Sellers® "S" Series Modulating Digital-Control Immersion-Fired Hot Water Boilers

INSTALLATION & OPERATING INSTRUCTIONS

The innovative *Sellers*® immersion-fired boilers are durable, reliable, proven

- Low maintenance
- No thermal shock
- Quick warmup
- Longest warranty

Note: Place a copy of these instructions adjacent to the boiler/heater; notify the owner to keep for future reference.

If Shipping Damage is noted, receiver must make damage claim to recover damage.

WARNING: If these instructions are not followed exactly, a fire or explosion may result causing property damage, personal injury or death.

FOR YOUR SAFETY: Do not store or use gasoline or other flammable vapors and liquids or other combustible materials in the vicinity of this or any other appliance. To do so may result in an explosion or fire.

WHAT TO DO IF YOU SMELL GAS:

- Do not try to light any appliance.
- Do not touch any electrical switch; do not use any phone in your building.
- Immediately call your gas supplier from a neighbor's phone. Follow the gas supplier's instructions.
- If you cannot reach your gas supplier, call the fire department.

Sellers® MANUFACTURING CO.

18 West Walnut St. Danville, Kentucky 40422
Visit Us on the Web: **www.sellersmfg.com**
For Customer Service: info@sellersmfg.com or call 859-236-3181

Industrial boiler equipment design and manufacturing excellence for over 80 years.
Proudly made in Danville, Kentucky, USA.

SAFETY

Safety messages and instructions located in this manual and on the heater/boiler provide warnings to you and others of potential hazards. Before installing, operating or servicing this heater/boiler, it is important to read and understand these safety instructions and messages.

DANGER indicates the presence of immediate hazards which, if not avoided, could result in severe personal injury, death, or substantial property damage.

WARNING indicates a potentially hazardous situation which, if not avoided, could result in severe personal injury, death or substantial property damage.

CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury, or property damage.

Qualified Installer: Must have the ability of a licensed tradesman in the fields of gas supply, plumbing and venting, including a thorough understanding of the National Fuel Gas Code as it relates to gas fired water heaters and boilers. The installer must thoroughly review and understand this manual.

Service Technician: An individual trained and experienced in boiler startup, and trained in Sellers boiler startups. Individual must also have training and experience in the controls used, steam and feedwater systems and related utilities

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Verify that the gas hooked up to the boiler is the same type specified on the Name Plate label, located on the heater/boiler.

Should overheating occur, or the gas valve fails to shut, do not turn off the electrical supply to the heater/boiler. Shut off the gas supply at a location away from the heater/boiler.

Do not use this heater if any part has been under water. Have the heater/boiler inspected by a qualified Service Technician. Replace any electrical or gas control system which has been under water.

Maintain the area surrounding the heater/boiler clean and free of combustible materials, gasoline, and other flammable liquids or vapors. The heater/boiler should never be covered
This heater/boiler requires a constant supply of fresh air for proper combustion. Failure to provide an adequate flow of fresh air may result in series injury or death.

Sellers S-Series Immersion Fired Boiler Pre-Startup Check List

S.O. Number: _____ Model Number: _____

Job Name: _____ Location: _____

Representative: _____ Purchaser: _____

Mark the following once they have been completed and checked to be in accordance with quote:

Service Room Around Boiler:	_____	Pilot Gas Connection:	_____
Front Burner Swing:	_____	Main Gas Connection:	_____
Tube Pull Clearance:	_____	Gas Train Venting:	_____
Housekeeping Pad or Piers:	_____	Gas Cleanout Leg:	_____
Combustion Air Supply:	_____	Gas Supply Pressure:	_____
Feedwater Connection:	_____	Electrical Connection:	_____
Steam Connection:	_____	Wiring Alteration?	_____
Bottom Blowoff Connection:	_____	Supply Voltage:	_____
Water Column Blowoff Connection:	_____	Control Circuit Voltage:	_____
Surface Blowdown Connection:	_____	Blower Rotation Correct:	_____
Safety Relief Valve Piping:	_____	Boilout/Cleanout Completed?	_____
Stack Installation and Proper Draft:	_____	Record Draft (Manometer) Reading:	_____

Additional Notes:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Performed By: _____ Date: _____

MUSE BE RETURNED TO INFO@SELLERSMFG.COM
FOR WARRANTY VALIDATION

D-755

Sellers S-Series Immersion Fired Boiler Startup Report

S.O. Number: _____ Model Number: _____

Job Name: _____ Location: _____

Purchaser: _____ Representative: _____

Mark the following controls once checked:

Primary LWCO: _____ Combustion Air Proving Switch: _____

Aux. LWCO: _____ Operating Temp Sensor: _____

High Gas Pressure Switch: _____ High Pressure Limit: _____

Low Gas Pressure Switch: _____

Gas Pressures

Gas Pressure to Gas Train: _____ Regulated Gas Pressure: _____

Regulated Pressure to Pilot: _____

Combustion Settings

	Low									High
Firing Rate										
% O_2										
% CO_2										
Co pm										
NO_x										
Air Temp										
Gross Stack Temp										
Draft (at stack)										
Steam Press.										
Damper Degree										
Fuel Degree										
2nd Valve Degree										
Flame Signal										

High Fire Motor Amps and Volts L1: _____ L2: _____ L3: _____

Performed By: _____ Date: _____

Company: _____ Phone Number: _____

Notes:

_____

_____

_____

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Table of Contents

1. General Information 8
1.1. Product Offering 8
1.2. Model Designation 9
1.3. Nameplate Information 10
1.4. Your Complete Manual 11
1.5. Parts and Warranty 11
1.6. Acronyms and Definition of terms 11
2. EQUIPMENT AND COMPONENT DESCRIPTION 13
2.1. General Description 13
2.2. Standard Components 13
2.3. Standard Boiler Openings 17
2.4. Burner Internal Components 18
3. INSTALLATION 20
3.1. General Considerations 20
3.1.1. Receiving the Boiler 21
3.1.2. Positioning the Boiler 21
3.1.3. Installation of Ship Loose Items 22
3.1.4. Combustion Air Requirements: The Forgotten Element in Boiler Rooms 22
3.2. Hot Water Boiler Connections 23
3.2.1. Pressure Vessel 23
3.2.2. Relief Valve Piping 24
3.2.3. Water Level and Controls Piping 24
3.3. Gas Piping 24
3.4. Electrical Connection 26
3.5. Flue Connection 27
3.6. Condensate Connection 28
4. Waterside Care and Requirements 29
4.1. General 29
4.2. Water Requirements – Hot Water Boilers 29
4.3. Thermal Shock 30
4.4. Cleaning 30
4.5. Periodic Inspections 31
4.6. Preparation for Extended Lay-up 32
5. SEQUENCE OF OPERATION 33
5.1. Pre-Purge Cycle 33

5.2. Pilot trial for ignition 33
5.3. Main Flame trial for ignition 33
5.4. Run Period 34
5.5. POST PURGE PERIOD 35
6. PREPARING FOR OPERATION 36
6.1. General Inspection 36
6.1.1. System Inspection and Preparation 36
6.1.2. Vessel Inspection 37
6.1.3. Burner Inspection and Preparation 37
6.2. Burner Adjustments 37
6.2.1. Ignition Electrode 37
6.2.2. Pilot Assembly and Flame Rod 38
6.2.3. Nozzle Flame Rod 38
6.2.4. Front door gasket seal 39
6.2.5. Combustion Settings 39
6.3. Controls and Safety Check 40
6.3.1. Low Water Cutoff (float type) 40
6.3.2. Air Flow Proving Switch 40
6.3.3. High Gas Pressure Switch 40
6.3.4. High Limit Temperature Control 40
6.3.5. Operating Temperature Control 40
6.3.6. Flame Safeguard and Combustion Controls 41
6.3.7. Low Gas Pressure Switch 41
6.4. External Controls and Building Management Systems (BMS) 41
6.5. Energy Extractors 42
7. COMBUSTION ADJUSTMENTS 44
7.1. General Burner Description 44
7.2. Ignition Point 44
7.3. Main Flame 44
7.4. Secondary Air 45
7.5. Internal Load Controller PID Loop 46
7.6. Impact of Changing Environment 46
7.7. Data Logging 47
8. STARTUP 48
8.1. Pre-start check list 48
8.2. Initial Startup 48
8.3. Safety Controls Set-up 50

8.3.1. Gas Pressure Switches 50
8.3.2. Combustion Air Proving Switch 50
8.3.3. Operating & Modulating Control 50
8.4. Normal Operation 50
9. MAINTENANCE 52
9.1. GENERAL 52
9.2. Safety Checklist for Inspection 52
9.3. Water Side Checklist 52
9.4. Fire Side Checklist 52
9.5. Maintenance Schedule 53
10. TROUBLESHOOTING 54
11. Appendix A 57

1. General Information

This manual covers the "S Series" packaged immersion-fired Firetube boiler manufactured by Sellers Manufacturing Co. These boilers are intended to be used in commercial and industrial applications that require steam or hot water for heating or process applications. The boiler is assembled with an integral burner and includes many of the basic controls and fuel trains, but many other components and utilities are required to make the unit operational. The field installation would typically include stacks and breechings, fuel, electrical and water supply, steam or hot water lines, and all installed in a properly designed boiler or mechanical room. The proper design and installation of these systems is the responsibility of the owner.

This manual is supplied to the boiler owner and operator with information regarding installation, startup, operation, and maintenance. It is the ultimate responsibility of the boiler owner to operate and maintain this equipment in a safe manner.

The "S" series are "packaged Boilers", which means that it has an integral burner and includes all of the burner controls, gas trains and water controls, but not all of the auxiliary systems required for operation. Typically, this is used as part of a much larger boiler room system that would include pumps, piping, controls and stacks designed as an integral system, engineered by an experienced boiler room engineer, installed and maintained by an experienced boiler room mechanical contractor.

The vessel is a single pass design where individual burners are fired into each of the boiler tubes. The burner incorporates a fuel-air pre-mix that is channeled to the individual firing nozzles located in front of each tube. Because this vessel is a single pass design, there is no furnace chamber and there are no turnaround chambers with the related refractory or additional pressure vessel components.

This manual is intended to cover the vessel and burner, focused on those components manufactured by Seller Manufacturing Co. There are many other significant components that are made by other vendors, and their component manuals are included with this product, and the details of their operation are not covered within this manual. Also, Sellers provides a wiring diagram and parts list that identify the specifics of this unit.

⚠ WARNING

DO NOT ATTEMPT TO START, ADJUST OR MAINTAIN THIS BURNER WITHOUT PROPER TRAINING OR EXPERIENCE. FAILURE TO USE KNOWLEDGEABLE TECHNICIANS CAN RESULT IN EQUIPMENT DAMAGE, INJURY OR DEATH.

While the information in this manual is deemed to be correct at the time of the printing, Sellers Manufacturing retains the right to make product improvements which may not be represented in this manual. Any product changes on the unit will be reflected in the Bills of Material and Wiring Diagrams. If there are any questions concerning this manual or its representation of the product, please feel free to contact Sellers at 859-236-3181.

1.1. Product Offering

The S series product is offered in hot water and steam, and designed according to the A.S.M.E. Pressure Vessel Codes in both low pressure hot water (Section IV of the ASME code, for a maximum of 160 PSI and/or 250 ^{o}F design) and high pressure hot water (section I of the ASME code, over160 PSI or 250 ^{o}F). The sizes range is from 40 to 800 Boiler Horsepower. The standard fuel is natural gas, but the unit can also be designed to handle LP and other gas fuels, including biogas. The unit includes an integral burner, controls, fuel train and other components to provide a complete package boiler.

A low NOx option is also available which provides sub 30 ppm NOx (corrected to 3% O2) on natural gas firing. This option would normally use a large fan and motor to maintain the rated capacity, and may have slightly different dimensions as a result.

The burner can also be operated as a low emission product when adjusted accordingly, and can provide low NOx emissions under 30 ppm. These lower emission rates can impact the ratings, and should be coordinated with the sale of the unit to verify performance. The turndown rates for this product varies with size, fuel, options and fuel

trains, but can be up to 5:1 turndown.

Numerous options are available for the S series product, including the controls, fuel trains, and trim. The product can also be engineered and manufactured to meet numerous specifications and/or regulations.

Firetube Boilers are rated on the energy output of the hot water, with each Boiler HP representing 33,475 Btu/hr. For simplicity, an assumed efficiency of 80% is used to provide both the energy input and output, as shown in Table 1.1. The actual efficiency will vary with the operating pressure and/or temperatures of the boiler and makeup of the fuel and air, so that the input can vary.

Boiler Horse Power	Rated Output (MBH)	Estimated Heat Input (MBH)	
		Based of 80% Efficiency	Based on 82% Efficiency
40	1,339	1,674	1,594
50	1,674	2,092	1,993
60	2,009	2,511	2,391
70	2,343	2,929	2,790
80	2,678	3,348	3,188
100	3,348	4,184	3,985
125	4,184	5,230	4,981
150	5,021	6,277	5,978
175	5,858	7,323	6,974
200	6,695	8,369	7,970
250	8,369	10,461	9,963
300	10,043	12,553	11,955
350	11,716	14,645	13,948
400	13,390	16,738	15,940
500	16,738	20,922	19,926
600	20,085	25,106	23,911
700	23,433	29,291	27,896
800	26,780	33,475	31,881

Table 1-1 Rated Capacity

The Sellers Immersion boiler is a one pass design, with tubes only, and no combustion chamber or turnaround. It does not require thermal protection controls or other special startup sequencing. It can be driven to high fire after startup

1.2. Model Designation

The model designation provides a lot of information on what the unit it. In the model number, the first numbers/letter sequence defines the design pressure, as stated in the chart. The numbers vary by size as well as pressure. The next number indicates the boiler horsepower (BHP) of the unit. One BHP = 33,475 BTU/hr of energy output of the vessel in hot water. The energy input to the unit is often calculated from an assumed efficiency of 80%, even though the efficiency is usually much higher. With a higher efficiency, the input is reduced. This should be considered in the setup of the unit to prevent over-firing, which would impact the potential safety provided by the safety relief valves, which are sized on the vessel energy rating.

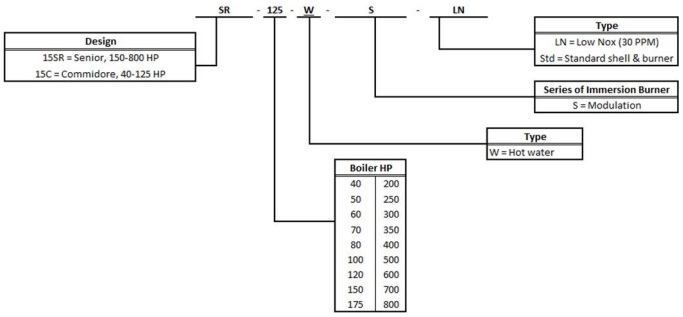


Figure 1-1 Model Numbering

The next letter in the sequence (W) defines it as a hot water unit.

The next sequence (S) defines the Series of the boiler. The "S" Series is defined as a Firetube Immersion boiler with full modulation. An "X" series would be an On-Off boiler.

The last sequence in the model number (LN) indicates if this is a standard or low NOx burner with will provide an emission level of under 30 ppm NOx. Typically, the low NOx burner uses a larger fan and sometimes a larger motor to maintain the rated capacity of the unit. The standard burner would have the letters "STD" in this location.

1.3. Nameplate Information

Each boiler has a nameplate that contains critical information on the boiler. The nameplate is located on the face of the burner and looks like the photo below.

The information on the nameplate is critical for operation, parts and maintenance of the equipment. Here is a more detailed description of the information:

- Model number – see Section 1.2
- Max Design Pressure: The design pressure of the vessel, used to calculate the design of the vessel.
- Serial Number: A unique number assigned by Sellers to the specific boiler.
- ASME Number: Sellers ASME certificate number
- National Board: A unique number assigned by the National Board of boiler inspectors.
- Input – BTU/hr: The maximum energy input of the burner, expressed in BTU/hr, and based on 80% efficiency.
- Kind of Fuel: The fuel planned for this boiler, which is used to design the burner components.
- Fuel Supply Pressure: The gas pressure to the inlet of the gas train (upstream of the main gas pressure regulator).
- Output: The energy output of hot water, in BTU/hr.
- Capacity: The rating of the vessel in pounds of hot water per hour, from and at 212 °F.
- Motor HP: Rated motor HP of the combustion air fan.
- Electrical Characteristics
    - Volts: The voltage rating of the electrical supply
    - Hertz: The frequency rating of the electrical supply, usually 60 hz.
    - Phase: The number of phases in the electrical supply, usually 1 or 3
    - Assembly Amps: Current rating for the boiler/burner assembly
    - Control Circuit is 120 Volts, 60hz.
    - Wiring Diagram Number: Drawing number of the wiring diagram for this unit.
    - Minimum Circuit Ampacity: Calculation of what the minimum size wire for the unit.
- MFG Date: The date this unit was completed and fire-tested.
- Enclosure Type: NEMA Class of enclosure
- Additional Info: Short Circuit Current Rating

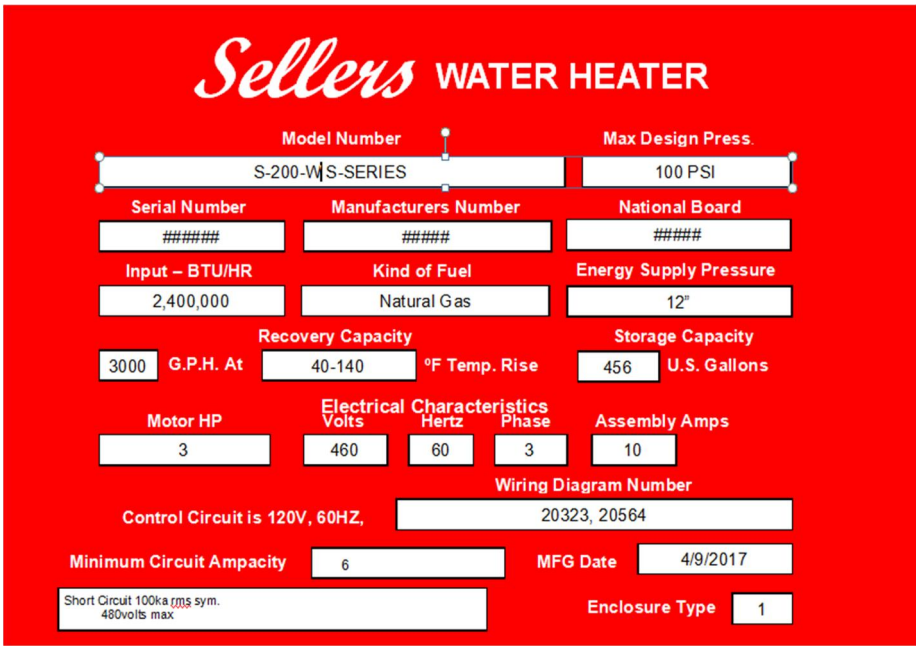


Figure 1-2 Name Plate

In addition to the nameplate above, an extra rating plate is used on the "S" burner to indicate the minimum as well as the maximum input and the manifold pressure at those rated inputs. This label is attached to the burner near the manifold pressure tap.

1.4. Your Complete Manual

This manual provides information on the equipment manufactured by Sellers Manufacturing. In addition, separate manuals are provided for the purchased components used on this product. As a minimum, this would include the Flame Safeguard and combustion control, fuel control valves, safety limit controls, water level controls.

A wiring diagram and parts list are supplied with the boiler manual. The wiring diagram must be used to properly wire the boiler and connect other related equipment. The parts list should be used when ordering spare or replacement parts.

A copy of the fire test report is included with the boiler manual packet, placed in the control panel on the face of the burner assembly. The fire test report is a document that provides the information obtained at the initial test fire of the unit at the factory, including the fuel inputs, combustion settings, pressures and motor amps. It contains several key details that can be very helpful in setting up the boiler in the boiler room application.

⚠ WARNING

DO NOT ATTEMPT TO OPERATE THIS PRODUCT UNTIL YOU HAVE READ AND UNDERSTAND THE COMPLETE MANAUAL. RUNNING THIS EQUIPMENT WITHOUT A PROPER UNDERSTANDING OF HOW TO PROPERLY START, ADJUST AND OPERATE IT CAN RESULT IN DAMAGE, INJURY OR DEATH.

