MODEL 4 BOILER

1,500 - 6,000 MBTU &
Watertube Boiler

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ILLUSTRATIONS

TABLES

This section contains information on the Model 4 Commercial Watertube Boiler product line for low and high pressure steam applications. Sizes range from 1.5 to 6 MMBtu/hr. The Model 4 Boiler is an excellent choice where high outputs are needed but space limitations exist. The model number designation is 1500 through 6000, representing MBtu/hr input (1,500,000 to 6,000,000 Btu/hr).

Fuel series designation is as follows:

- Series 100: No. 2 oil firing.
- Series 700: Natural gas firing.
- Series 200: No. 2 oil/natural gas firing.

Design pressure designation is stated as 15 psig, 150 psig, and 250 psig for steam. For example, an M4P-700-2500-150ST boiler designates a gas-fired, 2,500,000 Btu/hr, 150 psig, steam boiler.

FEATURES AND BENEFITS

The following features and benefits apply to the Model 4 Boiler product line.

33" Cased Width:

- Boiler fits through most standard doorways.
- Reduced installation costs.

Direct Driven, Vibration-Free Centrifugal Impeller:

- Quiet operation.
- Sound levels below 79 dBA.
- Ideal for noise critical areas such as hospitals, churches, etc.

Minimum Refractory:

- Membrane waterwalls reduce the need for refractory by 95%.
- Reduced maintenance costs and refractory repair requirements.

Membrane Waterwalls:

- Enhanced heat transfer area in compact design.
- Full water wall furnace improves heat transfer for high efficiency.

Small Boiler Footprint:

- Savings of up to 50% in floor space.

Weighs up to 40% less than Comparable Boilers:

- Lower freight and rigging costs.
- Reduced structural requirements.

Standard Built-in Soot Washers:

- Boiler fireside cleaning without shutdown.
- Maintains peak boiler performance.

Packaged Forced Draft Burner:

- High pressure drop design.
- Optimum fuel and air mixing.
- Improved combustion efficiency.

Burner/Windbox Davit:

- Easy access to furnace with swing-open windbox.
- Reduced maintenance costs.

Steam Design Pressures to 500 psig (optional):

- High performance in a compact design.
- Proven vessel design for high design pressure applications.

PRODUCT OFFERING

The Model 4 (M4) Boiler is a compact carbon steel, extended fin, watertube boiler. Heat transfer design is configured in a "3-pass" gas travel across the watertube surfaces. The pressure vessel is constructed to conform to the A.S.M.E. Code, either Section IV for low pressure steam @ 15 PSIG MAWP (maximum allowable working pressure) or Section I for MAWP greater than 15 PSIG.

The vessel (boiler) consists of two rows on each side of the vessel, of formed seamless tubes with extended fin surfaces and downcomers connected to the steam drum and lower drum. To reduce standby losses, the vessel is insulated with a fiberglass blanket and removable steel jacket.

Complete with an integral burner for either No.2 fuel oil or Natural Gas, the complete burner/boiler package is UL Approved, listed, and labeled.

Standard Equipment

The standard boiler/burner package is described below. Optional controls, trim, and devices may be added to meet project requirements. Some of those options are noted following this standards list.

1. Boiler

A. Designed, constructed, and hydrostatically tested in accordance with the A.S.M.E. Boiler and Pressure Vessel Code. The complete vessel is mounted on a structural steel frame.

B. Steam drum includes a hand hole in the rear head for drum water side inspection. Connections are included for the following:

- Feedwater Makeup w/internal dispersion tube.
- Surface Blowoff.
- Steam Supply.
- Safety Relief Valve.

C. Lower Drum includes hand holes at each end for waterside inspection. A drain/blowoff tapping is provided at the front, bottom centerline.

D. Soot washer lances are provided on each side of the vessel between the two rows of tubes for fireside cleaning. Soot washer drains are located at the bottom of the boiler, with connections to drain located on each side of the lower drum at the rear.

E. Refractory is limited to the furnace floor, lower drum, and burner throat tile. High temperature insulation is installed on the front water wall and furnace access door.

F. Two lifting eyes are provided on the top centerline of the upper drum for ease of installation.

G. Furnace inspection/access door is provided in the furnace front wall.

H. The exhaust gas vent is located at the top rear centerline of the boiler. A stack thermometer is shipped loose for field installation by the installing contractor into the stack.

I. The complete vessel is fully insulated (2" fiberglass blanket) under a preformed, sectional steel jacket.

Table B2-1. Model 4 Boiler Sizes

MODEL NO.	INPUT MBH	HEAT OUTPUT MBH	EQUIV HP	STEAM OUTPUT LB/HR	SHIPPING WEIGHT LBS
1500	1500	1200	35	1237	3100
2000	2000	1600	47	1649	3100
2500	2500	2000	59	2062	3700
3000	3000	2400	71	2474	3700
3500	3500	2800	83	2887	4100
4000	4000	3200	95	3299	4100
4500	4500	3600	107	3711	4700
5000	5000	4000	119	4124	4700
6000	6000	4800	143	4949	5400

NOTE: Steam output from and at 212 °F.

J. Factory painted using hard-finish enamel.

2. Forced Draft Burner

A. The burner is a high radiant multi-port type approved for operation on natural gas and a pressure atomizing type approved for operation with commercial grade No. 2 fuel oil.

B. Consisting of the fan which is direct connected to the fan motor, wind box, air damper that is linkage connected to a damper drive motor, the complete assembly is factory mounted and tested.

C. To ensure proper air for pre purge and combustion is provided by the fan, a combustion air proving switch is provided.

D. The complete burner/wind box swings open via a davit arm attached to the upper drum. This permits fireside inspection of the furnace and burner internals.

E. Responding to steam demand from the drum mounted pressure control, the burner operates in the low-high-low-off firing mode. Ultra-violet (UV) flame scanner is provided for flame presence during firing.

F. An Ignition transformer is provided.

G. Ignition is direct spark on straight oil fired burners, and gas pilot on straight gas or combination gas/oil burners.

H. Oil Train consists of the following:

- 4 Solenoid Shutoff Valves providing low fire, intermediate transitional firing from low to high and high fire.
- An oil pump is mounted (belt driven from the fan motor) for pressure atomization of the fuel oil.
- Oil Pressure Gauge.
- Suction and return tubing connected to an oil connection block.

Gas Train consists of the following:

- Primary gas shutoff valve with integral proof of closure switch.
- A manual shutoff valve located ahead of the primary gas valve.
- A plugged leakage test connection and a second manual shutoff valve for tightness checking of the primary shutoff valve.
- Separate Gas Pressure Regulators for the pilot train and main gas train.
- Low Gas Pressure and High Gas Pressure Switches for units at 3000 and greater.
- A second motorized gas valve is provided in addition to the primary valve on size 6000 units.
- The pilot gas train includes a manual shutoff valve and solenoid shutoff valve.

3. Boiler Trim and Controls

A. 15 psig or 150 psig set A.S.M.E. safety relief valves.

B. Steam pressure gauge with inspectors test cock and connection.

C. Primary Water Column complete with gauge glass and column drain valve.

D. Low Water cutoff switch and pump control switch, integrally mounted in the primary water column.

E. Auxiliary Low Water Cutoff, manual reset type.

F. Steam Pressure Controls:

- Operating Limit.
- Excess Steam Pressure (High Limit), manual reset.
- Burner firing rate, low high low.

4. Burner Control Panel and Controls

A. The control panel is enclosed within a NEMA 1A Rated enclosure, mounted on the burner wind box at approximately eye level height.

B. Mounted within or on the control panel box are the following controls. Panel wiring is factory tested.

- Combustion Flame Safeguard Control, Model CB120 that provides pre purge, post purge, trial for ignition, main flame/burner operation, and safety shutdown.
- Fan Motor Starter wired into the non recycling circuit of the flame safeguard control.
- Indicating Lights for low water, flame failure, load demand, and fuel valve on.
- Burner On/Off Switch.
- Damper Positioning Switch.
- Fuel Selector Switch for combination fuel fired burners.
- Control Circuit Step-down Transformer with primary fuse protection.
- Terminals for interface wiring connection of controls.
- Oil, heat, and moisture resistant wire used. Each wire is number coded relative to the wiring diagram.

5. Electric Service Panel

An electric service panel (entrance box) is provided on the side of the boiler for all external wiring connections to remote control devices and the main power for the boiler. Wiring to this panel eliminates the need to disconnect wiring when the front burner wind box is opened for burner or boiler servicing.

Optional Equipment

For more detailed information on optional equipment, contact your local Cleaver-Brooks authorized representative. In summary, options include the following:

1. Boiler
   - Larger pressure gauges or specific manufacturer type.
   - Bottom Drain Valves for low pressure applications.
   - Bottom Blowoff Valves for high pressure applications.
   - Surface Blowoff Valve with internal collector pipe.
   - Feedwater Stop and Check Valves.
   - Steam Stop Valve.
   - ASME Hydro Test of Valves and Valve Piping.
   - Design pressures above 150 PSIG.
2. Burner/Control Options
   - Full Modulation Firing on Gas.
   - Lead/Lag Control.
   - Day-Night Controls.
   - Low Fire Hold Control.
   - Elapsed Time Meter.
   - Alarm with silence switch.
   - Additional Indicator Lights.
   - Main Power Disconnect.
   - Remote Oil Pump.
   - Optional NEMA Enclosures.
   - Special Fan Motor requirements (TEFC).
3. Fuel Options
   - Automatic Fuel Changeover (combination burner).
   - Propane Fuel Firing.
   - Special Gas Pressure Regulators.
   - Special fuel shut-off valves.
   - Dual Pilots (gas and oil).
   - Gas strainer.

Insurance/Codes

The boiler package can be equipped to meet various insurance or code requirements. Some of these insurance/code requirements are:

- Factory Mutual (FM)
- XL GAP (Formerly GE GAP/IRI).
- A.S.M.E. CSD-1.

A. Factory Mutual (FM Global) - Recommended guidelines as described by FM pertain to boilers rated at greater than 2.5 MMBtu/hr input on gas and 2.8 MMBtu/hr input on oil. Boilers that are labeled and tested in accordance with an independent testing lab such as UL or CSA and are below these inputs are exempt from these recommendations.

The Model 4 boiler is UL listed and labeled. In addition to the standard UL requirements the following are needed to comply with FM when required.

- Alarm Bell with silence switch for low water and safety shutdowns.
- Low Oil Pressure Switch if the oil pump is not direct driven from the fan motor.

