SPEED CLIPS,1-1/2" SQ. S.S.	72
11	903-00236	WELDING PINS	72
12	930-00135	WIRE MESH, S.S.,1/2" x 22" x 300".	1
13	872-00362	INSULATION, KAOWOOL, 2400°, 1" x 23" x 300"	1
14	149-00748	SIZED ANGLE, 1/4" x 2" x 2" x 2"LG.	24
15	077A00505	LAGGING SPACER	2

NOTE: SEE SHEET 2 FOR ADDITION DETAILS.

INSULATION AND JACKET FOR 138"DIA,3/4-PASS CBL 465 02138

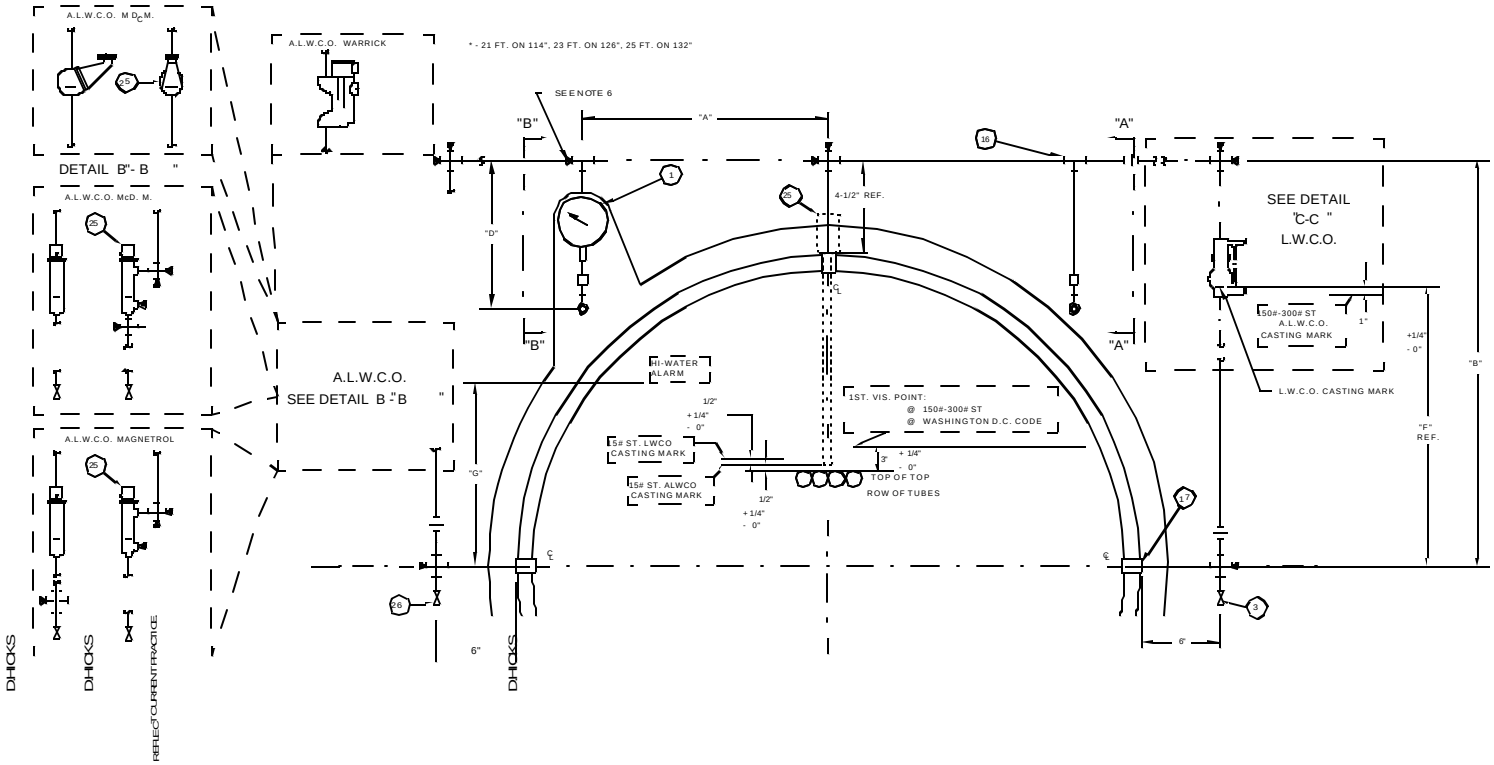
NOTES:

1. POSITION BRACKET BEHIND SHELL FLG., AND WELD TO FLG.
2. FOR (OLC), (HLC) AND (MC) CONTROLS SEE REFERENCE DRAWING #146-B-210.
4. IF HOT WATER, ELIMINATE 3/4" TEES, AND ALL PRESSURE CONTROL PIPING. REPLACE WITH STRAIGHT PIPE FROM UNION TO GAUGE PIPING.
6. IF AUXILIARY COLUMN REQUIRED, REMOVE PLUG AND CONNECT AUXILIARY PIPING TO MAIN COLUMN.
7. EVEN THOUGH ALWCO IS AUTO RESET IT IS TO BE WIRED W/ A LATCHING SWITCH TO HAVE MAN. RESET ON PANEL
8. IF WASHINGTON D.C. CODE, "A" DIMENSION IS 1". ALL PIPING & FITTINGS TO BE BRASS.

DIMENSION TABLE

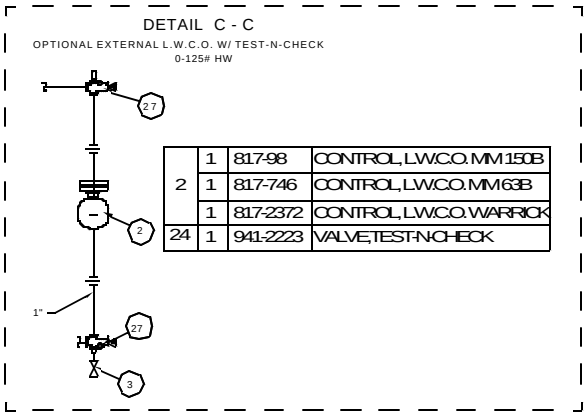
DIMN.	PRESSURE	CBL 114"	CBL 126"	CBL 138"
"A"	ALL HW	41-3/4"	47-1/4"	50"
"B"	150#	64-1/4"	70-1/4"	76-1/4"
	151#-250#	64-7/16"	70-7/16"	76-7/16"
"C"	ALL	41 1/2"	45 1/2"	-
"D"	150#ST.	19-1/8"	21-3/4"	22-1/2"
	151#-250#	19-5/16"	21-15/16"	22-11/16"
"E"	ALL	-	-	-
"F"	15ST/30-125HW	33-3/16"	32-3/8"	34"
	150# ST/HW	37"	36-3/16"	37-13/16"
	151-250# ST	36-5/16"	35-1/2"	37-1/8"
"G" REF	ALL	51"	51"	57"

ITEM	QTY	PART NO. M. D. M.	PART NO. MAGNETROL	DESCRIPTION	USED ON	
1	1	850-264		PRESSURE GAUGE	15 ST	
	1	850-104		PRESSURE GAUGE	150-200 ST/160 HT-HW	
	1	850-150		PRESSURE GAUGE	250 ST	
	1	850-172		PRESSURE GAUGE	300 ST	
	1	850-101		TEMPERATURE GAUGE	30 HW	
	1	850-103		TEMPERATURE GAUGE	125 HW	
2		817-621	———	LOW WATER CUT-OFF	15-150 ST	PNEUMATIC FEEDWATER
	1	817-1307				ELECTRIC FEEDWATER
		817-303	817-1962	LOW WATER CUT-OFF	200-250 ST	PNEUMATIC FEEDWATER
	1	817-1211				ELECTRIC FEEDWATER
	1	———	817-1962	LOW WATER CUT-OFF	300 ST	PNEUMATIC FEEDWATER
	1	817-3246	———	LOW WATER CUT-OFF	0-160 HW	
3	1	-		-	-	
	1	-		-	-	
4	1	941-401		VALVE, GLOBE, 3/4"	15-300 ST	
	2	825-31	———	COCK, UNION, 1/4"	15-250 ST	
	2	------	941-318	VALVE, GLOBE 1/4"	300 ST	
	1	825-31	———	COCK, UNION, 1/4"	0-160 HW	
5	1	-		-		
6	1	851-44	———	GAUGE, GLASS	15-150 ST	
	1	851-199	851-391 CLARK-REL	GAUGE, GLASS	200-250 ST	
	1			GAUGE, GLASS	300 ST	
7	4	912-34	912-34	ROD,GAUGE GLASS	15-150 ST	
	4	912-85	912-34	ROD,GAUGE GLASS	200-250 ST	
8	1	825-352		SET, GAUGE GLASS VALVE	15-250 ST	
	1	825-370		SET, GAUGE GLASS VALVE	300 ST	
10	1	941-55		VALVE, BALL, 1/4"	15-200 ST	
	1	941-318		VALVE, GLOBE 1/4"	250-300 ST	
11	*	971-13		FLAT BAR, 1/8" x 1" x 48"	ALL	
12	*	830-28		CHAIN SASH, NO. 35	*15-300 ST	



WATER COLUMN, MAIN & AUX. 114", 126" & 138" CBL

146 00076



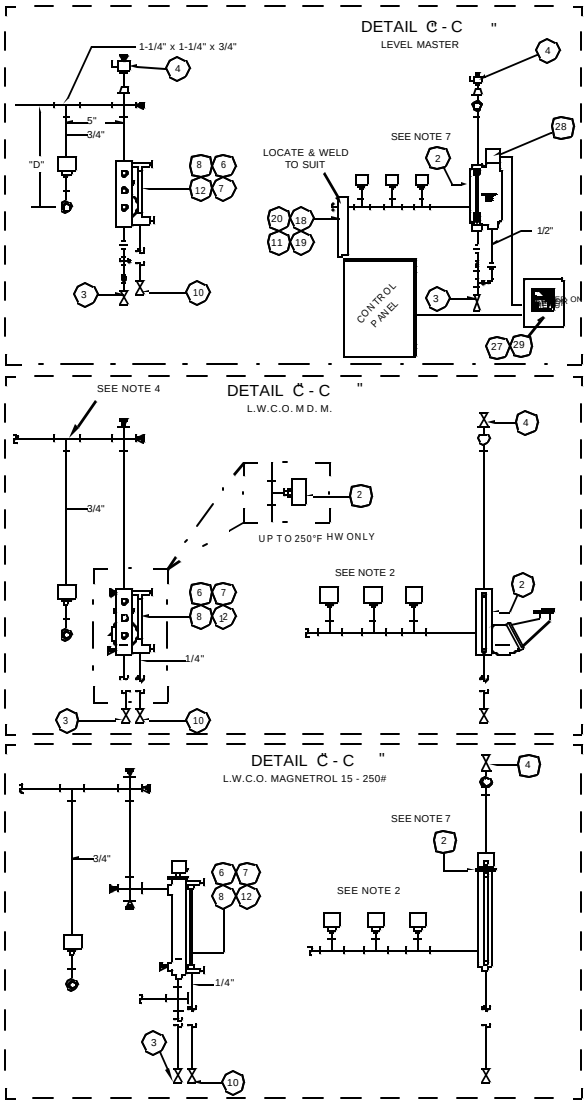
2	1	817-98	CONTROL, L.W.C.O. MM 150B
	1	817-746	CONTROL, L.W.C.O. MM 63B
	1	817-2372	CONTROL, L.W.C.O. WARRICK
24	1	941-2223	VALVE, TEST-N-CHECK

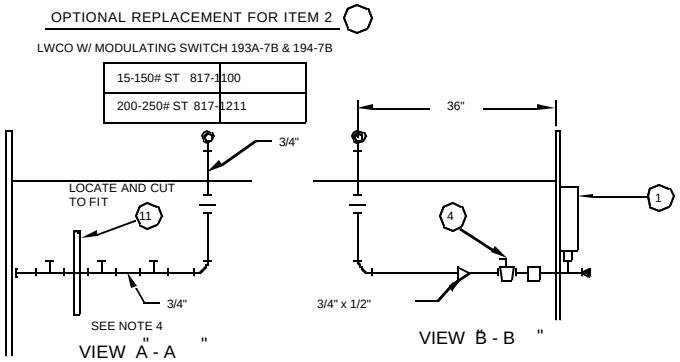
		McD. M.	MAGNETROL	A.L.W.C.O.	USED ON
	1	817-2286	———	CONTROL, AUX. L.W.C.O.	♣ 0-160 PSI HW
	A.L.W.C.O. / HI-WATER ALARM				
25	1	817-2372	———	CONTROL, AUX. L.W.C.O. (EXT. PROBE)	♣ 15-250 PSI ST
	1	817-558	———	CONTROL, AUX. L.W.C.O.	♣ 15-150 PSI ST
	1	817-305	817-301	CONTROL, AUX. L.W.C.O.	✿ 151-250 PSI ST
	1	———	817-1517	CONTROL, AUX. L.W.C.O.	✿ 251-300 PSI ST
26	1	941-401		VALVE, GLOBE 3/4"	✿ 0-300 PSI

SEE NOTE 7

LEVEL MASTER EQUIPMENT

					OPTION
2	1	289-141	LOW WATER CUTOFF	15#	LV
	1	289-141		150-250#	
3	1	941-402	VALVE, GLOBE, 1" NPT	0#-250#	
27	1	623-116	LEVEL MASTER CONTROL PANEL	0#-250# AUTO RESET	
	1	623-117		0#-250# MANUAL RESET	
28	1	623-36	LEVEL MASTER PROBE	0#-250#	
29	1	8-3267	BRACKET	0#-250#	





WATER COLUMN, MAIN & AUX. 114", 126" & 138"
CBL

146 00076

PRESSURETROL SELECTIONS 15 PSI
FULL MODULATION OPERATION

item:	cb part no:	description	qty:
1	817-00016	OPER PRES. SWITCH, HNYWLL. NO. L404A1511	1
2	817-00251	MOD PRES. SWITCH, HNYWLL. NO. L91A1169	1
3	817-00113	HI-LIMIT PRES. SWITCH, HNYWLL. NO. L604A1169	1
4	847-00267	TEE, RED., 3/4" x 3/4" x 1/4", 150 LB., BLK.	3
5	857-00677	NIPPLE, 3/4", SCH. 80 x 6", SA106B	3
6	857-00680	NIPPLE, 1/4", SCH. 80 x 6", SA106B	3

PRESSURETROL SELECTIONS 150 PSI
FULL MODULATION OPERATION

item:	cb part no:	description	qty:
1	817-02322	OPER PRES. SWITCH, HNYWLL. NO. L404A1396	1
2	817-00244	MOD PRES. SWITCH, HNYWLL. NO. L91B1050	1
3	817-00114	HI-LIMIT PRES. SWITCH, HNYWLL. NO. L604A1185	1
4	847-00267	TEE, RED., 3/4" x 3/4" x 1/4", 150 LB., BLK.	3
5	857-00677	NIPPLE, 3/4", SCH. 80 x 6", SA106B	3
6	857-00680	NIPPLE, 1/4", SCH. 80 x 6", SA106B	3

PRESSURETROL SELECTIONS 200-300 PSI
FULL MODULATION OPERATION

item:	cb part no:	description	qty:
1	817-00111	OPER PRES. SWITCH, HNYWLL. NO. L404A1404	2
2	817-00269	MOD PRES. SWITCH, HNYWLL. NO. L91B1068	1
3	817-00115	HI-LIMIT PRES. SWITCH, HNYWLL. NO. L604A1193	1
4	847-00318	TEE, RED., 3/4" x 3/4" x 1/4", 300 LB., BLK.	3
5	857-00677	NIPPLE, 3/4", SCH. 80 x 6", SA106B	3
6	857-00680	NIPPLE, 1/4", SCH. 80 x 6", SA106B	3

SEE NOTE 6

OPTIONAL CONTROL

2.) LOW-FIRE-HOLD W/ METRIC SCALE
A. TEMPERATURE SWITCH,UNITED ELECTRIC#54 MODEL D23BC,W/ OPTOPN 0500 & M270 CB P\N 817-0?????
B. WELL, UNITED ELEC# KP 145071-A-051 CB P/N 817-00705
C. BUSHING,3/4"x 1/2"CB P/N 847-00152

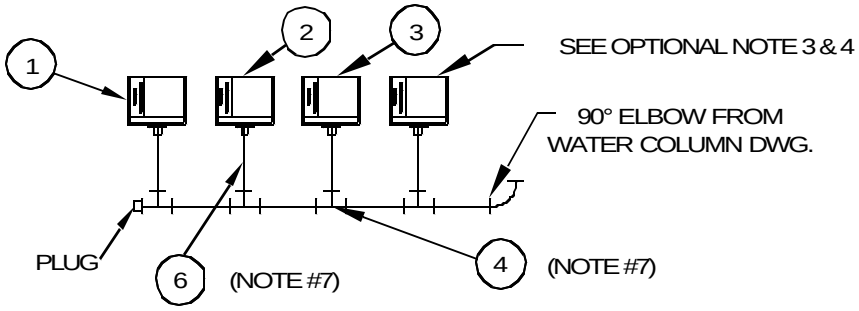
3.) LOW STEAM PRESSURE 150 PSI
A. PRESSURE SWITCH HONEYWELL L404B1346 CB P/N 817-00448
B. TEE,RED.3/4"x 3/4"x 1/4" 150 LB.CB P/N 847-00267
C. NIPPLE,1/4"x 6"SCH 80 SA106B,CB P/N 857-00680
D. NIPPLE,3/4"x 6"SCH 80 SA106B,CB P/N 857-00677

4.) LOW STEAM PRESSURE 200-300 PSI
A. PRESSURE SWITCH HONEYWELL L404B1353 CB P/N 817-00112
B. TEE,RED.3/4"x 3/4"x 1/4" 150 LB.CB P/N 847-00267
C. NIPPLE,1/4"x 6"SCH 80 SA106B,CB P/N 857-00680
D. NIPPLE,3/4"x 6"SCH 80 SA106B,CB P/N 857-00677

5.) EVEN THOUGH HI-LIMIT SWITCH IS AUTO RESET IT IS TO BE WIRED W/ A LATCHING RELAY TO HAVE MAN. RESET ON PANEL

6. STOP LIMIT SWITCH 880-605 IS REQ`D WITH 151-250 PSI BOILERS WHEN UL AND/OR CSD-1 IS REQ`D AND ARE TO BE SET SO THAT THE STEAM PRESS. IN THE BOILER WILL NOT EXCEED THE MAX. ALLOWABLE WORKING PRESS. OF THE BOILER.