1.5. Parts and Warranty

Parts, warrantee information, and field service support is available from your local Sellers Representative. For a list of Sellers Representative, please visit the Sellers web site at www.sellersmfg.com. To better support a quick response, please have the Sales Order Number and other information on the unit available.

The "Startup" report is required to be filled out and submitted to Sellers within 4 weeks of the initial startup of the unit to qualify for warrantee. The Startup Report form can be found at the end of this manual, and additional copies can be obtained from Sellers by asking for W/V-SS-3916. After startup, and completing this form, submit the document to Sellers Manufacturing by email (info@sellersmfg.com).

1.6. Acronyms and Definition of terms

The following acronyms and abbreviations are used in this manual;

ASME Code: A code written by the American Society of Mechanical Engineers that cover boiler and piping design
ASME CSD-1: An ASME code that covers controls and safety devices for automatically fired boilers.
ASME B31: ASME code for pressure piping
Aux LWCO: Auxiliary Low water cutoff
BHP: Boiler Horse Power (1 BHP = 33,475 BTU/hr)
Capacity or Rated Capacity: The maximum input or out of a boiler, which can be in BTU/hr or pounds of water/hr
Combustion Controls: Controls used to manage the flow of air and fuel to provide different firing rates.
Design Pressure: The pressure used for the design of the pressure vessel and related components
Draft: The pressure measured at the outlet of the boiler, where it is connected to the stack. This pressure should be maintained at a pressure of +/- 0.1" wc.
FGR: Flue Gas Recirculation
Flame Safeguard: The controls used to ensure that the combustion process is managed in a safe manner
Combustion chamber Pressure: The pressure in the chamber (combustion chamber) where the nozzles fire into the tubes. This is also where the secondary air is injected to support the pilot and main flame.

Inches water column (“wc): Pressure measured in inches of water (1PSIG = 27.7” wc)
Input: the energy input into the boiler, BTU/hr or MBH (100’s or BTU/hr) or KBTU/hr (100’s BTU/hr)
LWCO: Low water cutoff
MAWP: Maximum allowable working pressure
MS #: Manufacturers Serial number, a unique number assigned by Sellers to that sales order
Nameplate: A plate containing key boiler information (see Section 1.3)
National Board Number: A unique sequence number assigned by the National Board
NPS: Nominal pipe size
NPT: National pipe thread, tapered
NFPA: National Fire Protection Agency
NFPA 54: National Fuel Gas Code
NFPA 70: National Electric Code (NEC)
NFPA 85: Boiler and Combustion System Hazard Code
OUTPUT: The energy output of the vessel in steam or hot water, expressed in BTU/hr or BHP. Often the boiler output is approximated at 80% of the input, but actual efficiencies can vary.
Manifold: The chamber downstream of where the fuel and air are mixed, and before they enter the nozzles.
Manual Reset Switch: A switch which will remain tripped once triggered, and requires a manual reset.
Manifold Pressure: The pressure inside the manifold chamber.
Manufacturing Date: The date the boiler manufacturing was completed.
Maximum Input: The maximum fuel input for this unit, expressed in BTU/hr.
Minimum Input: The minimum fuel input for this unit, expressed in BTU/hr.
PSI: Pressure in pounds per square inch.
PSIG: PSI gage reading.
Primary air: Combustion air mixed with fuel before the combustion process.
Secondary air: Air that is added to the combustion process after the combustion has started
Section I: ASME code that covers high pressure (over 15 PSIG steam and 160 PSIG or 250 ^{o}F hot water).
Section IV: ASME code that covers low pressure (up to 15 PSIG steam and 160 PSIG or 250 ^{o}F hot water).
Serial Number: A unique manufacturer’s number assigned to each boiler for identification
VOLTS, HERTZ and PHASE: Refers to the electrical supply characteristics provided to the boiler.

2. EQUIPMENT AND COMPONENT DESCRIPTION

2.1. General Description

The Sellers "S" Series boiler is a packaged Firetube Boiler with an integral burner manufactured by Sellers Manufacturing Company. It is intended for commercial heating and process applications, and is offered as a hot water or steam boiler in sizes from 40 HP to 800 HP.

The burner is a pre-mix type that fires natural gas, LP, digester gas and other gases. It is a modulating burner. The burner is also offered with an optional low NOx firing for emission levels of 30 ppm or lower (corrected to 3% O2). The burner and boiler package is listed by Underwriters Laboratories (UL) from 40 to 400 HP.

The boiler and burner are pre-assembled and shipped as a packaged unit, and include the gas train, combustion air fan, burner controls, vessel controls, safety valves and many other components as listed below. The boiler is test fired at the factory, and the results of that test firing are recorded on the "Fire Test Sheet" which is included in the manual.

The standard boiler is provided with a Siemens LMV 5 Parallel positioning control which uses servo motors to modulate the air damper, fuel valve and in some cases, the secondary air valve as required for modulation from the minimum to the maximum firing rates. Options are available for linkage control, ratio relay controls and other combustion control systems. Details on the control systems are provided in separate manuals.

The burner uses a ribbon pilot, which provides a small pilot under each nozzle. The pilot ribbon runs across the burner front as well as up and down the burner front. At pilot ignition, a spark ignites the ribbon pilot at one end, and this flame spreads across the burner face to the far corner, where the flame is proven by a flame rod. On main flame, a flame rod on one of the nozzles is used to prove that the main flame is established. The pilot remains on as long as the burner is on, and cycles off when the burner turns off.

The Sellers "S" Series boiler has several unique differences from conventional Firetube boiler. The primary difference is that the vessel is a single pass boiler (no furnace) and individual burners firing into the 2" tubes in the vessel. This means no furnace or turnaround chamber. There is also no refractory or baffles to direct flue gases.

Because there is no furnace that will grow at a different rate from the tubes in the other passes, there is no thermal shock. Every tube inside the vessel receives the same heat input and has exactly the same growth, so there is no uneven heating to cause thermal stress. The "S" Series boiler can be operated at high firing rates immediately after startup, and the "X" series (On-Off firing) Immersion Firetube boilers have been doing this for many decades.

The following is a list of the main components used in the S Series boiler and a description of their function.

2.2. Standard Components

1. Burner Assembly – An assembly of the components required to provide the fuel and air for combustion, and the controls to provide safe light-off and control of the combustion process. A more detailed explanation of the internals of the burner is covered at the end of this section. Some of the vessel controls are also included in the burner controls.

2. Blower Motor - Drives blower fan to provide the air required for combustion. All motors are 3500 RPM. An open drip-proof (ODP) style motor is provided as a standard offering, but other versions are available as options. A totally enclosed fan cooled (TEFC) motor would typically be used for dirty or outside environments.

3. Air Proving Switch – This is a safety interlock switch that measures the pressure developed by the combustion air fan, and opens if that pressure drops below its setting. It prevents the ignition sequence or shuts off the burner under conditions of insufficient combustion air pressure. (automatic reset device)

4. Pilot Shutoff Cock – A ball valve that is used to manually control the pilot gas volume or isolate the pilot gas flow. The actual adjustment of the pilot gas flow is done by adjusting the pilot gas pressure regulator (item

5. Pilot Gas Pressure Regulator – A manually adjusted pressure regulating valve that provides a constant gas pressure to the pilot. It is the primary means of controlling the pilot gas flow.

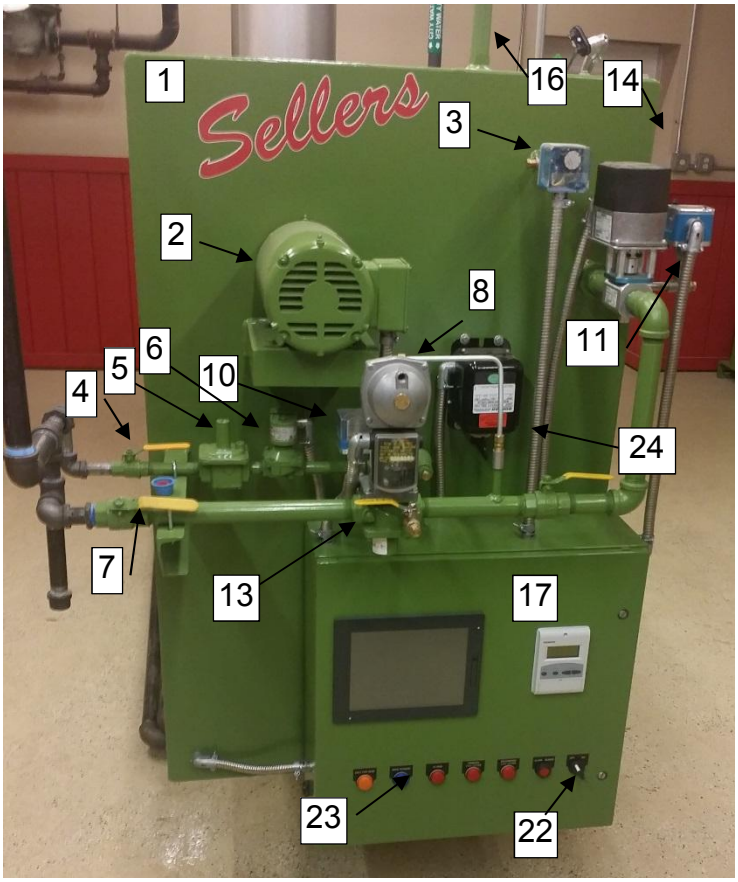
6. Automatic Pilot Gas Valve – Solenoid valve(s) that automatically control pilot gas supply in response to burner operation through the flame safeguard sequence. The pilot remains on through the main flame operation in addition to the pilot proving period.

7. Main Gas Shutoff Cock – A manual valve used to isolate the main gas supply to the burner assembly. (Installed upstream of main gas train components).

8. Main Gas Pressure Regulating Valve – A manually adjusted pressure reducing valve that provides a constant gas pressure to the main burner. In some cases, this is built into the Safety Shutoff Valve; otherwise it would be located in front of the Safety Shutoff Valve(s).

9. Safety Shutoff Valve(s) – Electric valve(s) (can be motor and/or solenoid) that control gas supply to the main burner in response to the operating sequence of the controls, including the flame safeguard. They can also be integrated into the gas pressure regulator as show as item #8.

10. Low Gas Pressure Switch (if provided) – A gas pressure switch that prevents the operation of burner in the event of unsafe low gas supply pressure. This is a manual reset device which requires that the rest button be pressed to allow the switch to re-start and allow the burner to operate.



11. High Gas Pressure Switch (if provided) – A gas pressure switch that prevents the operation of burner in the event of unsafe high gas supply pressure. This is a manual reset device which requires that the rest button be pressed to allow the switch to re-start and allow the burner to operate.

12. Normally Open Vent Valve (if provided) - Provides unrestricted vent to atmosphere between dual main automatic safety gas valves when burner is off. (not pictured) This is not normally used with propane (or LP) because it is heavier than air and will tend to pool at a low point which could explode.

13. Leakage Gas Shutoff Cock - Manually controls main gas supply to the burner assembly. This valve is also sometimes called the safety valve because it is used to manually control gas flow on initial startup, and quickly shut off gas flow if combustion is not correct. It is also allowing for manual leak testing of automatic safety gas valves. (Installed down stream of last automatic safety gas valve.)

14. Gas Control Valve and Servo – A combination of a butterfly control valve and a servo motor that modulates the valve to control the volume of gas to the main burner. This valve is controlled in combination with the air damper to provide the correct fuel-air-ratio to the burner nozzle. The butterfly control valve is sized for the specific application, based on the flow rate and available pressure.

15. Combustion Air Damper and Servo – A combination of a modulating air control box that changes the volume of total air supplied to the burner and a servo motor that positions the damper. The servo is controlled in combination with the fuel valve to provide the correct fuel-air-ratio to the burner nozzle.

16. Secondary Air Adjustment(s) - A manual adjustment (and lock) for controlling the secondary air. (On smaller boilers, a single adjustment may be mounted on top of the burner assembly. This will change how much air is used in the primary air and how much in the secondary air flow.

17. Control Panel - Houses and protects electrical controls and wiring and provides terminals for wiring connections. See details below.

18. Manufacturers Nameplate (not shown)- Provides identification and rating information specific to the boiler, see Section 1.2.

19. Flame Safeguard and Combustion Control – The Flame safeguard provides and controls safe sequence of the burner and inter-related operating and safety controls. The combustion control provides the physical control of the fuel and air flow rates from low fire to high fire and through modulation. The unit shown contains both controls in a single package, but other products can have individual controls.

20. Control Circuit Transformer - Converts primary electric supply voltage to 120-60-1 phase for the boiler control circuit.

21. Blower Motor Starter – A relay that provides on-off control of the blower motor in response to flame safeguard sequence.

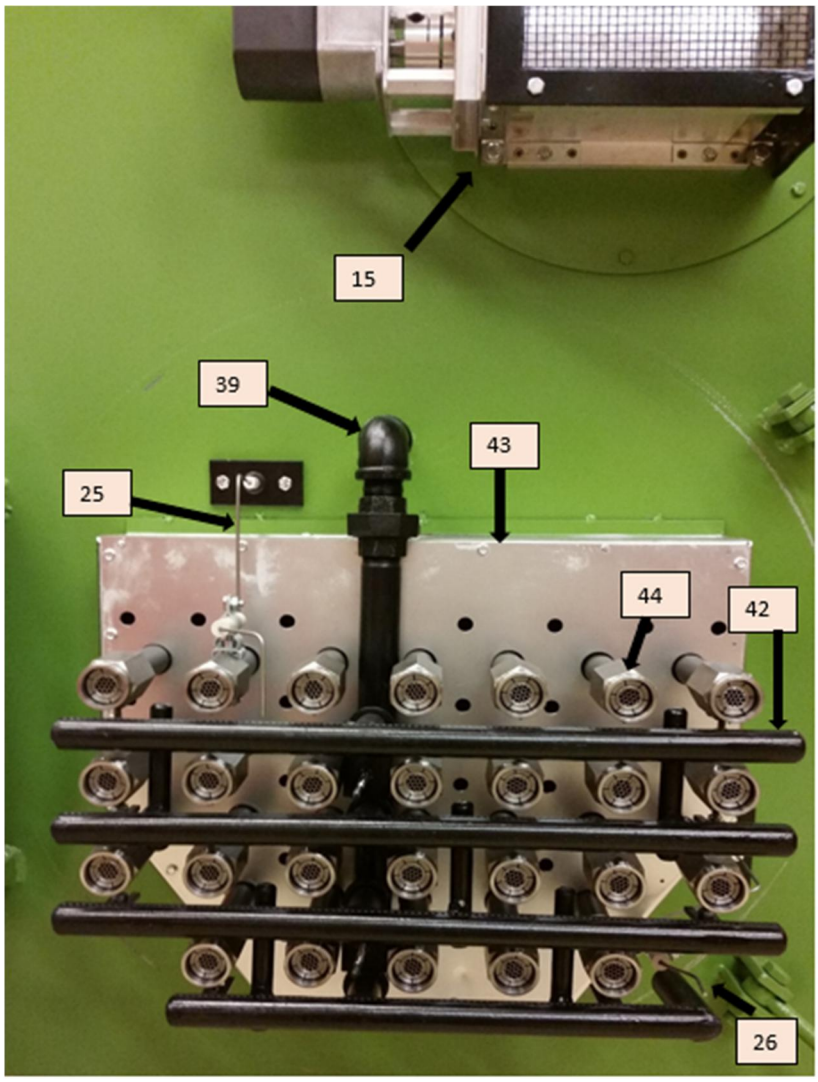


Figure 2-2 Burner

22. On-Off Control Switch - Provides manual on-off control of the boiler (sometimes called safe start switch).

23. Indicating Lights - Provides visual signal to verify current operating status of boiler.

24. Ignition Transformer - Provides high voltage electric output to ignition electrode for safe ignition.

25. Ignition Electrode - Provides spark for safe pilot ignition.

26. Pilot Flame Proving Electrode - Senses presence and proper location of the pilot flame for safe main burner ignition. The proving rod is opposite the ignition electrode, so that the pilot must ignite across the full burner face to prove all of the pilots have ignited.

27. Main Flame Proving Electrode - Senses presence of main burner flame in proper position for safe main burner operation. (Not furnished on boilers less than 60 HP.) (not pictured - same as 26 but located on main burner nozzle)

28. Structural Steel Base - Supports entire boiler for handling and rigging, and evenly distributes boiler weight.

29. Lifting Eyes – Connection points for lifting the boiler. See Section 3 for details.

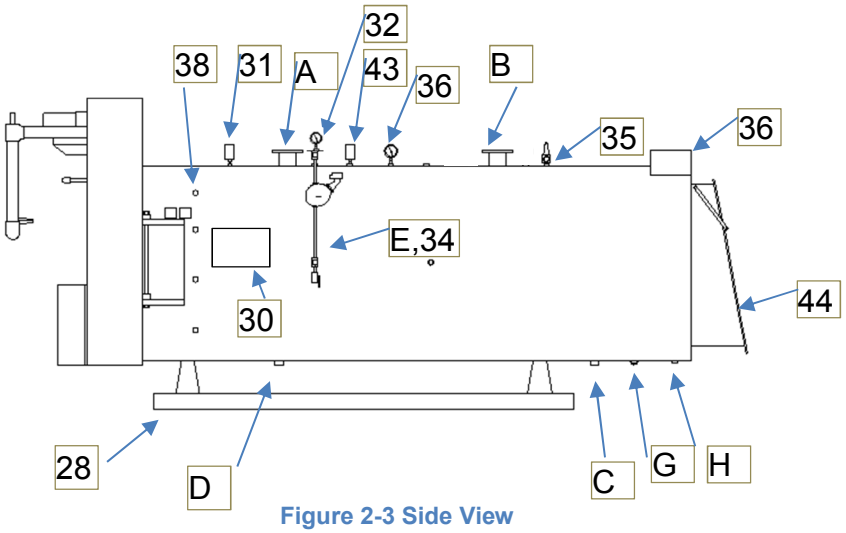


Figure 2-3 Side View

30. Electrical Supply Junction Box - Provides convenient primary electrical supply connection to the boiler.

31. High Limit Temperature Control – A manual reset temperature switch that monitors the water temperature and will shut down the boiler if that temperature is exceeded. Once the switch is tripped, it must be manually reset to allow the burner to operate. The set temperature is adjustable.

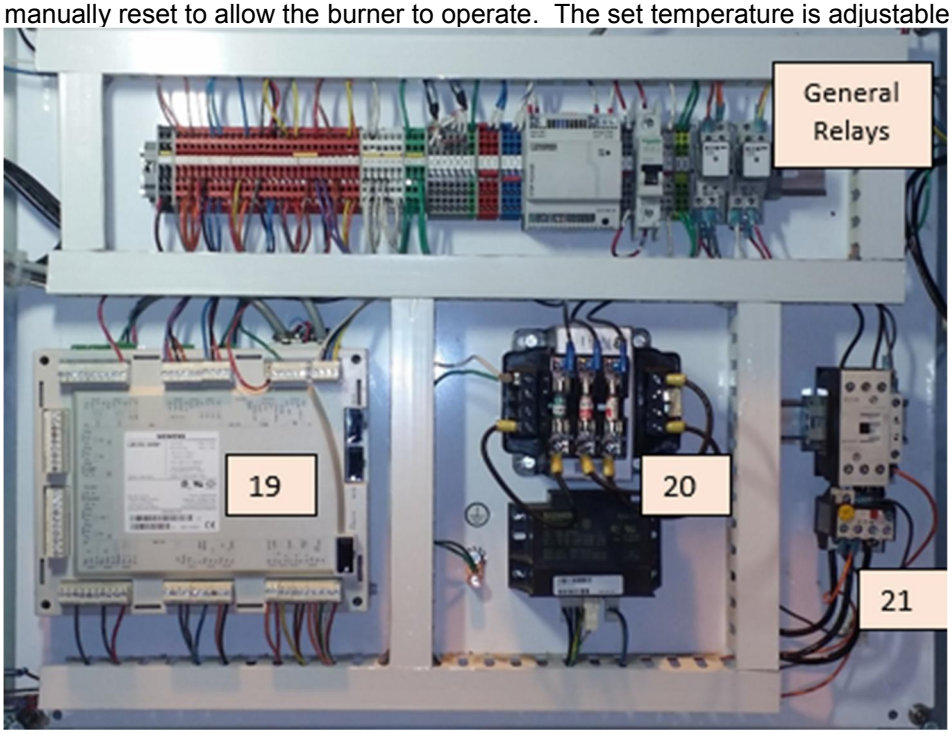


Figure 2-4 Control Panel

32. Pressure Gauge - Provides visual verification of boiler operating pressure.

33. Water Gauge Set – Provides visual indication of the water level in the water column and the boiler shell.

34. Low Water Cutoff – (LWCO) Prevents operation of burner assembly in the event of unsafe water level condition. (manual reset device). The LWO can be a float controlled switch (as shown) or an electronic control mounted in the center of the vessel.