B. XL GAP (Formerly GE GAP/IRI) Recommended guidelines as described by XL GAP pertain to boilers rated at 400,000 Btu/hr input to 12.0 MMBtu/hr input. For

these boilers, the requirements are the same as for A.S.M.E CSD-1 requirements. Above 12.0 MMBtu/hr input, the requirements defer to the NFPA 85 standards for single burner boilers.

C. A.S.M.E. CSD-1 - Recommended guidelines as described by this Code pertain to boilers rated at 400,000 Btu/hr input to 12.0 MMBtu/hr input. Above 12.0 MMBtu/hr input, the requirements defer to the NFPA 85 standards for single burner boilers. For the sizes this Code covers, the requirements are as follows, in addition to the standard UL package:

- Low Oil Pressure Switch for oil firing
- ¾" Pressure Control Piping
- If gas supply is > 5 psig, a relief valve is required after the gas pressure regulator in the main and pilot gas trains.
- Lever Handled shutoff cock for the pilot gas train.
- Non-fused disconnect to remove boiler from all sources of power.

DIMENSIONS AND RATINGS

For layout purposes, the nominal dimensions and connections for the Model 4 Standard Package Boiler are shown in Figure B2-1 and Table B2-2. Ratings of each boiler size are noted in Table B2-3. Additional information is shown in the following figures, tables, and illustrations.

Table B2-4: Recommended steam nozzle sizes for high pressure boilers operating at lower and higher pressures.

Figure B2-2: Standard gas train dimensions and components.

Table B2-5: Natural Gas Pressure Requirements, standard gas train size.

Table B2-6: Natural Gas Pressure Requirements, oversized gas train.

Table B2-7: Propane Gas Pressure Requirements, standard gas train size.

Table B2-8: Propane Gas Pressure Requirements, oversized gas train.

Table B2-9: Safety Valve Outlet Sizes.

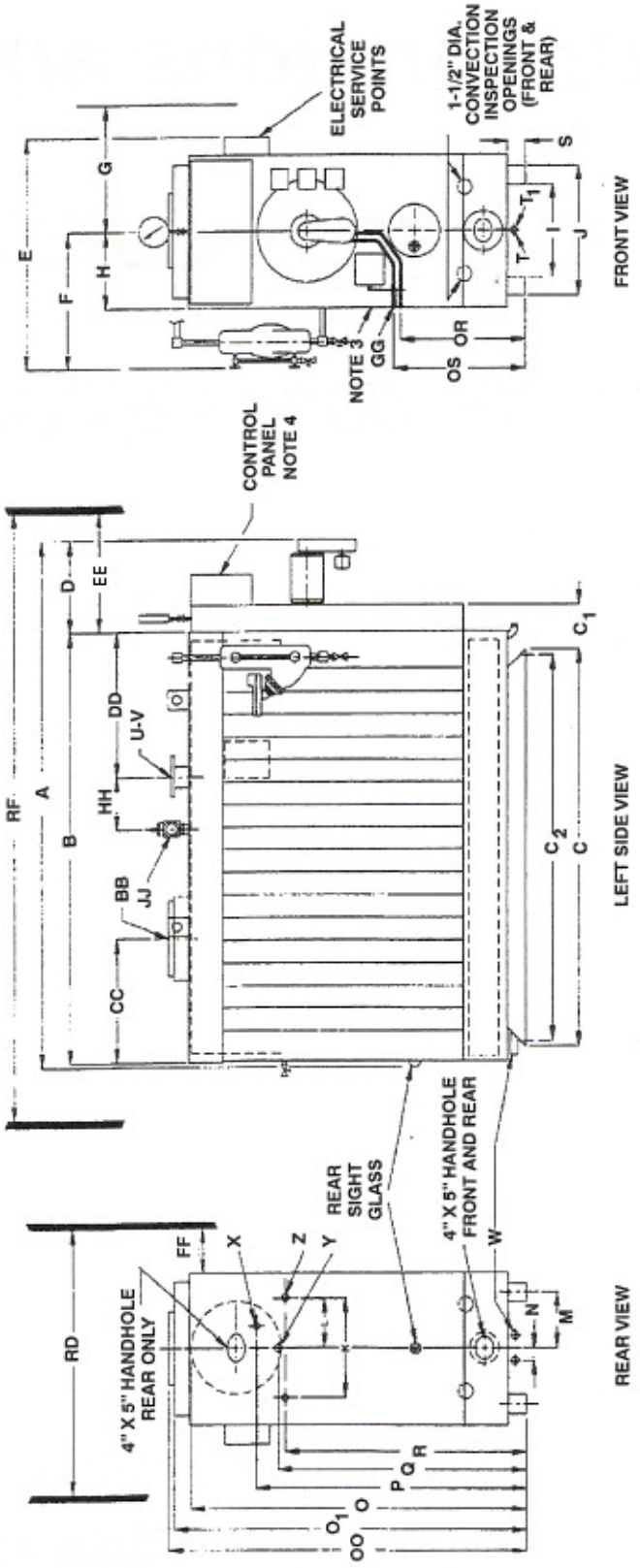

ELECTRICAL SERVICE POINTS
1-1/2" DIA. CONVECTION INSPECTION OPENINGS (FRONT & REAR)
FRONT VIEW
CONTROL PANEL NOTE 4
LEFT SIDE VIEW
REAR SIGHT GLASS
4" X 5" HANDHOLE FRONT AND REAR
4" X 5" HANDHOLE REAR ONLY
REAR VIEW
NOTE 3

Table B2-2. Model 4 Dimensions

		Boiler Size								
	Note 1	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**
		All Dimensions are in inches								
	Lengths									
A	Overall	84.25	84.25	100.25	100.25	117.375	117.375	136.75	136.75	152.375
B	Pressure Vessel w/casing	61	61	77	77	92.375	92.375	109	109	124.625
C	Base Frame	54	54	69.625	69.625	85.25	85.25	101	101	116.5
C_1	Base to Burner/Windbox	9.625	9.625	9.625	9.625	9.625	9.625	10	10	10
C_2	Base Frame Anchor Holes	51.5	51.5	67.125	67.125	82.75	82.75	98.375	98.375	114
CC	Rear Casing to Stack Connection	25.8	25.8	26.25	26.25	26.25	26.25	30.375	30.375	30.375
D	Burner/Windbox Extension	20.1	20.1	20.1	20.1	21.9	21.9	24.6	24.6	24.6
DD	Front Casing to Steam Nozzle	17.25	17.25	25.25	25.25	30.75	30.75	37.375	37.375	45.25
HH	Steam Nozzle to Safety Valve 15#	8	8	12	12	11.5	11.5	13	13	17
	Steam Nozzle to Safety Valve 150#	8	8	12	12	17	17	17	17	17
	Widths									
E	Overall	53.25	53.25	53.25	53.25	53.25	53.25	53.25	53.25	53.25
F	Center to Water Column	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4
G	Center to Opt. Aux. Water Column	26.6	26.6	26.5	26.6	26.6	26.6	26.6	26.6	26.6
H	Center to Outside Casing	16.375	16.375	17.375	16.375	16.375	16.375	16.375	16.375	16.375
I	Base Frame Inside	20	20	20	20	20	20	20	20	20
J	Base Frame Outside	28	28	28	28	28	28	28	28	28
K	Soot Washers, Center to Center	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4
L	Boiler Centerline to Soot Washer	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7
M	Boiler Centerline to Base Centerline	12	12	12	12	12	12	12	12	12
N	Boiler Centerline to Soot Drain	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25
	Heights									
OO	Overall [Base to Stack Connection]	78.75	78.75	78.75	78.75	78.75	78.75	78.75	78.75	78.75
O	Base to Steam Nozzle 150#	74.75	75.75	74.75	74.75	74.75	74.75	78	78	78
O	Base to Steam Nozzle 15#	75	75	75	75	78.25	78.25	78.25	78.25	78.25
O_1	Base to Stack Box.	77.8	77.8	77.8	77.8	77.8	77.8	77.8	77.8	77.8
O_2	Base to Top of Control Panel	83.25	83.25	83.25	83.25	83.25	83.25	83.25	83.25	83.25
P	Base to Surface Blowoff	59.25	59.25	59.25	59.25	59.25	59.25	59.25	59.25	59.25
Q	Base to Feedwater Inlet	57.25	57.25	57.25	57.25	57.25	57.25	57.25	57.25	57.25
R	Base to Soot Washer Lance	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5
S	Height of Base	4	4	4	4	4	4	4	4	4
OS	Base to Oil Supply Connection	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75
OR	Base to Oil Return Connection	25.75	25.75	25.75	25.75	25.75	25.75	25.75	25.75	25.75
	Connections									
BB.	OD Stack - Sleeve Connection	12	12	12	12	12	12	16	16	16
T	Bottom Drum Blow Down, 15# [one]	1.25	1.25	1.25	1.25	1.5	1.5	1.5	1.5	1.5
T_1	Bottom Drum Blow Down, 150# [one]	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
U	Steam Nozzle, 15#	4[A]	4[A]	4[A]	4[A]	6[B]	6[B]	6[B]	6[B]	6[B]
V	Steam Nozzle, 150#	2.5[A]	2.5[A]	3[A]	3[A]	3[A]	3[A]	4[B]	4[B]	4[B]
W	Soot Washer Drains [Two]	2	2	2	2	2	2	2	2	2
X	Surface Blow off [One]	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Y	Feedwater Inlet [One]	1	1	1	1	1	1	1	1	1
Z	Soot Washer [Two]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
GG	Oil Supply and Return	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
JJ	Relief Valve, 15#	2	2	2	2	2	2.5	2.5	2.5	3
	Relief Valve, 150#	1	1.25	1.25	1.25	1.5	1.5	1.5	1.5	2
	Clearances									
EE	Burner/Windbox Swing	33	33	33	33	33	33	33	33	33
FF	Tube removal each side	30	30	30	30	30	30	30	30	30
RF	Allowance for Burner/Windbox Swing and 30" Rear Aisle Space.	124	124	140	140	155	155	172	172	187
RD	Allowance for Tube Removal Each Side and Burner/Windbox Swing.	93	93	93	93	93	93	93	93	93

NOTES:
1. The above dimensions, while sufficiently accurate for layout purposes, must be confirmed for construction via certified prints. For 200 PSIG design pressure and greater, contact Milwaukee Sales for certified prints.
2. Allow sufficient space at rear of boiler for removal of soot washer lance.
3. For access to the furnace, a 13" x 21" access door is provided behind the front door.
4. Control Panel may be larger (up to 4" in height) if certain control options are provided.