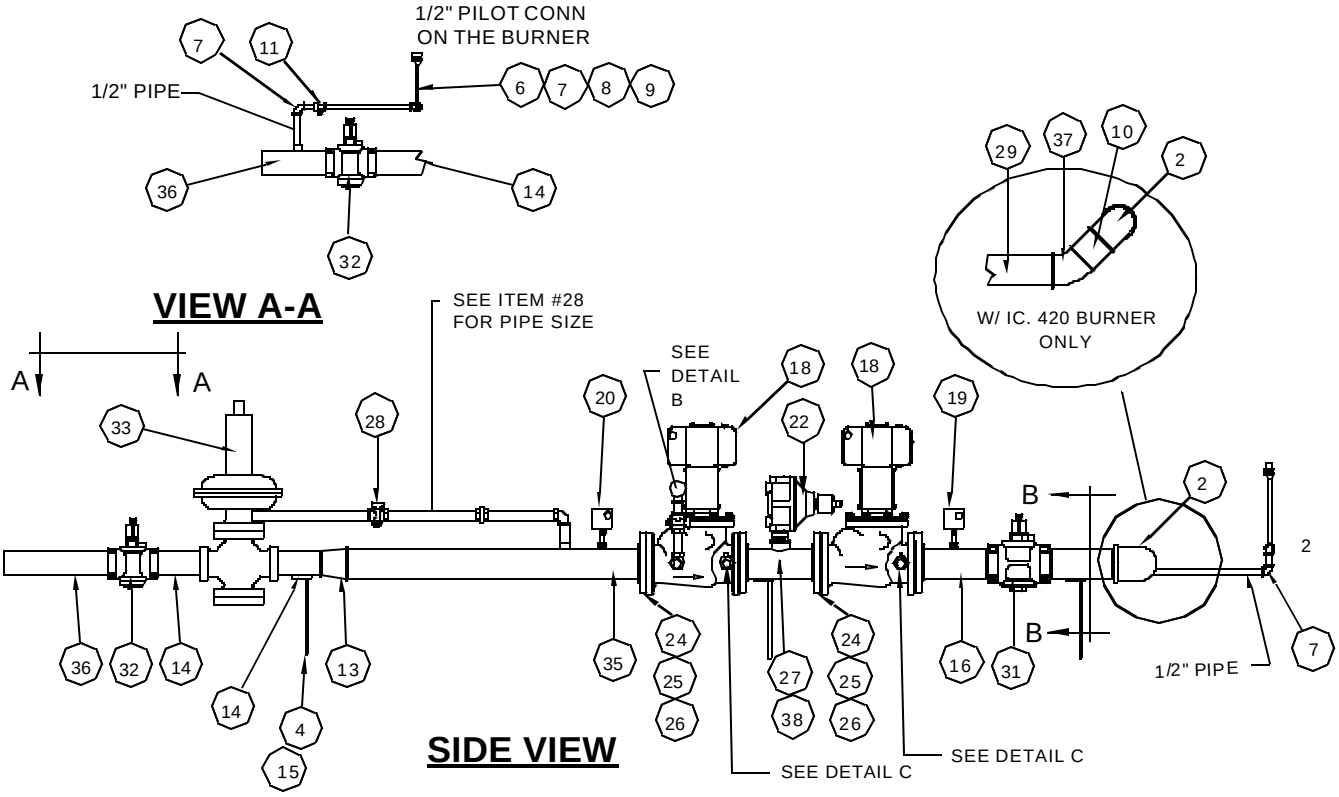
7. PRESSURE CONTROL LINE PIPING MUST NOT, AT ANY POINT, BE SMALLER IN SIZE THAN THE CONNECTION SIZE OF THE CONTROL. EX: IF CONTROL HAS 1/2" CONNECTION, USE 3/4"x3/4"x1/2" REDUCING TEE WITH 1/2" NIPPLE.



PRESSURE SWITCH PIPING FOR 15-300 PSI CBL

146 00210

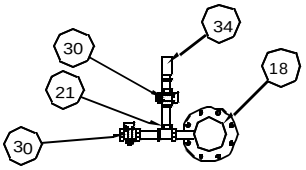
MATERIAL LIST					
ITEM	PARTNUMBER	DESCRIPTION	QTY.	USEDON	OPTION
1	057-01125	SIZED PIPE, 4" x 19-1/2" T.B.E.	1	IC. S1 BRNR.	-
	857-01417	NIPPLE, 4" x 12"		IC. 420 BRNR	
2	859-00089	ELBOW, 4" 150 LB. MI, 90°	1	ALL	-
3	858-00164	UNION,1/2" 150 LB. MI	1	ALL	- -
4	008-03408	GAS TRAIN BRACKET,	3	ALL	?
5	841-01141	U-BOLT, 4" PIPE SIZE	2	ALL	-
6	939-00266	BULK TUBING, ALUMINUM, 5/8" OD x 96"	1	ALL	?
7	859-00080	ELBOW, 1/2" 150 LB. MI.,90°	2	ALL	- -
8	845-00045	NUT,SHORT, SAE 45 DEG. FLARED,BRASS 5/8" ODT	2	ALL	-
9	845-00044	CONNECTOR,MALE, 5/8" OD x 1/2" NPT	2	ALL	-
10	857-00856	NIPPLE, 4" x 6"	1	IC 420 BRNR	-
11	825-00030	GAS COCK, 1/2"	1	ALL	?
*12	900-00080	BULK PIPE,4" SCH 40 x 14-3/8" T.B.E.	1	IC 420 BURNER	?
	057 05038	SIZED PIPE,4" SCH 40 x 36" T.B.E.		IC S1 BURNER	
13	847-01631	REDUCER,4" x 2" 150 LB. M.I.	1	ALL	?
14	857-00667	NIPPLE, 2" x 6"	2	ALL	-
15	841-01135	U-BOLT, 2" PIPE SIZE	1	ALL	-
16	157-01904	SPOOL PIECE,4" x 12" x 1/2" FLG`D x THD	1	ALL	?
17	-	-	-	-	-
18	949-00289	GAS VALVE, MOTORIZED W/ POC & ACTUATOR	2	ALL	?
19	817-02423	HIGH GAS PRESSURE SWITCH, 1.5-7 PSI	1	ALL	?
20	817-02418	LOW GAS PRESSURE SWITCH, 12-60"	1	ALL	?
21	859-00022	TEE,1/4" 150 LB. M.I.	1	NFPA-8501	-
22	948-00055	MAIN VENT VALVE, 2"	1	ALL	?
23	858-00335	FLANGED UNION, 4"125# CI, W/ HARDWARE	1	ALL	-



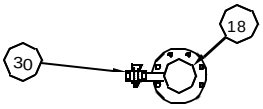
GAS TRAIN,800-1300HP CBL 4/5 SF. W/ FGR 3/4PASS

146 00398

ITEM	PARTNUMBER	DESCRIPTION	QTY.	USED ON	OPTION
24	869-00017	NUT,HEX HEAD, 5/8"-11	32	ALL	-
25	868-00192	CAPSCREW, 5/8"- 11 x 3" LG.	32	ALL	-
26	853-00403	GASKET, 4"	4	ALL	?
27	157-01891	SPOOL PIECE,4" x 12" x 2" FLG`D x FLG`D	1	ALL	?
28	941-02156	NEEDLE VALVE, 1/4"	1	800-1000HP 5SF	?
	941-02038	NEEDLE VALVE, 1/2"	1	ALL OTHERS	?
29	857-01417	NIPPLE, 4" SCH 40 x 12" LG.	1	ALL	?
30	825-00172	GAS COCK, 1/4"	4	NFPA-8501	?
31	941-00131	LUBRICATED PLUG VALVE, 4"	1	ALL	?
32	941-00128	LUBRICATED PLUG VALVE, 2"	1	ALL	?
33	918-00652	REG.,ROCKWELL 121-12,2"NPT, W/ 1.5 - 3 PSI OUT.	1	800-1000HP 5SF	?
	918-00824	REG.,ROCKWELL 441S,2"NPT, W/ 1.75 - 4 PSI OUT.		1100HP 5SF	
	918-00287	REG.,ROCKWELL 441S,2"NPT, W/ 1.75 - 4 PSI OUT.		1200HP 5SF	
	918-00826	REG.,ROCKWELL 441S,2"NPT, W/ 2.5 - 6 PSI OUT.		1300HP 5SF	
	918-00824	REG.,ROCKWELL 441S,2"NPT, W/ 1.75 - 4 PSI OUT.		1000HP 4SF	
	918-00287	REG.,ROCKWELL 441S,2"NPT, W/ 1.75 - 4 PSI OUT.		1100-1200HP 4SF	
	918-00826	REG.,ROCKWELL 441S,2"NPT, W/ 2.5 - 6 PSI OUT.		1300HP 4SF	
34	850-01093	PRESS. GAUGE, 1/4" BTM, 2-1/2", 0-100" W.C.	1	NFPA-8501 800-1200HP	?
	850-00613	PRESS. GAUGE, 1/4" BTM, 2-1/2", 0-160" W.C.		NFPA-8501 1300HP	
35	157-02018	DOUBLE SIDE OUTLET NIPPLE, 4" x 40" x 1/2"	1	ALL	?
36	157-00606	SIDE OUTLET NIPPLE, 2" x 10" x 1/2"	1	ALL	?
37	859-00102	ELBOW, 4" 150 LB. MI, 45°	1	IC 420 BRNR	?
38	857-00661	NIPPLE, 2" SCH 40 x 4" LG.	1	ALL	
39	8A753	BRACKET	2	ALL	
40	928-00044	CLAMP, FOR 1/2" PIPE	2	ALL	



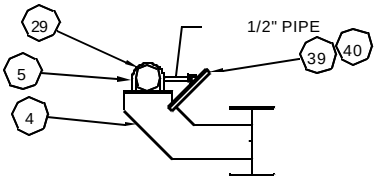
DETAIL B
REQ`D W/ NFPA-8501



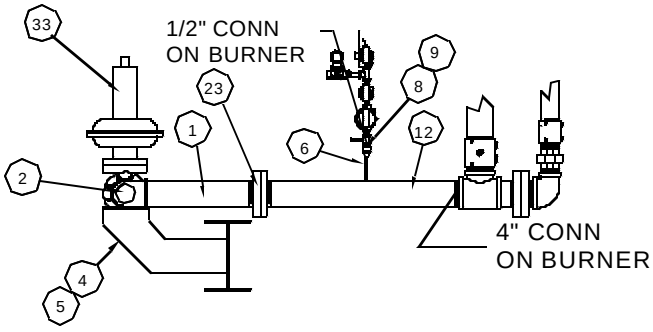
DETAIL C
REQ`D W/ NFPA-8501

SQ. FT. PER BOILER HP	BOILER HP	REGULATOR SET PRESSURE "W.C."
5 SF.	800	56"
	900	53"
	1000	53"
	1100	62"
	1200	74"
	1300	110"
4 SF.	1000	62"
	1100	74"
	1200	85"
	1300	110"

ALL REGULATOR ARE SIZED BASED OFF OF 10 PSI INLET PRESSURE.



SECTION B-B
FRONT 2 BACRKETS ONLY



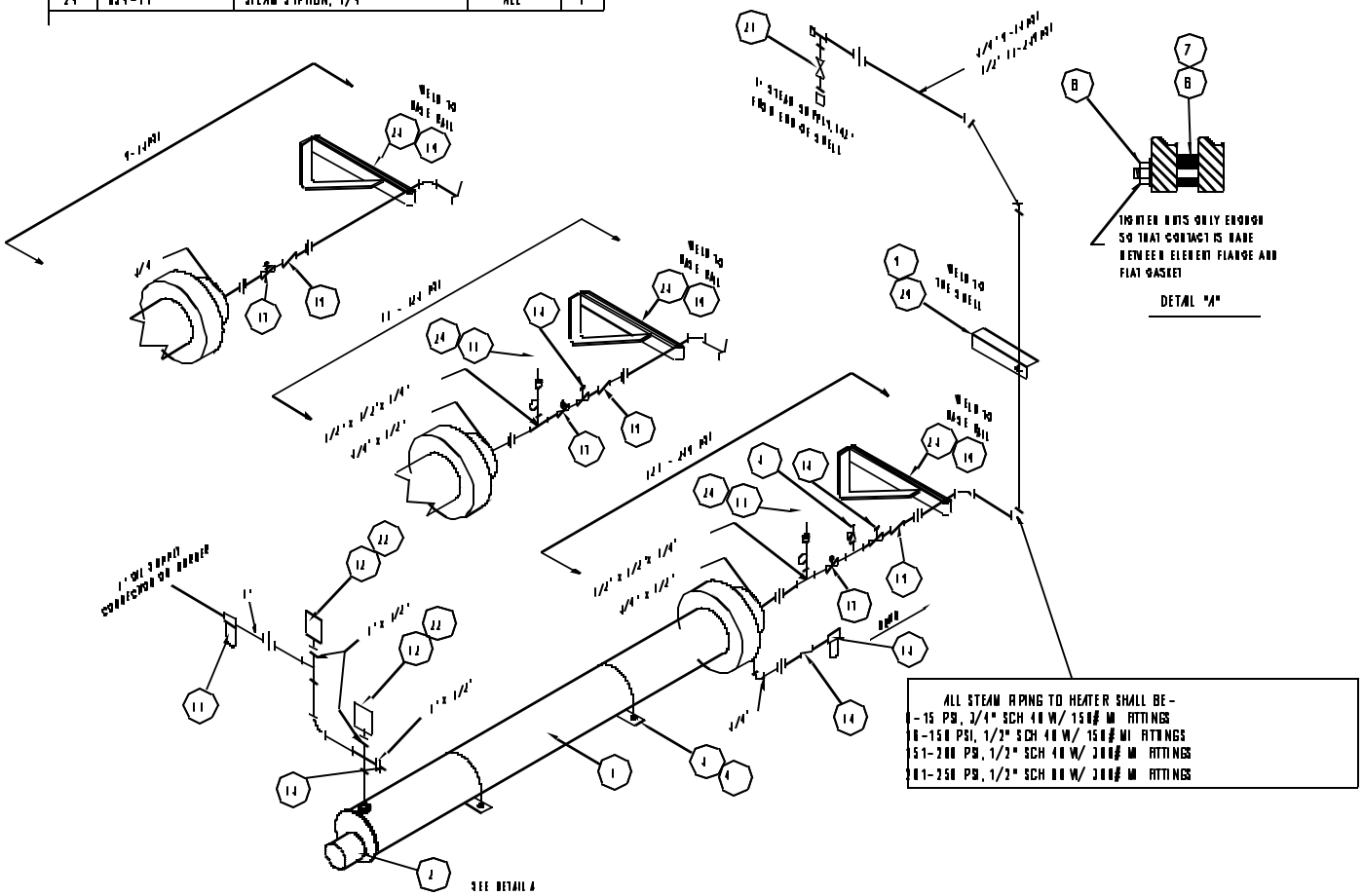
FRONT VIEW

GAS TRAIN,800-1300HP CBL 4/5 SF. W/ FGR 3/4PASS

146 00398

MATERIAL LIST				
ITEM	PART NUMBER	DESCRIPTION	CODE NO	QTY
1	852-20	STEAM ELEC. HEATER DWG 852C15	ALL	1
2	822-881	HEATER, ELEMENT, 10 KW	208-240V	1
	822-1578		380-415V	
	822-882		440-480V	
	822-883		575-600V	
3	883305	BRACKET	ALL	2
4	841-1142	U-BOLT	ALL	2
5	848-2874	RELIEF VALVE, 1/2"	120-300 PSI	1
6	852-882	O-RING	ALL	1
7	33A2384	GASKET	ALL	1
8	841-1458	STUD, 1/4" X 1-1/2" LG	ALL	8
9	841-1118	U-BOLT, 1/2" PIPE	ALL	1
10	8-1882	BRACKET	ALL	1
11	843-255	STRAINER, 1"	ALL	1
12	838-338	THERMOSTAT	ALL	2
13	858-82	PRESSURE GAUGE	ALL	1
14	848-142	CHECK VALVE, 3/4"	ALL	1
15	834-258	STEAM TRAP, 3/4"	ALL	1
16	858-3	PRESSURE GAUGE	ALL	1
17	848-227	SOLENOID VALVE, 3/4"	0-15 PSI	1
	848-273	SOLENOID VALVE, 1/2"	10-125 PSI	
	848-338	SOLENOID VALVE, 1/2"	120-250 PSI	
18	817-288	REGULATOR, STEAM, 1/2"	10-125 PSI	1
	818-713	REGULATOR, STEAM, 1/2"	120-250 PSI	
19	848-142	CHECK VALVE, 3/4" 200 LB	0-15 PSI	1
	848-135	CHECK VALVE, 1/2" 200 LB	10-200 PSI	
	848-458	CHECK VALVE, 1/2" 300 LB	201-250 PSI	
20	8-753	BRACKET	ALL	1
21	841-142	GLOBE VALVE 3/4", 200 LB	0-15 PSI	
	841-48	GLOBE VALVE,1/2", 300 LB	10-200 PSI	
	841-322	GLOBE VALVE,1/2", 300 LB	201-250 PSI	
22	822-211	CAPACITOR	ALL	2
23	838-44	PIPE, CLAMP, 1/2"	ALL	1
24	854-11	STEAM SYPHON, 1/4"	ALL	1