35. Relief Valve(s) - Relieves internal pressure in boiler in the event component failures allow unsafe pressure condition to develop. Once the boiler is installed, they should be piped to a safe point of discharge (see Section 3 for details).

36. Stack Outlet - A round stack connection is provided at the rear of the boiler for connection to the stack or breeching. The maximum stack weight that can be supported by the boiler is 1000 pounds on boilers up to 80 HP and 2000 pounds on boilers larger than 80 HP. See Section 3 for other design considerations for stacks and breechings.

37. Blast Shield (Optional) - Provides adequate space around the relief door prohibiting anyone from being in the range of motion of the relief door in case it was to open and relieve pressure due to a combustion explosion.

38. Combustion Sight Glass - Provides for visual inspection of pilot and main burner condition. There are several sight glasses (more on larger units) to visually inspect the pilot and main flame combustion.

39. Pilot Gas Header – Delivers pilot gas to the runner pilots.

40. Runner Pilots – Provides ribbon flame below all main burner nozzles for ignition. This pilot remains on during the burner firing.

41. Secondary Air Box – A pressurized box that has numerous small holes for uniform distribution of secondary air to the pilots and main flames.

42. Main Burner Nozzles – Flame retention type nozzles deliver pre-mixed air and gas across runner pilots and into the fire tubes for combustion.

Figure 2- 5 Relief Door

43. Temperature Sensor – Provides a signal to control the burner On-Off cycling and modulating firing rate in response to load changes. See Section 5 for details.

44. Relief Door – A combustion relief door is provided at the rear of the unit. It provides a relief opening in the event of a combustion explosion. The room layout should allow an open space behind this door that will not expose individuals to this area in the rare case that it may open and release hot gases. The door has a gasket seal that must be maintained to provide a tight seal and prevent air from entering, which would result in a false high excess oxygen reading. This is especially true if oxygen trim unit is used for combustion tuning, and if there is a high negative draft that would pull in more air.

2.3. Standard Boiler Openings

A. Heating water supply – Opening from the boiler to the heating system

B. Heating water return – opening to the boiler for return water circulating from the heating system.

C. Manual Fill Connection - opening to boiler for fresh make-up water or manual fill.

D. Blowdown /Drain - Opening for blowdown or complete draining of boiler.

E. Float type water column blowdown/drain connection – Opening for float type low water level blowdown and/or drain.

F. Manhole opening (if supplied) – Full sized opening for access to the water side of the boiler for inspection and cleaning

G. Handhole opening(s) – Small openings for access to water side of boiler for inspection and cleaning

H. Rear Condensate Drain - Opening for draining initial condensation of water vapor from flue gases out of rear of boiler.

I. Relief Valve Openings – Opening for the discharge of the relief valve outlet to safe terminating point. The number and size of the openings are based on operating pressure.

2.4. Burner Internal Components

The fan housing provides a chamber to enclose the impeller (or fan), and with the air inlet cone, allows a separation of the air inlet and the pressurized fan outlet. The inlet cone is connected to the housing, and helps provides an air path between the air damper and fan inlet on the suction side. The air damper is used to regulate the quantity of air flow for combustion, to match the fuel flow for the proper fuel-air-ratio. Inside the housing, the air inlet chamber (from the air damper to the inlet cone) is isolated from the pressurized impeller outlet. The impeller is connected to the combustion air motor.

The pressurized air is channeled across the top of the burner, where Secondary Air Valves are used to allow some air to flow to the secondary air box. Secondary air is used to provide air for the pilot and to envelope the flame and prevent a turbulent interaction with the tube. Small burners only have one secondary air valve while larger units have two valves. Also, the valves may be modulated automatically, to improve turndown and low NOx performance.

As the pressurized air flows across the top of the burner, it is channeled down along the right side, and is forced through the gas/air mixing valve, where the fuel is mixed with air. The gas fuel is delivered from the gas train, and the flow is regulated by the butterfly control valve to match the air flow. Form the mixing valve, the fuel-air mixture is channeled into the manifold, which is simply a box that feed the nozzles. The vessel side of the manifold has numerous pipe tapings used to connect to the nozzles, and provide a gas/air mix to the nozzles, and is fired into the combustion zone.

The nozzle contains several design features that provides a solid compact flame (to remain inside the tube), a flame retention zone that provide a stable flame front and a mechanism to prevent flashback with low firing rates. The small diameter flame is obvious during operation, and can be observed in the multiple flame viewing ports. Less obvious, but also observed, is the light blue “ball” around the flame base, which is used to maintain the flame stability. The nozzle with the flame rod may either be a special design or there may be an additional orifice in the pipe feeding this nozzle. This nozzle is different because the interaction of the flame rod causes added turbulence that can result in flame-outs at high rates, which would not occur without the flame rod.

The secondary air that is allowed to pass through the secondary air valves will flow through holes in the burner face (near the manifold), and into the secondary air box. The secondary air also flows across the back of the manifold and through a series of holes in the bottom of the burner into the secondary air box. The secondary air box has a number of holes which controls the air flow to provide uniform air flow to the pilot and nozzles. The amount of secondary air can vary a lot, depending on how the combustion is going to be set up. A small amount of secondary air offers the best NOx performance, but a large amount offers the best capacity. There are limits of secondary air, and too little or too much can cause combustion problems, and these rates can be different at different firing rates.

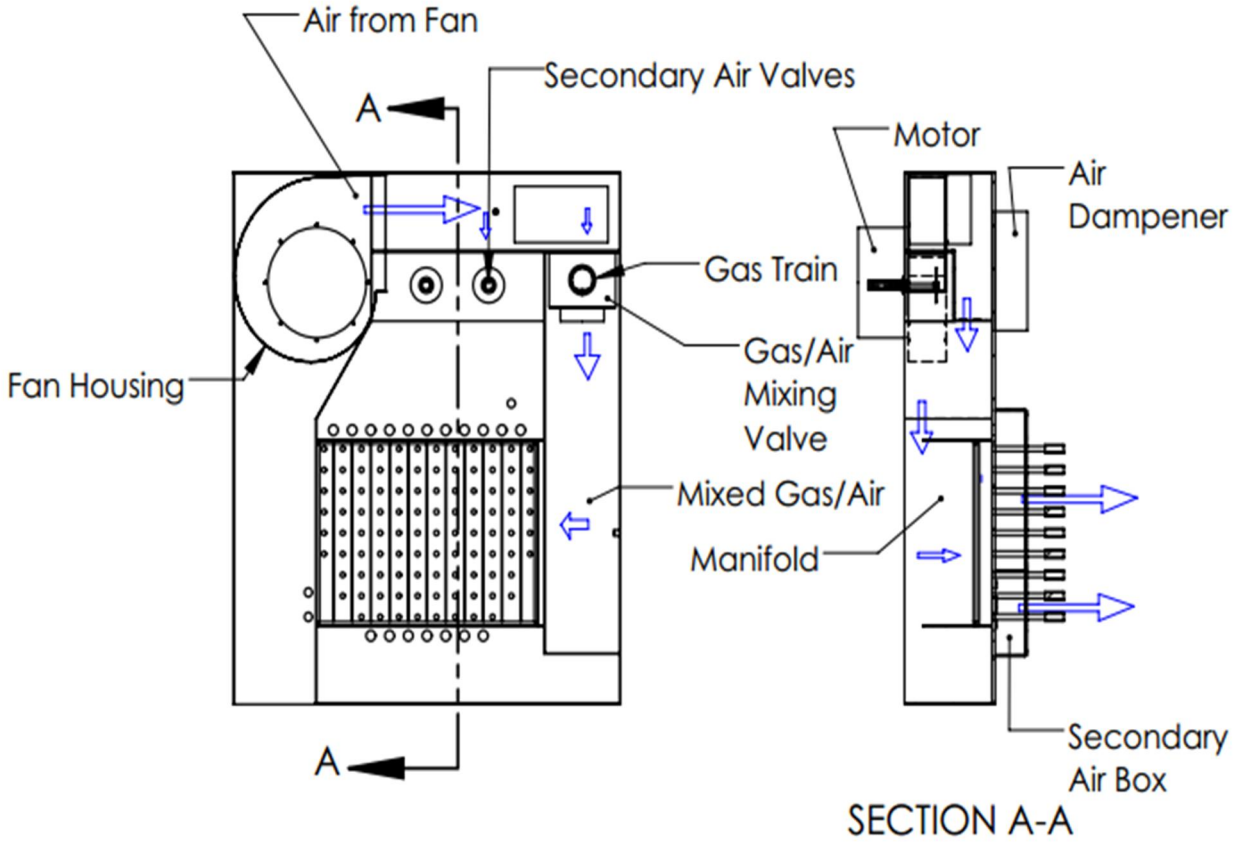


Figure 2-6 Typical Air Movement

3. INSTALLATION

This section covers some of the issues involved in the installation of the boiler. These should not be considered as the only issues or as a detail review of these issues. Also, there will be several vendor items not manufactured by Sellers which need to be installed, and the installer must use those vendor manuals for that purpose. Finally, there is a great variety of options on any given boiler that make it difficult to cover in a single manual, so be sure to look at all of the vendor information in addition to this manual.

Before proceeding with installation. Locate the *Mandatory Pre-Startup Check List*¸ found in the front of this manual. Once preparation is complete and Check List is filled out, it must be returned to Sellers prior to starting your boiler.

Prior to starting, all technical literature should be assembled and reviewed. As a minimum, for a hot water boiler installation, this should include the boiler, flame safety controls, feedwater system (piping and controls), blowdown equipment and any other additional equipment that may be used like draft controls, combustion trim systems, building management controls, and hot water or steam piping. All of these systems must work together for the system to work properly and efficiently, and that includes both the piping and control systems.

This equipment shall be installed in accordance with the state and local requirements, and the ASME and National Electric Code (NEC) as well as any insurance codes and requested regulations.

Note to Installer: The main power disconnect for this equipment shall be conspicuously labeled and placed within sight of the operating system and equipped with lockout provisions.

3.1. General Considerations

The installer should contact the local gas utility relative to available supply pressures, limitations on allowable pressures in the building, general piping requirements and applicable codes, restrictions and regulations.

Most states require that the boiler be inspected and/or registered with the state. In some cases, there may be environmental requirements for inspection and/or listing as well.

If the boiler is located in a dirty environment, consideration should be given to TEFC motors. If the type dirt or dust can plug small orifice holes (approximately 3/32" diameter), then the combustion air should be filtered. Additional maintenance will also be required for the fan and air passageways if this is a dirty environment.

If the boiler is to be located outside, special consideration must be given to the temperature extremes, humidity and protection from rain, ice, snow and wind. These conditions must be identified at the time of the order so that all of the controls are designed for that environment, including the temperatures. If the temperature can fall below freezing, the vessel, feedwater, blowdown, water columns and other entities with water must be protected from freezing. In addition, special controls may be required because of these temperatures. If there are large temperature swings, the fuel-air-ratio may get too far out of range, and result in combustion noise or rumbling without additional controls. Contact the factory if these conditions exist.

The boiler room floor should be designed to support the full weight of the boiler and water, as shown in Table 3.1 plus any connected components. A raised concrete pad or piers should be provided for the boiler base. The base dimensions are also provided in Table 3.1. Make certain the base assembly is level. If the boiler is to be mounted on a mechanical structure, the structure must be rigid enough to prevent vibrations from causing problems within the building. The combination of rotating equipment and the inherent vibrations in combustion can cause harmonic issues with structural members.

There should be an engineering review of the installation to ensure that there is sufficient space to support each of the following;

- There should be space to walk around the unit to get access to and maintain the components on the boiler.
- The burner is hinged and can swing open, but there must be sufficient clearance to allow this to occur. See chart 3.1 for front door swing clearance
- The rear relief door can open on a combustion puff, and there should be sufficient space for this to occur without hitting anything
- There should be space to replace tubes at some point in the future. This can be done from the front or the

back of the boiler, and the space required for this is listed. This can be accomplished with an overhead door or other approach that would yield this clearance

Boiler HP	Door clearance		Tube Removal		Base frame dim			Flooded water gallons	Shipping weight		Flooded weight	
	Front door swing	Rear relief door swing	From front door	From rear door	Width	Length	Distance to hinge		10 PSI	150 PSI	100 PDI	150 PSI
40	39	22	73	71	24	60	20	139	2,680	2,680	3,841	3,841
50	39	22	73	71	24	60	20	224	3,260	3,260	5,132	5,132
60	40	22	73	71	24	60	20	219	3,360	3,360	5,186	5,186
70	46	26	73	71	24	60	20	213	3,450	3,450	5,229	5,229
80	46	26	73	71	30	60	20	319	4,250	4,330	6,909	6,989
100	53	30	66	72	30	60	26	307	4,470	4,470	7,035	7,035
125	53	30	66	72	36	60	26	424	5,590	5,860	9,129	9,399
150	62	36	66	72	36	60	26	411	5,820	6,090	9,247	9,517
175	62	36	66	72	36	60	26	397	6,050	6,320	9,364	9,634
200	67	40	66	72	42	60	26	534	7,450	7,580	11,906	12,036
250	67	40	88	90	42	104	3	654	9,520	9,520	14,980	14,980
300	74	43	88	90	48	104	3	839	11,520	12,110	18,520	19,110
350	88	43	88	90	48	104	3	806	12,060	12,490	18,788	19,218
400	90	46	88	90	54	104	3	1015	12,840	13,780	21,311	22,251
500	96	50	88	90	57	104	3	1218	15,080	15,600	25,242	25,762
600	101	48	88	90	63	104	3	1446	17,390	18,520	29,457	30,587
700	106	50	88	90	66	104	3	1698	19,920	21,310	34,088	35,478
800	114	52	88	90	72	104	3	1981	23,330	24,190	39,865	40,725

Table 3-1 Dimensions and Weights

3.1.1. Receiving the Boiler

The equipment should be inspected prior to installation for missing parts and damage, which may be physical, moisture related or rust. All damage and missing parts should be addressed prior to installation. Check the parts list against the bill of lading to make sure all parts have been received. If this is a busy construction area, make sure to identify the parts that belong to the boiler so they can be retrieved later.

If the boiler has been stored outside for any period of time, the inspection should include the inside of cabinets and some electrical components to make sure they did not receive water damage. The boiler warrantee does not cover water damage.

It is the responsibility of the receiving party to properly inspect the unit for damage at the time it is received, and to file appropriate claims with the shipping company to recover damages.

3.1.2. Positioning the Boiler

Prior to starting the installation, a general overview of the equipment should be made. Check the location of access doors and insure that they can function properly when all equipment is installed. The burner and control panel should have sufficient clearance for the operator to monitor, inspect and perform maintenance.

Locate the boiler with due regard to local code regulations and insurance requirements. Local codes and specifications will apply to such conditions as foundation design and proximity to flammable materials. Adequate

clearance must be provided for normal service operations.

Provide sufficient unobstructed space at the firing end and the exhaust end of the boiler to fully open the hinged main burner assembly and the back plate (if hinged). This will allow convenient access to all internal areas for normal inspection and service operations. The minimum clearance necessary for opening the hinged boiler assemblies is listed Table 3.1.

Provide room at either the firing end or the exhaust end of the boiler for possible future tube replacement. The minimum clearance necessary for easy removal and re-installation of firing tubes is listed in Table 3.1. This can be supported with an overhead door that can be opened to provide the required length.

Verify that the boiler is sitting level. If the boiler is not level, add spacers to make it set level. This is critical to provide uniform water covering over the full length of each tube.

When unloading the boiler, use the lifting eyes provided. DO NOT USE a sling or forklift under the shell or attach cables to the legs or base rails. This could damage the boiler. See the loading Figure.

If the boiler is to be winched into position, use trucks under the boiler legs, and winch by connecting to the boiler legs. Do not place loads on the center or ends of the base rails.

The rear of the boiler has a combustion relief door that is used to unload pressure that can be caused by heavy combustion, including a hard light-off or gas side explosion. In the rare case that this may happen, that area of the boiler should remain free of personnel or working areas.

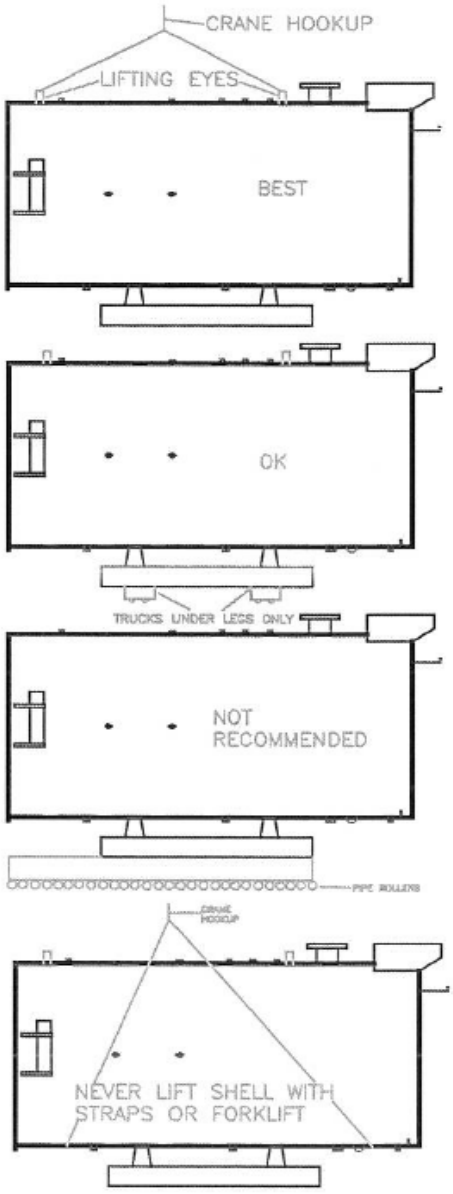


Figure 3-1 Handling Options

DANGER

THE COMBUSTION RELIEF DOOR MAY OPEN AND RELEASE HOT GASES. INDIVIDUALS SHOULD NOT BE IN THIS AREA, AS IT CAN RESULT IN PERSONAL INJURY OR DEATH.

3.1.3. Installation of Ship Loose Items

The pressure gauge is the only component normally shipped loose. It is stored in the control panel during shipment.

3.1.4. Combustion Air Requirements: The Forgotten Element in Boiler Rooms

The building must have a means of providing combustion air for the boiler. The total air need for the combination of the combustion process plus venting needs (like a barometric damper) and ventilation can be large. If sufficient air

is not available without restriction, the burner will not operate correctly, and could cause other issues.

Many states have regulations that determine the requirements for the combustion air supply openings, and these regulations must be followed. There are other sources of information on combustion air openings, including the ABMA (American Boiler Manufacturers Association) and NFPA-54. If there are no requirements for combustion air, the following is recommended by Sellers.

⚠WARNING

THE BUILDING DESIGN MUST PROVIDE SUFFICIENT AIR FOR COMBUSTION AND OTHER USERS WITHOUT RESTRICTION. FAILURE TO PROVIDE SUFFICIENT AIR CAN RESULT IN HIGH FUEL COST, EXCESSIVE EMISSIONS, EQUIPMENT DAMAGE, EXPLOSION, PERSONAL INJURY OR DEATH.

Sellers recommends a total minimum air supply opening of approximately 250 square inches per 1,000,000 BTU/hr of input. This minimum cross sectional area can increase with barometric dampers, forced ventilation systems or other users. Air can be provided through louvered panels in window or door openings or through specially prepared openings in the walls of the room. Remember that the open area for air flow is reduced with louvers, and the size must be increased to allow for this. It is also recommended that multiple opening be provided, with some located higher and some lower to improve ventilation. The effect of exhaust fans in the general area must be considered as they can greatly increase the opening requirements. A further explanation of this can be found in an article written by The National Board, entitled “Combustion Air Requirements: The Forgotten Element in Boiler Rooms.”