A. Connection is a Female Pipe Thread.

B. Connection is a 150# Flange, Flat Face.

Table B2-3. Model 4 Steam Ratings

Boiler SIZE	1500	2000	2500	3000	3500	4000	4500	5000	6000
Ratings [Note A]									
Rated Capacity - Steam (lbs. steam/hr from & at 212° F.)	1,237	1,649	2,062	2,474	2,887	3,299	3,711	4,124	4,949
Rated Steam Capacity [kg/hr from and at 100 C]	461.7	615.5	769.6	923.4	1,077.5	1,231.3	1,385.0	1,539.2	1,847.2
Output Btu/hr [1,000 Btu/h]	1,200	1,600	2,000	2,400	2,800	3,200	3,600	4,000	4,800
Output Kcal/Hr [1,000 Kcal/h]	302	403	504	605	706	806	907	1,007	1,210
Output KW	348	464	580	696	812	928	1,044	1,160	1,392
Approximate Fuel Consumption At Rated Capacity [Input - Note B]									
Natural Gas [ft^3/hr] - 15# Steam	1,511	1,538	2,500	3,038	3,487	4,025	4,494	5,050	6,052
Natural Gas [ft^3/hr] - 150# Steam	1,572	2,133	2,597	3,117	3,590	4,155	4,657	5,194	6,233
Natural Gas [m^3/hr] - 15# Steam	42.8	43.5	70.8	86	98.7	114.0	127.0	143.0	171.4
Natural Gas [m^3/hr] - 150# Steam	44.5	60.4	73.5	88.3	101.6	117.6	131.8	147.0	176.5
Propane Gas [ft^3/hr] - 15# Steam	604	615	1,000	1,215	1,395	1,610	1,798	2,020	2,421
Propane Gas [ft^3/hr] - 150# Steam	629	853	1,039	1,247	1,436	1,662	1,863	2,078	2,493
Propane Gas [m^3/hr] - 15# Steam	17	17.4	28.3	34.4	39.5	45.6	51	57.2	68.5
Propane Gas [m^3/hr] - 150# Steam	17.8	24.1	29.4	35.3	40.7	47	52.7	58.8	70.6
No.2 Oil Fuel - 15# Steam, gph	10	14	17	21	24	28	31	35	42
No.2 Oil Fuel - 150# Steam, gph	11	15	18	22	25	28.9	32	36	43
No.2 Oil Fuel - 15# Steam, liters/hour	38	53	64	79	91	106	117	132	159
No.2 Oil Fuel - 150# Steam, liters/hour	41	56	68	82	95	109	121	136	163
Power Requirements - 3 Phase 60 Hz Standard [Note C]									
Blower Motor HP - Gas Firing	3/4	1	1-1/2	2	2	3	3	3	5
Blower Motor HP - Oil or Combination	1-1/2	1-1/2	2	2	3	5	3	3	5
Oil Pump for Oil or Combination	← Belt Driven from the Blower Motor →								
Minimum Ampacity									
Blower Motor - Gas Firing Only, 230V	1.53	3.3	4.7	6	6	9	9	9	15
Blower Motor - Gas Firing Only, 460V	0.77	1.7	2.4	3	3	4.5	4.5	4.5	7.5
Blower Motor - Oil or Combination, 230V	4.7	4.7	6	6	9	15	9	9	15
Blower Motor - Oil or Combination, 460V	2.4	2.4	3	3	4.5	7.5	4.5	4.5	7.5
Control Circuit	1.7	1.7	1.7	1.9	1.9	1.9	2.4	2.4	2.4
Weights									
Operating Weight, lbs.	3,758	3,758	4,566	4,566	5,175	5,175	5,991	5,991	6,900
Operating Weight, kg	1,399	1,399	1,704	1,704	1,932	1,932	2,236	2,236	2,575
Water Content Normal, gallons	79	79	104	104	130	130	156	156	181
Water Content Normal, liters	299	299	394	394	492	492	591	591	685
Water Content Flooded, gallons	109	109	145	145	177	177	213	213	245
Water Content Flooded, liters	413	413	549	549	670	670	806	806	927
Shipping Weight, approximate lbs.	3,100	3,100	3,700	3,700	4,100	4,100	4,700	4,700	5,400
Shipping Weight, approximate kg	1,157	1,157	1,381	1,381	1,530	1,530	1,754	1,754	2,015

Notes:

A. Ratings shown for elevation to 1000 Feet. For ratings above 1000 Feet, contact your local Cleaver-Brooks Representative.

B. Input calculated with Nat. Gas @ 1000 Btu/ft^3, Propane @ 2500 Btu/ft^3, and Oil @ 140,000Btu/gal.

C. For altitudes above 1000 Feet, contact your local Cleaver-Brooks authorized representative for verification of capacity rating.

Table B2-4. Recommended Steam Nozzle Size (to maintain 4000 to 5000 fpm nozzle velocity)

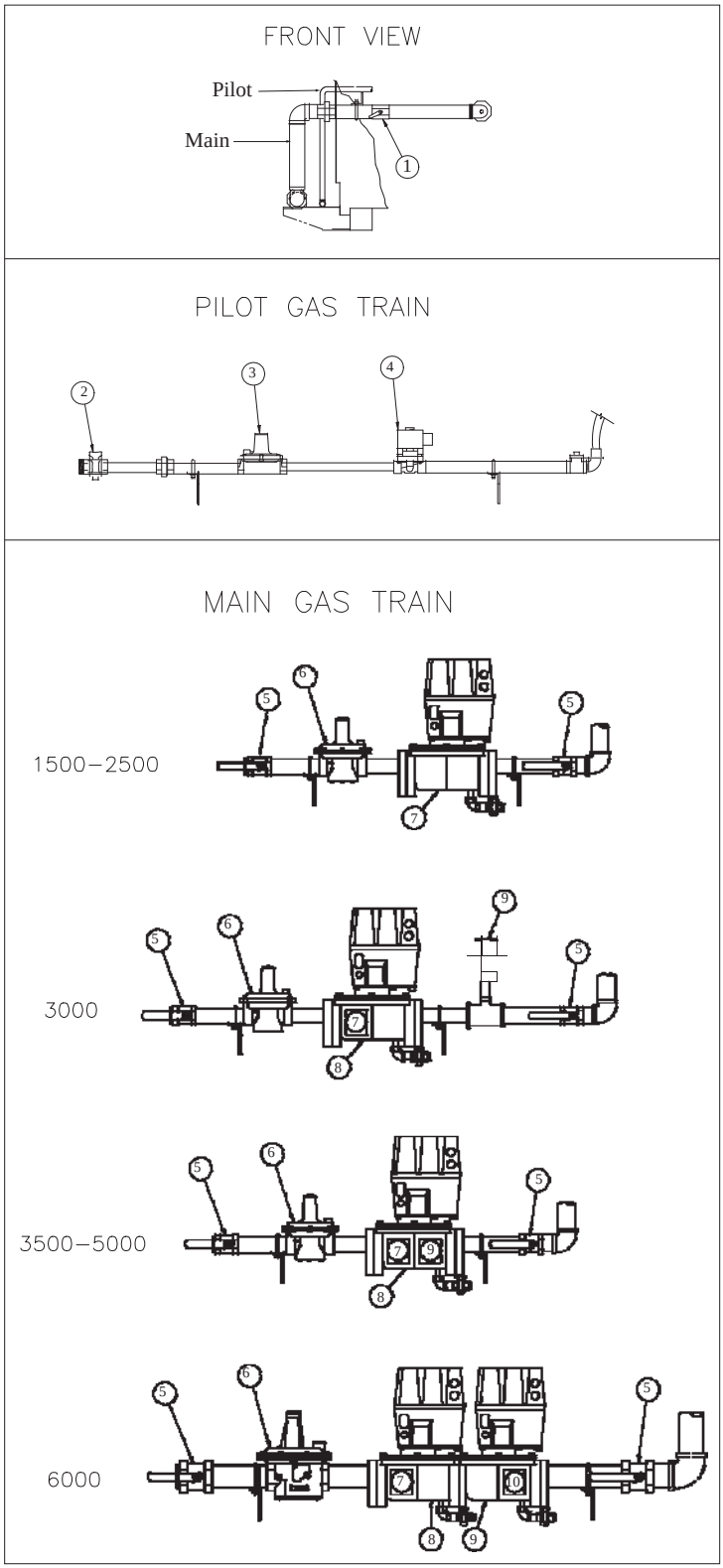
Operating Pressure (PSIG)	BOILER SIZE								
	1500	2000	2500	3000	3500	4000	4500	5000	6000
15	4	4	6	6	6	6	8	8	8
20	3	4	4	6	6	6	8	8	8
30	3	4	4	4	4	6	6	6	6
40	2-1/2	3	3	4	4	4	6	6	6
50	2-1/2	3	3	4	4	4	4	4	6
65	2-1/2	2-1/2	3	3	3	4	4	4	4
75	2-1/2	2-1/2	3	3	3	4	4	4	4
95 - 125[A]	2-1/2	2-1/2	3	3	3	3	4	4	4
150	1-1/2	2	2	2-1/2	2-1/2	2-1/2	3	3	3
200	1-1/2	1-1/2	1-1/2	2	2	2-1/2	2-1/2	2-1/2	3
250 - 400	1-1/2	1-1/2	1-1/2	1-1/2	2	2	2	2	2-1/2

A. Standard nozzle size for 150 PSIG MAWP Boiler Design

Example 1: Size 3500, 150# boiler to operate @ 30 PSIG requires 4" steam nozzle in lieu of standard 3" nozzle.

Example 2: Size 3500, 150# boiler to operate @ 200 PSIG requires 2" steam nozzle in lieu of standard 2-1/2" nozzle.