ASSY NO				
PRESSURE	HEATER VOLTAGE			
	208-240V	380-415V	440-480V	575-600V
0-15 PSI	1A1-4001	1A1-4002	1A1-4003	1A1-4004
10-125 PSI	1A1-4005	1A1-4006	1A1-4007	1A1-4008
120-250 PSI	1A1-4009	1A1-4010	1A1-4011	1A1-4012
201-250 PSI	1A1-4013	1A1-4014	1A1-4015	1A1-4016

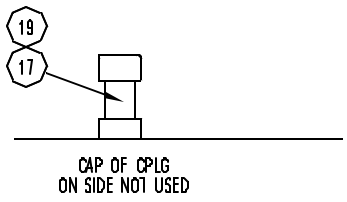


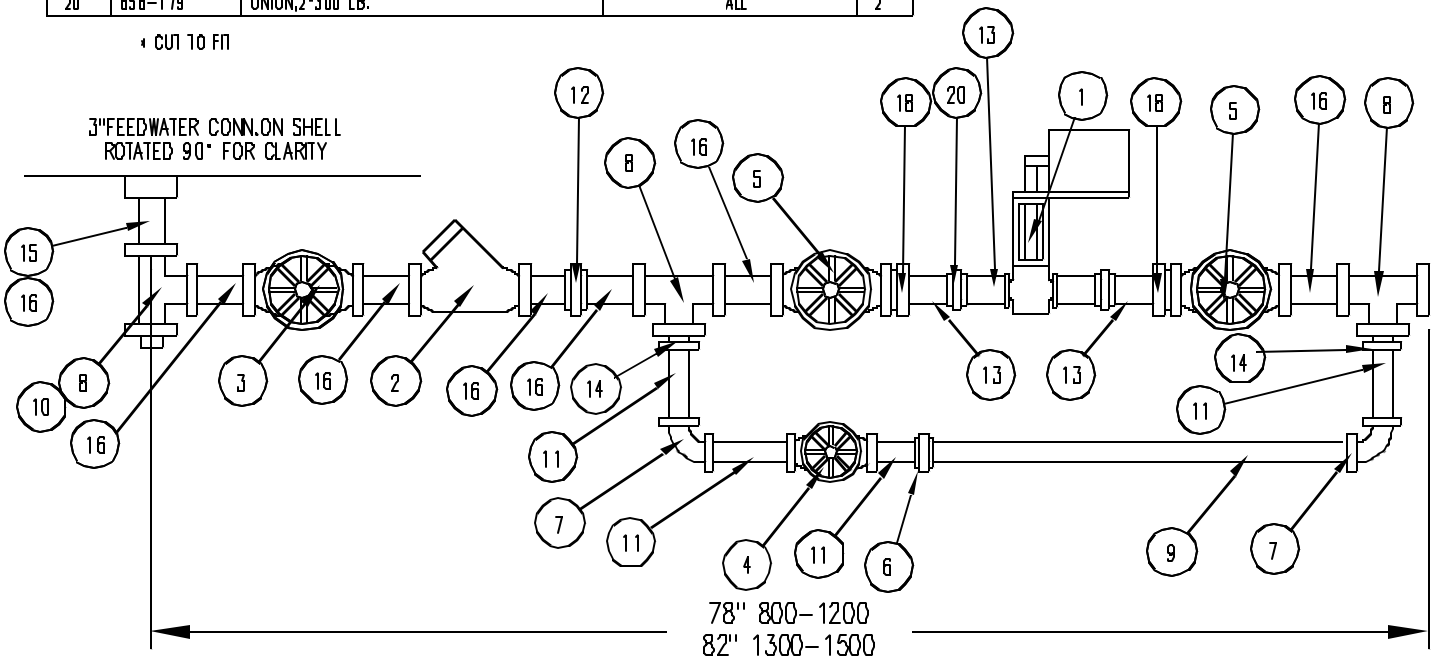
INSTALL., ST/ELEC. HTR & PIPING #6 OIL,CBL,0-250PSI,200-600V

146 80432

ITEM	PART NUMBER	DESCRIPTION	USED ON		QTY
1	940-4912	JORDAN,33-200-DI/PT13FARER17SRC,2"NPT	ALL		1
2	940-336	SWING CHECK,2-1/2"200 LB THD.	800-1200HP	15-150 PSI	1
	940-228	SWING CHECK,3"200 LB THD.	1300-1500HP		
	940-352	SWING CHECK,2-1/2"300 LB THD.	800-1200HP	200-250 PSI	
	940-2299	SWING CHECK,3"300 LB THD.	1300-1500HP		
3	941-407	GLOBE VALVE,2-1/2"200 LB.THD	800-1200HP	15-150 PSI	1
	941-1692	GLOBE VALVE,3"200 LB.THD	1300-1500HP		
	941-408	GLOBE VALVE,2-1/2"300 LB.THD	800-1200HP	200-250 PSI	
	941-414	GLOBE VALVE,3"300 LB.THD	1300-1500HP		
4	941-144	GLOBE,1 1/2",200 LB.THD	800-1500HP	15-150 PSI	1
	941-404	GLOBE,1 1/2",300 LB.THD	800-1500HP	200-250 PSI	
5	941-950	GATE VALVE,2-1/2" 200 LB.	800-1200HP	15-150 PSI	2
	941-238	GATE VALVE,3" 200 LB.	1300-1500HP		
	941-850	GATE VALVE,2-1/2" 300 LB.	800-1200HP	200-250 PSI	
	941-2133	GATE VALVE,3" 300 LB.	1300-1500HP		
6	858-178	UNION,1 1/2"300 LB.	ALL		1
7	859-129	ELBOW,1 1/2"300 LB.	ALL		2
8	859-40	TEE,2-1/2" 300 LB.	800-1500HP		3
	859-41	TEE,3" 300 LB.	800-1500HP		
*9	900-292	PIPE,1 1/2"SCH 80 SA106B x 30"	ALL		1
10	858-86	PLUG,2-1/2",SOLID BRASS	800-1200HP		1
	858-87	PLUG,3",SOLID BRASS	1300-1500HP		
11	857-689	NIPPLE,1 1/2"SCH 80 SA106B x 6"	ALL		4
12	858-180	UNION,2-1/2" 300LB.	800-1200HP		1
	858-181	UNION,3" 300 LB.	1200-1500HP		
13	857-661	NIPPLE,2"SCH 80 SA53B-CLS X 4"	ALL		4
14	847-484	BUSHING,2-1/2" x 1 1/2"	800-1200HP		2
	847-486	BUSHING,3"x 1 1/2"	1200-1500HP		
15	847-488	BUSHING,3 x 2-1/2"	800-1200HP		1
16	857-686	NIPPLE,2-1/2"SCH 80 SA53B-CLS X 4"	800-1200HP		7
	857-781	NIPPLE,3"SCH 80 SA53B-CLS X 4"	1200-1500HP		
17	858-456	CAP, 3" 300 LB.	ALL		1
18	847-485	BUSHING, 2-1/2" x 2", 300 LB.	800-1200HP		2
	847-487	BUSHING, 3" x 2", 300 LB.	1200-1500HP		
19	857-781	NIPPLE, 3" SCH 80 SA53B-CLS x 4"	ALL		1
20	858-179	UNION,2"300 LB.	ALL		2

* CUT TO FIT





ELECTRIC FEEDWATER PIPING 800-1500HP 15-250# CBL

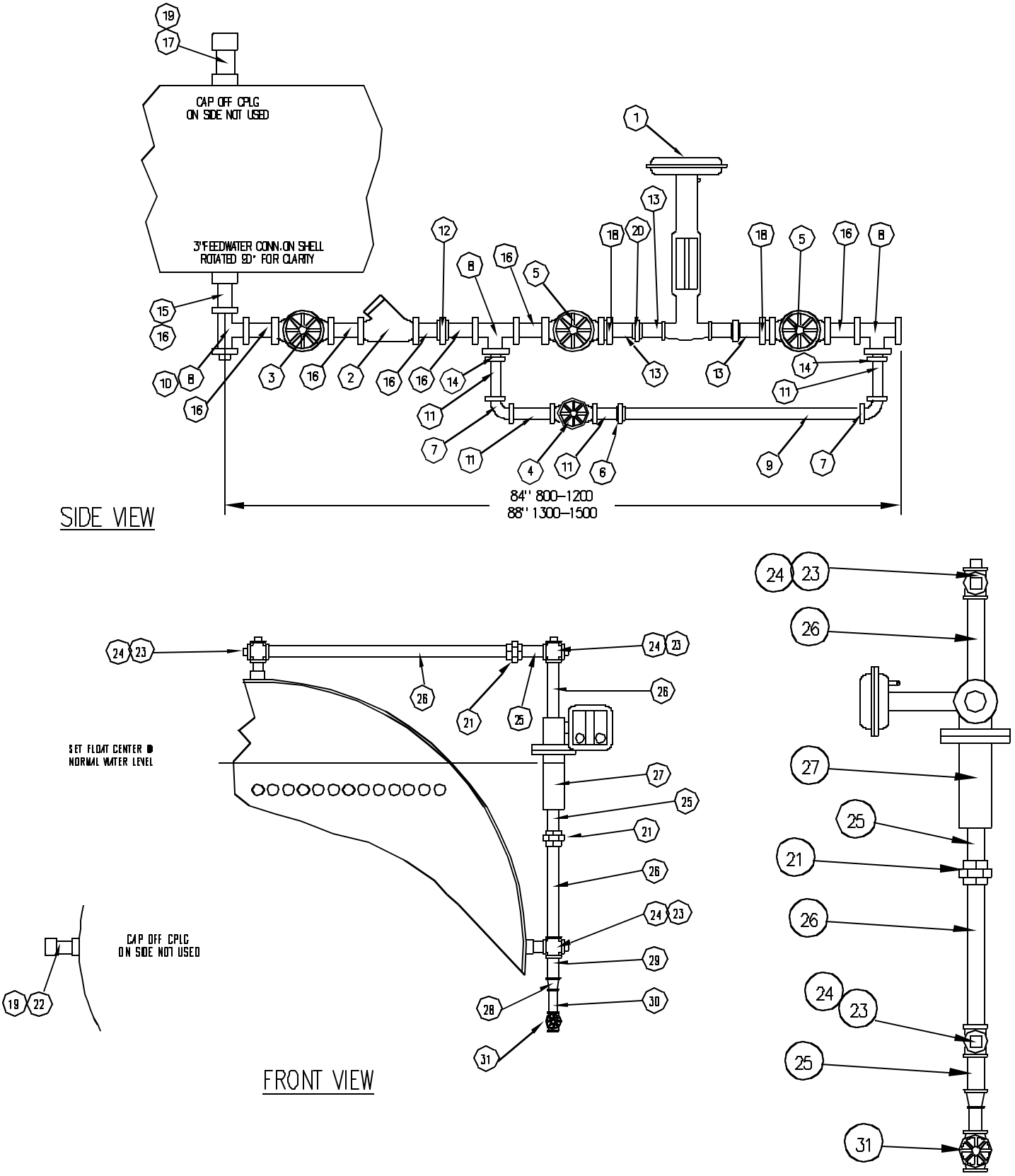
ITEM	PART NUMBER	DESCRIPTION	USED ON		QTY
1	915–270	CONTROL VALVE, FISHER, 1–1/2" 667–EZ	800–1000HP		
	915–249	CONTROL VALVE, FISHER, 2" 667–EZ	1100–1500HP		1
2	940–336	SWING CHECK,2–1/2"200 LB THD.	800–1200HP	15–150 PSI	1
	940–228	SWING CHECK,3"200 LB THD.	1300–1500HP		
	940–352	SWING CHECK,2–1/2"300 LB THD.	800–1200HP	200–250 PSI	
	940–2299	SWING CHECK,3"300 LB THD.	1300–1500HP		
3	941–407	GLOBE VALVE,2–1/2"200 LB.THD	800–1200HP	15–150 PSI	1
	941–1692	GLOBE VALVE,3"200 LB.THD	1300–1500HP		
	941–408	GLOBE VALVE,2–1/2"300 LB.THD	800–1200HP	200–250 PSI	
	941–414	GLOBE VALVE,3"300 LB.THD	1300–1500HP		
4	941–144	GLOBE,1 1/2",200 LB.THD	800–1500HP	15–150 PSI	1
	941–404	GLOBE,1 1/2",300 LB.THD	800–1500HP	200–250 PSI	
5	941–950	GATE VALVE,2–1/2" 200 LB.	800–1200HP	15–150 PSI	2
	941–238	GATE VALVE,3" 200 LB.	1300–1500HP		
	941–850	GATE VALVE,2–1/2" 300 LB.	800–1200HP	200–250 PSI	
	941–2133	GATE VALVE,3" 300 LB.	1300–1500HP		
6	858–178	UNION,1 1/2"300 LB.	ALL		1
7	859–129	ELBOW,1 1/2"300 LB.	ALL		2
8	859–40	TEE,2–1/2" 300 LB.	800–1500HP		3
	859–41	TEE,3" 300 LB.	800–1500HP		
*9	900–292	PIPE,1 1/2"SCH 80 SA106B x 30"	ALL		1

	PART NUMBER	DESCRIPTION	USED ON	QTY
10	858–86	PLUG,2–1/2",SOLID BRASS	800–1200HP	1
	858–87	PLUG,3",SOLID BRASS	1300–1500HP	
11	857–689	NIPPLE,1 1/2"SCH 80 SA106B x 6"	ALL	4
12	858–180	UNION,2–1/2" 300LB.	800–1200HP	1
	858–181	UNION,3" 300 LB.	1300–1500HP	
13	857–649	NIPPLE,1–1/2"SCH 80 SA53B–CLS X 4"	800–1000HP	4
	857–661	NIPPLE,2"SCH 80 SA53B–CLS X 4"	1100–1500HP	
14	847–484	BUSHING,2–1/2" x 1 1/2"	800–1200HP	2
	847–486	BUSHING,3"x 1 1/2"	1300–1500HP	
15	847–488	BUSHING,3 x 2–1/2"	800–1200HP	1
16	857–686	NIPPLE,2–1/2"SCH 80 SA53B–CLS X 4"	800–1200HP	7
	857–781	NIPPLE,3"SCH 80 SA53B–CLS X 4"	1300–1500HP	
17	858–456	CAP, 3" 300 LB.	ALL	1
18	847–484	BUSHING, 2–1/2" x 1–1/2", 300 LB.	800–1000HP	2
	847–485	BUSHING, 2–1/2" x 2", 300 LB.	1100–1200HP	
	847–487	BUSHING, 3" x 2", 300 LB.	1300–1500HP	
19	857–781	NIPPLE, 3" SCH 80 SA53B–CLS x 4"	ALL	1
20	858–178	UNION,1–1/2"300 LB.	800–1000HP	2
	858–179	UNION,2"300 LB.	1100–1500HP	
21	858–00222	UNION,2"300 LB.	ALL	2
22	858–00388	CAP,2" 300 LB.		1

	PART NUMBER	DESCRIPTION	USED ON	QTY
23	859–00277	CROSS,2",300 LB.	ALL	3
24	858–00009	PLUG,2"SOLID BRASS	ALL	5
25	857–00667	NIPPLE,2"SCH 80 SA53B–CLS X 6"	ALL	2
*26	900–00314	PIPE,2"SCH 80 SA53B–CLS x 144"	ALL	2
27	817–1528	FISHER CONTROLLER,2500R–249,2"NPT.	ALL	1
28	858–810	REDUCER, 2" x 1" 300 LB.	ALL	1
29	857–667	NIPPLE,2"SCH 80 SA53B–CLS X 6"	114"DIA.	1
	857–1385	NIPPLE,2"SCH 80 SA53B–CLS X 8"	126"DIA.	
	857–1585	NIPPLE,2"SCH 80 SA53B–CLS X 10"	138"DIA.	
30	857–645	NIPPLE,1"SCH 80 SA106–CLS X 6"	114"DIA.	1
	857–642	NIPPLE,1"SCH 80 SA106–CLS X 8"	126"DIA.	
	857–705	NIPPLE,1"SCH 80 SA106–CLS X 10"	138"DIA.	
31	941–39	GLOBE VALVE,1"200 LB.THD	15–150 PSI	1
	941–402	GLOBE VALVE,1"300 LB.THD	200–250 PSI	1