3.2. Hot Water Boiler Connections

All piping to the boiler must comply with all state and local code requirements in addition to the ASME code. The boiler openings are labeled at the factory. The specification sheet and job specific General Arrangement drawings also lists the openings on the boiler. Proper piping support must be used. Do not use the boiler to support the piping.

In a hot water system, chemical cleaning may be required to remove grease and contaminates from the system. The entire system should be drained after treatment. Consult your water treatment person for details.

The requirements for the piping may include components to isolate the boiler from the system as well as components to control the flow and temperature of the supply and return water. Consideration should be given to add valves to allow the pressure vessel to be isolated from the system, so that inspection and component replacements can be done without draining the complete heating system.

3.2.1. Pressure Vessel

The water side of the pressure vessel must be kept clean from grease, sludge and foreign materials. These deposits will shorten the life of the vessel and prevent the efficient operation of the unit. These deposits can also prevent the controls and safety devices from operating properly.

The installation and operating conditions of the boiler should be considered in the installation process, and as a minimum, the pressure vessel should be cleaned as part of the installation.

In a normal hot water system, the pressure vessel and piping represent a closed loop system. The cleaning process must also consider the hot water piping and system, which may also be contaminated or has new piping and/or components that have grease, sludge or foreign materials. Once the system has been properly cleaned, no further action should be required, unless there is a leak in the system and fresh water is added. It is recommended that a water meter be added to the make-up water supply to detect leaks, as this will indicate the amount of leakage.

WARNING

FEEDWATER MANAGEMENT IS CRITICAL TO THE OPERATING LIFE OF THE BOILER. FAILURE TO PROVIDE CLEAN WATER FREE OF CORROSIVE ELEMENTS WILL RESULT IN PREMATURE FAILURE OF THE BOILER

The fresh water added to the vessel should include some water treatment to prevent the accumulation of sludge

and deposits as well as oxygen or CO. Contact your water treatment specialist for a program that is correct for your operation.

3.2.2. Relief Valve Piping

Relief valves are installed to prevent the operation of the boiler above its maximum allowable working pressure. They are sized to relieve all of the pressure that can be generated at the set pressure of the valve and the energy output of the boiler. For this reason, there can be a wide variety of valves and sizes used to reach this specific capacity.

A discharge pipe shall be used to direct the expensed liquid to a safe location to prevent injury. The cross-sectional area of the discharge pipe shall not be less than the full area of the relief valve outlet or the total of the valve outlets discharged into the pipe. The pipe run shall be as short and straight as possible to and arranged to avoid any stress on the valve. The discharge piping must be independently supported to prevent adding stress to the valve outlet.

It is good practice to manually open the valve on regular intervals. This is done by lifting and releasing the handle on the valve.

3.2.3. Water Level and Controls Piping

The boiler is equipped with a low water cutoff (LWCO). The standard primary LWCO is a float control, but an electronic control installed in the pressure vessel (through a top centerline fitting) may be used as an option. It has a switch that will shut down the boiler if the water drops below a certain level. The switch has a manual reset that must be pressed to allow the boiler to operate once the water level is corrected.

All float controls shall have a blowdown connection tied into the blowdown system. The blowdown piping must be connected to a safe discharge blowdown system.

A sensor is used to monitor the operating temperature of the water and provide the modulating and On-Off firing controls. The sensor in located in a fitting in the top of the vessel

3.3. Gas Piping

The boiler includes a gas train that is designed to control the flow of gas to the burner, based on the gas pressure supplied to the boiler (determined at the time of the sales order), the volume of gas needed to make the rating of the boiler and to provide safety controls as designated by UL and other regulations that may apply to this order. It is critical that the supply pressure provided to Sellers at the time of the sale matches the actual pressure at the job site.

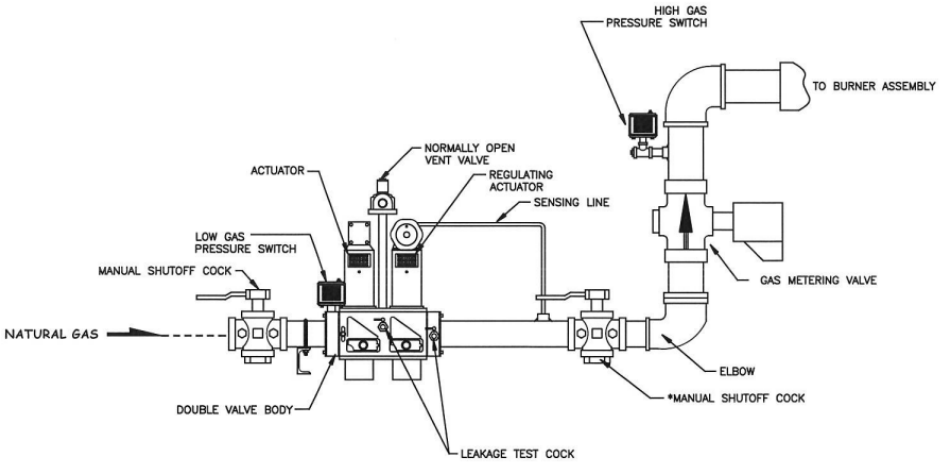


Figure 3-2 Gas Piping

As part of the gas supply to the boiler, a drip leg and main shutoff valve are required upstream of the boiler. Also, a union is required to allow the front door to be opened. The gas train provided by Sellers will include a connection to the pilot train, one or two safety shutoff valves, a gas pressure regulator, a downstream manual valve and a control valve with driver (servo). Optionally, gas pressure switches, proof of closure switches on the safety valves and vent valves may be included.

The pilot train includes a shutoff valve, pressure regulator and one or two safety shutoff valves, and then ties into the pilot header.

The specific makeup of any specific gas train will vary depending on the supply pressure, burner size, insurance

regulations that will apply, turndown, size (pipe diameter) and any request for specific controls. There are standard gas trains for common supply pressures, and they are listed below.

The gas supply pressure at the job site must match the pressures stated on the order... That means that the stated supply pressure (the gas pressure provided to Sellers at the time of the order) must be available at the entrance to the burner gas train when the boiler is off, operating at full capacity, and when other users may also be on line. In addition, the design of the gas supply to the boiler must include means to prevent the gas pressure from exceeding the pressure ratings of the boiler gas train.

There may be two different gas pressures, a static pressure which is the highest pressure in the line when there is no flow and the dynamic pressure which is the pressure available at the inlet to the boiler gas train when firing at full rate. These two pressures are normally very close to each other (within 5%), and if only one pressure is given, Sellers will design the train to operate at a value that is 5% below the listed pressure, and with a maximum pressure rating that matches or is higher than the stated pressure.

If the dynamic pressure is lower than the 5% drop allowed by Sellers, this must be identified and communicated to Sellers at the time of the sale. For example, if the building pressure regulator is a long distance from the boiler, the pressure drop in the line must be determined and stated in the order so that Sellers can design for the lower pressure that will be delivered to the boiler. Also, if other controls (flow meters, filters…) or other users that may also reduce the available gas pressure, that must be determined and communicated to Sellers at the time of the sale. If there is a large variation between the static and dynamic pressure, an additional regulator may be required to provide a more stable constant pressure.

⚠CAUTION

IF THE ACTUAL SUPPLY PRESSURE AT THE JOB SITE IS LESS THAN THE PRESSURE STATED ON THE ORDER, THE UNIT MAY NOT MAKE CAPACITY. THE GAS TRAIN IS DESIGNED TO PASS THE VOLUME OF GAS FOR CAPACITY WITH THE PRESSURE STATED. LOWER GAS PRESSURES WILL RESULT IN LOWER RATES.

There needs to be some safety consideration for the potential over-pressure to the boiler gas train. In other words, is there protection from a regulator failure that would cause high pressure gas to be feed into the boiler gas train, and exceed the rating of the gas train? This is generally done with dual regulators and/or safety release valves.

⚠DANGER

THE GAS SUPPLY PRESSURE CANNOT BE ALLOWED TO EXCEED THE RATINGS OF THE BURNER GAS TRAIN COMPONENTS. FAILURE TO PROVIDE PRESSURE PROTECTION COULD CAUSE EQUIPMENT DAMAGE, PERSONAL INJURY OR DEATH.

The gas piping to the boiler must comply with all applicable code requirements and may also need to meet local gas supplier requirements as well as insurance regulations. In addition, there should be a cleanout leg on all gas lines at the point of connection to the boiler.

⚠WARNING

IF THE PIPING IS NOT PROPERLY CLEANED, DEBRE CAN BECOME LODGED IN THE PRESSURE REDUCING VALVE AND PREVENT THE VALVE FROM WORKING. THIS CAN RESULT IN HIGH GAS PRESSURES WHICH COULD RESULT IN EXCESS GAS FLOW AND EXPLOSION, RESULTING IN DAMAGE, INJURY OR DEATH.

Make certain the main gas supply line is clean before connecting to the boiler. Loose materials in the gas lines such as scale, welding slag, or metal chips are almost certain to cause faulty operation of gas pressure regulators and control valves. These items must be removed and the piping cleaned prior to placing the boiler into service.

Teflon tape or compounds with Teflon content as a pipe sealant are not recommended. Component warrantees may be voided if Teflon is used.

WARNING

TEFLON TAPE OR COMPOUNDS CONTAINING TEFLON FOR PIPING SEALANT ARE NOT RECOMMENDED.

The burner gas supply lines should be located to allow full opening the main burner assembly for normal inspection and maintenance. Provide a union in both the main burner and pilot burner gas supply lines. Locate these unions so the gas lines can be readily disconnected when it is necessary to open the main burner assembly.

When pressure testing the gas lines, the gas trains on the boiler must be isolated. The gas cocks must be closed. If any question exists as to the rating of the gas cocks relative to the required test pressure, the lines should be disconnected and blocked off to avoid damage to gas train components.

Both the main burner gas pressure regulator and the pilot burner gas pressure regulator are supplied with the boiler. These regulators have been furnished to operate with specific gas type and inlet pressure that was defined at the time of the order. These regulators have been adjusted to provide the approximate outlet pressure when the boiler is in normal operation.

WARNING

IF THE GAS SUPPLIED IS OF A DIFFERENT TYPE OR IF THE GAS SUPPLY PRESSURE DOES NOT MATCH THAT LISTED ON THE NAMEPLATE, IT MAY CAUSE EQUIPMENT DAMAGE, PERSONAL INJURY OR DEATH.

It is important that vent lines be connected to all valves that require a vent. Typically, this may include the main and pilot regulator, the high and low gas pressure switches (if equipped) and the vent valve (if equipped). Some of these valves may not require venting. The venting requirements can be determined from the component details or from the gas train drawing for this boiler. Vent lines must be vented to the outside of the building. Vent lines should be of adequate size. The normally open vent valve must be vented with full size piping and must be vented separate from any other control containing a diaphragm. Unions must be supplied in appropriate locations in the vent lines to allow disconnection for opening the burner door. Where local governing agencies or gas companies have established regulations with regard to the venting of gas pressure regulators, their requirements should be followed. The termination points of the vent(s) should be turned down to prevent water from entering and should be protected against the entry of insects.

It should be noted that propane is generally not vented because it is heavier than air and would collect in pockets from the vent lines, creating a potential hazard.

Gas piping should be tested for leaks using soap bubbles. Shipping and handling can cause small leaks. These must be tightened prior to boiler operation.

3.4. Electrical Connection

All electrical wiring must comply with all applicable code requirements, including the National Electric Code, Insurance regulations and all local codes. Refer to the wiring diagram for this boiler for all wiring connections.

Connect the electric power supply lines to the marked wires or terminals in the junction box that is rigidly mounted on the boiler shell at the hinge. A fused line switch (safety switch) should be provided in the power supply line. This switch is not furnished with the boiler. The wire size must be adequate for the full electrical load on the boiler and the boiler must be well grounded. Any connections made to the single-phase boiler control circuit must also be made at the hinge location, and allow the door to be fully opened for inspection, maintenance and adjustments.

CAUTION

ANY CONNECTIONS MADE TO THE BURNER, ELECTRICALLY OR MECHANICALLY, SHOULD NOT PREVENT THE BURNER FROM OPENING. THE BURNER MUST BE OPENED PERIODICALLY FOR INSPECTION AND MAINTENANCE.

The main power disconnect for this equipment must be conspicuously labeled and placed within sight of the operating system and equipped with lockout provisions.

The control circuit on all Immersion Fired Boilers is arranged for operation with 120 volts, 60 cycles, single phase power supply. The blower motor may be either single phase or 3 phase with voltage as specified by the purchaser. When the blower motor circuit is other than 120 volts, single phase or when it is a 3-phase circuit, a control circuit transformer of suitable electrical characteristics to provide a 120 volt, 60 cycle, single phase power supply for the control circuit is furnished with the boiler.

The pump control contacts on the pump control/primary low water cutoff must be connected to the boiler feed system if on/off control of the boiler feed pump is to be accomplished using this control. Any alternative arrangement could require different electrical arrangements. Check the job specific engineering documents for required details.

3.5. Flue Connection

Stacks and breechings must be designed to maintain a constant draft at the boiler outlet without a large variation. The draft should be maintained at +/- 0.1" (from -0.1" to + 0.1" stack pressure measured at the outlet of the boiler). More critical than the actual pressure is the amount that it could vary at any given firing rate, which will upset the combustion fuel-air-ratio, and must be no more than +/- .05" or half of the total allowed draft variation. Larger variations in draft may result in combustion noise or rumbling. It is recommended that the stack design be performed by a qualified engineering firm or manufacturer that has experience in this equipment.

The stack should be designed to avoid wind influences from adjacent structures as well as preventing the flue products from entering inlet ducts, windows or other occupied areas. It should be of sufficient height to extend above the roof of the building or adjoining buildings to avoid down drafts in the stack or the possibility of carrying combustion gases to an undesirable location. Local codes should be checked for criteria on heights and other design codes.

The breeching should be designed to be as straight and short as practical. Smooth bends, gradual transitions, low velocities and tight construction are all important. Round breeching is preferred to square or rectangular ducts because they are more efficient and less likely to generate noise on the flat surfaces due to resonance. The size should be based on the total flow through the breeching, with diameter changes when adding additional boilers, using smooth transitions. Also, review the information in "Firetube Boiler Engineering Manual" published by the ABMA and NFPA 4.7.8.

Normally, a boiler fitted with a single stack of the correct diameter and is less than 30 feet tall will not have any major draft issues. On the other hand, tall stacks, complicated breeching, adjacent tall structures and multiple boilers connected to single stack can have serious draft problems and must be designed to deal with those issues to prevent the draft from exceeding the +/- 0.1" limit and to prevent turbulence that will feed back into the combustion and result in combustion noise or rumbling. The most common and effective draft controls are barometric dampers. If another type of draft control system is used, it should include a feed forward control tied to the modulation system to prevent over and under shoot, especially at low loads. Any draft control system should allow other boilers to modulate and start-stop without causing an upset in the draft at other boilers. Upsets in draft can result in "Combustion Noise" or rumble, which often will not stop until that boiler is taken off line.

All flue piping to the boiler must comply with all local code requirements. Install the flue piping full size from the flue outlet on the boiler to the building stack or to a separate stack. Horizontal runs of the flue piping should be avoided and when necessary should be as short and direct as possible and pitched upward approximately 1 inch per foot. The connection to the boiler must allow smooth exit of the gases from the boiler. Connection of the boiler exit to horizontal breechings must be accomplished using smooth angled wye connections or elbows. Tee connections will cause venting problems and must not be used. Many different brands of boiler stack are available on the market. These are often superior to the single wall, sheet metal stacks described above because of the ease of installation and double wall construction. If this material is used it should be properly sized and the manufacturer's instructions should be followed. Flue piping is not furnished with the boiler.

CAUTION

STACK DESIGNS AND DRAFT CONTOLS THAT DO NOT PROVIDE CONSISTENT DRAFT REGULATION WITHIN THE REQUIRED DRAFT RANGE OF -0.1" TO + 0.1" AND +0.05" TO -0.05" AT ANY RATE MAY CAUSE COMBUSTION NOISE AND WILL NOT BE ACCEPTABLE. SELLERS WILL NOT BE RESPONSIBLE FOR CORRECTING THESE ISSUES.

The flue gas stacks and breeching are part of the combustion system, and upsets in the flow of the flue gas can and usually do result in "Combustion Noise" in the system. To prevent this noise, always provide a smooth transition of the flue gas. Common considerations include;

- The connection of the breeching to the stack or other breeching should never use a 90-degree connection or a "T", but rather use a 45-degree sweep angle.
- When multiple boilers are connected together, increase the breeching diameter with each additional boiler, providing a 10-degree angle to connecting diameters.
- Do not align multiple breeching connections to the stack in line with each other, as they will tend to influence each other. Make the connections above or below other stack connections to prevent feedback.
- Do not use large flat surfaces, as they tend to resonate (from the inherent combustion pulsations)
- If the stack is connected directly to the vessel – don't allow rain or condensate to run back down into boiler as will cause corrosion in the vessel
- If barometric damper(s) are used, there cannot be a positive pressure in the stack or the flue gases will flow out of the stack and into the boiler room
- The connections to the stack and breeching must be tight. In addition to the stack and breeching, the relief door should be checked for a tight seal. If the gasket is damaged or is missing in some areas, it should be replaced. Air leaks in the boiler area can result in the burner being adjusted to a rich condition that can result in high CO and unburned gas when the air temperature is warmer.

Additional Stack information can be found in Appendix A

WARNING

FAILURE TO PROVIDE CONSISTENT STACK PRESSURES CAN RESULT IN GAS SIDE EXPLOSIONS CAUSING DAMAGE, INJURY OR DEATH. THE SYSTEM DESIGN MUST PROVIDE A CONSISTENT STACK PRESSURE AT ALL TIMES, INCLUDING STARTUP, SHUTDOWN AND CYCLING OF DIFFERENT BOILERS IN A MULTI BOILER SYSTEM.

WARNING

THE STACK DESIGN MUST PROVIDE SMOOTH FLUE GAS FLOW TRANSITIONS TO PREVENT UPSETTING THE COMBUSTION PROCESS AND CAUSE COMBUSTION NOISE. FAILURE TO PROVIDE SMOOTH FLOW TRANSITIONS CAN RESULT IN EQUIPMENT DAMAGE OR INJURY.

3.6. Condensate Connection

The condensate outlet on the boiler, located on the back of the shell of the boiler behind the rear tube sheet, should be piped to a drain. Do not install a shutoff valve in any of these lines. Condensate will occur on initial startup, when the cold boiler will cause some flue gases to condense, a condition that occurs on all cold boiler startups. It may also provide a drain to rain and condensate it that occurs in the stack and is allowed to flow into the vessel. If this water is not removed, it will cause serious corrosion in the vessel.

4. Waterside Care and Requirements

4.1. General

Waterside care is critical to the safety and longevity of the boiler. While this chapter will cover some of the important basics of water care and treatment, this is a complex subject and the owner should contact water treatment specialists to insure this is being handled properly. There are several key issues that need to be addressed, including the initial cleanout, water treatment (mechanical and chemical), testing and inspection to monitor effectiveness and frequent blowdown to remove accumulated sludge and impurities.

Special care must be taken when placing the boiler into initial service. The waterside of a new boiler and new or modified steam or hot water systems may contain oil, grease or other foreign matter and require a bailout to remove these impurities.

4.2. Water Requirements – Hot Water Boilers

CAUTION
THIS MANUAL ONLY COVER BOILER USING WATER. GLYCOL SOLUTIONS OR OTHER MEDIA WILL HAVE DIFFERENT TEMPERATURE LIMITS AND CIRCULATION RATES.

Air can be trapped in the vessel, and should be removed. There is an air vent tapping on the top centerline of the boiler that can be connected to the expansion tank for this purpose.

The minimum recommended boiler water temperature is 135 °F. Lower operating temperatures can result in start to condense, causing corrosion in the vessel. Condensation will be worse in a unit that cycles on and off, and may need a higher temperature to prevent condensation. If lower temperatures are required for the system, mixing valves should be used.