Figure B2-2. Model 4 Standard Pilot and Main Gas Trains



ITEM	PART DESCRIPTION	SIZES INCHES
Sizes 1500 TO 2500		
1	Butterfly Valve	1-1/2
2	Pilot Shutoff Cock	1/2
3	Pilot Gas Regulator	1/2
4	Pilot Solenoid Valve	1/2
5	Manual Shutoff Valve	1-1/2
6	Main Gas Regulator	1-1/2
7	Motorized Valve with P.O.C.	1-1/2
Size 3000		
1	Butterfly Valve	1-1/2
2	Pilot Shutoff Cock	1/2
3	Pilot Gas Regulator	1/2
4	Pilot Solenoid Valve	1/2
5	Manual Shutoff Valve	1-1/2
6	Main Gas Regulator	1-1/2
7	Low Gas Pressure Switch	1/4
8	Motorized Valve with P.O.C.	1-1/2
9	High Gas Pressure Switch	1/4
Sizes 3500 to 5000		
1	Butterfly Valve	2
2	Pilot Shutoff Cock	1/2
3	Pilot Gas Regulator	1/2
4	Pilot Solenoid Valve	1/2
5	Manual Shutoff Valve	2
6	Main Gas Regulator	2
7	Low Gas Pressure Switch	1/4
8	Motorized Valve with P.O.C.	2
9	High Gas Pressure Switch	1/4
Size 6000		
1	Butterfly Valve	2
2	Pilot Shutoff Cock	1/2
3	Pilot Gas Regulator	1/2
4	Pilot Solenoid Valve	1/2
5	Manual Shutoff Valve	2
6	Main Gas Regulator	2-1/2
7	Low Gas Pressure Switch	1/4
8	Motorized Valve (std)	2
9	Motorized Valve with P.O.C.	2
10	High Gas Pressure Switch	1/4

Table B2-5. Minimum required* NATURAL GAS *pressure at entrance to* STANDARD *UL, FM, & XL GAP gas trains (upstream of gas pressure regulator)

BOILER SIZE	INLET PIPE SIZE (inches)	HONEYWELL VALVE SIZE (inches)	PRESSURE REQUIRED		REQUIRED FUEL FLOW (SCFH)
			MIN ("W.C.)	MAX ("W.C.)	
1500	1.5	1.5	4.4	28.0	1500
2000	1.5	1.5	8.4	28.0	2000
2500	1.5	1.5	12.9	28.0	2500
3000	1.5	1.5	17.1	28.0	3000
3500	2.0	2.0	11.3	28.0	3500
4000	2.0	2.0	13.6	28.0	4000
4500	2.0	2.0	12.2	28.0	4500
5000	2.0	2.0	16.8	28.0	5000
6000	2.0	2.0	21.5	28.0	6000

Note: For altitude above 1000 feet, contact your local Cleaver-Brooks representative.
Natural Gas @ 1000 Btu/cu-ft, specific gravity @ 0.65

Table B2-6. Minimum required* NATURAL GAS *pressure at entrance to* OVERSIZED *UL, FM, & XL GAP gas trains (upstream of gas pressure regulator)

BOILER SIZE	INLET PIPE SIZE (inches)	HONEYWELL VALVE SIZE (inches)	PRESSURE REQUIRED		REQUIRED FUEL FLOW (SCFH)
			MIN ("W.C.)	MAX ("W.C.)	
1500	2.0	2.0	2.3	28.0	1500
2000	2.0	2.0	4.8	28.0	2000
2500	2.0	2.0	6.5	28.0	2500
	2.5	2.5	5.7		
3000	2.0	2.0	9.0	28.0	3000
	2.5	2.5	6.8		
	3.0	3.0	6.0		
3500	2.5	2.5	9.7		3500
	3.0	3.0	7.1		
4000	2.5	2.5	11.8		4000
	3.0	3.0	8.5		
4500	2.5	2.5	9.8		4500
	3.0	3.0	5.6		
5000	2.5	2.5	12.9	28.0	5000
	3.0	3.0	7.1		
	4.0	4.0	5.6		
6000	2.5	2.5	17.5	28.0	6000
	3.0	3.0	10.0		
	4.0	4.0	7.9		

Note: For altitude above 1000 feet, contact your local Cleaver-Brooks representative.
Natural Gas @ 1000 Btu/cu-ft, specific gravity @ 0.65

Table B2-7. Minimum required* PROPANE GAS *pressure at entrance to* STANDARD *UL, FM, & XL GAP gas trains (upstream of gas pressure regulator)

BOILER SIZE	INLET PIPE SIZE (inches)	HONEYWELL VALVE SIZE (inches)	PRESSURE REQUIRED		REQUIRED FUEL FLOW (SCFH)
			MIN ("W.C.)	MAX ("W.C.)	
1500	1.5	1.5	6.7	28.0	600
2000	1.5	1.5	10.5	28.0	800
2500	1.5	1.5	13.3	28.0	1000
3000	1.5	1.5	17.0	28.0	1200
3500	2.0	2.0	14.3	28.0	1400
4000	2.0	2.0	16.5	28.0	1600
4500	2.0	2.0	14.8	28.0	1800
5000	2.0	2.0	16.4	28.0	2000
6000	2.0	2.0	19.6	28.0	2400

Note: For altitude above 1000 feet, contact your local Cleaver-Brooks representative.
Propane @ 2500 Btu/cu-ft, specific gravity @ 1.6

Table B2-8. Minimum required* PROPANE GAS *pressure at entrance to* OVERSIZED *UL, FM, & XL GAP gas trains (upstream of gas pressure regulator)

BOILER SIZE	INLET PIPE SIZE (inches)	HONEYWELL VALVE SIZE (inches)	PRESSURE REQUIRED		REQUIRED FUEL FLOW (SCFH)
			MIN ("W.C.)	MAX ("W.C.)	
1500	2.0	2.0	5.9	28.0	600
2000	2.0	2.0	9.0	28.0	800
2500	2.0	2.0	10.8	28.0	1000
	2.5	2.5	10.5		
3000	2.0	2.0	13.8	28.0	1200
	2.5	2.5	12.9		
	3.0	3.0	12.6		
3500	2.5	2.5	13.6		1400
	3.0	3.0	12.6		
4000	2.5	2.5	15.8		1600
	3.0	3.0	14.5		
4500	2.5	2.5	13.8		1800
	3.0	3.0	12.1		
5000	2.5	2.5	14.8	28.0	2000
	3.0	3.0	12.5		
	4.0	4.0	12.0		
6000	2.5	2.5	18.0	28.0	2400
	3.0	3.0	15.0		
	4.0	4.0	14.1		

Note: For altitude above 1000 feet, contact your local Cleaver-Brooks representative.
Propane @ 2500 Btu/cu-ft, specific gravity @ 1.6

Table B2-9. Safety valve outlet size

Boiler Size	SAFETY VALVE SETTING					
	15 PSIG STEAM			150 PSIG STEAM		
	VALVES REQ'D	OUTLET SIZE (IN.)**	VALVE CAPACITY	VALVES REQ'D	OUTLET SIZE (IN.)**	VALVE CAPACITY
1500	1	2	3161 lbs/hr	1	1	1651 lbs/hr
2000	1	2	3161 lbs/hr	1	1-1/4	2585 lbs/hr
2500	1	2	3161 lbs/hr	1	1-1/4	2585 lbs/hr
3000	1	2	3161 lbs/hr	1	1-1/4	2585 lbs/hr
3500	1	2	3161 lbs/hr	1	1-1/2	4240 lbs/hr
4000	1	2-1/2	4676 lbs/hr	1	1-1/2	4240 lbs/hr
4500	1	2-1/2	4676 lbs/hr	1	1-1/2	4240 lbs/hr
5000	1	2-1/2	4676 lbs/hr	1	1-1/2	4240 lbs/hr
6000	1	3	6942 lbs/hr	1	2	6596 lbs/hr

** Female Pipe Thread Connection [FPT]

PERFORMANCE DATA

Efficiency

Efficiency data provided in Table B2-10 is based on low pressure steam operation. For high pressure steam operation contact your local Cleaver-Brooks authorized representative for expected efficiency data.

Table B2-10. Predicted efficiency, 10 psig operating (includes radiation and convection losses)

Boiler Size	Gas Fuel		Oil Fuel	
	Firing Rate		Firing Rate	
	Low Fire	High Fire	Low Fire	High Fire
1500	81.6	81.9	84.1	84.4
2000	81.1	80.0	83.6	82.5
2500	81.6	81.5	84.1	84.0
3000	81.3	80.3	83.8	82.8
3500	81.6	81.5	84.1	84.0
4000	81.3	80.7	83.8	83.0
4500	81.1	80.9	83.6	83.4
5000	81.3	80.0	83.8	82.5
6000	81.6	79.8	84.1	82.4

Emissions

The following tables give typical emission levels for Nature Gas and No. 2 Oil. Please contact your local Cleaver-Brooks authorized representative if an emission guarantee is required.

Table B2-11. Model 4 emission data - Natural Gas

POLLUTANT		UNCONTROLLED
CO	ppm	xx200
	lb/MMBtu	0.15
NOx	ppm	100
	lb/MMBtu	0.12
SOx	ppm	1
	lb/MMBtu	0.001
HC/ VOCs	ppm	40
	lb/MMBtu	0.016
PM	ppm	–
	lb/MMBtu	0.01

Table B2-12. Model 4 emission data - No. 2 Oil

POLLUTANT		UNCONTROLLED
CO	ppm	90
	lb/MMBtu	0.07
NOx	ppm	187
	lb/MMBtu	0.248
SOx	ppm	270
	lb/MMBtu	0.515
HC/ VOCs	ppm	50
	lb/MMBtu	0.025
PM	ppm	–
	lb/MMBtu	0.025

NOTES:
Based on fuel oil constituent levels:
Fuel bound nitrogen = 0.05% (max) by weight.
Sulfur = 0.5% (max) by weight.
Ash = 0.01% (max) by weight.

ENGINEERING DATA

The following engineering information is provided for the Model 4 steam boiler. Additional information may be obtained from your local Cleaver-Brooks authorized representative.

Feedwater

Steam boilers require make-up water for steam production. This make-up can be a combination of condensate return and raw make-up, 100% condensate return or 100% raw make-up. Proper treatment of make-up water and boiler water is essential to the longevity and performance of the boiler. Table B2-13 shows the rate of make-up required and Table B2-14 shows the recommended water quality guidelines.

As a minimum, raw make-up should be piped into a water softener and then to a feed tank, which also can be the container that receives the system condensate returns. Chemical feed is recommended to be fed via a quill into the water make-up line feeding the boiler.

Table B2-13. Feedwater makeup rates

Boiler Size	Gallons/Minute
1500	2.5
2000	3.3
2500	4.1
3000	5
3500	5.8
4000	6.6
4500	7.5
5000	8.3
6000	9.9

Table B2-14. Water quality parameters

Parameter	Boiler Water Limit
pH	8.3 - 10.5
Iron	0.1 ppm
Oxygen	0.1 mg/liter
Specific Conductivity	2000 µmho/cm
Suspended Solids	300 ppm
Total Hardness	0 ppm as $CaCO_3$

Blowdown

As steam is produced, unwanted solids are left behind in the boiler water and become concentrated within the vessel. If these constituents are allowed to adhere to the heat transfer surfaces, they will impede the flow of energy into the water. Their removal requires proper blowdown that will include bottom and possibly surface blowoff. For proper TDS control, surface blowoff with a TDS monitoring device is recommended. Local codes will dictate the manner of treating the blowdown affluent.