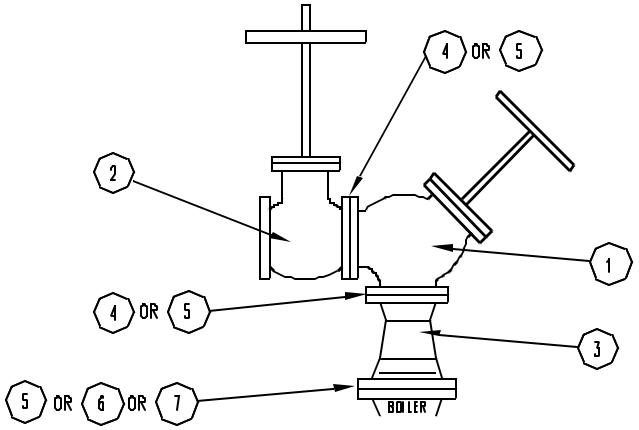
PNEUMATIC FEEDWATER PIPING 800-1500HP 15-250# CBL

145 00191



PNEUMATIC FEEDWATER PIPING 800-1500HP 15-250# CBL

MATERIAL LIST				
ITEM	PART NUMBER	DESCRIPTION	OPTION	QTY
1	"A"	"A" ANGLE NON-RETURN VALVE (SEE CHART)	U2,56	1
2	"B"	"B" GATE VALVE (SEE CHART)	5W,5X,5Z,	1
3	"C"	"C" ADAPTER FLANGE (SEE CHART)	"C"	1
4	603-00367	STUD, GASKET & NUT ASSY, 6" 300 LB.		"D"
5	603-00368	STUD, GASKET & NUT ASSY, 8" 300 LB.		"E"
6	603-00369	STUD, GASKET & NUT ASSY, 10" 300 LB.		"F"
7	603-00370	STUD, GASKET & NUT ASSY, 12" 300LB.		"G"



MAIN STEAM ASSEMBLY CHART									
MAIN STEAM ASSY TYPE	DESIGN PRESSURE	BOILER NOZZLE SIZE	"A" VALVE SIZE- P/N	"B" VALVE SIZE- P/N	"C" ADAPTER SIZE- P/N	"D" QTY ITEM 4	"E" QTY ITEM 5	"F" QTY ITEM 6	"G" QTY ITEM 7
1	150-200#	8" 300 LB. FLG	6" 941-00276	6" 941-01350	8"x6" 029 01938	2	1	N/A	N/A
2	150-200#	10" 300 LB. FLG	6" 941-00276	6" 941-01350	10"x6" 029 01939	2	N/A	1	N/A
3	150-200#	10" 300 LB. FLG.	8" 940-02482	8" 941-01848	10"x8" 029 01940	N/A	2	1	N/A
4	150-200#	12" 300 LB. FLG.	8" 940-02482	8" 941-01848	12"x8" 029 01990	N/A	2	N/A	1
5	250#	8" 300 LB. FLG	6" 941-00276	6" 941-01363	8"x6" 029 01938	2	1	N/A	N/A
6	250#	10" 300 LB. FLG.	8" 940-02482	8" 941-00762	10"x8" 029 01940	N/A	2	1	N/A
7	250#	10" 300 LB. FLG.	6" 941-00276	6" 941-01363	10"x6" 029 01939	2	N/A	1	N/A

STANDARD SELECTION FOR A 150#,4 SQ.FT./BOILER HP		
MAIN STEAM ASSY TYPE	BOILER HP.	BOILER SF.
2	1000 HP	4000 SF
3	1100 HP	4500 SF
	1200 HP	5000 SF
4	1300 HP	5500 SF
	1500 HP	6000 SF

STANDARD SELECTION FOR A 200#,4 SQ.FT./BOILER HP		
MAIN STEAM ASSY TYPE	BOILER HP.	BOILER SF.
1	1000 HP	4000 SF
	1100 HP	4500 SF
3	1200 HP	5000 SF
	1300 HP	5500 SF
	1500 HP	6000 SF

STANDARD SELECTION FOR A 250#,4 SQ.FT./BOILER HP		
MAIN STEAM ASSY TYPE	BOILER HP.	BOILER SF.
5	1000 HP	4000 SF
	1100 HP	4500 SF
	1200 HP	5000 SF
6	1300 HP	5500 SF
	1500 HP	6000 SF

STANDARD SELECTION FOR A 150#,5 SQ.FT./BOILER HP		
MAIN STEAM ASSY TYPE	BOILER HP.	BOILER SF.
2	800 HP	4000 SF
	900 HP	4500 SF
3	1000 HP	5000 SF
4	1100 HP	5500 SF
	1200 HP	6000 SF
	1300 HP	6500 SF
	1400 HP	7000 SF
	1500 HP	7500 SF

STANDARD SELECTION FOR A 200#,5 SQ.FT./BOILER HP		
MAIN STEAM ASSY TYPE	BOILER HP.	BOILER SF.
1	800 HP	4000 SF
	900 HP	4500 SF
2	1000 HP	5000 SF
	1100 HP	5500 SF
3	1200 HP	6000 SF
	1300 HP	6500 SF
	1400 HP	7000 SF
	1500 HP	7500 SF

STANDARD SELECTION FOR A 250#,5 SQ.FT./BOILER HP		
MAIN STEAM ASSY TYPE	BOILER HP.	BOILER SF.
5	800 HP	4000 SF
	900 HP	4500 SF
	1000 HP	5000 SF
7	1100 HP	5500 SF
	1200 HP	6000 SF

MAIN STEAM VALVE ASSY FOR 150-250# 3/4 CBL

MATERIAL LIST

ITEM	PART NO	DESCRIPTION	QTY
1	"A"	SAFETY VALVE NO 1 "A" (SEE CHART)	1
2	"B"	SAFETY VALVE NO 2 "B" (SEE CHART)	1
2	"C"	SAFETY VALVE NO 3 " C" (SEE CHART)	1
3	"D"	PIPE NIPPLE, 4" LG.	1
4	"E"	PIPE NIPPLE, 4" LG.	1
5	"F"	PIPE NIPPLE, 4" LG.	1
6	"G"	BUSHING	1

STANDARD SELECTIONS FOR 150PSI BOILER'S 5 SQ FT PER BHP

BOILER SIZE		VALVE # 1	PART NO	VALVE # 2	PART NO	VALVE # 3	PART NO	PART NO	PART NO	PART NO	PART NO
SQ. FT	H P	"A"	"A"	"B"	"B"	"C"	"C"	"D"	"E"	"F"	"G"
4000	800	6252 AKH	940 6080	6252 ALJ	940 06081	N/A	N/A	857-661	857-686	N/A	N/A
4500	900	6252 AKH	940 6080	6252 ALJ	940 06081	N/A	N/A	857-661	857-686	N/A	N/A
5000	1000	6252 ALJ	940 06081	6252 ALJ	940 06081	N/A	N/A	857-686	857-686	N/A	N/A
5500	1100	6252 ALJ	940 06081	6252 ALJ	940 06081	N/A	N/A	857-686	857-686	N/A	N/A
6000	1200	6252 ALJ	940 06081	6252 AMK	940 06082	N/A	N/A	857-686	857-781	N/A	N/A
6500	1300	6252 AKH	940 06080	6252 AKH	940 06080	6252 ALJ	940 06081	857-661	857-661	857-686	847-488
7000	1400	6252 AKH	940 06080	6252 ALJ	940 06081	6252 ALJ	940 06081	857-661	857-686	857-686	847-488
7500	1500	6252 AKH	940 06080	6252 ALJ	940 06081	6252 ALJ	940 06081	857-661	857-686	857-686	847-488

STANDARD SELECTIONS FOR 150PSI BOILER'S 4.5 SQ FT PER BHP

BOILER SIZE		VALVE # 1	PART NO	VALVE # 2	PART NO	VALVE # 3	PART NO	PART NO	PART NO	PART NO	PART NO
SQ. FT.	H P	"A"	"A"	"B"	"B"	"C"	"C"	"D"	"E"	"F"	"G"
4000	900	6252 AKH	940 6080	6252 ALJ	940 06081	N/A	N/A	857-661	857-686	N/A	N/A
4500	1000	6252 AKH	940 6080	6252 ALJ	940 06081	N/A	N/A	857-661	857-686	N/A	N/A
5000	1100	6252 ALJ	940 06081	6252 ALJ	940 06081	N/A	N/A	857-686	857-686	N/A	N/A
5500	1200	6252 ALJ	940 06081	6252 ALJ	940 06081	N/A	N/A	857-686	857-686	N/A	N/A
6000	1300	6252 ALJ	940 06081	6252 AMK	940 06082	N/A	N/A	857-686	857-781	N/A	N/A
6500	1400	6252 AKH	940 06080	6252 AKH	940 06080	6252 ALJ	940 06081	857-661	857-661	857-686	847-488
7000	1500	6252 AKH	940 06080	6252 ALJ	940 06081	6252 ALJ	940 06081	857-661	857-686	857-686	847-488
7500	1600	6252 AKH	940 06080	6252 ALJ	940 06081	6252 ALJ	940 06081	857-661	857-686	857-686	847-488

STANDARD SELECTIONS FOR 150PSI BOILERS 4 SQ FT PER BHP

BOILER SIZE		VALVE # 1	PART NO	VALVE # 2	PART NO	VALVE # 3	PART NO	PART NO	PART NO	PART NO	PART NO
SQ. FT.	H P	"A"	"A"	"B"	"B"	"C"	"C"	"D"	"E"	"F"	"G"
4000	1000	6252 AKH	940 6080	6252 ALJ	940 06081	N/A	N/A	857-661	857-686	N/A	N/A
4500	1100	6252 AKH	940 6080	6252 ALJ	940 06081	N/A	N/A	857-661	857-686	N/A	N/A
5000	1200	6252 ALJ	940 06081	6252 ALJ	940 06081	N/A	N/A	857-686	857-686	N/A	N/A
5500	1300	6252 ALJ	940 06081	6252 ALJ	940 06081	N/A	N/A	857-686	857-686	N/A	N/A
6000	1500	6252 ALJ	940 06081	6252 AMK	940 06082	N/A	N/A	857-686	857-781	N/A	N/A
6500	1600	6252 AKH	940 06080	6252 AKH	940 06080	6252 AMK	940 06082	857-661	857-661	857-781	N/A
7000	1700	6252 AKH	940 06080	6252 AKH	940 06080	6252 AMK	940 06082	857-661	857-686	857-781	847-485
7500	1800	6252 AKH	940 06080	6252 ALJ	940 06081	6252 AMK	940 06082	857-661	857-686	857-781	N/A

SAFETY VALVES (KUNKLE) FOR CBL 150 PSI DESIGN

a

MATERIAL LIST

ITEM	PART NO	DESCRIPTION	QTY
1	"A"	SAFETY VALVE NO 1 "A" (SEE CHART)	1
2	"B"	SAFETY VALVE NO 2 "B" (SEE CHART)	1
2	"C"	SAFETY VALVE NO 3 " C" (SEE CHART)	1
3	"D"	PIPE NIPPLE, 4" LG.	1
4	"E"	PIPE NIPPLE, 4" LG.	1
5	"F"	PIPE NIPPLE, 4" LG.	1
6	"G"	BUSHING	1

STANDARD SELECTIONS FOR 200PSI BOILERS 5 SQ FT PER BHP

BOILER SIZE		VALVE # 1	PART NO	VALVE # 2	PART NO	VALVE # 3	PART NO	PART NO	PART NO	PART NO	PART NO
SQ. FT.	H P	"A"	"A"	"B"	"B"	"C"	"C"	"D"	"E"	"F"	"G"
4000	800	6252 AKH	940 6084	6252 AJG	940 06083	N/A	N/A	857-661	857-669	N/A	847-480
4500	900	6252 AKH	940 6084	6252 AKH	940 06084	N/A	N/A	857-661	857-661	N/A	N/A
5000	1000	6252 AKH	940 6084	6252 AKH	940 06084	N/A	N/A	857-661	857-661	N/A	847-485
5500	1100	6252 AKH	940 6084	6252 ALJ	940 06085	N/A	N/A	857-661	857-686	N/A	N/A
6000	1200	6252 AKH	940 6084	6252 ALJ	940 06085	N/A	N/A	857-661	857-686	N/A	847-485
6500	1300	6252 AKH	940 6084	6252 AKH	940 06084	6252 AJG	940 06083	857-661	857-661	857-669	847-488
7000	1400	6252 AKH	940 6084	6252 AKH	940 06084	6252 AKH	940 06084	857-661	857-661	857-661	N/A
7500	1500	6252 AKH	940 6084	6252 AKH	940 06084	6252 AKH	940 06084	857-661	857-661	857-661	847-485

STANDARD SELECTIONS FOR 200PSI BOILERS 4.5 SQ FT PER BHP

BOILER SIZE		VALVE # 1	PART NO	VALVE # 2	PART NO	VALVE # 3	PART NO	PART NO	PART NO	PART NO	PART NO
SQ. FT.	H P	"A"	"A"	"B"	"B"	"C"	"C"	"D"	"E"	"F"	"G"
4000	900	6252 AKH	940 6084	6252 AJG	940 06083	N/A	N/A	857-661	857-669	N/A	847-480
4500	1000	6252 AKH	940 6084	6252 AKH	940 06084	N/A	N/A	857-661	857-661	N/A	N/A
5000	1100	6252 AKH	940 6084	6252 AKH	940 06084	N/A	N/A	857-661	857-661	N/A	847-485
5500	1200	6252 AKH	940 6084	6252 ALJ	940 06085	N/A	N/A	857-661	857-686	N/A	N/A
6000	1300	6252 AKH	940 6084	6252 ALJ	940 06085	N/A	N/A	857-661	857-686	N/A	847-485
6500	1400	6252 AKH	940 6084	6252 AKH	940 06084	6252 AJG	940 06083	857-661	857-661	857-669	847-488
7000	1500	6252 AKH	940 6084	6252 AKH	940 06084	6252 AKH	940 06084	857-661	857-661	857-661	N/A
7500	1600	6252 AKH	940 6084	6252 AKH	940 06084	6252 AKH	940 06084	857-661	857-661	857-661	847-485

STANDARD SELECTIONS FOR 200PSI BOILERS 4 SQ FT PER BHP

BOILER SIZE		VALVE # 1	PART NO	VALVE # 2	PART NO	VALVE # 3	PART NO	PART NO	PART NO	PART NO	PART NO
SQ. FT.	H P	"A"	"A"	"B"	"B"	"C"	"C"	"D"	"E"	"F"	"G"
4000	1000	6252 AKH	940 6084	6252 AKH	940 06084	N/A	N/A	857-661	857-661	N/A	N/A
4500	1100	6252 AKH	940 6084	6252 AKH	940 06084	N/A	N/A	857-661	857-661	N/A	N/A
5000	1200	6252 AKH	940 6084	6252 ALJ	940 06085	N/A	N/A	857-661	857-686	N/A	N/A
5500	1300	6252 AKH	940 6084	6252 ALJ	940 06085	N/A	N/A	857-661	857-686	N/A	N/A
6000	1500	6252 ALJ	940 6085	6252 ALJ	940 06085	N/A	N/A	857-661	857-686	N/A	N/A
6500	1600	6252 AKH	940 6084	6252 AKH	940 06084	6252 AKH	940 06084	857-661	857-661	857-661	N/A
7000	1700	6252 AKH	940 6084	6252 AKH	940 06084	6252 AKH	940 06084	857-661	857-661	857-661	N/A
7500	1800	6252 AKH	940 6084	6252 AKH	940 06084	6252 ALJ	940 06085	857-661	857-661	857-686	N/A

SAFETY VALVES (KUNKLE) FOR CBL 200 PSI DESIGN

b

MATERIAL LIST

ITEM	PART NO	DESCRIPTION	QTY
1	"A"	SAFETY VALVE NO 1 "A" (SEE CHART)	1
2	"B"	SAFETY VALVE NO 2 "B" (SEE CHART)	1
2	"C"	SAFETY VALVE NO 3 " C" (SEE CHART)	1
3	"D"	PIPE NIPPLE, 4" LG.	1
4	"E"	PIPE NIPPLE, 4" LG.	1
5	"F"	PIPE NIPPLE, 4" LG.	1
6	"G"	BUSHING	1