The system must be operated in a manner to provide continuous water flow through the boiler whenever the burner is operating. Loss of circulation while the burner is operating can cause stratification (and uneven water temperatures), localized steaming and overheating of some components. The circulation rate is a function of the boiler size and operating temperature differential. The larger the temperature differential, the small the circulation rate, as shown in the following chart.

BHP	Water Temperature Differential °F									
	10	20	30	40	50	60	70	80	90	100
	Maximum circulating rate - Gallons/min									
40	268	134	89	67	54	45	38	33	30	27
50	335	167	112	84	67	56	48	42	37	33
60	402	201	134	100	80	67	57	50	45	40
70	469	234	156	117	94	78	67	59	52	47
80	536	268	179	134	107	89	77	67	60	54
100	670	335	223	167	134	112	96	84	74	67
125	837	419	279	209	167	140	120	105	93	84
150	1005	502	335	251	201	167	144	126	112	100
200	1340	670	447	335	268	223	191	167	149	134
250	1674	837	558	419	335	279	239	209	186	167
300	2009	1005	670	502	402	335	287	251	223	201
350	2344	1172	781	586	469	391	335	293	260	234
400	2679	1340	893	670	536	447	383	335	298	268
500	3349	1674	1116	837	670	558	478	419	372	335
600	4019	2009	1340	1005	804	670	574	502	447	402
700	4688	2344	1563	1172	938	781	670	586	521	469
800	5358	2679	1786	1340	1072	893	765	670	595	536

Table 4-1 Circulation Rate (GPM) For Temperature Differences

Multiple boiler installations require careful planning to place an equal load on each boiler and to provide the correct circulation rate for each boiler. This is often done with balancing valves and gauges in the supply to each boiler. A reasonably large pressure drop is required across these balancing valves to achieve uniform flow distribution. If there is not uniform flow through each boiler, a situation can occur where one boiler is at full rate, and the other boiler(s) are at low fire, and there is not sufficient heat to satisfy the load.

The system operating pressure is determined by the boiler operating temperature. To prevent steaming from occurring, the operating pressure must be higher than the saturated steam pressure, as shown in the following chart. Special care must be used in placing a boiler into an operating system, to match the pressures before connecting to the system.

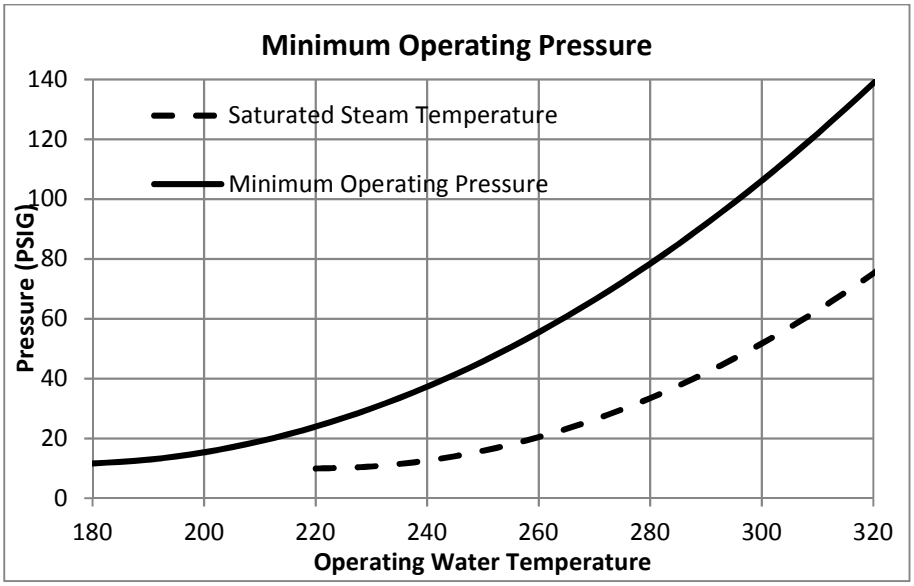


Figure 4-1 Minimum Operating Pressure

Hot water circulating pumps are normally started and stopped by manual switches. It is recommended that an interlock switch be added to ensure that the pumps are operating before a boiler is allowed to run.

4.3. Thermal Shock

Hot water boilers can easily incur rapid changes in water temperature due to system operation from circulating pumps, system On-Off timing and cold start-ups. Normally these are detrimental to a Firetube boiler because it results in uneven expansions of the furnace, tubes and shell. The uneven expansions will cause tube attachment and tube sheet failures over time. The Seller Firetube boiler does not have a separate furnace or multiple passes that have uneven expansion rates. All Sellers Immersion Firetube boilers have a single pass design that provide uniform expansion in each tube, and no resulting thermal shock. There are no special operating or warmup requirements for the Sellers Immersion Firetube boiler. The unit can be started and immediately driven to high fire (Sellers has been doing this for over 50 years).

4.4. Cleaning

Hot water piping systems connected to the boiler may contain oil, grease or foreign matter that is harmful to the boiler. These contaminates must be cleaned to prevent damage to the vessel and control valves.

The pressure vessel must be kept clean from oil, grease, sludge and foreign material. These impurities can prevent the boiler from operating properly, and cause water carryover, poor efficiency and overheating of the vessel components in severe cases. If these impurities are present, the boiler internal may need to be cleaned. Cleaning is also recommended in the initial installation and startup process. In some cases, impurities from the system or

condensate can carry into the vessel, even if the vessel was properly cleaned.

A “Boil-out” of the vessel interior is recommended on a new boiler startup to remove oil, grease and other impurities that could be part of the construction and installation process. This does require that the boiler be operated at low rates to warm up the vessel for the correct cleaning action, and the operator must be prepared for this, and fully versed in the startup of the unit contained in the future chapters. There are several different methods and chemicals that can be used for the boil-out process, and the detailed instructions for the chemicals used should be followed. Some general guidelines would include;

- Refer to the table for the flooded water capacities, which should be used to determine the quantity of chemicals needed.
- Be careful in adding chemicals to the vessel. Often, they are done in smaller containers first to make them easier to handle
- The relief valves should be removed from the boiler to protect them from the chemicals
- An overflow pipe should be attached to one of the boiler outlets, and routed to safe point of discharge Often the safety valve or relief valve connection is used.
- All valves leading to or from the vessel should be closed to protect the system form the chemicals
- The boiler should be fired intermittently to warm it up, allowing a more uniform temperature
- Remove the handhole plates and wash the waterside of the vessel until the drain water appears clean
- Disposal of the boil-out water must be considered, as it may not be allowed into the septic system. As a minimum, it may be too hot to put down the drain. Check local requirements in advance of the boilout.
- After completing the process, fill the boiler with fresh water, and fire the boiler to at least 180 ^{o}F to drive off any gases from the fresh fill water.
- Dump the condensate until it can be verified to be clean. Pay special attention to the fresh makeup water treatment during this time, because you will be using large quantity of makeup, even more than the system was designed to handle.

⚠WARNING

ONLY PROPERLY TRAINED AND EXPERIENCED SERVICE TECHICIANS SHOULD PERFORM THESE OPERATIONS. FAILURE TO PROPERLY HANDLE THE CHEMICALS OR PROPERLY START THE BURNER CAN CAUSE SERIOUS INJURY OR DEATH.

4.5. Periodic Inspections

Insurance regulations and local laws will require periodic inspections of the pressure vessel by an authorized inspector. Normally, each state has jurisdiction over boilers, and have different requirements. Depending on the type of inspection, the vessel may need to be opened for inspection, with the water drained out and the hand hole and manway covers removed. They may also require the front and rear doors to be opened and water columns opened. The authorized inspectors will be checking the pressure vessel to ensure that it is safe to operate, and no damage has occurred.

This is a good time to inspect the water columns for free and smooth operation and replace any parts showing wear or distortion. The bowl should be checked for any solids buildup, and cleaned if required. Also check the column piping to be sure it is clean, removing the pipe plugs and pushing a rod through the piping to make sure they are clear. Proper water level maintenance is one of the most critical safety issues with a boiler, and these controls are the only means of providing that safety.

The fireside of the vessel should also be cleaned if needed. Dirt and soot accumulation can result in higher stack temperatures which will reduce the boiler efficiency. This is also a good time to inspect the vessel metal, joints, weldments, tubes and other components.

Prior to performing an inspection, new gaskets for the hand holes, manway, front and rear doors, water columns and other inspection points should be obtained.

4.6. Preparation for Extended Lay-up

Boilers that will be off line for an extended period of time can be put into either dry or wet storage. There is no simple rule for which type is best, but some specific issues may help determine which to use. Special attention should be given to idle boilers so that the fireside or waterside surfaces do not deteriorate from corrosion.

The dry method is best for very long term storage or if there is the potential for freezing. In this method, the water is drained out of the boiler, then the vessel is cleaned and dried. A moisture absorbing material is placed inside the vessel (about 2 to 3 pounds of quick lime per cubic feet of space or 1 pound of silica gel for each 6 cubic feet of space), in trays inside the vessel. Fireside surfaces may be coated with an anticorrosive material. All openings to the vessel, including handholes and manhole must be sealed off. Feedwater and steam connections must be sealed off. Damper and vents should be closed to prevent air form reaching the fireside surfaces. Period inspections should be done to check the condition of the boiler and replace the moisture absorbing material.

For wet storage, the vessel is flooded with water for storage. All of the fireside surfaces should be cleaned, and protective coverings can be used if longer storage periods are expected. The water in the vessel must either be properly treated or heated (to 180 ^{o}F) to remove dissolved gases. Chemicals may also be added to the water to prevent corrosion. The vessel should be pressurized with nitrogen, as an open vessel would attract oxygen and corrosion.

If the unit is being stored in a humid location, the power should be left on to keep the control panel warm to prevent condensation. Also, the control could be removed and stored in a dry location.

Locations with high humidity may require other methods to prevent corrosion.

5. SEQUENCE OF OPERATION

The Flame Safeguard provides the safety sequence of the burner, by checking various interlock switches at critical points in the sequence and by providing a very specific startup and shutdown procedures. There are some adjustments that can be made to this process, depending on the control, but most of this is fixed in the control logic. The flame safeguard can be a standalone control or built into the combustion control system. A user manual for the flame safeguard is included in the information provided by Sellers. The following describes the sequence of operation for the Siemens flame safeguard. Other controls may have slight differences in timing and adjustments.

5.1. Pre-Purge Cycle

At the initial startup of the burner, the unit will go through a Pre-Purge period that lasts about 30 seconds. This cycle uses the fan to blow air through the burner, combustion zone and vessel to clear any combustible gases that may have collected there. In addition to running the fan, the air damper is also opened to increase the air flow rate.

a. The following switches or controls must be closed (contacts made) to complete this cycle:
   - Low water cutoff(s) (sufficient water is in the boiler)
   - Manual on-off switch in “ON” position
   - Low gas pressure switch (if provided)
   - High gas pressure switch (if provided)
   - High limit temperature control
   - Operating temperature control
b. The call for heat light on the control panel is illuminated.
c. Main gas valve proof of closure switch (if provided) must be closed (contacts made.)
d. The blower motor starter is energized from the flame safeguard control and the blower starts.
e. The air flow proving switch must close (contacts made) within 7.5 seconds.
f. Blower runs and purges burner and boiler with air for about 30 seconds.
g. The air damper modulates to high fire (as determined by a switch or position), and depending on the codes, must remain there for a period of time before modulating to low fire.

5.2. Pilot trial for ignition

Once the purge cycle is complete, the burner will go through a cycle to ignite the pilot, and prove that it is lit, which takes about up to 10 seconds.

a. All above switches and controls are still closed (contacts made).
b. The pilot gas valve(s) and the ignition transformer are energized from flame safeguard control.
c. The ignition transformer and electrode produce a spark at the top pilot tube. Pilot gas is partially mixed with air in the pilot assembly and this mixture is ignited starting at the ignition electrode. The flames spread and travel (flash) down and across pilot runners. The pilot flame engulfs the pilot flame proving electrode at the bottom of the pilot assembly on the perpendicular proving leg at the end of the bottom pilot tube.
d. The pilot flame proving electrode proves the presence of a proper pilot, in the proper location, to the flame safeguard control.
e. If the pilot proving electrode (flame rod) does not register a pilot flame within the 10 seconds, the flame safeguard will shut down the burner and indicate a pilot failure.

5.3. Main Flame trial for ignition

Once the pilot has been proven, the control will go through a main flame startup, which will last about 10 to 20 seconds.

a. The pilot has been ignited and proved.
b. Main burner indicator light is illuminated.
c. Main burner gas valve(s) and the normally open vent valve (if furnished) are energized from the flame safeguard control.
d. Gas flows to the proportioning mixer and mixes thoroughly with the combustion air. This mixture exits the main burner nozzles, crossing the pilot flames, and is ignited.

e. If the boiler is 50 horsepower or smaller, the control will allow a delay of 3.2 seconds (adjustable in the control) for the main flame ignition, then look for a signal from the flame rod. If the electrode proves a flame is present, the cycle is complete. If there is no flame signal, the burner will shut down and indicate a “Flame Failure”.
f. If the boiler is 60 horsepower or above, the flame rod switching relay will be energized and after 3.2 second delay (adjustable in the control) the control will look for the main flame rod to prove a flame is present. If the main flame proving electrode proves the presence of the main burner flame to the flame safeguard control through the flame safeguard, the cycle is complete. If the flame rod is not energized by the main flame within the trial period, the flame safeguard will cause a shutdown and indicate a “Flame Failure”.

5.4. Run Period

The flame safeguard control monitors all of the safety controls during the run period and will shut the unit down if any of the safety switches or flame rods indicate a change in position. The combustion control takes over at this point, and drive the fuel and air flows to meet the load conditions, as defined by the operating pressure.

All combustion control systems use operating pressure as an indication of the load demand. If the operating load is greater than the operating output of the boiler, the operating pressure will drop off. Likewise, if the operating load is less than the operating output of the boiler, the operating pressure will increase. The modulating control (low fire to high fire modulation) and operating controls (on-off cycling) use these operating pressures to determine how to operate the burner in response to the load demand.

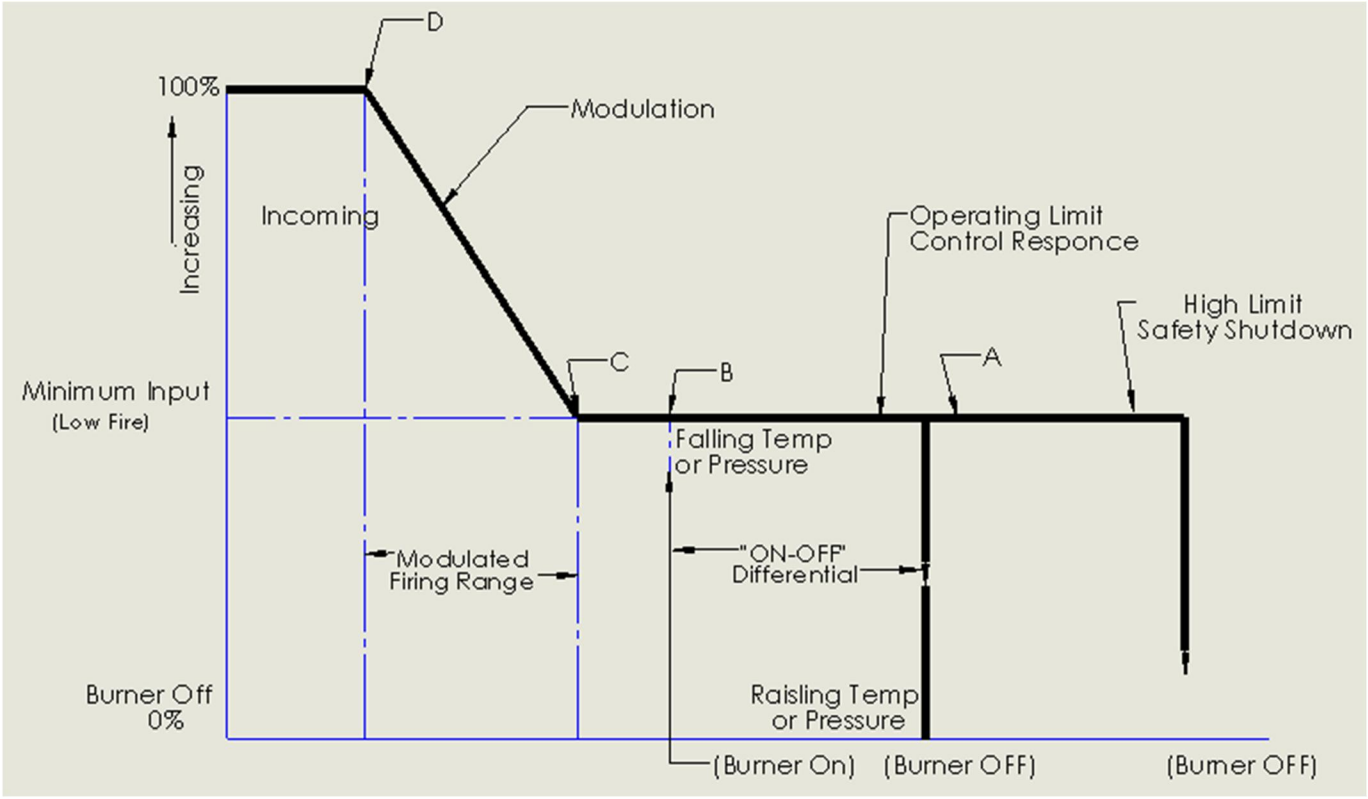


Figure 5-1 Operating and Modulating Control

Figure 5.1 shows a typical operating cycle. As the pressure drops (moving from right to left), it will eventually arrive at the “Burner On” pressure, and the combustion control will start the burner (the startup sequence is actually controlled by the flame safeguard), and position the fuel and air valves at their minimum flow rates, which would be the low fire of the burner. The burner would initially light off at the “Ignition” point, which is about 35% of rate, then modulate to low fire. If the pressure continued to drop into the “Modulating Firing Range”, then the firing rate would be increased as shown in the graph, until the water output matched the load use of water, and the operating pressure stabilized. The ramp up of the firing rate is done by increasing the gas and air flow rates in a pre-defined sequence from low fire to high fire. This pre-defined sequence is the combustion turning done at the startup of the unit, and ties the gas and air flow rates together to provide good combustion. These positions are loaded into the combustion control, and used for the modulating control of the boiler.

When the load decreases, the operating pressure will build up, because the boiler is generating more water than the load is using. This will cause the modulating rate to be reduced to the low fire point. If the water pressure continues to rise, it will finally reach a pressure that causes the boiler to cycle off (Burner Off pressure). With the burner off, the water pressure will drop, and the cycle will repeat. Normally the load remains within the modulation range and the burner does not cycle off with any frequency, but at very low loads it must cycle off.

In the Siemens control, the operating and modulating pressures are adjustable settings in the control, and the control compares these to actual pressures from the water pressure sensor on the vessel. In some other controls, they can be individual pressure switches and a rheostat driven by the water pressure.

Once the load is satisfied and the operating control no longer has a call for heat, the unit will modulate to low fire and the main and pilot gas valves will close.

5.5. POST PURGE PERIOD

When the burner cycles off, it will go through another purge cycle to remove combustible gases from the furnace. This is a much shorter cycle than the pre-purge, but can be adjusted.

a. The operating water pressure control causes the burner to cycle off, and all gas valves and the ignition transformer are de-energized. All indicating lights are out.
b. The blower motor runs for 15 seconds then shut off.
c. The boiler is in standby waiting for the next call for heat.
d. The flame safeguard control also will shut off the burner and initiate a post purge on the trip of any safety device.

6. PREPARING FOR OPERATION

6.1. General Inspection

If this is a new boiler startup, then the boiler has initial setting that will support the initial startup process. These settings include the primary air, secondary air, pilot gas pressure, main gas pressure, and a fuel curve with the fuel and air settings from low to high fire. These adjustments should be left undisturbed for initial start-up of the boiler. These settings are listed in the factory fire test report, and a copy of this report should be readily available to help with the startup process. The data listed on the factory fire test report was recorded with the boiler firing. The blower pressure, manifold pressure, and combustion chamber pressure will not match the factory readings unless the main burners are on and stable. It should be remembered that the actual pressures will vary, especially at different air temperatures and elevations (the factory test is done at 500 feet).