Boiler Stacks

General - The Model 4 boiler operates with a positive vent pressure and a vent gas temperature that is non-condensing. Therefore, the stack must be a positive pressure design.

Proper design and installation of the flue gas venting is critical to efficient and safe operation of the burner. The vent should be designed with proper supports and clearances from combustible materials. Use insulated vent pipe spacers where the vent passes through walls and roofs.

The design of the stack and breeching must provide the required draft at each boiler stack connection. Although constant pressure at the flue gas outlet is not required, it is necessary to size the breeching and stack to limit flue gas pressure variations. Consideration of the draft must be given where lengthy runs of breeching or unusually high stacks are employed. Please note: the allowable pressure range for design of the stack and breeching is negative 0.25" w.c. (-62 Pa) to a positive 0.25" w.c. (+62 Pa) for proper light offs and combustion. **NOTE:** This pressure range does not pertain to the boiler room; that is, the boiler room must be neutral or slightly positive, never negative when using air from the boiler room for combustion.

When two or more Model 4 boilers are connected to a common breeching/stack, one should evaluate the affects of pressure variations that may occur during boiler sequencing while boilers are firing. It may be determined that some type of mechanical draft system be employed to ensure proper draft at each boiler is maintained.

Combustion Air - The burner for each boiler must be supplied with adequate volume of uncontaminated air to support proper combustion and equipment ventilation. Air shall be free of chlorides, halogens, fluorocarbons, construction dust or other contaminants that are detrimental to the burner or boiler heating surfaces.

Combustion air can be supplied by means of conventional venting, that is, with combustion air drawn from the area immediately surrounding the boiler (boiler

room is neutral or slightly positive pressure), or with a direct vent to outside the boiler room where air is drawn directly from the exterior of the building. Regardless of the method, all installations must comply with NFPA 54 (National Fuel Gas Code - NFGC) for U.S. installations and CAN/CSA B149/.1 and B149.2 for Canadian installations.

Engineered Design - When determining boiler room air requirements for the boiler, the "Engineered Design" method may be used. Following this method, consideration must be given to the size of the boiler room, airflow, and air velocity as follows:

A. Two permanent air supply openings in the outer walls of the boiler room are recommended. Locate one at each end of the boiler room, preferably below a height of 7 feet. This allows air to sweep the length of the boiler. Refer to Figure B2-3.

B. Air supply openings can be louvered for weather protection, but they should not be covered with a fine mesh wire, as this type of covering has poor air flow qualities and is subject to clogging with dirt and dust.

C. A vent fan in the boiler room is not recommended as it could create a slight vacuum under certain conditions and cause variations in the quantity of combustion air. This can result in unsafe burner performance.

D. It is forbidden to have the total area of the air supply openings at less than one square foot.

E. Size the openings by using the formula (Area in $ft^2 = cfm_a/fpm_a$), where $cfm_a =$ cubic feet per minute of air; $fpm_a =$ feet per minute of air.

F. Amount of air required (cfm):

1. Combustion Air = Maximum boiler horsepower (bhp) times 8 cfm.

2. Ventilation Air = Maximum boiler horsepower (bhp) times 2 cfm.

3. Total Air = 10 cfm per bhp (up to 1000 feet elevation, add 3% more per 1000 feet of added elevation).

G. Acceptable air velocity in the boiler room (fpm):

1. From floor to 7 feet high = 250 fpm.

2. Above 7 feet from boiler room floor = 500 fpm.

Example of required air openings (Engineered Method):

Determine the area of the boiler room air supply openings for [2] size 4500 Model 4 boilers at 750 feet elevation; each have a rating of 107 boiler horsepower. The air openings will be 5 feet above the floor level.

The total boiler horsepower (bhp): 107 x 2 = 214 bhp.

From F.3 above, total air required = 214 bhp x 10 = 2140 cfm.

Air Velocity: From G.1 above = 250 fpm.

Area required: From the formula in E above, 2140 cfm/250 fpm = 8.56 square feet total.

Area opening: 8.56 divided by 2 = 4.28 ft^2 per opening (2 required).

Notice

Consult local codes, which may supersede these requirements.

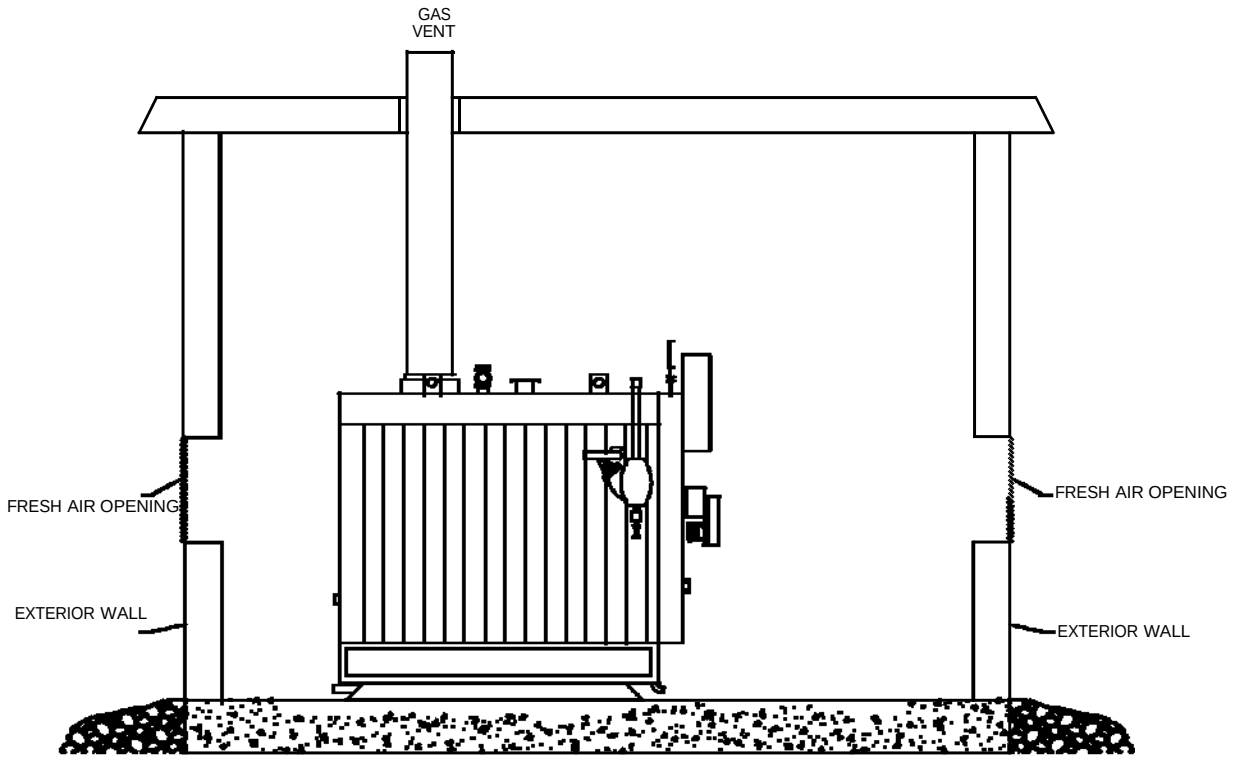
See Table B2-15 for combustion air and flue gas flow.

Table B2-15. Model 4 fuel, combustion air, and flue gas flow rates

			Boiler Size								
			1500	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**
Fuel Consumpi on	Gas	cfh	1500	1500	2500	3000	3500	4000	4500	5000	6000
	Oil	gph	10.72	14.29	17.86	21.43	25.00	28.57	32.14	35.71	42.85
Combustion Air	Gas	scfh	15,480	20,640	25,800	30,960	36,120	41,280	46,440	51,600	61,920
		lb/hr	1207	1609	2012	2414	2817	3219	3621	4024	4828
	Oil	scfh	17,049	22,733	28,414	34,098	39,782	45,463	51,147	56,831	68,196
		lb/hr	1269	1692	2115	2538	2961	3384	3808	4231	5077
Flue Gas	Gas	scfh	17,520	23,360	29,200	35,040	40,880	46,720	52,560	58,400	70,080
		lb/hr	1,278	1,704	2,130	2,556	2,983	3,409	3,835	4,261	5,113
	Oil	scfh	17,914	23,886	29,855	35,827	41,799	47,769	53,741	59,713	71,655
		lb/hr	1,357	1,809	2,261	2,714	3,166	3,618	4,070	4,523	5,427

Notes:
A. Gas consumption, expressed in cubic feet per hour, is based on 1,000 Btu/cu.ft gas value.
B. Oil consumption,expressed in pounds per hour, is based on 140,000 Btu/gal oil value.
C. Oil supply lines must be sized for 125 gph pumping rate. Oil pump suction pressure to be -10" Hg to 3 psig.

Figure B2-3. Boiler room air supply - "Engineered Design"



Oil Piping

General - Oil operation of the Model 4 boiler requires proper oil to the standard burner mounted oil pump. As the combustion of oil utilizes mechanical pressure atomization, line sizing to the pump must be sufficient to provide 125 gph of oil to the suction side of the pump.

Oil Train Components - Oil flow to the burner is controlled by four solenoid valves. The oil flows through a primary or safety shutoff valve into a manifold block. This valve and the low fire valve are energized simultaneously by the flame safeguard control and when opened, allow flow of oil to the low fire nozzle.

As the damper motor moves to high fire position, the damper motor end switches close to energize in sequence, the intermediate and then high fire oil valve. The purpose of the intermediate valve is to smooth the transition from low to high fire by balancing the oil input with increasing flow of air.

High fire rating of the burner is obtained when all three nozzles are firing, assuming proper oil pressure and normally sized nozzles.

Gas Piping

General - The Model 4 boiler requires appropriate gas supply pressure and volume for proper operation and long burner life. The gas requirements specified in this section must be satisfied to ensure efficient and stable combustion. Installation must follow these guidelines and of the local authorities that have installation jurisdiction.

Gas Train Components - Model 4 boilers are equipped with a gas train that meets the requirements of UL as standard. These components also comply with the recommendations of FM, XL GAP (formerly IRI/GE GAP) and ASME CSD-1. The gas train and its components have been designed and tested to operate for the highest combustion efficiency.