STANDARD SELECTIONS FOR 250PSI BOILERS 5 SQ FT PER BHP

BOILER SIZE		VALVE # 1	PART NO	VALVE # 2	PART NO	VALVE # 3	PART NO	PART NO	PART NO	PART NO	PART NO
SQ. FT.	H P	"A"	"A"	"B"	"B"	"C"	"C"	"D"	"E"	"F"	"G"
4000	800	6252 AJG	940 6086	6252 AJG	940 6086	N/A	N/A	857-669	857-669	N/A	N/A
4500	900	6252 AKH	940 6087	6252 AJG	940 6086	N/A	N/A	857-661	857-669	N/A	N/A
5000	1000	6252 AKH	940 6087	6252 AJG	940 6086	N/A	N/A	857-661	857-669	N/A	847-480
5500	1100	6252 AKH	940 6087	6252 AKH	940 6087	N/A	N/A	857-661	857-661	N/A	N/A
6000	1200	6252 AKH	940 6087	6252 AKH	940 6087	N/A	N/A	857-661	857-661	N/A	847-485
6500	1300	6252 AJG	940 6086	6252 AJG	940 6086	6252 AJG	940 6086	857-669	857-669	857-669	847-480
7000	1400	6252 AKH	940 6087	6252 AJG	940 6086	6252 AJG	940 6086	857-661	857-669	857-669	847-480
7500	1500	6252 AKH	940 6087	6252 AKH	940 6087	6252 AJG	940 6086	857-661	857-661	857-669	N/A

STANDARD SELECTIONS FOR 250PSI BOILERS 4.5 SQ FT PER BHP

BOILER SIZE		VALVE # 1	PART NO	VALVE # 2	PART NO	VALVE # 3	PART NO	PART NO	PART NO	PART NO	PART NO
SQ. FT.	H P	"A"	"A"	"B"	"B"			"D"	"E"	"F"	"G"
4000	900	6252 AJG	940 6086	6252 AJG	940 6086	N/A	N/A	857-669	857-669	N/A	N/A
4500	1000	6252 AKH	940 6087	6252 AJG	940 6086	N/A	N/A	857-661	857-669	N/A	N/A
5000	1100	6252 AKH	940 6087	6252 AJG	940 6086	N/A	N/A	857-661	857-669	N/A	847-480
5500	1200	6252 AKH	940 6087	6252 AKH	940 6087	N/A	N/A	857-661	857-661	N/A	N/A
6000	1300	6252 AKH	940 6087	6252 AKH	940 6087	N/A	N/A	857-661	857-661	N/A	847-485
6500	1400	6252 AJG	940 6086	6252 AJG	940 6086	6252 AJG	940 6086	857-669	857-669	857-669	847-480
7000	1500	6252 AKH	940 6087	6252 AJG	940 6086	6252 AJG	940 6086	857-661	857-669	857-669	847-480
7500	1600	6252 AKH	940 6087	6252 AKH	940 6087	6252 AJG	940 6086	857-661	857-661	857-669	N/A

STANDARD SELECTIONS FOR 250PSI BOILERS 4 SQ FT PER BHP

BOILER SIZE		VALVE # 1	PART NO	VALVE # 2	PART NO	VALVE # 3	PART NO	PART NO	PART NO	PART NO	PART NO
SQ. FT.	H P	"A"	"A"	"B"	"B"			"D"	"E"	"F"	"G"
4000	1000	6252 AJG	940 6086	6252 AJG	940 6086	N/A	N/A	857-669	857-669	N/A	N/A
4500	1100	6252 AKH	940 6087	6252 AJG	940 6086	N/A	N/A	857-661	857-669	N/A	N/A
5000	1200	6252 AKH	940 6087	6252 AKH	940 6087	N/A	N/A	857-661	857-661	N/A	N/A
5500	1300	6252 AKH	940 6087	6252 AKH	940 6087	N/A	N/A	857-661	857-661	N/A	N/A
6000	1500	6252 AKH	940 6087	6252 ALJ	940 6088	N/A	N/A	857-661	857-686	N/A	N/A
6500	1600	6252 AKH	940 6087	6252 AJG	940 6086	6252 AJG	940 6086	857-661	857-669	857-669	N/A
7000	1700	6252 AKH	940 6087	6252 AKH	940 6087	6252 AJG	940 6086	857-661	857-661	857-669	N/A
7500	1800	6252 AKH	940 6087	6252 AKH	940 6087	6252 AJG	940 6086	857-661	857-661	857-669	N/A

SAFETY VALVES (KUNKLE) FOR CBL 250 PSI DESIGN

C

MATERIAL LIST

ITEM	PART NO	DESCRIPTION	QTY
1	"A"	SAFETY VALVE NO 1 "A" (SEE CHART)	"A"
2	"B"	SAFETY VALVE NO 2 "B" (SEE CHART)	"B"
3	"C"	SAFETY VALVE NO 3 "C" (SEE CHART)	"C"

STANDARD SELECTIONS FOR 15PSI BOILERS 5 SQ FT PER BHP

BOILER SIZE		VALVE #1	PART NO	QTY.	VALVE #2	PART NO	QTY.
SQ. FT.	HP	"A"	"A"	"A"	"B"	"B"	"B"
4000	800	KUNKLE 6252KQP	940 5816	2	N/A	N/A	1
4500	900	KUNKLE 6252KRP	940 5817	1	KUNKLE #6252KQP	940 5816	1
5000	1000	KUNKLE 6252KQP	940 5816	2	KUNKLE #6252KPM	940 5815	1
5500	1100	KUNKLE 6252KQP	940 5816	2	KUNKLE #6252KPM	940 5815	1
6000	1200	KUNKLE 6252KRP	940 5817	2	N/A	N/A	N/A
6500	1300	KUNKLE 6252KQP	940 5816	3	N/A	N/A	N/A
7000	1400	KUNKLE 6252KQP	940 5816	2	KUNKLE 6252KRP	940 5817	1
7500	1500	KUNKLE 6252KQP	940 5816	2	KUNKLE 6252KRP	940 5817	1

STANDARD SELECTIONS FOR 15PSI BOILERS 4.5 SQ FT PER BHP

BOILER SIZE		VALVE #1	PART NO	QTY.	VALVE #2	PART NO	QTY.
SQ. FT.	HP	"A"	"A"	"A"	"B"	"B"	"B"
4000	900	KUNKLE 6252KQP	940 5816	2	N/A	N/A	1
4500	1000	KUNKLE 6252KRP	940 5817	1	KUNKLE #6252KQP	940 5816	1
5000	1100	KUNKLE 6252KQP	940 5816	2	KUNKLE #6252KPM	940 5815	1
5500	1200	KUNKLE 6252KQP	940 5816	2	KUNKLE #6252KPM	940 5815	N/A
6000	1300	KUNKLE 6252KRP	940 5817	2	N/A	N/A	N/A
6500	1400	KUNKLE 6252KQP	940 5816	3	N/A	N/A	N/A
7000	1500	KUNKLE 6252KQP	940 5816	2	KUNKLE 6252KRP	940 5817	1
7500	1600	KUNKLE 6252KQP	940 5816	2	KUNKLE 6252KRP	940 5817	1

STANDARD SELECTIONS FOR 15PSI BOILERS 4 SQ FT PER BHP

BOILER SIZE		VALVE #1	PART NO	QTY.	VALVE #2	PART NO	QTY.	VALVE #2	PART NO	QTY.
SQ. FT.	HP	"A"	"A"	"A"	"B"	"B"	"B"	"C"	"C"	"C"
4000	1000	KUNKLE 6252KQP	940 5816	2	N/A	N/A	1			
4500	1100	KUNKLE 6252KRP	940 5817	1	KUNKLE #6252KQP	940 5816	1			
5000	1200	KUNKLE 6252KQP	940 5816	2	KUNKLE #6252KPM	940 5815	1			
5500	1300	KUNKLE 6252KQP	940 5816	2	KUNKLE #6252KPM	940 5815	N/A			
6000	1500	KUNKLE 6252KRP	940 5817	1	KUNKLE #6252KQP	940 5816	1	KUNKLE #6252KPM	940 5815	1
6500	1600	KUNKLE 6252KQP	940 5816	3	N/A	N/A	N/A			
7000	1700	KUNKLE 6252KQP	940 5816	2	KUNKLE 6252KRP	940 5817	1			
7500	1800	KUNKLE 6252KRP	940 5817	2	KUNKLE 6252KQP	940 5816	1			

SAFETY VALVES FOR CBL 15 PSI

d

15# THRU 150# (STEAM & HOT WATER)				
MODEL "CBL" 800–1500 H.P.		BILL OF MATERIAL U.S.		OPTION
REQ.	PART NO.	ITEM	DESCRIPTION	
1	814–38	1	BRUSH, FLUE	B8
6	853–972	2	GASKET, HANDHOLE	
1	853–939	3	GASKET, MANHOLE	

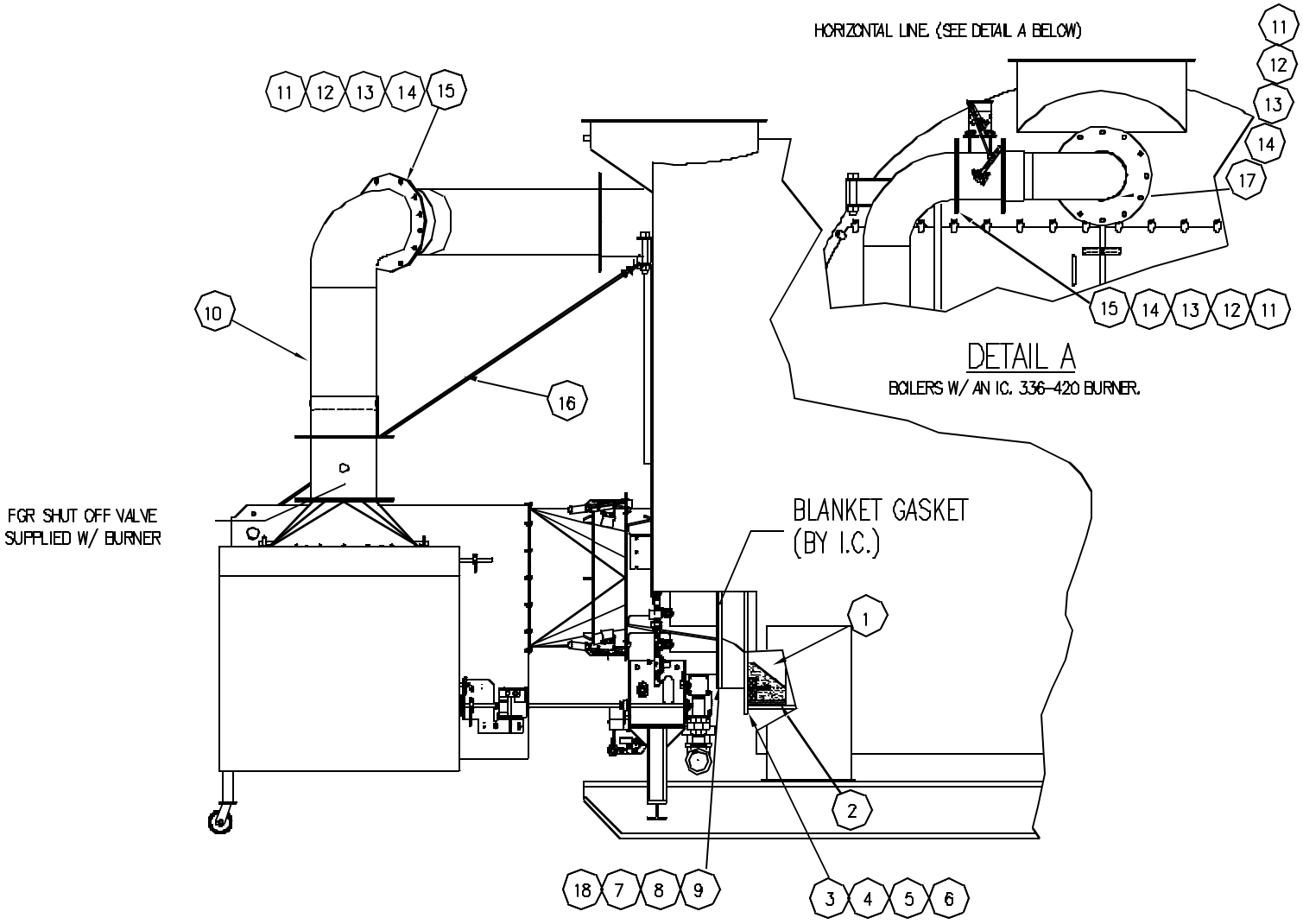
200# THRU 250# STEAM				
MODEL "CBL" 800-1500 H.P.		BILL OF MATERIAL U.S.		OPTION
REQ.	PART NO.	ITEM	DESCRIPTION	
1	814-38	1	BRUSH, FLUE	B8
6	853-1103	2	GASKET, HANDHOLE	
1	853-1095	3	GASKET, MANHOLE	

SPARE PARTS LIST CBE, CEW, CIW, CBL & ICB

146 00257

TABLE 3	
BOILER DIA. AND BURNER	P/N ITEM 18
114" W/ D/LND 336-420	530B579
126" W/ D/LND 378-420	
114-138" W/ D/LND 462-630	530B583

NOTES:
1) ITEM #2 TO BE PACKED AROUND DRYCOVEN INSIDE OF FURNACE AFTER DRY OVEN IS INSTALLED.
2) PREASSEMBLE FGR DUCT TO BOILER AND DISASSEMBLE FOR SHIPMENT.
3) THIS IS PICTORIALLY INCORECT FOR BOILERS W/ AN IC. 336–420 BURNER. THE DUCT ACTUALLY CONNECTS TO THE SIDE OF THE BURNER ILO THE TOP AND THE FGR VALVE MOUNTS IN THE FRONT



INSTALL., BURNER, CBL 3/4P & 4P W/ FGR W/ IC.336-630. BURNER

MATERIAL LIST					
ITEM	PART NUMBER	DESCRIPTION	OPTION CODE	USED ON	QTY
1	SEE TABLE 1	DRY OVEN	??	SEE TABLE 1	1
2	872-00500	BLANKET INSUL. 1-1/2"x 8" x 160" 2600°	??	114"	1
		BLANKET INSUL. 1-1/2"x 8" x 170" 2600°	??	126"	1
		BLANKET INSUL. 1-1/2"x 8" x 190" 2600°	??	138"	1
3	872-00622	ROPE,1/2" DIA. x 192"	??	-	1
4	952-00094	LOCK WASHER, 1/2"		-	12
5	869-00015	NUT, 1/2"		-	12
6	952-00286	FLAT WASHER, 1/2"		-	12
7	952-00287	FLAT WASHER, 5/8"		-	12
8	952-00084	LOCK WASHER, 5/8"		-	12
9	869-00017	NUT, 5/8"		-	12
10	SEE TABLE 2	FGR DUCT DETAILS	??	IFGR SEE TABLE 2	1
11	869-00018	NUT, 3/4"		IFGR	*48
12	952-00124	FLAT WASHER, 3/4"		IFGR	*48
13	952-00095	LOCK WASHER, 3/4"		IFGR	*48
14	868-00196	BOLT, 3/4" X 1-1/2"	??	IFGR	*48
15	853-00871	GASKET, 14" PS. FULL FACE	??	IC BRNR 378-420	1
				IC BRNR 462-630	4
16	083-00448	SHIPPING BRACE.	??	IC BRNR 462-630	1
17	853-00869	GASKET, 10" PS. FULL FACE	??	IC BRNR 378-420	4
18	530B579	BURNER SUPPORT	??	IC BRNR 336-420	1
	530B583			IC BRNR 462-630	

TABLE 1	
BOILER DIA. AND BURNER	P/N ITEM 1
114" W/ D/LND 336	059B7028
114" W/ D/LND 378-420	059B7027
114" W D/LND/PH/LNS1 462-630	059B6943
126" W/ D/LND 378-420	059B7030
126" DIA. W D/LND/PH/LNS1 462-630	059B7020
138" DIA. W D/LND/PH/LNSI 462-630	059B7065