If this is a re-start of an existing unit that has been moved, modified or otherwise changed, additional setup work will be required to determine the proper setting. If the initial setup data is available, then that data can be used to help set the equipment. Remember that if components have been changed, they may not (and probably will not) follow the same settings as the original components.

The first step is to make sure the complete system is ready for operation, including the feed system, electrical, fuel supply, breeching and stack, controls and water system. Proper operation of the boiler may require that some water be dumped to allow the boiler to fire at full rate. Consideration may need to be given to the feed system if it is not capable of handling a low condensate return rate during this period.

Prior to burner startup, contact the local gas company to determine if any correction factors have to be applied to their indicated flow rates. This information is important as relates to achieving specific BTU/hr input rates.

State boiler inspector, environmental authorities, local building inspectors (if building changes occurred)

6.1.1. System Inspection and Preparation

a. The circulating pump and related piping and controls are connected and operational
b. There is sufficient load to operate the boiler at full rate.

A HOT WATER HEAT DUMP MAY BE REQUIRED TO ALLOW THE BOILER TO OPERATE FOR A SUFFICIENT TIME TO MAKE COMBUSTION ADJUSTMENTS. FAILURE TO PROVIDE AN ADAQUATE LOAD WILL PREVENT PROPER SETUP OF THE BOILER.

c. There is sufficient water to support the operation of the boiler, including operation at full rated capacity
d. The stack and breeching are connected to the boiler
e. The breeching and stack are designed and installed according to the guidelines of Section 3
f. If this is a tall stack (over 30 feet) or multiple boilers connected to a common stack, there is a draft control system that will maintain the required draft
g. Have the fuel lines been cleaned, especially if they are new lines.
h. The fuel supply pressure should match the stated gas supply pressure and cannot exceed the rating of the fuel train components or the stated pressure for which the gas train was designed.
i. Install a pressure gauge on the gas supply line to the burner (before the main gas pressure regulator). The gauge should have a range that is twice the expected supply pressure. Make sure all main manual valves are closed before installation. Slowly open the manual main gas valve while monitoring the gas pressure. If the pressure does not match the stated supply pressure, contact the installing party to resolve this pressure problem.
j. There is sufficient fuel supply and pressure to operate all of the users, and the supply pressure matches the pressure listed on the Sellers order information
k. The fuel lines should be purged of air with fuel. Disconnect the pilot line at the inlet to the pilot gas pressure regulator and purge air from the gas line. Purging of the gas lines must be done in accordance with NFPA 54 of the National Fire Protection Association's National Fire Protect Code. After the air is purged from the gas supply line, close the pilot manual valve and reconnect the line. Leave the manual pilot valve closed.
l. The fuel lines should be checked for leaks. Usually this is done by brushing soap water on all joints while the gas train is under pressure. Leaks will show up as bubbles.
m. Is there a source of combustion air for the burner?
n. Make certain electric power supply is properly connected and that proper voltage and current characteristics are being supplied.

o. Place all electric switches in the OFF position.
p. Check rear relief door gasket for a tight seal. The gasket should be in good condition and provide a continuous seal.

6.1.2. Vessel Inspection

a. The boiler and new piping should be cleaned with the appropriate “Boil Out” procedures.
b. Check all boiler connections and all hand hole and man hole openings for possible leaks. Correct any leaks.
c. All hand hole and manhole covers are in place with new gaskets (after boil-out) and tightened.
d. All unused opening are capped off
e. The safety valves are installed and piped to a safe discharge location
f. The hot water lines are connected to the hot water system with appropriate valves and controls to manage the load.
g. The water column is in place and checked for proper operation

6.1.3. Burner Inspection and Preparation

a. Make sure the electrical power is turned off
b. Check all screw type electrical terminal connections in the boiler control cabinet for normal tightness. Such terminals can loosen during shipment and a careful check will help to avoid unnecessary trouble during initial start-up operations.
c. Check rotation of combustion air fan motor. The rotation is marked with an arrow on the burner face. Normally, the motor is started momentarily using the contactor, and the direction detected as the motor slows down. If the motor is rotating in the wrong direction, reverse the wiring leads.
d. Close all manual gas valves
e. Prepare pressure test points for measurement. This should include adding connections and/or gauges to measure the main regulated gas pressure, the pilot regulated gas pressure, the fan pressure, manifold pressure and furnace pressure. Refer to the Sellers Factory Fire Test report for expected pressures and selection of manometers and gauges.

6.2. Burner Adjustments

In preparation to operating the unit, several checks should be done to verify correct positions, and that they did not move as a result in shipping and rigging into positon.

6.2.1. Ignition Electrode

The end of the ignition electrode should be positioned directly over the runner pilot ports between two of the main burner nozzles. The gap between the end of the electrode and the pilot is called the spark gap. This spark gap should be 3/32” minimum to 1/8” maximum. Improper spark gap is the leading cause of nuisance flame failures.

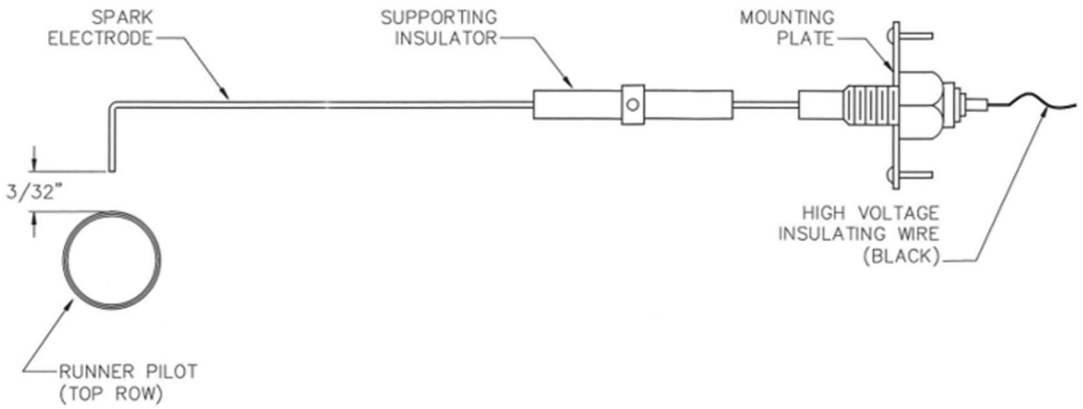


Figure 6.1 Spark Rod

6.2.2. Pilot Assembly and Flame Rod

The runner pilot assembly has a flame proving leg attached to the lower bottom pilot tube. This proving leg extends back in perpendicular fashion towards the burner manifold. The flame rod, or flame proving electrode should be positioned directly over the drilled flame ports of this runner pilot proving leg. The flame rod should be 3/8" minimum and 1/2" maximum above the pilot proving leg. Positioning the flame rod too close or too far from the pilot proving leg can cause nuisance flame failures. If these electrodes are not in proper position, they can usually be correctly repositioned by opening the burner door and bending the rod slightly to the desired position. Make sure the electric power is off when checking the flame rods as they have a high voltage electrical supply.

The pilot assemble is made up of several "Running Pilot" pipes which have small holes in the top that allow the gas to escape and provides a ribbon of flame in front of each nozzle. The pilot is a pre-mix style, and has an air inducer fitting that allows some air into the gas steam ahead of the running pilots. In addition to the horizontal pilot pipes, there are vertical runs that will prove a flame path between each of the horizontal pilot pipes. The pilot flame rod is located in the opposite corner of the ignitor, and proves that all of the horizontal and vertical pilot runs are functional, allowing the flame to reach across the burner face.

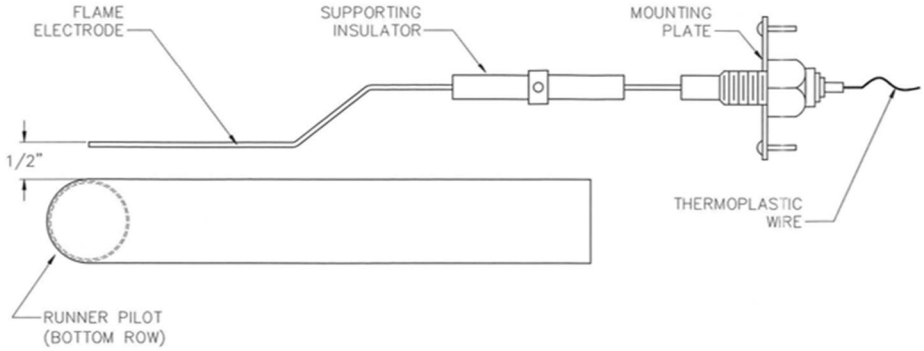


Figure 6.2 Pilot Flame Rod

6.2.3. Nozzle Flame Rod

The main flame rod is located in front of one of the main nozzles, centered across the face of the nozzle and ½" from the nozzle.

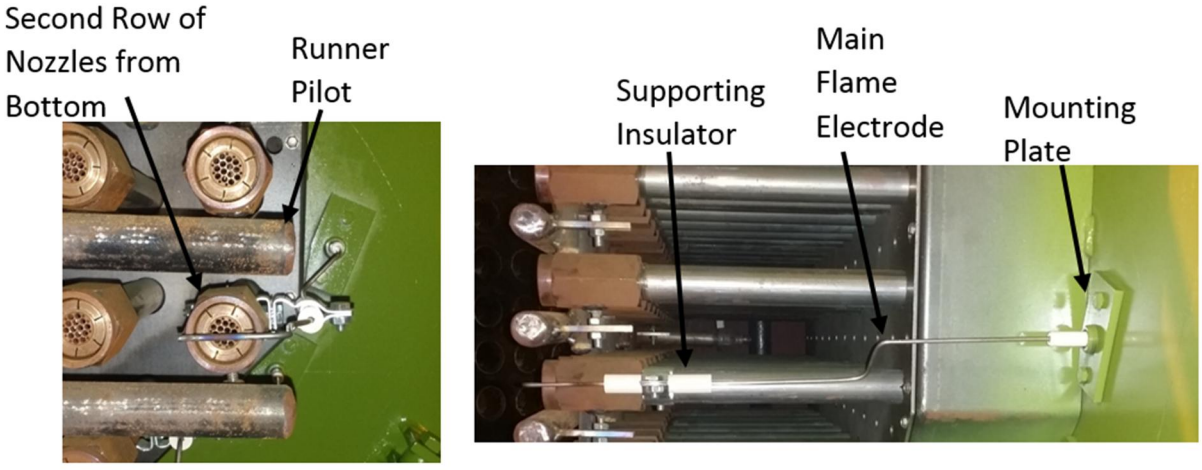


Figure 6.3 Main Flame Rod

The nozzle at the main flame rod will be different from the standard nozzles to prevent problems at high fire, where the presence of the flame rod can cause turbulence and flame outs simply because it is blocking some of the space for combustion to occur. In some cases, the nozzle is different and in other cases, an orifice is placed in the feeder pipe to the nozzle.

The flame proving electrodes are powered when the boiler control circuit is powered. To avoid electrical shock, be certain that the power is OFF prior to adjusting the electrodes.

6.2.4. Front door gasket seal

The gasket seal on the front door must be checked for a tight seal. The gasket is held in place with a clamping ring, and the ring may need to be positioned closer to the door to get a good seal. The gasket should be compressed against the door, so that it will seal the gases in the furnace. If the gasket is not compressed against the door, move the clamp ring closer to the door by simply tapping it towards the door.

If there is a leak in this gasket seal, it can also be detected by checking for a gas leak while in high fire purge. If the gasket cannot be sealed, it should be replaced.

6.2.5. Combustion Settings

If this is the initial startup of a new unit from Sellers, the settings made at the factory during the fire test should be adequate to begin the startup process. This does not mean that a complete startup sequence is not required, or that the combustion setting do not need to be verified and/or adjusted. Each location has different fuel properties and air density and stack conditions which will alter the combustion and safety control settings. Also, the specific operating conditions, like modulating pressure ranges and on-off cycling points will need to be set for that specific job site.

If this is located at a very high elevation, there may need to be adjustment made before the unit will operate. In this situation, the air pressure from the fan will be lower, and the combustion air pressure switch may need to be lowered. Likewise, the gas pressures may need to be higher to overcome the low barometric pressure. The Sellers factory is located at about 500 feet elevation. Some differences in pressure setting will start to occur at about 1500 feet, and more major differences as the elevation increases.

⚠WARNING

ALL BOILERS REQUIRE A COMPLETE STARTUP WHEN INSTALLED. INSPECTIONS ARE REQUIRED TO ENSURE THAT THE OPERATING CONTROLS AND SAFETY CONTROLS HAVE NOT BEEN DAMAGED IN SHIPMENT OR INSTALLATION AND THAT THEY ARE FUNCTIONING CORRECTLY AND ADJUSTED TO LOCAL CONDITIONS. COMBUSTION MUST ALSO BE ADJUSTED TO LOCAL CONDITIONS. FAILURE TO PERFORM A COMPLETE STARTUP MAY RESULT IN EQUIPMENT FAILURES, PERSONAL INJURY OR DEATH.

The initial positions of the air damper and fuel valve are normally set by Sellers Manufacturing when the unit is fire tested, and should be adequate to initially perform the startup process. The air and fuel valves should be checked to show they are in a lower firing position for light off. If this burner is being installed in the field, the light off positions will need to be determined.

⚠CAUTION

THE BURNER IS NORMALLY ADJUSTED TO START AT A RATE OF 30% - 50%. THIS CAN BE ADJUSTED, BUT IT WILL NOT LIGHT OFF AT VERY LOW RATES BECAUSE IT DOES NOT HAVE SUFFICIENT TIME TO FILL THE MANIFOLD. HIGHER RATES, TO HIGH FIRE, CAN BE USED BUT MAY REQUIRE ADDITIONAL ASDJUSTMENTWS.

If the burner is adjusted for light off at higher rates, the pilot flame detector may need to be re-positioned to detect the pilot at the higher firing rate. Monitor the pilot when it is at the desired light off position, and determine where the flame rod should be located to detect the pilot at that rate. Readjust as required (see above).

Monitor the operation of the fuel valve and air damper as they are driven from low to high fire. Their operation should be smooth with no jerks or sudden movements. If they are not smooth acting, check for binding or misalignment.

Check the combustion air fan motor rotation. There is an arrow on the burner indicating the correct direction of rotation.

The secondary air settings are set in the factory, but may need to be changed due to altitude, fuel makeup and other combustion setting changes. The secondary air position is determined by train and error, making small changes and

observing the change to determine if that improve the combustion or makes it worse. There is usually a wide range of settings that will provide good combustion, but this range of settings may different at high and low firing rates. This adjustment becomes more critical as turndowns increase and if the unit is operating at low NOx. The best performance for a low NOx setting is when the secondary air is set to a minimum position, so that more air is used to cool the flame.

6.3. Controls and Safety Check

The initial setting done by Seller at the factory fire test should provide a base to begin the startup process. There are several control settings that may need to be adjusted to meet the specific needs of your job site. Sellers does not attempt to cover all of the application details in the fire test, and is primarily concerned with checking the proper operation of the unit.

In addition, there may be other controls added at the job site that are not part of the boiler equipment. It is expected that the job site startup will cover all of these issues in concert with the requirements of the customer and local conditions.

Prior to startup, it is essential that all safety and operating controls be checked. The primary source of information on these controls comes from the instruction sheets from the manufacturer of the control, included in the boiler manual. The following general guidelines are given to provide a general process of checking the controls.

6.3.1. Low Water Cutoff (float type)

Check the controls for smooth and free operation, as well as matching the positions LWCO function, to make sure they were not damaged in shipping and rigging.

6.3.2. Air Flow Proving Switch

The initial setting for this switch was used during factory test firing. This setting should be adjusted before start up to match the environment where the unit is being installed. After tuning the boiler, this switch should be properly adjusted to match the final burner setting settings.

6.3.3. High Gas Pressure Switch

After fire testing, this is set to a point that does not allow the unit to turn on for safety. This setting should be adjusted before start up to match the environment where the unit is being installed. Once the gas pressures and combustion are set, this switch can be adjusted to match the high fire gas pressure.

6.3.4. High Limit Temperature Control

To perform the startup, this switch should be set at a temperature that is close to the maximum temperature. This will allow the widest operating range without causing a shutdown. If there are other factors that would suggest a more limited operating range, then this switch should be set with that consideration.

6.3.5. Operating Temperature Control

The boiler is equipped with a control to automatically control the burner to match the system load. It is a combination of an “Operating Control” which cycles the burner on and off and a “Modulating Control” which will change the firing rate of the boiler to match the system load. If the system load remains within the modulation range of the burner, the burner will remain on and modulate as needed. If the load falls below the minimum firing rate of the burner, the burner will cycle on and off to match the load. Likewise, if the load is greater than the boiler output, it will simply drive to the maximum output and remain there.

The initial settings should be placed into the control at this time. If the boiler is equipped with a Siemens LMV5 parallel positioning control or similar control, these setting will be done in the control, and a pressure sensor will be

used to determine how the unit operates. If this is a linkage or ratio relay system, then pressure switches will be used to determine the operating control points and a modulating potentiometer will be used to set the modulating range.

Figure 6.1 shows how a typical operating cycle works. As the pressure/temperature drops (moving from right to left), it will eventually arrive at the "Burner On" pressure, and the combustion control will start the burner (the startup sequence is actually controlled by the flame safeguard), and position the fuel and air valves at their minimum flow rates, which would be the low fire of the burner. The burner would initially light off at the "Ignition" point, which is about 35% of rate, then modulate to low fire. If the pressure or temperature continued to drop into the "Modulating Firing Range", then the firing rate would be increased as shown in the graph, until the steam or hot water output matched the load, and the pressure or temperature stabilized. The ramp up of the firing rate is done by increasing the gas and air flow rates in a pre-defined sequence from low fire to high fire. This pre-defined sequence is the combustion tuning done at the startup of the unit, and ties the gas and air flow rates together to provide good combustion. These positions are loaded into the combustion control, and used for the modulating control of the boiler.

When the load decreases, the pressure or temperature will build up, because the boiler is generating more steam or hot water than the load is using. This will cause the modulating rate to be reduced to the low fire point. If the pressure or temperature continues to rise, it will finally reach a pressure that causes the boiler to cycle off (Burner Off pressure or temperature). With the burner off, the pressure or temperature will drop, and the cycle will repeat. Normally the load remains within the modulation range and the burner does not cycle off with any frequency, but at very low loads it must cycle off.

In the Siemens control, the operating and modulating pressures and temperatures are adjustable settings in the control, and the control compares these to actual pressures and temperatures from the sensor on the vessel. In some other controls, they can be individual pressure switches and a rheostat driven by the pressure or temperature.

Once the load is satisfied and the operating control no longer has a call for heat, the unit will modulate to low fire and the main and pilot gas valves will close.

The exact details of how each system accepts these setting will vary, but all systems will use the same inputs. Also, some system may provide additional control functions for the modulating control, to provide a tighter pressure setting (PI or PID control) rather than the proportional control shown.

6.3.6. Flame Safeguard and Combustion Controls

Modern combustion controls like the Siemens LMV5 offer a very wide array of options that will change how the burner operates and what information can be made available. These settings can be very helpful to customers and service technicians, and are often tailored to meet customer and service needs. Sellers generally limits adjustments to handle the basic operation of the unit in a manual mode, which allows verification of the burner and boiler operation. It is expected that numerous other adjustments can be made to the unit, but they are the responsibility of the customer and/or Service Company.

A representative of the owner and/or the person or persons responsible for operating and maintaining the unit should be present during initial startup. A service representative may also be required by the local utility on gas-fired equipment. Instructions regarding the proper care and maintenance of the unit should be outlined with these people present.

6.3.7. Low Gas Pressure Switch

After fire testing, this is set to a point that does not allow the unit to turn on for safety. This setting should be adjusted before start up to match the environment where the unit is being installed. Once the gas pressures and combustion are set, this switch can be adjusted to match the low fire gas pressure.