Gas Pressure Requirements - For proper and safe operation, each Model 4 boiler requires a stable gas pressure supply. The pressure requirements are listed in previous sections for standard gas train size, and oversized trains for reduced available pressure.

Gas Piping - Model 4 units are standardly equipped with a gas pressure regulator. If upstream pressure to the standard regulator will be greater than 1 psig, an additional upstream regulator should be provided with a pressure relief valve.

For buildings or boiler rooms with gas supply pressure exceeding 28" w.c., a "full lockup" type regulator is recommended along with proper overpressure protection. In addition to the regulator, a plug type or "butterball" type gas shutoff cock should be provided upstream of the regulator for use as a service valve. This is also required to provide positive shutoff and isolate the boiler gas train during gas piping tests.

Drip legs are required on any vertical piping at the gas supply to each boiler so that any dirt, weld slag, or debris can deposit in the drip leg rather than into the boiler gas train. The bottom of the drip leg should be removable without disassembling any gas piping. The connected piping to the boiler should be supported from pipe supports and not supported by the boiler gas train or the bottom of the drip leg.

All gas piping and components to the boiler gas train connection must comply with NFPA 54, local codes, and utility requirements as a minimum. Only gas approved fittings, valves, or pipe should be used. Standard industry practice for gas piping is normally Schedule 40 black iron pipe and fittings.

Gas Supply Pipe Sizing - For proper operation of a single unit or multiple units, we recommend that the gas pipe be sized to allow no more than 0.3" w.c. pressure drop from the source (gas header or utility meter) to the final unit location. The gas supplier (utility) should be consulted to confirm that sufficient volume and normal pressure are provided to the building at the discharge side of the gas meter or supply pipe (for installations of new boilers into an existing building, gas pressure should be measured with a manometer to ensure sufficient pressure is available).

A survey of all connected gas using devices should be made. If appliances other than the boiler are connected to the gas supply line, then a determination should be made of how much flow volume (cfh = cubic feet per hour) will be demanded at one time and the pressure drop requirements when all appliances are operating.

The total length of gas piping and all fittings must be considered when sizing the gas piping. Total equivalent length should be calculated from the utility meter or source to the final connection. As a minimum guideline, gas piping Tables B2 - 16 through B2 - 20 should be used. The data in these tables is from the NFPA source book, 2006 edition.

Table B2-16. Gas line capacity - Schedule 40 metallic pipe

Pipe Size							
Nominal	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
Actual I.D.	1.049	1.380"	1.610"	2.067"	2.469"	3.068"	4.026"
Length in feet	**Maximum Capacity in Cubic Feet of Gas per Hour (cfh)						
10	514	1,060	1,580	3,050	4,860	8,580	17,500
20	363	726	1,090	2,090	3,340	5,900	12,000
30	284	583	873	1,680	2,680	4,740	9,660
40	243	499	747	1,440	2,290	4,050	8,290
50	215	442	662	1,280	2,030	3,590	7,330
60	195	400	600	1,160	1,840	3,260	6,640
70	179	368	552	1,060	1,690	3,000	6,110
80	167	343	514	989	1,580	2,790	5,680
90	157	322	482	928	1,480	2,610	5,330
100	148	304	455	877	1,400	2,470	5,040
125	131	269	403	777	1,240	2,190	4,460
150	119	244	366	704	1,120	1,980	4,050
175	109	209	336	648	1,030	1,820	3,720
200	102	185	313	602	960	1,700	3,460

**Fuel: Natural Gas
**Inlet Pressure: Less than 2.0 psi
**Pressure Drop: 0.30" w.c.
**Specific Gravity: 0.60

Table B2-17. Gas line capacity - Schedule 40 metallic pipe

Pipe Size							
Nominal	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
Actual I.D.	1.049"	1.380"	1.610"	2.067"	2.469"	3.068"	4.026"
Length in feet	**Maximum Capacity in Cubic Feet of Gas per Hour (cfh)						
10	678	1,390	2,090	4,020	6,400	11,300	23,100
20	466	957	1,430	2,760	4,400	7,780	15,900
30	374	768	1,150	2,220	3,530	6,250	12,700
40	320	657	985	1,900	3,020	5,350	10,900
50	284	583	873	1,680	2,680	4,740	9,600
60	257	528	791	1,520	2,430	4,290	8,760
70	237	486	728	1,400	2,230	3,950	8,050
80	220	452	677	1,300	2,080	3,670	7,490
90	207	424	635	1,220	1,950	3,450	7,030
100	195	400	600	1,160	1,840	3,260	6,640
125	173	355	532	1,020	1,630	2,890	5,890
150	157	322	482	928	1,480	2,610	5,330
175	144	296	443	854	1,360	2,410	4,910
200	134	275	412	794	1,270	2,240	4,560

**Fuel: Natural Gas
**Inlet Pressure: Less than 2.0 psi
**Pressure Drop: 0.50" w.c.
**Specific Gravity: 0.60

Table B2-18. Gas line capacity - Schedule 40 metallic pipe

Pipe Size									
Nominal	**1/2"**	**3/4"**	**1"**	**1-1/4"**	**1-1/2"**	**2"**	**2-1/2"**	**3"**	**4"**
Actual I.D.	**0.622**	**0.824**	**1.049"**	**1.380"**	**1.610"**	**2.067"**	**2.469"**	**3.068"**	**4.026"**
Length in feet	****Maximum Capacity in Cubic Feet of Gas per Hour (cfh)**								
10	1,510	3,040	5,560	11,400	17,100	32,900	52,500	92,800	189,000
20	1,070	2,150	3,930	8,070	12,100	23,300	57,100	65,600	134,000
30	869	1,760	3,210	6,590	9,880	19,000	30,300	53,600	109,000
40	753	1,520	2,780	5,710	8,550	16,500	26,300	46,400	94,700
50	673	1,360	2,490	5,110	7,650	14,700	23,500	41,500	84,700
60	615	1,240	2,270	4,660	6,980	13,500	21,400	37,900	77,300
70	569	1,150	2,100	4,320	6,470	12,500	19,900	35,100	71,600
80	532	1,080	1,970	4,040	6,050	11,700	18,600	32,800	67,000
90	502	1,010	1,850	3,810	5,700	11,000	17,500	30,900	63,100
100	462	954	1,710	3,510	5,260	10,100	16,100	28,500	58,200
125	414	836	1,530	3,140	4,700	9,060	14,400	25,500	52,100
150	372	751	1,370	2,820	4,220	8,130	13,000	22,900	46,700
175	344	695	1,270	2,601	3,910	7,530	12,000	21,200	43,300
200	318	642	1,170	2,410	3,610	6,960	11,100	19,600	40,000
500	192	401	717	1,470	2,210	4,250	6,770	12,000	24,400
1000	132	275	493	1,010	1,520	2,920	4,650	8,220	16,800
1500	106	221	396	812	1,220	2,340	3,740	6,600	13,500

****Fuel: Natural Gas**

****Inlet Pressure: 2.0 psi**

****Pressure Drop: 1.0 psi**

****Specific Gravity: 0.60**

Table B2-19. Gas line capacity - Schedule 40 metallic pipe

Pipe Size									
Nominal	**1/2"**	**3/4"**	**1"**	**1-1/4"**	**1-1/2"**	**2"**	**2-1/2"**	**3"**	**4"**
Actual I.D.	**0.622**	**0.824**	**1.049"**	**1.380"**	**1.610"**	**2.067"**	**2.469"**	**3.068"**	**4.026"**
Length in feet	****Maximum Capacity in Cubic Feet of Gas per Hour (cfh)**								
10	2,350	4,920	9,270	19,000	28,500	54,900	87,500	155,000	316,000
20	1,620	3,380	6,370	13,100	19,600	37,700	60,100	106,000	217,000
30	1,300	2,720	5,110	10,500	15,700	30,300	48,300	85,400	174,000
40	1,110	2,320	4,380	8,990	13,500	25,900	41,300	75,100	149,000
50	985	2,060	3,880	7,970	11,900	23,000	36,600	64,800	132,000
60	892	1,870	3,520	7,220	10,300	20,300	33,200	58,700	120,000
70	821	1,720	3,230	6,640	9,950	19,200	30,500	54,000	110,000
80	764	1,600	3,010	6,180	9,260	17,800	28,400	50,200	102,000
90	717	1,500	2,820	5,800	8,680	16,700	26,700	47,100	96,100
100	677	1,420	2,670	5,470	8,200	15,800	25,200	44,500	90,300
125	600	1,250	2,360	4,850	7,270	14,000	22,300	39,500	80,500
150	544	1,140	2,140	4,400	6,590	12,700	20,200	35,700	72,900
175	500	1,050	1,970	4,040	6,060	11,700	18,600	32,900	67,100
200	465	973	1,830	3,760	5,640	10,900	17,300	30,600	62,400
500	283	593	1,120	2,290	3,430	6,610	10,300	18,600	38,000
1000	195	407	897	1,380	2,360	4,550	7,240	12,000	26,100
1500	156	327	616	1,270	1,900	3,650	5,820	10,300	21,000

****Fuel: Natural Gas**

****Inlet Pressure: 3.0 psi**

****Pressure Drop: 2.0 psi**

****Specific Gravity: 0.60**

Table B2-20. Gas line capacity - Schedule 40 metallic pipe

Pipe Size									
Nominal	**1/2"**	**3/4"**	**1"**	**1-1/4"**	**1-1/2"**	**2"**	**2-1/2"**	**3"**	**4"**
Actual I.D.	**0.622**	**0.824**	**1.049"**	**1.380"**	**1.610"**	**2.067"**	**2.469"**	**3.068"**	**4.026"**
Length in feet	****Maximum Capacity in Cubic Feet of Gas per Hour (cfh)**								
10	3,190	6,430	11,800	24,200	36,200	69,700	111,000	196,000	401,000
20	2,250	4,550	8,320	17,100	25,600	49,300	78,600	139,000	283,000
30	1,840	3,720	6,790	14,000	20,900	40,300	64,200	113,000	231,000
40	1,590	3,220	5,880	12,100	18,100	34,900	55,600	98,200	200,000
50	1,430	2,880	5,260	10,800	16,200	31,200	49,700	87,900	179,000
60	1,300	2,630	4,800	9,860	14,800	28,500	45,400	80,200	164,000
70	1,200	2,430	4,450	9,130	13,700	26,400	42,000	74,300	151,000
80	1,150	2,330	4,260	8,540	12,800	24,700	39,300	69,500	142,000
90	1,060	2,150	3,920	8,050	12,100	23,200	37,000	65,500	134,000
100	979	1,980	3,620	7,430	11,100	21,400	34,200	60,400	123,000
125	876	1,770	3,240	6,640	9,950	19,200	30,600	54,000	110,000
150	786	1,590	2,910	5,960	8,940	17,200	27,400	48,500	98,900
175	728	1,470	2,690	5,520	8,270	15,900	25,400	44,900	91,600
200	673	1,360	2,490	5,100	7,650	14,700	23,500	41,500	84,700
500	384	802	1,510	3,100	4,650	8,950	14,300	25,200	51,500
1000	264	551	1,040	2,130	3,200	6,150	9,810	17,300	35,400
1500	212	443	834	1,710	2,570	4,940	7,880	13,900	28,400