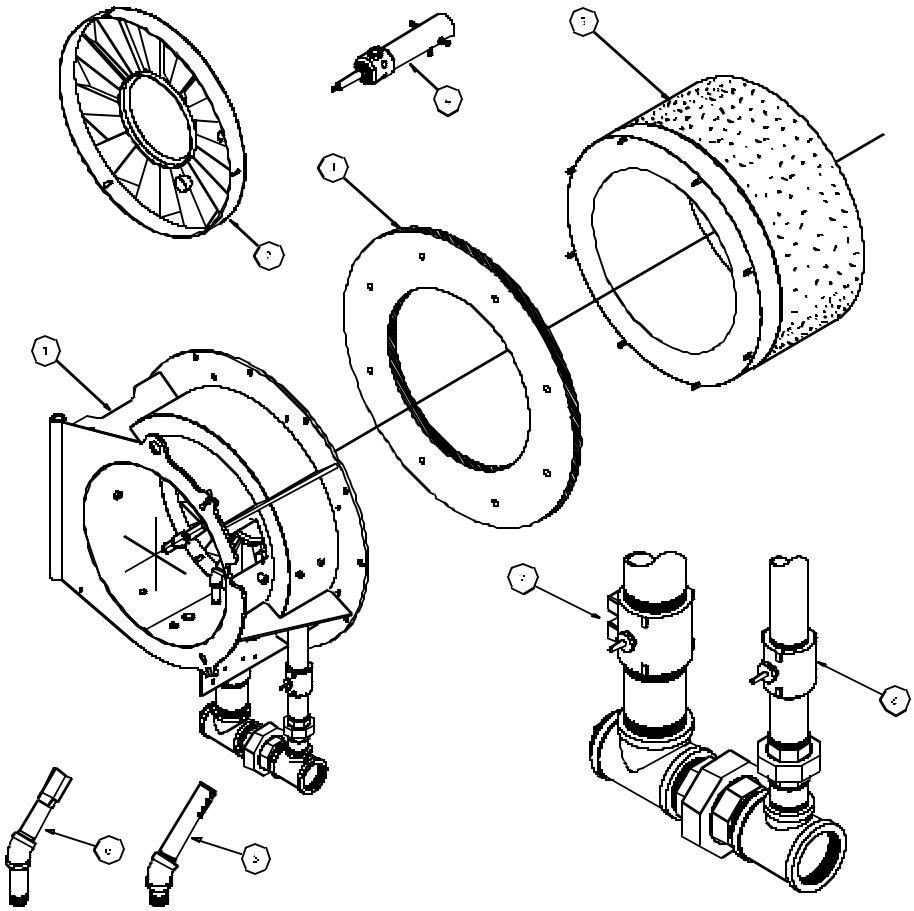
TABLE 2	
BOILER DIA. AND BURNER	P/N ITEM 10
114" W/ I.C. LND 378-420	619B651
126" W/ I.C. LND 378-420	619-652
114" W/ LNS1 462-630	619B653
126" DIA. W/ LNS1 462-630	619-654
138" DIA. W/ LNS1 462-630	619-655

INSTALL., BURNER, CBL 3/4P & 4P W/ FGR W/ IC.336-630. BURNER

Notes

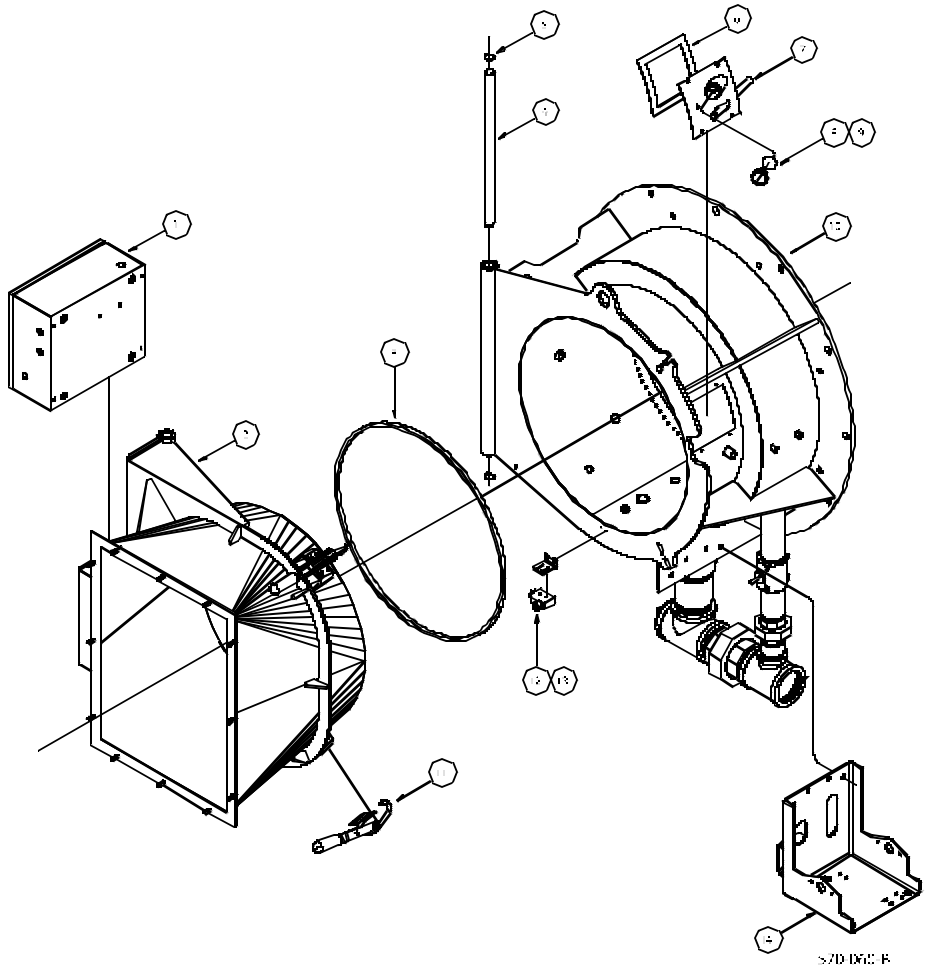
Section 6b
Burner Parts

Note: The part numbers listed in section 6b are Industrial Combustion Part numbers, and should not be confused with Cleaver-Brooks



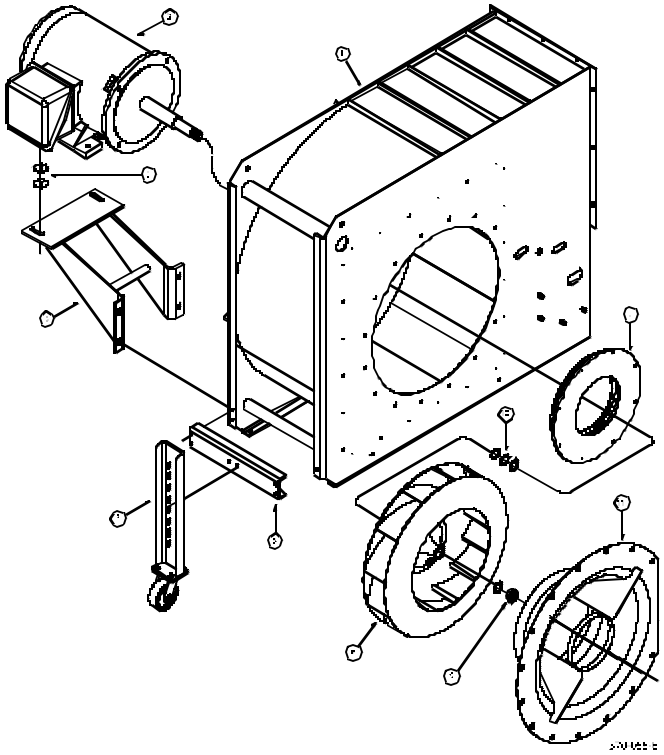
ITEM	REQ'D	PART NUMBER	DESCRIPTION
1	1	040-00446	Gas Manifold Assembly
2	1	275-00567	Diffuser Assy. S1/LNS1-Series 462 & 504
2	1	275-00568	Diffuser Assy. S1/LNS1-Series 546 & S1-Series 588
2	1	275-00505	Diffuser Assy. LNS1-Series 588
2	1	275-00610	Diffuser Assy. S1/LNS1-Series 630
2	1	275-00566	Diffuser Assy. S1/LNS1-Series 462, 504, 546, 588, 630 (CBL Only)
2	1	275-00611	Diffuser Assy. S1-Series 462, 504, 546 (#6 Oil Applications)
3	1	032-01146	Dry Oven Gasket
4	1	048-00197	Gas Pilot Assembly
5	1	279-00141	Dry Oven Assembly
6	6	042-00152	Secondary Gas Spud Assy. S1-Series 462-630 & LNS1 462, 504, 546
6	6	042-00182	Secondary Gas Spud Assy. LNS1 588 & 630
6	6	042-00161	Secondary Gas Spud Assy. LNS1-Series 462-630 (CBL Only)
7	1	940-01195	4" NPT Reduced Port Butterfly Valve
8	1	940-01230	2-1/2" NPT Full Port Butterfly Valve

Figure 6-1: Head Assembly



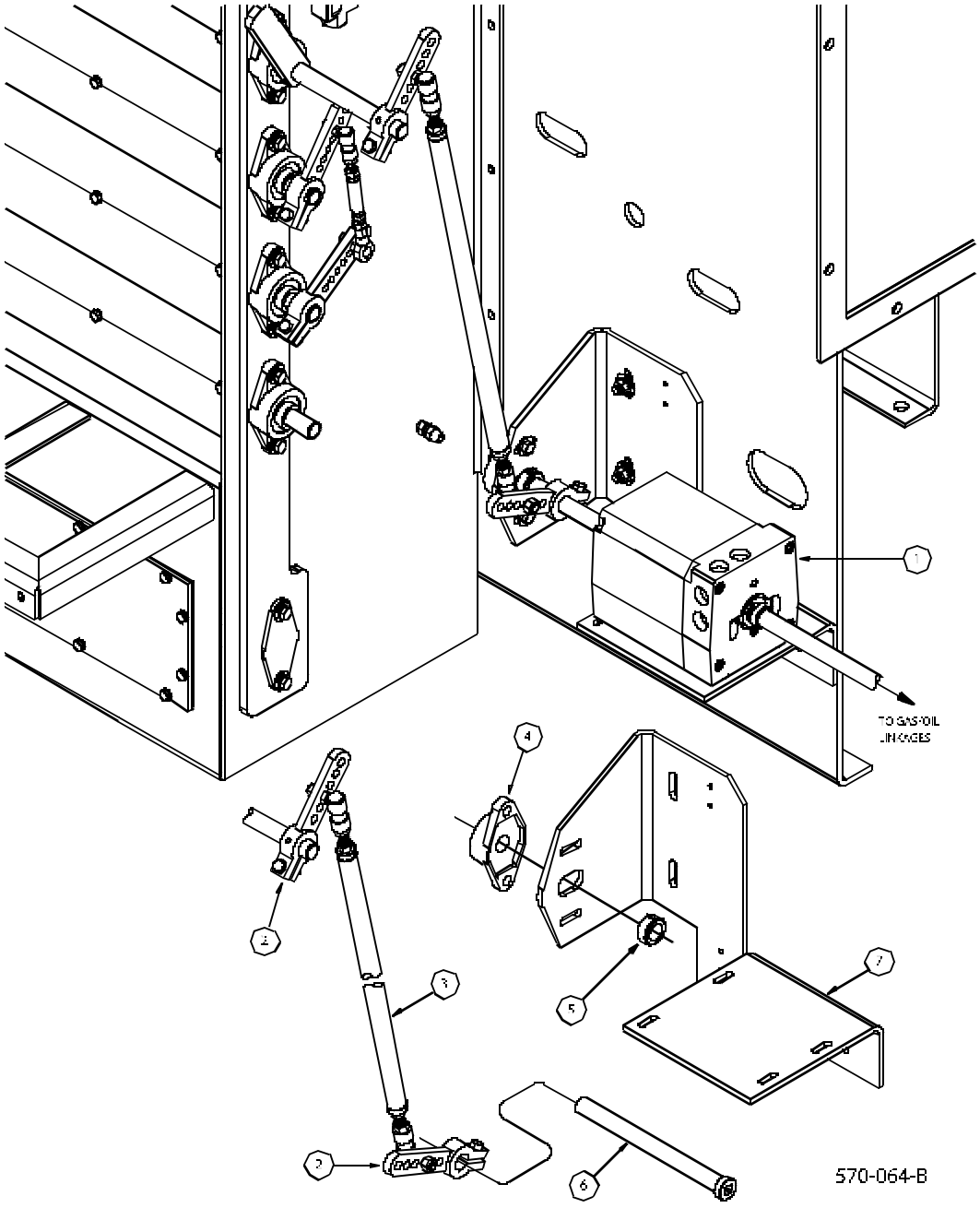
ITEM	REQ'D	PART NUM-BER	DESCRIPTION
1	1	119-00477	Junction Box
2	1	040-00448	Transition Housing
3	1	032-01060	Fan Housing Seal Gasket
4	1	056-00290	Hinge Pin
5	2	914-00205	Retaining Snap Ring
6	1	032-01127	Access Cover Gasket
7	1	019-00593	Scanner and Access Cover
8	1	031-00036	Sight Glass
9	1	869-00184	Sight Glass Nut
10	1	040-00446	Gas Manifold Assembly (Manifold Only)
11	2	043-00013	Toggle clamp Latch
12	1	836-00301	Safety Interlock Switch
13	1	010-01018	Switch Bracket
14	1	085-00939	Burner Support

Figure 6-2: Blast Tube and J-Box



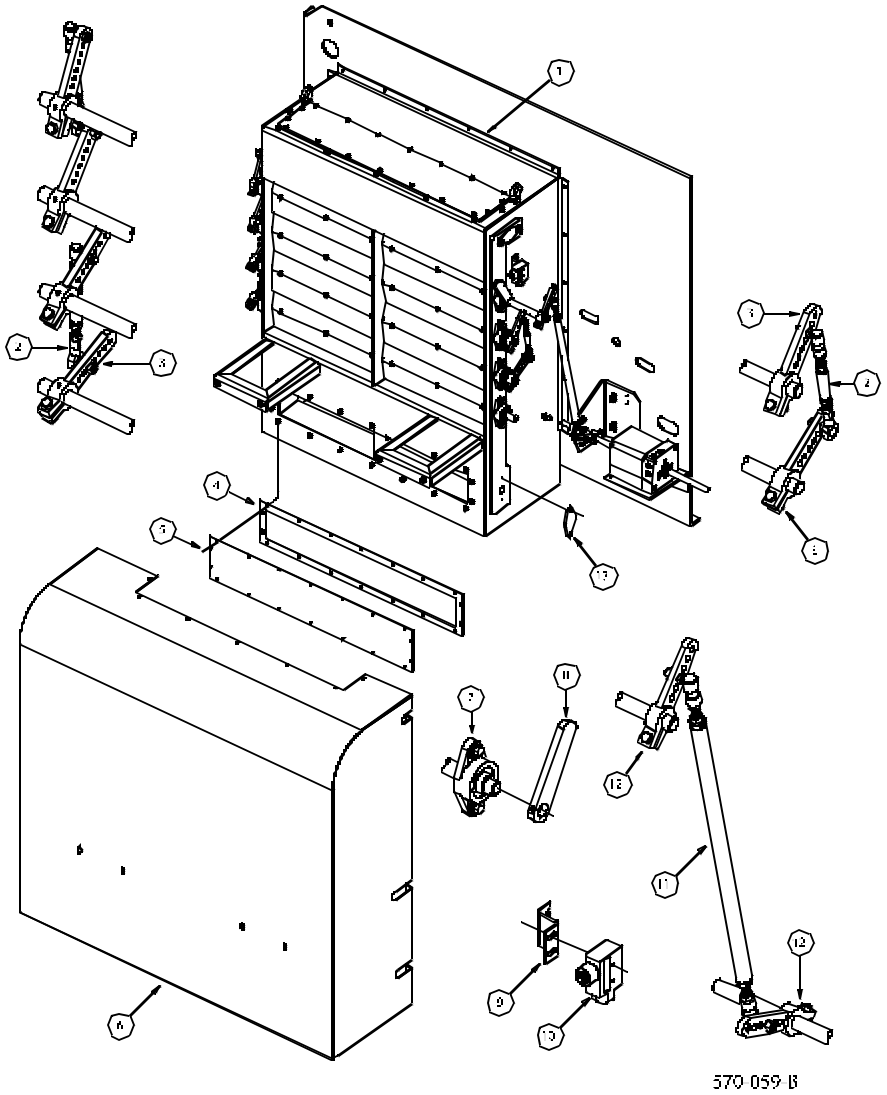
ITEM	REQ'D	PART NUM-BER	DESCRIPTION
1	1	040-00465	Fan Housing S1-Series 462-630 & LNS1-Series 462, 504 & 546
1	1	040-00537	Fan Housing LNS1-Series 588 & 630
2	1	894-01372	Blower Motor 75 HP S1/LNS1-Series 462 & 504
2	1	894-01457	Blower Motor 100 HP S1-Series 546, 588 & 630 & LNS1-Series 546
2	1	894-01459	Blower Motor 125 HP LNS1-Series 588 & 630
3	4	152-00017	Rubber Cushion
4	1	085-00923	Motor Support Bracket S1-Series 462-630 & LNS1- 462, 504 & 546
4	1	085-00955	Motor Support Bracket LNS1-Series 588 & 630
5	1	029-01452	Motor Mounting Flange
6	1	008-01838	Leg Support Bracket
7	1	085-00943	Wheel Assembly
8	1	192-00344	Impeller S1-Series 462 & 504
8	1	192-00327	Impeller S1-Series 546, 588 & 630 & LNS1-Series 462 & 504
8	1	192-00345	Impeller LNS1-Series 546
8	1	192-00343	Impeller LNS1-Series 588 & 630
9	1	869-00185	Hex Locknut
10	various	091-00088	Spacer .049" Thickness
10	various	091-00089	Spacer .071" Thickness
10	various	920-00076	Spacer .134" Thickness
11	1	265-00148	Air Inlet Cone Assembly