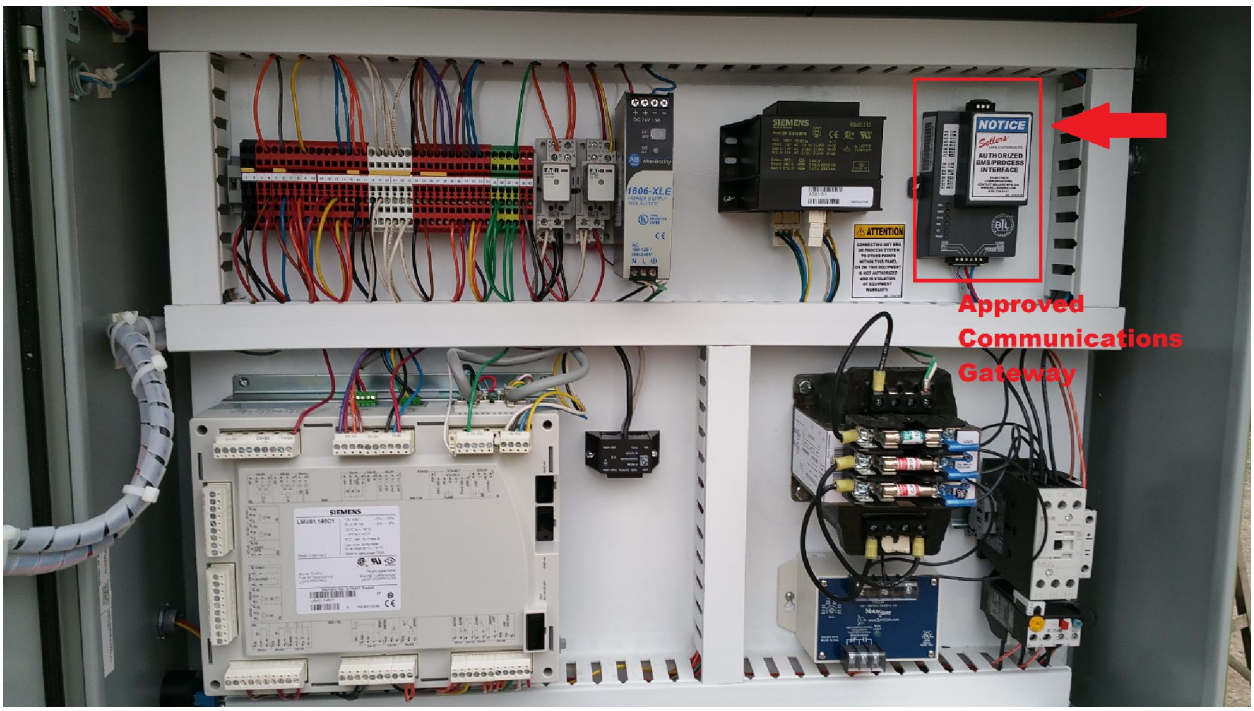
6.4. External Controls and Building Management Systems (BMS)

Building management systems (BMS), energy management systems (EMS), process control and

other types of communications networks can be connected to this product for outside monitoring and control. Sellers Mfg recommends that ALL outside communications to the unit be disconnected for the initial startup process. This is recommended due to any number of conditions: false startups, false shutdowns, false errors, incorrect set points, incorrect loads and any number of other issues including **SAFETY**.
Sellers Mfg has provided a company approved communications gateway within the electrical enclosure. See "approved communication gateway" in the photo below. Upon request to Sellers Mfg, this device can be activated to provide communication in the below protocols:

- BACnet MS/TP
- BACnet/IP
- Modbus TCP/IP
- Modbus RTU
- Metasys N2
- LonWorks (requires prior request)

Connecting any communication network to this unit in any other location, other than the one provided, is not authorized and is in violation of the equipment warranty. Regardless of how you interface with Sellers equipment, remember that at all times the equipment and facility owner is solely responsible for the proper and safe operation of any and all equipment. Hire a qualified contractor to properly maintain, troubleshoot and prepare for required authority inspections of your equipment, as every installation and application is unique to the site. Sellers authorizes communications connections only to the provided Ethernet or Serial ports. Any alteration or attempts to connect to other connection points voids the equipment warranty. DANGER! Never interfere with any factory wiring or controls, which is in conformance to applicable codes and integral to the safe operation of the equipment.



6.5. Energy Extractors

Stainless Steel Energy Extractors are installed in each firing tube at the factory. Check to make certain they are flush with the rear or exhaust end of the firing tube. The heat extractors can move partially out of the firing tubes during

shipment. To restore the heat extractors to proper position, push them forward into the firing tube until flush with the tube end. This will assure maximum efficiency during operation.

7. COMBUSTION ADJUSTMENTS

Combustion in a Sellers Immersion Boiler is much different than combustion in a normal boiler. This is because the flame is broken into many small combustion chambers, to fire into the individual 2" tubes of the Firetube boiler. Normally combustion occurs in a large furnace, and then is routed through a turnaround chamber to go through the boiler tubes. Firing into individual tubes requires some different combustion settings and considerations, which are outlined below.

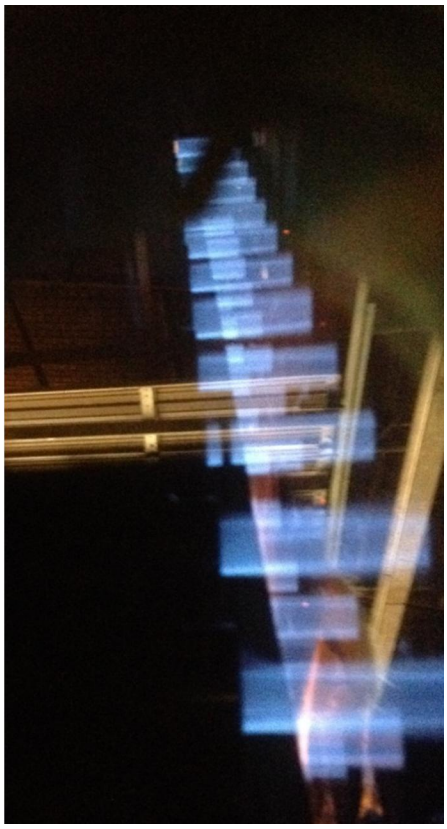


Figure 7.1 Typical Flame

7.1. General Burner Description

The burner is a pre-mix type, which means that the fuel and air are mixed prior to entering the nozzle. Combustion occurs at the tip of the nozzle, which is about 2" in front of the tube. The flame is centered on the tube, and travels into the center of the tube. The chamber where the nozzle is located is called the combustion chamber, and while the combustion is initiated here, very little heat is released in the combustion chamber. The photo at right shows how this appears through the viewing windows on the combustion chamber. The blue flame has a very sharp cylinder like appearance, with a diameter of less than 1". The pilot flame typically has more yellow in it and can appear to be more candle like at some firing rates, but this can vary depending on the amount of air being fed to the pilot (secondary air).

The pilot is actually made up of several "Running Pilots" or ribbon burners arranged so that there is a pilot flame in front of each nozzle. The pilot has an air "Inducer" fitting that brings in air to the pilot gas and makes it a pre-mix pilot. A spark ignitor is placed on one end of the pilot array to start the pilot and a flame rod is place on the opposite side, so that the pilot flame must travel throughout the full range of the burner (across the horizontal width and down the vertical length) to prove the pilot operation. At mid rates, the pilot (without main flame) will have a lazy appearance with yellow tips. At very low rates, the pilot will start to disappear, although only in color (the low CO reading is proof that it is still burning properly). At high rates the pilot also tends to disappear due to the higher air and fuel flow rates.

7.2. Ignition Point

Startup of the burner normally occurs at about 1/3 to1/2 of the capacity. It is difficult to start at lower rates because of the time it takes to fill the chambers with gas before the Flame Safeguard timer times out. The ignition point can be adjusted to start at higher firing rates, including starting at full rate if this helps the operation by providing quicker load response. The non-modulating versions of the Sellers Immersion boiler always start at full rate, and because there is no thermal shock with this boiler design, it does not require any warmup time to prevent thermal shock.

⚠CAUTION

DO NOT ATTEMPT TO START THE BURNER AT LOW RATES AS THE FUEL WILL NOT BE ABLE TO REACH THE COMBUSTION CHAMBER WITHIN THE ALLOWED TIME. THIS WILL RESULT IN FLAME FAILURES

7.3. Main Flame

The "Main Flame" is actually a series of small diameter blue flames passing from the nozzle tip into the tube. The view ports allow you to monitor these flames, and this is a key source of information on how the combustion is doing. A good flame will have a blue translucent appearance, with very clear surfaces. At low rates, the flame is more transparent (less actual combustion). If the flame starts to flicker on and off, that is an indication that you are at the minimum firing rate for the burner. If the flame starts to pulsate, immediately turn the burner off, as this can cause problems.

WARNING

DO NOT ATTEMP TO FIRE THE UNIT AT A LOWER FIRING RATE THEN STATED ON THE FIRETEST REPORT. VERY LOW RATES MAY CAUSE COMBUSTION PULSATION, CAUSING THE STACK OR OTHER EQUIPMENT DAMAGE. THIS IN TURN CAN CAUSE PERSONAL INJURY AND DEATH.

The primary combustion adjustment is the fuel-air-ratio. A calibrated combustion analyzer is required to set combustion. It should be capable of measuring O_2, CO and NO_x. The normal excess ranges (% O_2) for the burner vary with operation as a low NOx (30 ppm) burner or a standard Burner;

% Rate	Standard Burner Settings, % O2	Low NOx (30 ppm) Settings, % O2
> 50%	2.5 - 4.5%	3.5 - 5.5%
30 - 50%	3.5 - 5.5%	4.0 - 6.0%
< 30%	4.0 – 6.5%	4.5 - 6.5%

Table 7.1 Typical %0_2 Levels

When adjusting the burner for operation at low NOx (30 ppm corrected to 3% O2), the burner generally will require a higher O2 setting to obtain the lower NOx level. The higher % O2 (excess air) is required to cool the flame to achieve the lower NOx levels. These higher % O2 levels are normal for lower firing rates, but not for higher firing rates. In addition, the amount of secondary air will need to be adjusted to a minimum or lower level (valve adjusted to amore closed position) to obtain the NOx settings without operating at high levels of excess air. Increasing either the primary or secondary air will result in higher % O2 readings, but only increasing the primary air will result in lower NOx. If the secondary air setting is too high, the burner will be operating at a lower efficiency and may not make capacity.

7.4. Secondary Air

The secondary air adjustment is done primarily by trial and error adjustment. The purpose of the secondary air is to provide air for the pilot and to provide some air flow around the individual flames to prevent contact and disturbance with the tube, which would result in combustion noise. One setting can be used for all firing rates, but it may take some trial and errors adjustment to determine this best setting.

To increase the amount of secondary air to the unit, you spin the rod counter clockwise. And to decrease the amount of secondary air you spin the rod clockwise. The locking nut must be properly tightened after desired air is achieved to prevent it from changing over time.

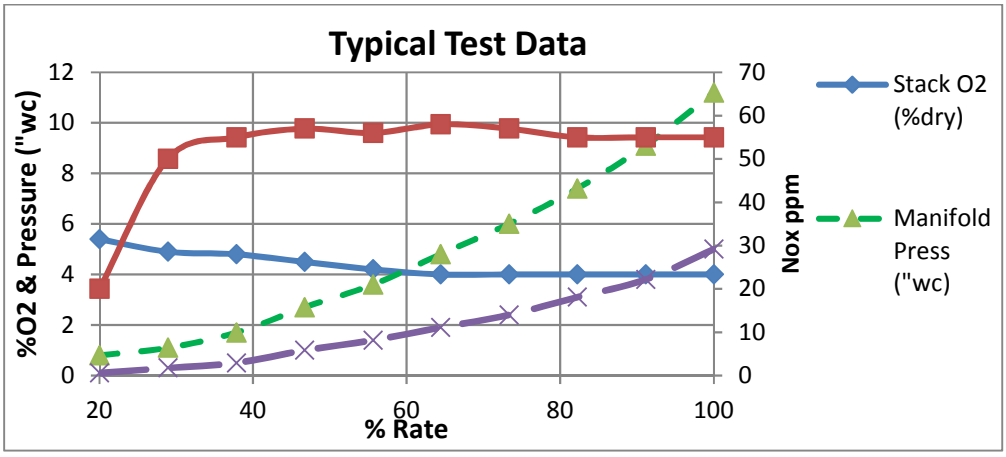


Figure 7.2 Typical Test Data

If the secondary air is adjusted to a point of too little air, the pilot flame will disappear (the visual blue flame will become transparent) and at some point, combustion noise will occur. It is OK for the pilot to become transparent, but do not adjust close to the point of where the combustion noise occurs. If the secondary air is adjusted to a point of too much air, the %O2 will increase (which may be OK if it remains in the normal operating range) and at some point, the combustion noise will occur, which is not acceptable. In addition to adjusting to prevent combustion noise,

some margin of safety must also be included in the settings to prevent combustion noise when conditions change.

Monitoring the NOx level while adjust the secondary is one way to tell if the combustion process is within normal ranges. At high rates, the NOx level should be in the 50 to 60 ppm range for a standard burner setup. As the firing rate goes down to low fire, the NOx will drop to 20 or 30 ppm for typical turndowns, and may be less than 20 ppm for turndowns in the 5:1 range. These are not absolute values, but offer some indication of how the combustion should appear. If, for example, a standard burner has a NOx reading of 35 ppm at high fire, the secondary air is probably closed too far, and should be more open. Too little excess air may prevent the unit from reaching capacity.

If this is a low NOx burner that must meet a 30 ppm NOx requirement, the setting and readings would be much different at higher rates. In this case, the secondary air would be adjusted to a minimum setting while the primary air is increased to obtain a NOx level of under 30 ppm (typically adjusted to be 27 or 28 ppm).

7.5. Internal Load Controller PID Loop

The maker of the LMV5 flame safeguard, Siemens Combustion Controls, recommends preset combination of values for the internal load controller PID loop when necessary due to outside system integrations.

Type	P (%)	I (Sec)	D (Sec)
Default	14.5	120	0
Very Slow	3.4	273	48
Slow	4.7	250	44
Normal	6.4	136	24
Fast	14.5	77	14
Very Fast	42.5	68	12

Disclaimer: Sellers Manufacturing Co. does not warrant external load controller or any other alteration to the LMV5's combustion or safety controls.

7.6. Impact of Changing Environment

There are several environmental changes that should be considered when tuning a boiler, to prevent future problems. The most common issue is the impact of changing combustion air temperature. The actual quantity of air supplied for combustion changes with the air temperature. For example, if the burner is tuned when hot, say 110 ^{o}F, and set for 3% O2, then on a cold morning when it is 50 ^{o}F, the resulting O2 will be less than 1%, and the burner will probably have very high CO (unburned fuel) and perhaps sooting. The reason is that the fan produces a constant volume of air, but the air density, or pounds of air per cubic feet changes with temperature.

A change of about 25 °F will produce a change in 5% excess air. The 5% excess air is approximately 1% O2. Using this information to help set the burner will result in a more efficient operation, rather than simply running at a higher excess air all of the time.

If this is an outside installation, larger swings in air temperature should be expected, and some effort must be applied to cover this. There are controls that can compensate for changing air temperature, and these could be applied. The other approach is to simply tune the burner on a seasonal basis.

Another variable to consider in the combustion setting is the impact of operating at lower or higher than normal steam pressures. If the burner is tuned while operating at very low pressures, then placed into operation at a much higher pressure, the resulting combustion will be much richer than the initial setting. The reason is that the stack temperature increases with steam pressure. At 10 PSI, the steam temperature is 240 ^{o}F. At 125 PSI, the steam temperature is 353 ^{o}F. This 113 ^{o}F increase in steam temperature will increase the stack temperature by the same amount, and that will increase the combustion chamber pressure which reduces the fan output. The actual amount of change will vary by boiler, but can easily result in a change of more than 1% O2. The combustion tuning should be done at or close to the normal operating pressure

Changes in stack draft can also cause major upsets in the combustion results. The amount of draft created changes

with the temperature difference between the stack and outside air, so a small draft may exist in summer, but a large draft can occur in winter months. The draft must be controlled to within +/- 0.1" wc, and at any singe firing rate, the variation can be no more than +/- 0.05" wc. Draft controls like barometric dampers, can help provide this control if needed.

One source of combustion problems is the lack of combustion air to the boiler. Even if the boiler room is equipped with sufficient air inlets, they are sometimes blocked off because of the cold air coming into the room. If the burner does not receive enough air for combustion, it can result in high CO, unburned fuel and delayed ignition

WARNING

THE BURNER MUST HAVE OPEN ACCESS TO COMBUSTION AIR. BLOCKING OR RESTRICTING THE COMBUSTION AIR OPENING CAN RESULT IN EQUIPEMENT DAMAGE, INJURY OR DEATH

Elevation can change the burner pressures, so that they will be different from those stated in the factory fire test report. The factory is located at about 500 feet elevation, and higher elevations will have different reading. At 2000 feet, the numbers will be slightly different, but at 5000 feet they will be significantly different. Keep this in mind when comparing your setup data with the factory fire test.

7.7. Data Logging

Whenever a new boiler is placed in service, operating data should be recorded, compared to predicted data and saved for future reference. Figure 7.2 shows some typical data for a unit in graphical form. This information will be extremely valuable for diagnosing problems and monitoring the condition of the equipment to help set maintenance schedules. The fire test report is the first and original set of data, and the startup data collected with the startup of the unit.

The operating data can assist the operator to spot trends and take corrective actions. Maintenance plans can be made by comparing data on a time line to indicate when cleaning and adjustments would be required. For this data to be meaningful, the instruments and controls must be well maintained and properly calibrated.

A typical data log would include operating parameters such of pressures, temperatures, flows, draft, motor amps, firing rates, fuel and air positions, date and time.

8. STARTUP

A new burner startup should only be done by an individual that is properly trained to work on this equipment, and has experience doing this. That includes the burner, vessel, controls and general system.

DANGER

BURNER STARTUP AND COMBUSTION ADJUSTMENTS SHOULD ONLY BE DONE BY A TRAINED AND EXPEEIENCED SERVICE TECHNICIAN. ATTEMPTING TO PERFORM THESE TASKS WITHOUT PROPER TRAINING AND EXPERIENCE CAN RESULT IN EQUIPMENT DAMAGE, INJURY OR DEATH.

If you are not qualified to service this equipment, DO NOT TAMPER WITH THE UNIT OR CONTROLS, CALL A QUALIFIED SERVICE PERSON.

Before proceeding with the startup of the burner, be sure that the overall installation is complete and that all components are ready for operation, as identified in Sections 6 and 7. Review this manual as well as the manual for the controls and other supporting equipment. These manuals must be read and understood prior to starting the burner.

8.1. Pre-start check list

Before attempting to start the boiler, make certain the following switches and valves are in the position indicated. Refer to Equipment and Component Description and Cross Reference for the location of these devices.

1. The manual gas shutoff valves should be in the CLOSED position.
2. The pilot gas manual valve should be in the CLOSED position.
3. The fused line switch should be in the OFF position.
4. The manual on/off switch (see wiring diagram) should be in the OFF position. This switch is located on the side of the control cabinet.

The following equipment should be available;

- Combustion analyzer, that measures %O2, CO ppm and NOx, with recent calibration
- Stack thermometer
- Use a manometer with tapings to measure pilot gas pressure, manifold pressure and combustion chamber pressure
- Calibrated gauges and pipe connections to measure gas supply and regulated pressure (ranges to match the expected pressures)
- Inclined manometer to measure stack pressure (draft)
- Electric Multimeter

8.2. Initial Startup

WARNING

THIS MANUAL IS NOT INTENDED TO INSTRUCT UNTRAINED PEOPLE TO START THIS UNIT. THE STARTUP REQUIRES THAT A TRAINED AND EXPERIENCED SERVICE PERSON PERFORM THE STARTUP. FAILURE TO PERFORM THE STARTUP WITHOUT A TRAINED AND EXPERIENCED SERVICE PERSON CAN RESULT IN EQUIPMENT DAMAGE, PERSONAL INJURY OR DEATH.

The initial start-up of the burner, or any start-up after re-working the burner should use the following general procedure. Once the burner has been tuned and the controls adjusted, the burner can operate in the normal or automatic operation.