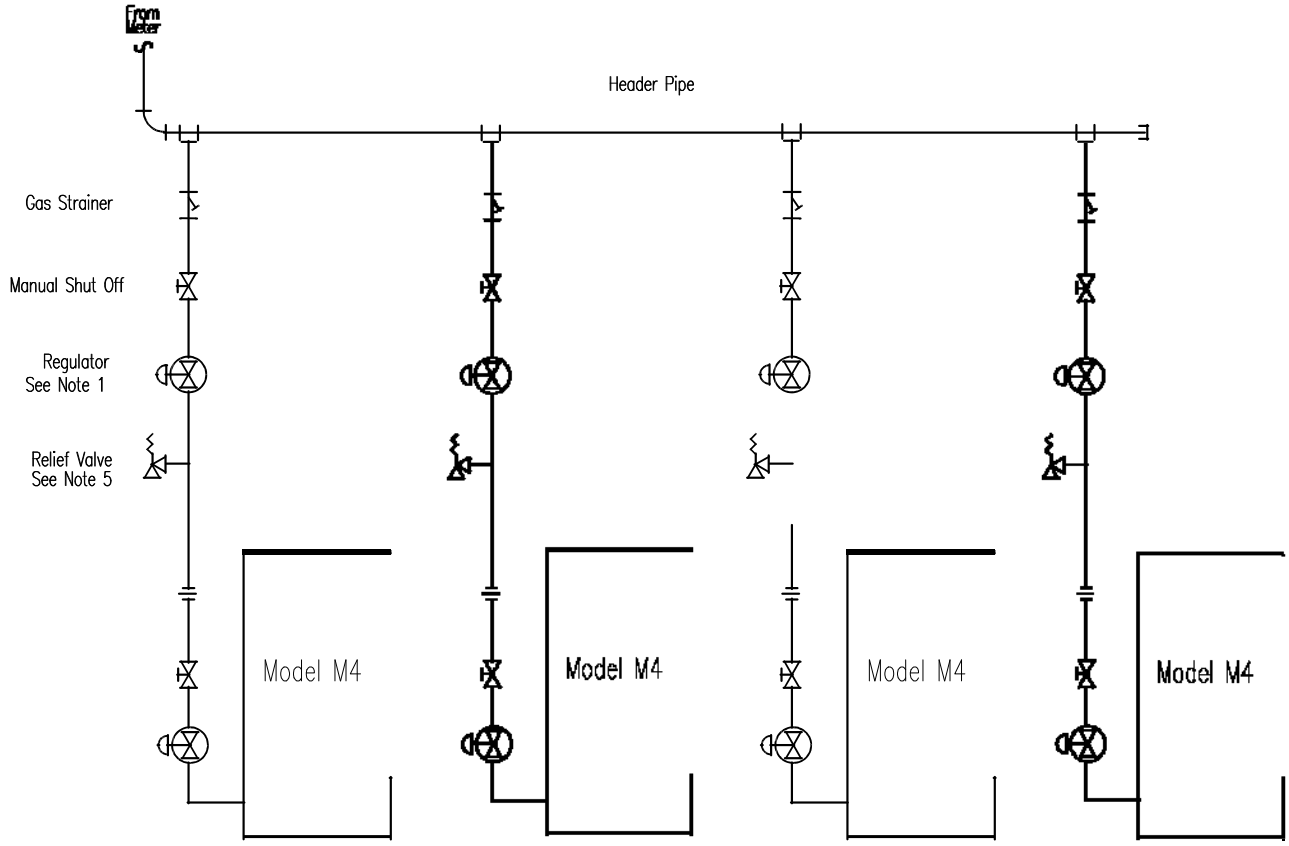
****Fuel: Natural Gas**

****Inlet Pressure: 5.0 psi**

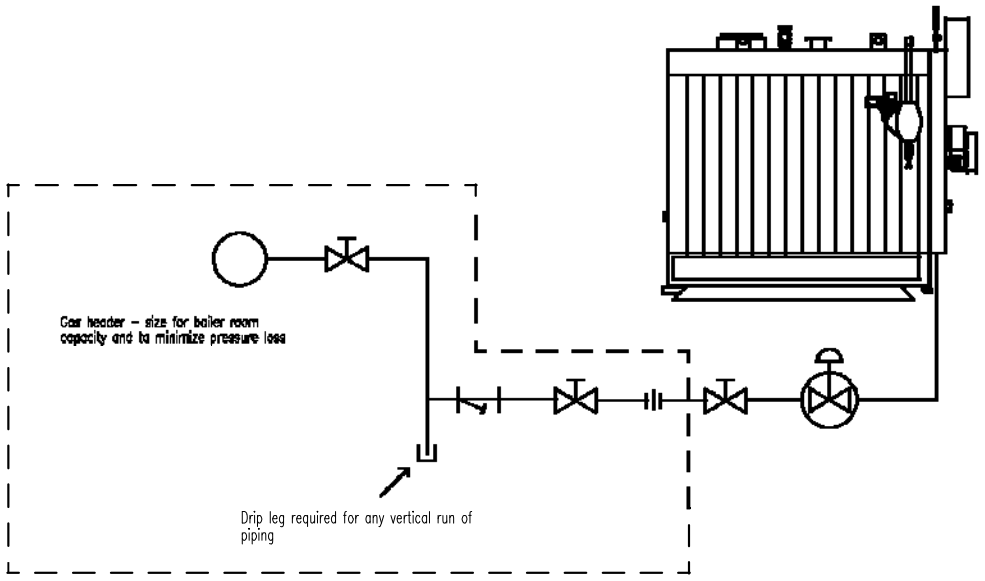
****Pressure Drop: 3.5 psi**

****Specific Gravity: 0.60**

Figure B2-4. Typical gas header piping



NOTES:
1. Upstream regulator required if supply pressure >1 psig.
2. Refer to local fuel gas codes when applicable.
3. Header to be sized for room capacity.
4. Provision required for measuring gas supply pressure at boiler.
5. Relief valve required if gas supply pressure >1 psig.



Model 4 Boiler
Steam Specifications

SAMPLE SPECIFICATIONS

The following sample specifications are provided by Cleaver-Brooks to assist you in specifying your customer's specific needs and application.

PART 1 GENERAL

1.1 SUBMITTALS

A. The manufacturer shall supply ____copies of a dimensional drawing indicating all relevant unit dimensions, layout and required clearances.

B. The manufacturer shall supply ____copies of a ladder type wiring diagram to include all internal unit wiring, external connections, and power supply requirements.

C. The manufacturer shall supply a copy of the authorized inspection report, to the purchaser, upon completion and shipment of the unit.

1.2 CODES

A. The boiler shall be designed, constructed, and hydrostatically tested in accordance with the ASME Boiler and Pressure Vessel Code.

B. The boiler shall be wired in accordance with the rules of the National Electric Code.

C. All electrical equipment shall be in conformity with the Underwriters Laboratories requirements.

D. The complete boiler–burner package shall be approved by Underwriters Laboratories and shall bear a UL label.

E. The boiler shall be built to comply with the following insurances _____. (Factory Mutual, XL-GAP, ASME CSD–1)

1.3 GUARANTEES

A. The complete boiler package shall be warranted from defects in materials and/or workmanship for a period of not less than 18 months from shipment or 12 months from unit start–up.

PART 2 PRODUCTS

2.1 TYPE

A. The boiler shall be a watertube type steam boiler with all steel membrane walls.

B. The boiler shall be a three gas pass type boiler mounted on a heavy duty steel frame.

C. The boiler shall have an integral forced draft burner and burner controls.

D. The boiler shall be a Cleaver Brooks Model 4, series _____(100 = No. 2 oil, 200 = No. 2 oil and gas, 700 = gas) steam boiler.

2.2 DESIGN CRITERIA

A. The boiler shall be designed in accordance with the ASME Boiler and Pressure Code Section ____(IV for low pressure, I for high pressure).

B. The boiler shall be designed for ____psig (15, 150, 250, 350, or 500). The maximum operating pressure will be ____psig.

C. The boiler shall be designed for a maximum output of _____lbs/hr of steam, or _____bhp. The boiler shall develop _____ lbs/hr of steam when operating at _____psig with a feedwater temperature of _____°F.

D. Electrical power available will be _____volts, _____phase, _____Hz.

E. The maximum sound level shall not exceed 80 dBA measured 3 feet in front of the boiler.

2.3 PRODUCT DESIGN

A. Pressure Vessel

1. The upper drum shall have a 20" OD, manufactured from SA–53 Gr. B seamless pipe, with a minimum wall thickness of 0.375".
2. The lower drum shall have an 8–5/8" OD, manufactured from SA–53 Gr. B seamless pipe, with a minimum wall thickness of 0.322".
3. The generating tubes shall be 2" OD, manufactured from SA–178 Gr. A tubing, with a minimum wall thickness of 0.095".
4. The boiler shall have two downcomers, located at the rear of the boiler, and be totally insulated from the generating tubes. These shall be a minimum of 2–1/2" OD, manufactured from SA–178 Gr. A tubing, with a minimum wall thickness of .105".
5. The upper drum shall have an inspection opening, located at the rear of the unit, to allow internal inspection, and shall be a minimum of 4"x6".
6. The lower drum shall have inspection openings, located at the front and rear of the unit, to allow internal inspection, and shall be a minimum of 4-7/8" x 5-7/8".
7. The boiler shall have inspection openings in the convection area.
8. A feedwater tapping and integral feedwater distribution pipe shall be located in the upper drum. The distribution pipe shall blend the feedwater with the boiler water.
9. A 3/4" surface blowoff connection shall be located in the rear head of the upper drum.
10. A _____" bottom blowoff connection shall be located in the lower drum.

B. Refractory

1. Refractory shall be limited to the furnace floor to insulate the lower drum, and to the burner throat tile.
2. High temperature insulation shall be installed on the front wall of the furnace.