Figure 6-3: Fan Housing Assembly



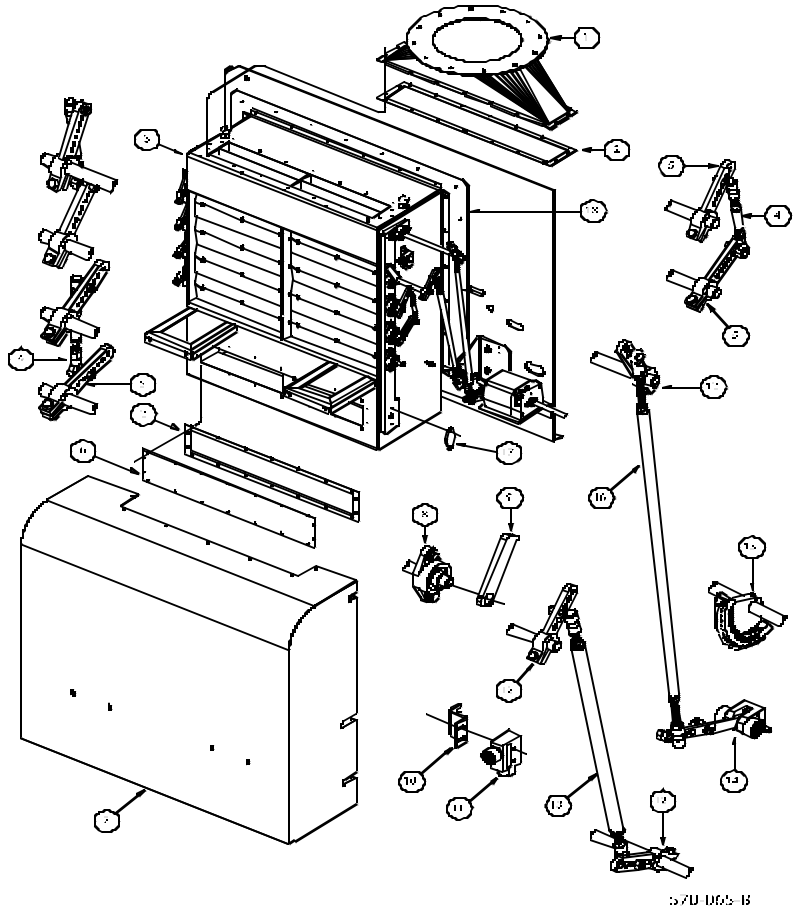
ITEM	REQ'D	PART NUMBER	DESCRIPTION
1	1	894-01462	Reversing Actuator
2	2	002-00259	Linkage Arm
3	1	067-00519	Linkage Rod Assembly
4	1	807-00344	Bearing
5	1	018-00149	Collar
6	1	010-00309	Bushing Assembly
7	1	008-01832	Actuator Mounting Bracket Assembly

Figure 6-4: Modulating Motor



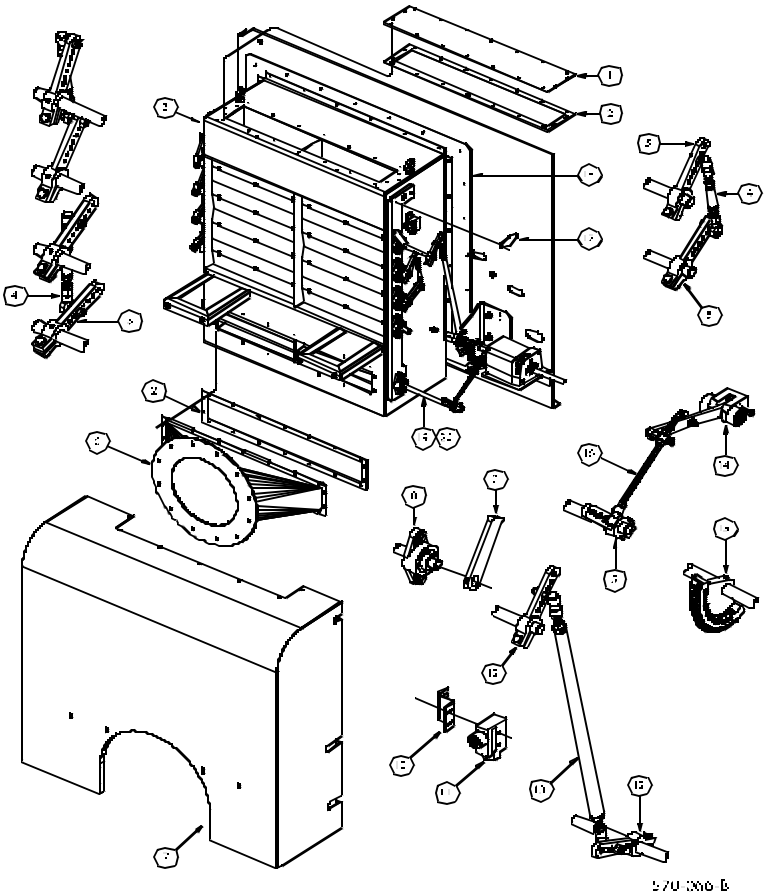
ITEM	REQ'D	PART NUM-BER	DESCRIPTION
1	1	119-00477	Junction Box
2	1	040-00448	Transition Housing
3	1	032-01060	Fan Housing Seal Gasket
4	1	056-00290	Hinge Pin
5	2	914-00205	Retaining Snap Ring
6	1	032-01127	Access Cover Gasket
7	1	019-00593	Scanner and Access Cover
8	1	031-00036	Sight Glass
9	1	869-00184	Sight Glass Nut
10	1	040-00446	Gas Manifold Assembly (Manifold Only)
11	2	043-00013	Toggle clamp Latch
12	1	836-00301	Safety Interlock Switch
13	1	010-01018	Switch Bracket

Figure 6-5: S1 Air Box and Linkages



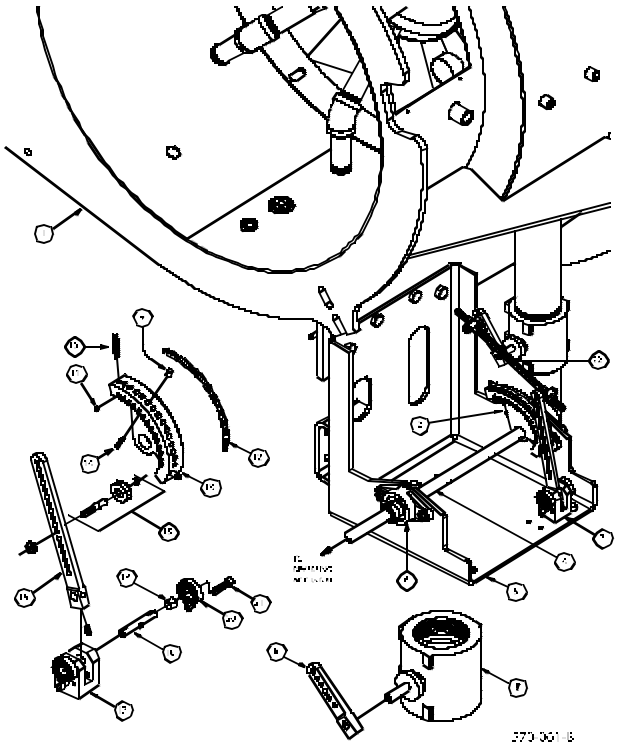
ITEM	REQ'D	PART NUM-BER	DESCRIPTION
1	1	097-00364	F.G.R. Transition Assembly
2	2	032-01147	Gasket
3	1	427-00206	Air Damper Box Assembly
4	3	067-00475	Linkage Rod Assembly
5	6	002-00141	Linkage Arm
6	1	019-00581	Cover F.G.R. Opening
7	1	461-00138	Silencer Assembly
8	10	807-00341	Bearing
9	1	002-00378	Linkage Arm
10	1	008-01272	Switch Mounting Bracket
11	1	836-00301	High Fire Interlock Switch
12	3	002-00259	Linkage Arm
13	1	067-00519	Linkage Rod Assembly
14	1	476-00088	Cam Trim Assembly
15	1	313-00017	Cam Assembly (Right Hand)
16	1	067-00355	Linkage Rod Assembly
17	2	019-00582	F.G.R. Shaft Opening Cover
18	1	059-01487	Spacer Plate (LNS1-Series 588 & 630 Only)

Figure 6-6: LNS1 with top F.G.R. Air Box and Linkages



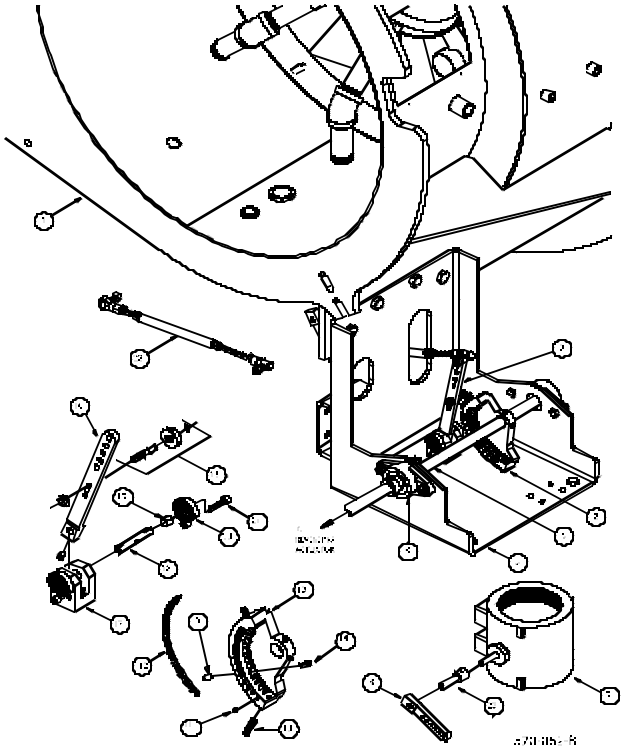
ITEM	REQ'D	PART NUM-BER	DESCRIPTION
1	1	019-00581	Cover, F.G.R. Opening
2	2	032-01147	Gasket
3	1	427-00206	Air Damper Box Assembly
4	3	067-00475	Linkage Rod Assembly
5	7	002-00141	Linkage Arm
6	1	097-00364	F.G.R. Transition Assembly
7	1	461-00136	Silencer Assembly
8	10	807-00341	Bearing
9	1	002-00378	Linkage Arm
10	1	008-01272	Switch Mounting Bracket
11	1	836-00301	High Fire Interlock Switch
12	2	002-00259	Linkage Arm
13	1	067-00519	Linkage Rod Assembly
14	1	476-00088	Cam Trim Assembly
15	1	313-00017	Cam Trim Assembly (Right Hand)
16	1	067-00527	Linkage Rod Assembly
17	2	019-00582	F.G.R. Shaft Opening Cover
18	1	059-01487	Spacer Plate (LNS1-Series 588 & 630 Only)
19	1	067-00472	F.G.R. Control Blade Shaft
20	2	005-00551	F.G.R. Control Blade

Figure 6-7: LNS1 with Bottom FGR Air Box and Linkages



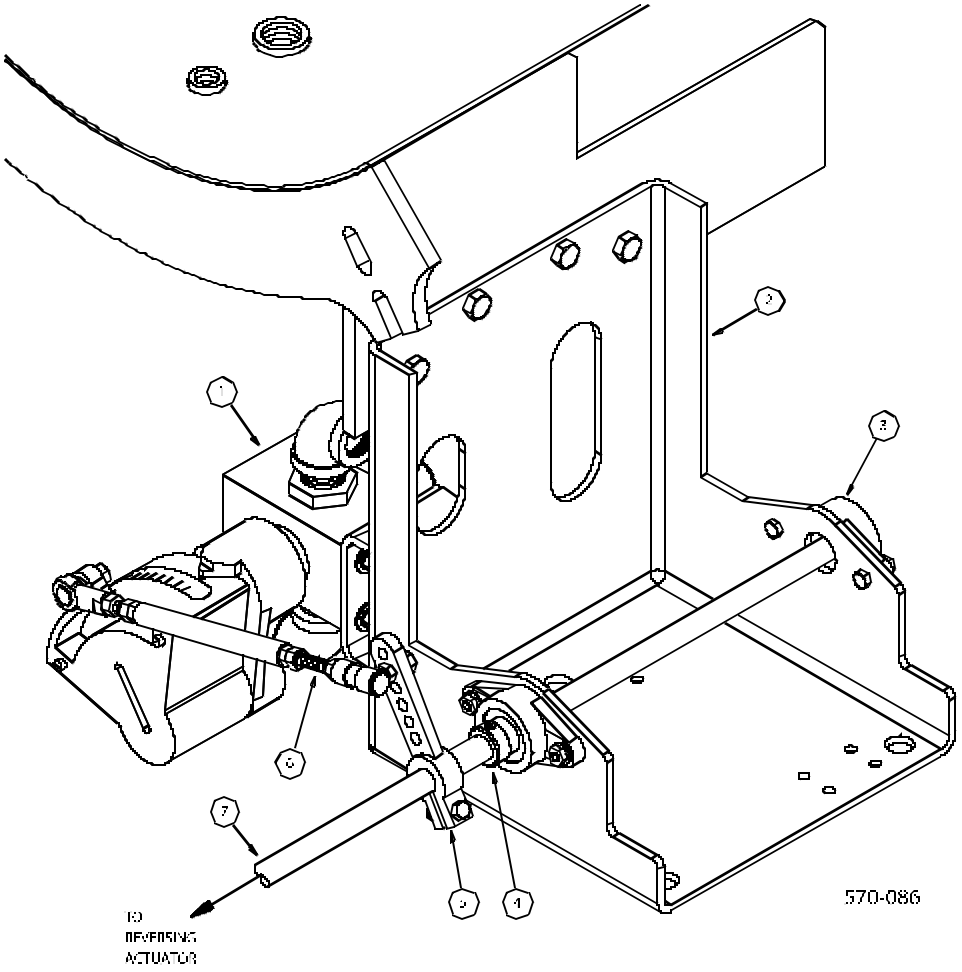
ITEM	REQ'D	PART NUMBER	DESCRIPTION
1	1	040-00446	Gas Manifold Assembly
2	1	313-00016	Cam Assembly (Left Hand)
3	1	476-00084	Cam Follower Assembly
4	1	010-00343	Bushing Assembly
5	1	085-00939	Burner & Linkage Support Assembly
6	2	807-00344	Bearing
7	1	940-01230	2-1/2" Full Port Butterfly Valve
8	1	002-00142	Linkage Arm
9	16	847-00260	Cam Spring Guide
10	2	071-00024	Spring Fastner Screw
11	1	860-00301	Locking Set Screw Kit (16 pcs. Per Kit)
12	1	082-00203	Cam Spring
13	1	012-00109	Cam
14	16	860-00299	Set Screw
15	1	069-00303	Roller Guide Assembly
16	1	002-00013	Linkage Arm
17	1	009-01356	Linkage Arm Bracket
18	1	074-00504	Linkage Arm Shaft
19	2	807-00339	3/8" Nylon Bearing
20	2	082-00140	Spring
21	2	868-00213	1/4-20 x 1" Lg. Socket Hd. Capscrew
22	1	067-00528	Linkage Rod Assembly

Figure 6-8: Gas Control Valve for Center Spuds, Cam and Linkages



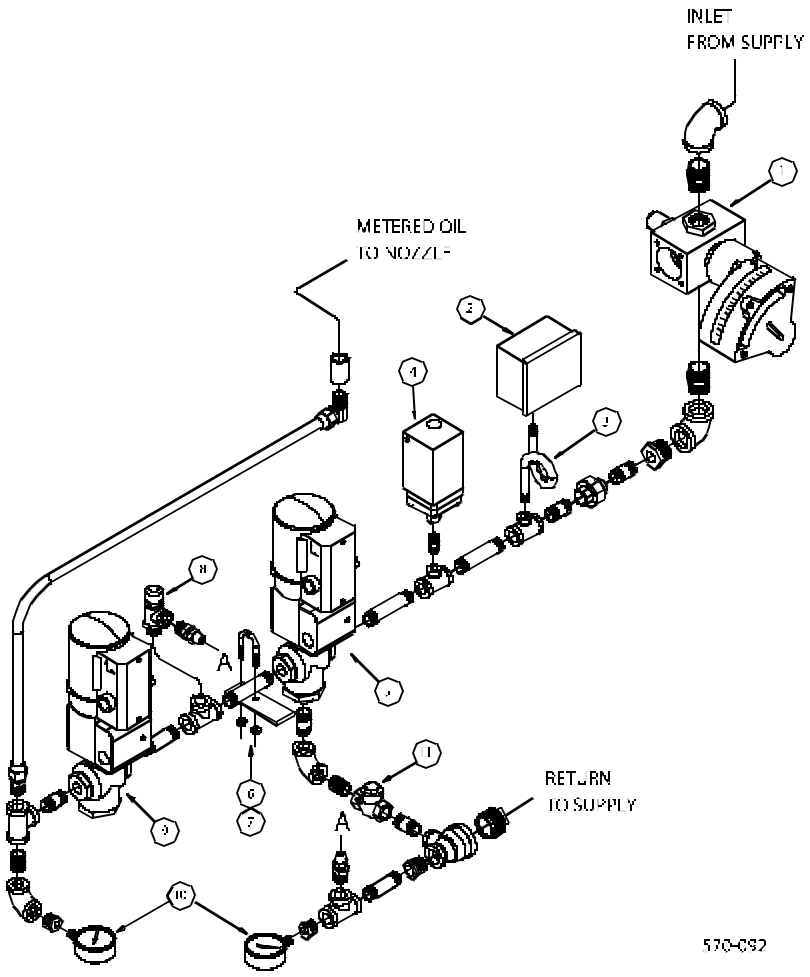
ITEM	REQ'D	PART NUM-BER	DESCRIPTION
1	1	040-00446	Gas Manifold Assembly
2	1	313-00016	Cam Assembly (Left Hand)
3	1	476-00089	Cam Follower Assembly
4	1	010-00343	Bushing Assembly
5	1	085-00939	Burner & Linkage Support Assembly
6	2	807-00344	Bearing
7	1	940-01195	4" Reduced Port Butterfly Valve
8	1	002-00260	Linkage Arm
9	16	847-00260	Cam Spring Guide
10	2	071-00024	Spring Fastner Screw
11	1	860-00301	Locking Set Screw Kit (16 pcs. Per Kit)
12	1	082-00203	Cam Spring
13	1	012-00109	Cam
14	16	860-00299	Set Screw
15	1	069-00303	Roller Guide Assembly
16	1	002-00393	Linkage Arm
17	1	009-01356	Linkage Arm Bracket
18	1	074-00504	Linkage Arm Shaft
19	2	807-00339	3/8" Nylon Bearing
20	2	082-00140	Spring
21	2	868-00213	1/4-20 x 1" Lg. Socket Hd. Capscrew
22	1	067-00489	Linkage Rod Assembly
23	1	074-00621	Extension