1 The combustion control system should be set to “Program Stop” in the start position, and not modulate once main flame is obtained.
2 Turn the burner switch on. This will start the combustion air fan, and start the air damper to open for the pre-purge cycle

3 After the pre-purge cycle is complete, the damper will start to close, and at a positon of about 1/3 rate, verify that the pilot solenoid valve opens. The burner shut down on pilot failure, because the pilot gas valve is closed. If the unit properly follows this sequence, move to the next step. If the unit did not perform the proper sequence, go to the troubleshooting section, and correct the problem. Remember that there may be controls added to the unit that are not on the Wiring Diagram, but can impact the operation.
4 Open the manual pilot valve and the any main upstream gas valves required to provide gas to the burner. At this time, if there is a means of safely purging the gas lines, that should be done.
5 Program Stop Set to 44 Interval 1 (Pilot Stabilize).
6 Reset the control and re-start the unit, and monitor the pilot operation. You should be able to see all of the pilots light across the face of the burner in a few seconds. If all of the pilots do not start properly, turn the burner off and follow the instructions in the troubleshooting section. Remember that if this is the initial startup of the burner, the failure may be due to a lack of fuel in the gas train, and that a few start attempts may be required to fill the lines with fuel.
7 When the pilot has been established, the main flame safeguard will attempt to start the main flame. Verify that the main safety valves are opening, and then closing at flame failure (the main flame will not light because the safety valve is closed).
8 After pilot is stabilized, then set Program Stop to 52 Interval 2 (Main Stabilize).
9 Once the main flame cycle has proven to function properly and safely, reset the control on the flame safeguard and allow the burner to re-start. Keep the manual safety valve closed (the manual valve closet to the burner).
10 Deactivate the program stop.
11 When it is time for the main flame to start, open the safety valve, but keep your hand on it for quick shutoff if required. If the main flame did not start, and this is the initial operation of the burner, it may be due to the lack of fuel in the gas line. It is also possible that the settings are incorrect for light off, and adjustments are needed. Refer to the troubleshooting section if the main burner fails to light after a few attempts.
12 Only adjust the air as the fuel was clocked with a flowmeter at the factory.
13 Once the main flame is established, it should remain at the light off position. If the combustion analyzer shows it to be in the normal operating range, allow the unit to warm up. If the combustion is out of range, adjust it to bring it on range
14 The next step is to bring the unit up to full rate. Ideally, a gas flow meter is available to verify rate. If there is no flow meter, the manifold pressure from the factory fire test can be used as an approximate valve. If this job is located at a higher elevation, adjustments to the expected gas pressure may be required. Once at the rated capacity of the unit, the flow control valve should be fully opened (about 70 degrees) and the regulator adjusted to provide the correct rate. This will allow the gas control valve to have good control at low rates.
15 If needed, adjust the fuel-air-ratio at high fire. Check the NOx reading. If this is a low NOx boiler, the NOx should be under the limit by about 10%. If this is not a low NOx unit, the NOx should be around 50 ppm. The secondary air should be adjusting to help obtain the desired NOx, which will allow the unit to operate in the most efficient manner. Verify that you have not set the secondary air in a position that is close to causing combustion noise, and if needed, adjust to provide some safety margin (see Section 7 for details on combustion settings).
16 If needed, adjust the fuel-air curve from high to low fire, remembering that the points should be closer together at lower rates because small changes in the fuel and damper position cause relatively large flow changes, and the fuel-air ratio can be too rich or lean between points. But always start with factory curve settings first, since the unit functioned properly with those settings during factory fire-test.
17 Modulate the unit several times from low to high fire, and cycle on and off to verify that the settings are well established. It is not uncommon for some hysteresis to exist in the equipment, and the settings should be made to allow for an average of these values.

At this point, the burner should be operating, but the startup is not complete until the safety switches have been checked and adjusted. These checks need to be done periodically, as outlined in the maintenance section of this manual.

⚠ DANGER

FAILURE TO PROPERLY ADJUST AND VERIFY THE OPERATION OF THE SAFETY CONTROLS CAN CAUSE EQUIPEMENT DAMAGE, INJURY OR DEATH.

8.3. Safety Controls Set-up

There are several safety controls on the boiler that must be properly set and routinely checked to provide adequate safety for the operation of the boiler. The information given here covers the normal adjustments of typical safety controls, but is not intended to cover any or all controls that may be installed on the boiler. In addition, vendors can change the design and operation of the safety controls over time, and the installer must verify that they have the correct tuning procedure for each control. Finally, the Flame Safeguard and Combustion Controls will contain many safety features that must also be addressed in this process. These are not covered in this manual because of the wide variety of controls that can be used. Refer to the specific manual for your control to cover these items.

⚠ DANGER

WATERN LEVEL CONTOLS MUST BE CHECKED FOR PROPER OPERATION. IF THE WATER LEVEL CONTROLS ARE NOT WORKING CORRECTLY, MAJOR EQUIPMENT DAMAGE WILL OCCUR, AND INJURY OR DEATH MAY OCCUR.

8.3.1. Gas Pressure Switches

Adjust the low gas pressure switch to be approximately 10% below the lowest expected gas pressure. Use a gage or manometer at the same point as the low gas pressure switch to determine the lowest gas pressure. At this lowest pressure, adjust the switch until the switch breaks and turns the burner off. From this point, adjust the pressure setting to a point 10% lower than the trip point. Cycle the burner to ensure that it functions properly. If this setting causes nuance shutdowns, reduce the pressure setting.

Adjust the high gas pressure switch to be 10% above the highest expected gas pressure. Use a gage or manometer at the same point as the high gas pressure switch to determine the highest gas pressure. At this highest pressure, adjust the switch until the switch breaks and turns the burner off. From this point, adjust the pressure setting to a point 10% higher than the trip point. Cycle the burner to ensure that it functions properly. If this setting causes nuance shutdowns, increase the pressure setting.

If the gas pressure has pulsations that do not allow the pressure setting to be reasonable close to the operating points, consider adding an orifice block to the control, if the control manufacturer offers one. This will steady out the pressures that the switch sees, and will not trip out because of momentary pulses.

8.3.2. Combustion Air Proving Switch

The combustion air proving switch measures the pressure from the combustion air fan, and is used to prove that the fan is providing air for combustion. It must be adjusted at startup to match the field conditions. At low fire, turn the adjusting screw in (clockwise) until the burner trips out. Then turn the adjusting screw our (ccw) 1 ½ turns from the point of shutdown. Start the burner and verify that it functions properly at all rates.

8.3.3. Operating & Modulating Control

The operating and modulating controls are used to cause the burner to cycle on or off and to modulate in response to load changes. They must be adjusted properly to have the boiler respond properly to the load requirements. See Section 7 for complete details.

8.4. Normal Operation

Normal operation is a term describing the daily automatic operation of the boiler in the system. Prior to normal operation, the boiler must have been properly installed and started by a qualified contractor or combustion specialist. The owner and operating personnel should have received training in the operation and maintenance of the boiler.

If the boiler has been out of serve for a short interval, like overnight or a weekend, the following sequence should be included in the startup sequence. There will be other actions required to support the auxiliary equipment and controls, so these are not all of the actions required. The boiler should be visually inspected for any abnormal conditions. Any problems found should be corrected prior to operation of the boiler.

1. Confirm that the boiler water level is correct.
2. Make sure the on/off switch is off and turn the main power on.
3. Open the main gas shutoff valve, the pilot gas shutoff valve, and other gas valves that may have been closed.
4. Reset low gas pressure switch and any other control requiring a reset after power interruption.

5. Turn on the boiler by placing the on/off switch in the on position.
6. Observe the lighting sequence and turn the on/off switch off in the event of an abnormal occurrence of any kind.
7. Refer to the troubleshooting section of the manual to identify basic problems and call your Sellers Representative for qualified service.

When taking the boiler out of service for a short time, this sequence should be followed in reverse.

9. MAINTENANCE

9.1. GENERAL

The dependable and consistent operation of your Sellers boiler will be maintained as long as a careful maintenance schedule is followed. This section of the manual describes periodic inspection and maintenance requirements.

a. Keep the boiler, the burner, and the entire boiler room clean. Do not allow fuel, water, or steam to leak anywhere. A clean boiler room is essential to reliable boiler operation.
b. Never close vents supplying air to the boiler room when firing the boiler. If cold air currents cause difficulty with other equipment, air ducts should be installed to direct the flow of fresh air.
c. Repair all leaks promptly. All piping connections to the boiler and all accessories should be maintained leak-free because even a minor leak, if neglected, may soon become serious. This applies especially to water level control piping and manhole and hand hole gaskets. If serious leaks occur shut down the boiler immediately and reduce pressure. Close return and supply valves to isolate boiler if the system allows. Do not attempt to make repairs while boiler is under pressure or at a high temperature.

9.2. Safety Checklist for Inspection

The following general procedure should be followed when the boiler needs to be opened for inspection. In addition, the procedure covers the most common areas that an annual inspection would require

a. Before entering a boiler, lock out and tag all equipment items with movable parts connected to boiler and fuel system and place a sign at the operating controls indicating that a workman is in the boiler.
b. Before entering a boiler, make sure it is properly isolated from ALL fuel, flue gas, steam and water sources. Make sure that it is properly vented and obtain an air sample to check for breathing quality. Use low voltage or explosion proof lights.
c. Notify the person in charge at the site when beginning and upon completion of the inspection
d. Inspect with another person so if assistance is required, help will be close at hand
e. Always be aware of the nearest escape routes
f. Before closing manholes and doors, it is essential that all personnel are out of the boiler.

9.3. Water Side Checklist

a. The tubes and tube sheets should be free of deposits and scale buildup. If these exist, the water treatment program is not working correctly and needs to be modified. The scale and deposits must be cleaned off the tubes and tube sheets. In some cases, a chemical cleaning is required to accomplish this. Contact a water treatment specialist for these areas.
b. All internal fittings should be in serviceable condition and securely installed in the correct position.
c. Look for evidence of corrosion. Oxygen pitting on tubes is an indication that the oxygen and other gases are not being removed in the feedwater, and the treatment program must be modified.
d. Look for erosion of mating surfaces of manholes, hand holes and flanges
e. Note the location of trouble spots in the log book and compare to previous log entries to see if they are the same, and have not been corrected by upgrades to the treatment program.
f. The water side (tubes and tube sheets) should be free from extraneous material such as dirt, tools, rags and so on.

9.4. Fire Side Checklist

a. Stack dampers should be examined to have free movement and not show signs of potential corrosion failure.
b. Breechings should be cleaned of dirt and soot
c. The breeching and stack seams should be tight, and there should not be any holes.
d. Record any findings in the log book and compare to previous log entries to determine if corrective actions are needed.

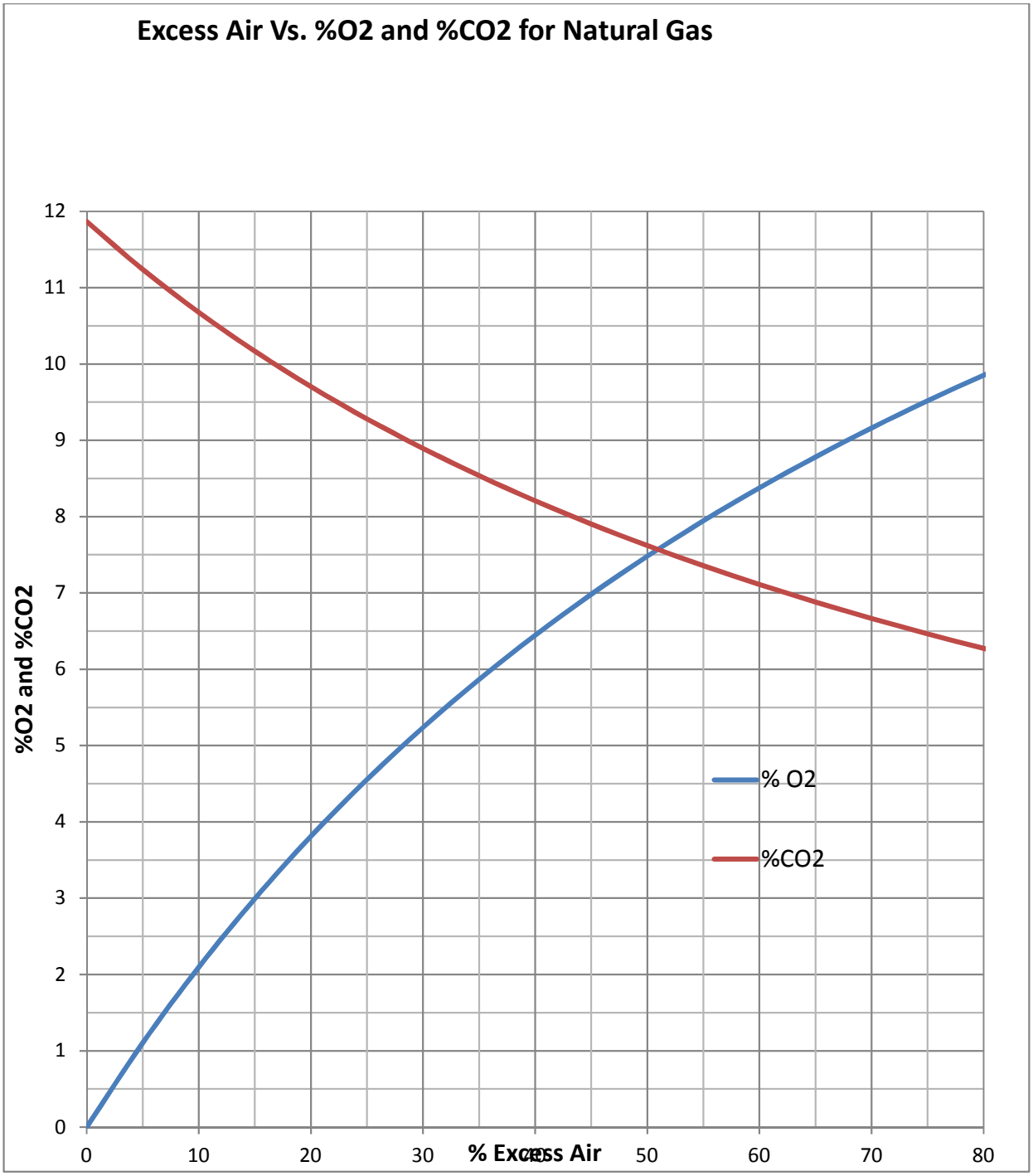
9.5. Maintenance Schedule

Daily	Weekly	Monthly	Seasonal	Annual	Annual As Required	Component / Item	Recommended Action or Test	Boiler Operator	Qualified Technician
X						Burner Flame	Visual inspection of burner flame	X	
X						Air and fuel valve	Smooth and free travel	X	
X						Draft controls	Smooth and free travel	X	
X						Gas fuel pressure	Record in log book, compare trends	X	
X						Pilot flame	Visual inspection of pilot flame	X	
X						Pilot flame signal	Record in log book, compare trends	X	
X						Main flame signal	Record in log book, compare trends	X	
X						Temperatures & pressures	Record in log book, compare trends	X	
X						Check vessel for leaks	Look for leaks in hand hole, manhole, safety valves and other components	X	
X						Fuel leaks	Check for gas leaks by smell	X	
X						Log book data	Enter operating data in log book	X	
	X					Flame failure response	Close pilot manual valve during pilot, verify shutdown		
	X					Flame failure response	Close main manual valve during pilot, verify shutdown		
	X					Pilot turndown test			
	X					Fuel valves	Verify POC action by cycling off if continuous operation	X	
		X				Front door seal	Check front door seal for leakage, adjust or replace	X	
		X				Stack, breeching, draft control	Visual inspection, free operation	X	
		X				Combustion Air	Visual inspection for Clean and open pathways	X	
			X			Combustion Tuning	Verify combustion settings, %O2, Co and NOx		X
				X		Gas line	Check drip leg for material buildup, clean as needed	X	
				X		Burner hardware	Inspect burner hardware, clamps and wiring. Adjust and replace as needed		X
				X		Fuel valve leak tests	Perform leak tests on main and pilot valves		X
				X		Inspect Vessel Fireside	Open front and rear doors and inspect tubes for cleanliness. Clean if required		X
				X		Inspect Vessel Waterside	Open handholes and manholes, inspect waterside. Clean if needed		X
				X		Gas strainer	Remove and clean gas strainer		X
				X		Sight ports	Clean sight port glass, replace if needed	X	
				X		Ignitor	Inspect for wear and replace or adjust		X
				X		Flame rods	Inspect pilot and main flame rods, replace if needed		X
				X		Condensate drain	Check condensate drain line for free flow	X	
				X		Combustion air fan	Clean combustion air fan	X	
					X	Flame safeguard replacement	Replace flame safeguard as recommended		X

10. TROUBLESHOOTING

Problem	Possible Cause
Burner does not start	1. No power to controller A. Main disconnect switch open B. Blown control circuit fuse C. Loose of broken electrical wire D. BMS/EMS system command or signal
	2. Limit circuit not completed, no power at end of limit string A. Pressure or temperature is above setting B. Water level is below required level C. Check manual reset switch on ALWCO (if equipped) D. Fuel pressure out of range (low or high pressure)
	3. Fuel valve interlock circuit not completed A. Fuel interlock switch on gas valve not made B. Loose connection or broken wire
No Ignition in pilot cycle	1. Lack of spark A. Electrode grounded or porcelain cracked B. Improper electrode setting, see Section 6 C. Loose terminal on ignition cable or shorted cable D. Inoperative ignition transformer E. Insufficient or no voltage at pilot ignition circuit terminal.
	2. Spark but no flame A. lack of fuel - no gas pressure, closed valve, broken line first startup … B. Inoperative pilot solenoid C. Insufficient or no voltage at pilot ignition circuit terminal D. Initial startup, gas lines empty E. Too much air (reduce secondary air flow) F. Manual valve closed, blocking gas flow
	3. Running interlock circuit not completed A. Combustion air switch not made or faulty or not set correctly B. Motor starter interlock not closed 4. Insufficient gas flow to fill manifold before time out
	A. Increase ignition rate to increase gas flow B. Increase time allowed before shutdown (within the control, if available)
Pilot flame starts but locks out on trial for pilot flame	1. Pilot flame rod not properly positioned A. Re-position flam rod, see Section 6 2. Flame rod does not work A. Check wiring to and from flame rod B. Replace flame rod 3. Flame too small to operate flame rod A. Adjust pilot flame. The control can be locked in the pilot cycle with a program lock feature to provide more time for adjustments.

Pilot flame but no main flame	1. Insufficient pilot flame A. Pilot gas pressure too low B. Firing rate of burner too high
	2. insufficient gas flow to burner A. Manual gas valve closed B. Main gas valve inoperative C. Flow control valve not properly set (too little flow) D. Gas pressure regulator not properly set E. Initial startup, gas lines empty
	3. Flame rod inoperative
Combustion Noise, pulsations	1. Improper fuel-air ratio A. Excess air too high or low B. Hysteresis causes some high or low excess air during modulation C. Set points too far apart, causing rich/lean zones between points
	2. Secondary air adjustment not correct A. Adjust for smooth operation at all rates. See Section 7.
	3. Improper stack layout A. Draft too high (limit is +/- 0.1"wc) B. Sharp elbows or entries causing flow disruptions C. Draft controls upsetting draft on modulation
Shutdown occurs during firing	1. Loss or restriction of fuel flow or pressure 2. Defective fuel valve, loose connection 3. Weak flame signal, marginal flame detection 4. Safety controls set too close to tripping point 5. Improper fuel-air ratio (too lean) 6. BMS/EMS system command or signal 7. Gas supply quality 8. Improper stack design or rooftop stack issue
Fuel-air-ratio changes	1. Air leak around air damper, fan inlet cone or front door A. Re-seal gaskets
	2. Fuel or air valve sticky, or servo not positioning correctly A. Check fuel and air valve for proper positioning and replace as needed


Excess Air Vs. %O2 and %CO2 for Natural Gas
%O2 and %CO2
% Excess Air
% O2
%CO2
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11. Appendix A

Revision Table Data

Date	Rev. #	Who	Changes Made
3/4/16	0	GT	First Edition
4/11/17	1	DTB	First Released Edition
5/25/17	3	DTB	Call out update
9/7/17	4	DTB	Revised D-756
1/4/18	5	DTB	Removed Appendix A, match all steam manual updates that apply to hot water