C. Insulation and Casing

1. The boiler insulation shall be a minimum of 2" fiberglass, and shall cover the entire pressure vessel.
2. The insulation shall be covered with a corrugated metal lagging.
3. The metal lagging and insulation shall be arranged for easy removal and installation if required.
4. The front head (windbox) shall be attached with a davit arm, gasket sealed, and bolted. The front head shall swing open to provide full access to the furnace chamber and burner throat tile.

5. Observation ports shall be provided at each end of the boiler for visual inspection of the pilot and main flame conditions.
6. Two lifting eyes shall be located on top of the boiler.
7. The exhaust gases shall vent at the rear of the boiler, on the top centerline.

D. Trim

1. The water column shall be located on the left side of the boiler. It shall be piped with unions for easy removal.
2. A gauge glass set, gauge glass blowdown valve, and water column blowdown valve shall be provided.
3. The boiler feedwater control switch shall be included as an integral item of the water column. It shall provide automatic actuation of a motor driven feedwater pump or valve to maintain the boiler water level within normal limits.
4. The primary low water cutoff switch shall be an integral part of the water column. It shall be wired into the burner control circuit preventing burner operation if the boiler water level falls below the designated safe level.
5. A steam pressure gauge shall be located at the front end of the boiler and shall include a cock and test connection.
6. A safety relief valve shall be provided of a size and type to comply with ASME Code requirements. The safety relief valve set pressure shall be _____psig.
7. A high limit pressure control shall be provided. It shall be a manual reset type and shall be wired to prevent burner operation and lockout if excessive steam pressure occurs.
8. An operating limit control shall be provided. It shall be wired to provided on– off control of the burner at operating set points.
9. A firing rate control shall be provided. It shall control the firing rate of the burner based on the boiler load.
10. An auxiliary low water cutoff shall be provided (manual reset type). It shall be wired into the burner control circuit preventing burner operation if the boiler water level falls below the designated safe level.
11. A stack thermometer shall be shipped loose for field installation.

E. Soot Cleaning

1. Soot washer lances shall be provided in the convection area of the boiler measuring the full length of the pressure vessel.
2. Each lance shall be provided with a shutoff valve and the assembly shall be capable of rotating 360 degrees. This shall ensure complete washing of the convection zone while the boiler is operating in the low fire mode.
3. Soot washer troughs shall be provided at the bottom of the boiler. These shall be furnished for each convection side and shall The soot washer troughs shall be provided with 2" drain connections at the rear of the boiler, and shall have inspection/ cleanout openings at the front of the boiler.

F. Burner Design – General

1. The burner shall be integral to the windbox.
2. All air for combustion shall be supplied by a forced draft blower mounted in the windbox, above the burner, to minimize noise and vibration level.
3. The blower motor shall be an open drip proof type with a minimum service factor of 1.15.
4. The impeller shall be an enclosed centrifugal fan type, properly balanced, and directly connected to the blower motor shaft.
5. The combustion air damper shall be integral to the windbox and shall be operated by a single damper motor.
6. The burner shall remain in the low fire position during ignition and until main flame has been established.
7. A combustion air proving switch shall be provided to ensure adequate air for pre-purge and combustion.

G. Burner Design – Gas

1. The burner shall be the high radiant multi–port type approved for operation with natural gas.
2. The burner shall operate on the _____(low–high–low or full modulation) principle and must return to the low fire position prior to ignition.
3. Automatic electric ignition of the premix gas pilot shall be furnished. An electric scanner, of the UV principle, shall monitor the pilot, preventing the primary fuel valve from opening until the pilot flame has been established.
4. The single combustion air damper motor shall operate the gas butterfly valve. The damper motor shall regulate the fire according to system demand in response to the firing rate control.

H. Burner Design – No. 2 Oil

1. The burner shall be the pressure atomizing type approved for operation with commercial grade No. 2 oil.
2. The burner shall operate on the low–high–low principle, and must return to the low fire position prior to ignition.
3. The burner shall remain in the low fire position during ignition and until main flame has been proven. The ignition period shall be monitored with an electric scanner, of the UV principle, to confirm the presence of the low fire oil flame.
4. Automatic electric ignition of the low fire oil supply shall be provided with a minimum 10,000 volt transformer and heavy duty electrodes.

Notice

Optional insurance compliance may require a premix gas pilot in lieu of direct spark ignition.

5. [Optional] Automatic electric ignition of the premix gas pilot shall be furnished. An electric scanner, of the UV principle, shall confirm the pilot prior to the delivery of the low fire oil supply.
6. The single combustion air damper motor shall operate the low and high fire oil valves. The damper motor shall regulate the fire according to system demand in response to the firing rate control.

I. Burner Design – Gas and No. 2 Oil

1. The burner shall be the high radiant multi–port type for gas and shall be the pressure atomizing for oil. The burner must be approved for operation with either natural gas or commercial grade No. 2 oil.
2. The burner shall operate on the low–high–low principle, and must return to the low fire position prior to ignition.
3. The burner shall remain in the low fire position during ignition and until main flame has been proven.
4. Automatic electric ignition of the premix gas pilot shall be furnished. An electric scanner, of the UV principle, shall monitor the pilot, preventing the primary fuel valve from opening until the pilot flame has been established.
5. The single combustion air damper motor shall operate the low and high fire oil valves and the gas butterfly valve. The damper motor shall regulate the fire according to system demand in response to the firing rate control.

J. Main Gas Train

1. The gas burner piping shall include a primary gas shutoff valve. It shall be controlled by the programming relay to start or stop the burner and to close automatically in the event of power failure, flame failure, or a low water condition.
2. A manual shutoff valve shall be located ahead of the primary gas valve.
3. A plugged leakage test connection and a second manual shutoff valve shall be provided as a means for a tightness check of the primary shutoff valve.
4. A gas pressure regulator shall be factory mounted and piped for pressure regulation to the burner.
5. Gas Train Components
   a. [Sizes 1500–2500] The primary gas shutoff valve shall be motorized with a proof of closure switch.
   b. [Sizes 3000–5000] The primary gas shutoff valve shall be motorized with a proof of closure switch. High and low gas pressure switches shall be provided.
   c. [Size 6000] The primary gas shutoff valve shall be motorized with a proof of closure switch. A second gas safety shutoff valve and an additional plugged leakage test cock shall be provided. High and low gas pressure switches shall be provided.

K. Natural Gas Pilot Train

1. A pilot gas pressure regulator shall be factory mounted and piped for pressure regulation of the pilot gas to the burner.
2. The pilot gas train shall include a safety shutoff valve. It shall be controlled by the programming relay to start the burner.
3. A manual shutoff valve shall be located ahead of the pilot gas pressure regulator.

L. 2.3.12 Oil System

1. An oil pump shall be provided. The oil pump, integral with the burner, shall include a built–in relief valve and self–cleaning strainer.
2. The oil pump shall be belt driven from the blower motor.
3. The fuel oil system shall include supply and return tubing to a terminal block, an oil pressure gauge, shutoff cock, and four solenoid oil shutoff valves. These items shall be factory mounted and piped on the front head (windbox).

2.4 BURNER MANAGEMENT SYSTEM

A. Control Panels

1. The control panel shall be a NEMA 1 rated panel and have a key lock.
2. The control panel shall be mounted on the front head of the boiler and shall be conveniently located for the boiler operator.
3. The panel shall contain the blower motor starter, control circuit fuses, control circuit transformer, and control switches. A damper selector switch shall be provided to permit selection of automatic or manual selection of low or high firing.
4. A terminal board shall be provided to which all wires entering or leaving the panel shall be connected.
5. The panel shall include four indicating lights to show operating conditions of: red = low water; red = flame failure; white = load demand; and white = fuel valve open. The lights and switches shall be located on the panel switch ledge.
6. All electrical service connections shall be made to an electrical entrance box to be mounted on the right hand side of the boiler.
7. All electrical wiring shall be oil, heat, and moisture resistant and shall be number coded.

B. Combustion Safeguard Control

1. A combustion safeguard control (program relay) shall be provided to control ignition, starting, and stopping of the burner. It shall provide precombustion and postcombustion purge periods and shall stop burner operation in the event of ignition, pilot, or main flame failure. Trial for ignition shall be limited to 10 seconds.
2. The boiler shall be provided with a combustion safeguard controller that provides technology and functions equal to the Cleaver Brooks Model CB120E.

3. The combustion safeguard control shall be microprocessor based, with self–diagnostics, non–volatile memory, and a message center with a vocabulary of 42 different messages. Messages shall scroll across an alpha–numeric display and provide sequence status and flame failure mode information.
4. The combustion safeguard control shall have a fixed operating sequence incapable of being manually altered. The sequence shall include start, pre– purge, pilot and main fuel ignition run, and post–purge cycles.
5. The controller shall be the non–recycle type for maximum safety that will shut down the burner and indicate as a minimum the following trip functions: pilot failure, main flame failure, high and low fire proving switch faults, running interlocks open, false flame signal, and fuel valve open.
6. The controller shall have a test/run switch. It will allow interruptions to sequence just after pre–purge, during pilot ignition trial, and during run cycles, for adjustments to firing rate motor, damper linkages, and pilot flame for turndown tests.
7. The controller shall also have the following functions: display history of operating hours and totals of completed on–off cycles; provide a constant flame signal strength read–out; and have provisions for remote display capability and Modbus communication.

PART 3 EXECUTION

3.1 SHOP TESTS

A. The pressure vessel shall be hydrostatically tested in accordance with ASME requirements.

B. The boiler will be test fired by the manufactured, prior to shipment, to verify proper and safe operation.

3.2 SHIPMENT

A. Painting

1. The entire boiler, base frame, and other components shall be factory painted, before shipment, using a hard finish enamel.
2. The boiler surface shall be cleaned/prepared for painting using manufacturer's specifications and standard industrial painting practices.

B. Preparation

1. All boiler openings shall be plugged/covered prior to shipment.
2. The boiler shall be skid mounted and protected with a weather resistant covering.
3. All shipped loose components shall wrapped in protective material and packaged in a separate container(s).

3.3 INSTALLATION

3.4 START–UP

A. The boiler start–up shall be performed by a factory trained representative and will be done in accordance with the manufacturer's recommended procedures.

B. The boiler start–up shall include boiler operator training and shall cover boiler operation, water treatment, and maintenance of the unit.

3.5 OPERATION AND MAINTENANCE MANUALS

Manufacturer shall supply _____copies of the Operating & Maintenance Manual.