Figure 6-9: Main Gas Control Valve, Cam and Linkages



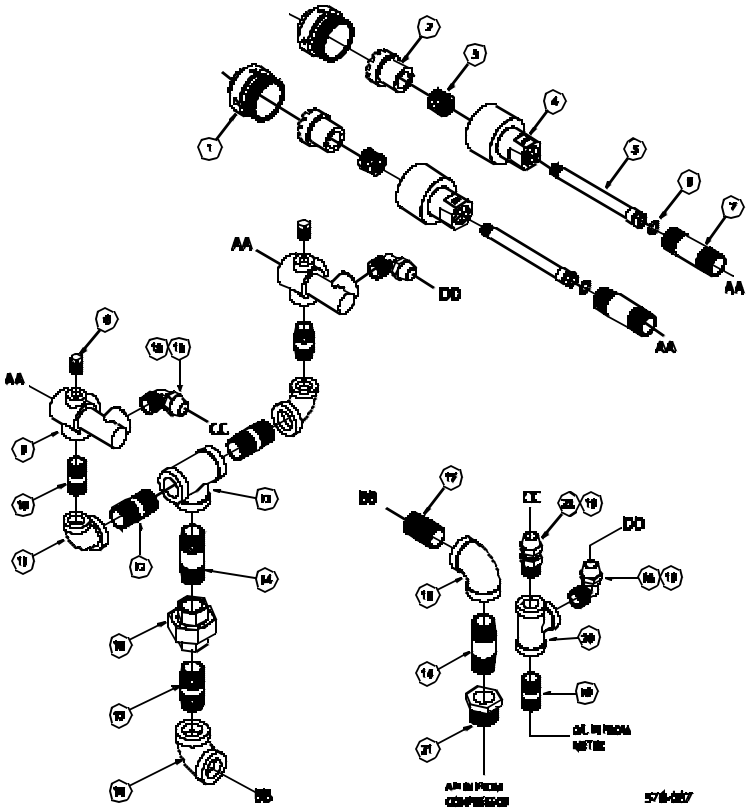
ITEM	REQ'D	PART NUMBER	DESCRIPTION
1	1	940-01516	Oil Flow Control Valve
2	1	085-00939	Burner & Linkage Support Assembly
3	2	807-00344	Bearing
4	1	018-00149	Collar
5	1	002-00259	Linkage Arm
6	1	067-00487	Linkage Rod Assembly
7	1	010-00343	Bushing Assembly

Figure 6-10: Oil Flow Control Valve



ITEM	REQ'D	PART NUM-BER	DESCRIPTION
1	1	947-01516	Maxon Flow Control Valve
2	1	817-00110	High Oil Pressure Switch
3	1	900-00290	1/4" NPT Pipe Siphon
4	1	817-00687	Low Oil Pressure Switch
5	1	940-01233	1/2" NPT Motorized 3-Way Oil Valve
6	1	008-01830	Oil Piping Support Bracket
7	1	007-00209	1-1/8" Dia. U-Bolt
8	1	940-01224	1/2" NPT Relief Valve
9	1	940-01190	1/2" NPT Motorized 2-Way Oil Valve
10	2	850-00003	0-60 PSI Gauge
11	1	940-01169	1/2" NPT Horizontal Check Valve

Figure 6-11: Oil Fuel Train

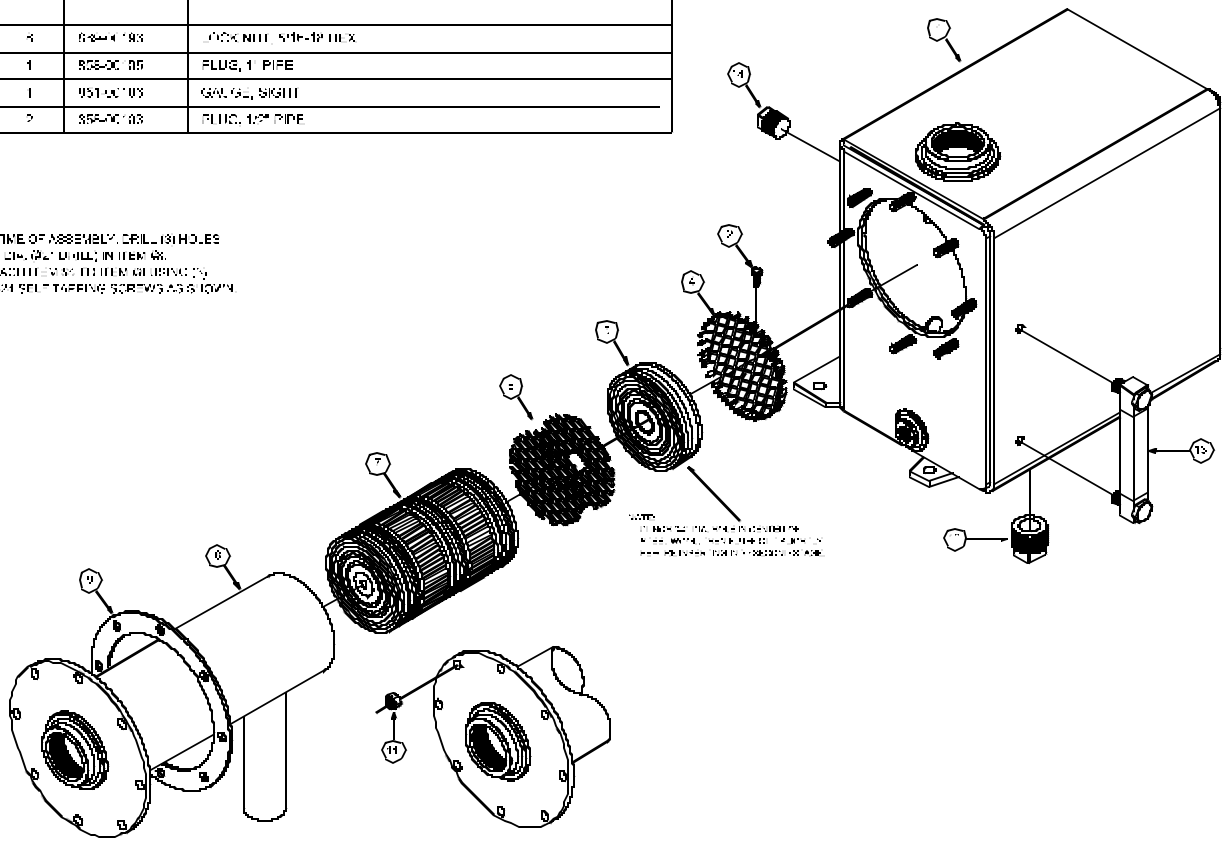


ITEM	REQ'D	PART NUMBER	DESCRIPTION
1	2	048-00203	Nozzle Tip (Ref. 528-00050)
2	2	109-00051	Swirler (Ref. 528-00050)
3	2	082-00121	Spring
4	2	277-00107	Nozzle Body
5	2	090-00732	Tube Sleeve Assembly
6	2	853-00613	O-Ring
7	2	857-00169	3/4" x 3-1/2" Lg. Pipe Nipple
8	2	858-00101	1/4" Pipe Plug
9	2	106-00101	Air/Oil Inlet Manifold
10	3	857-00153	1/2" x 1-1/2" Lg. Pipe Nipple
11	2	847-00548	3/4" x 1/2" Reducing Elbow
12	3	857-00166	3/4" x 2" Lg. Pipe Nipple
13	1	859-00025	3/4" x 3/4" x 3/4" Pipe Tee
14	2	857-00167	3/4" x 2-1/2" Lg. Pipe Nipple
15	1	858-00217	3/4" Pipe Union
16	2	859-00081	3/4" x 90 Pipe Elbow
17	1	857-00163	3/4" Close Pipe Nipple
18	3	845-00313	1/2" Odc. x 1/2" MPT x 90 Flared Fitting
19	4	845-00224	1/2" Flare Nut
20	1	859-00024	1/2" x 1/2" x 1/2" Pipe Tee
21	1	847-00426	1" x 3/4" Reducing Bushing
22	1	845-00312	1/2" Odc. x 1/2" MPT x Str. Flared Fitting

Figure 6-12: Dual Oil Nozzle Assembly

ITEM	REQD.	PART NO.	DESCRIPTION
1	1	[illegible]	TANK WELDMENT, AIR/OIL
2	3	541-0078?	SCREW, #10-24 x 5/8" T.C. SELF TAPPING MACHINE
3			
4	1	A-319-0697	COVER ASSEMBLY, STRAINER
5	[illegible]	819-0023	STEEL WOOL, #3 COARSE (PUNCHED)
6	1	[illegible]	STRAINER, STRAINER
7	[illegible]	819-0023	STEEL WOOL, #3 COARSE
8	1	C-929-0118	STRAINER WELDMENT
9	1	A-329-1118	GASKET, STRAINER ASSEMBLY
10			
11	4	[illegible]	LOCK NUT, 5/16-18 HEX
12	1	556-0035	PLUG, 1" PIPE
13	1	951-0003	GAUGE, SIGHT
14	2	554-0003	PLUG, 1/8" PIPE

NOTE:
AT TIME OF ASSEMBLY, DRILL (8) HOLES
[illegible] DRILL IN ITEM 4B.
ATTACH ITEM 4 TO ITEM 9 USING (2)
6-1/2" SELF TAPPING SCREWS AS SHOWN.



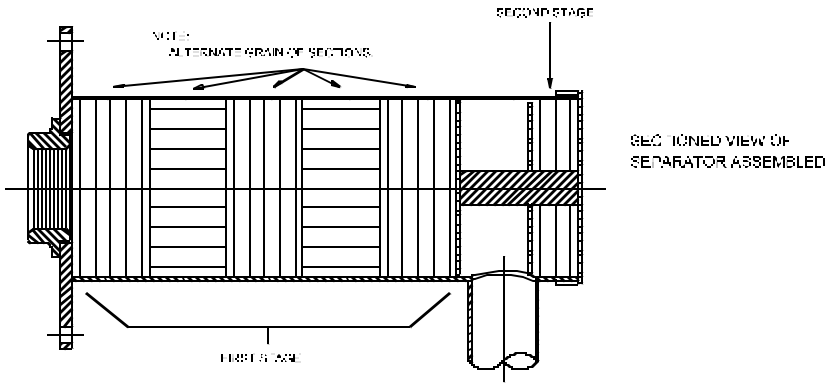


Figure 6-13: Air Oil Tank Assembly

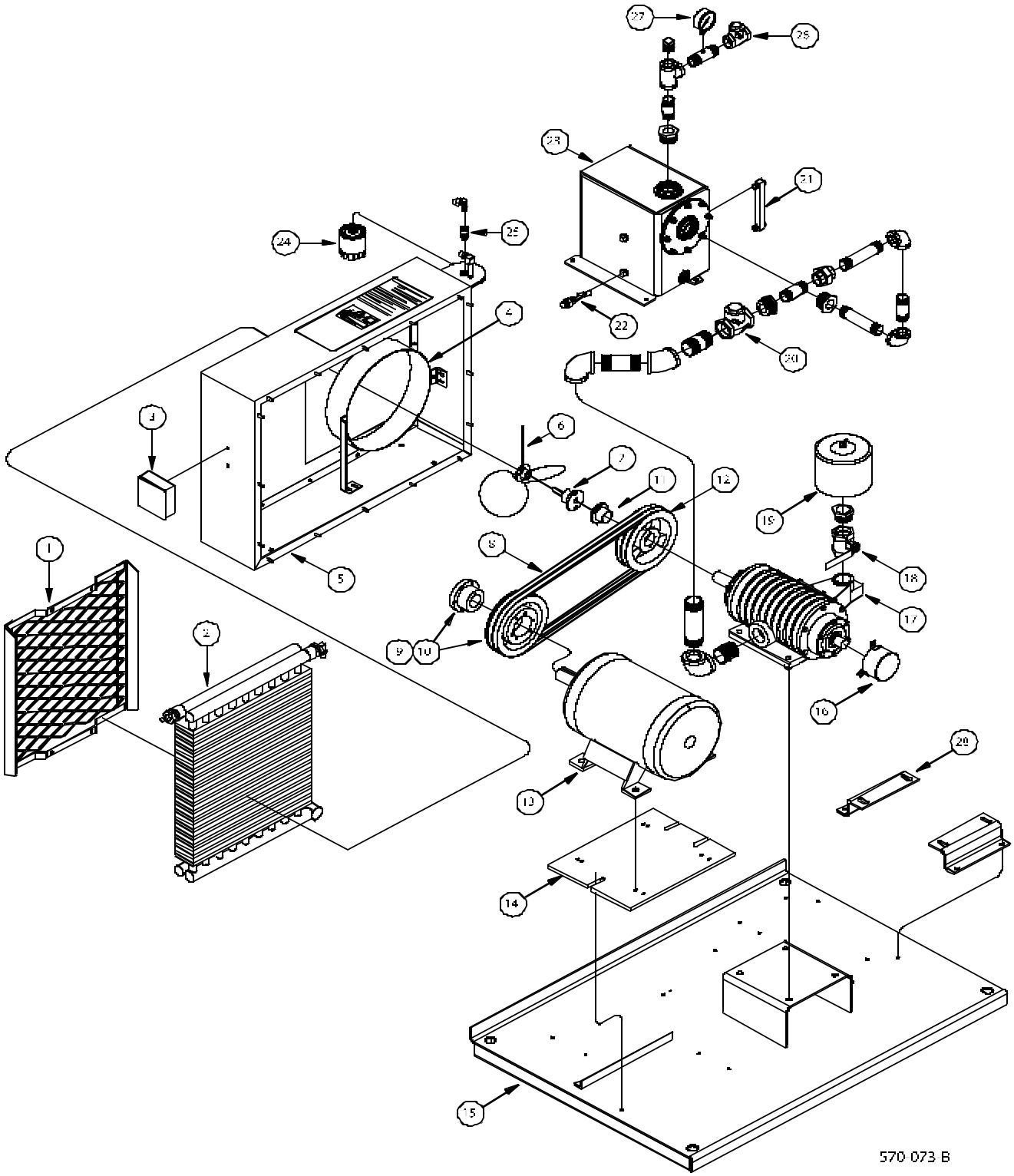


Figure 6-14: Separate Compressor Assembly

ITEM	REQ'D	PART NUM-BER	DESCRIPTION
1	1	035-00440	Radiator Guide Assembly
2	1	017-00234	Radiator Assembly
3	1	848-00514	Electrical Junction Box
4	1	039-00446	AirFlow Duct Assembly
5	1	035-00439	Belt Guard Weldment
6	1	951-00174	Fan Blade
7	1	074-00516	Fan Mounting Shaft
8	1	809-00223	V-Belt
9	1	810-00073	Bushing
10	1	921-00538	Sheave
11	1	810-00072	Bushing
12	1	921-00537	Sheave
13	1	894-01380	Motor, 15 HP, 3 ph, 208 Volt
13	1	894-01381	Motor, 15 HP, 3 ph, 230/460 Volt
14	1	059-01284	Motor Mounting Plate
15	1	003-00377	Compressor Base
16	1	035-00438	Compressor End Shaft
17	1	505-00322	Air Compressor
18	1	941-00127	1-1/2" NPT Shutoff Valve
19	1	923-00112	Air Filter
20	1	940-01281	1-1/2" NPT Horizontal Check Valve
21	1	851-00180	Sight Glass
22	1	832-00925	Low/High Lube Oil Sensor (Optional)
23	1	195-00264	Oil/Air Tank Assembly
24	1	843-00106	Oil Filter
25	1	010-00315	Oil Filter Mounting Bushing
26	1	940-01279	1" NPT Horizontal Check Valve
27	1	850-00003	0-60 PSI Gauge
28	1	008-01903	Oil/Air Tank Mounting Bracket