Model M5M
Watertube Boiler

Figures

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PRODUCT OFFERING

The Model M5M Boiler is a compact carbon steel, extended fin, watertube boiler. Heat transfer design is configured in a 2-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] hydronic heating @ 140 PSIG or Section I for MAWP greater than 15 PSIG steam or hot water greater than 250 degrees F.

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 Natural Gas, the complete burner/boiler package is UL and cUL 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, and 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. Upper drum includes a hand hole in the rear head for drum water side inspection.
   - C. Connections on steam units are included for the following:
     - Feedwater Makeup w/internal dispersion tube.
     - Surface Blowoff.
     - Steam Supply.
     - Safety Relief Valve.
   - D. Connections on hot water units are included for supply water and internal circulating pump.
   - E. Lower Drum includes hand holes at each end for waterside inspection. A drain/blowoff tapping is provided at the front, bottom centerline.
   - F. 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.
   - G. Two lifting eyes are provided on the top centerline of the upper drum for ease of installation.
   - H. Furnace inspection/access door is provided in the rear via a removable access plug.
   - I. The exhaust gas vent is located at the top front centerline of the boiler. A stack thermometer is shipped loose for field installation by the installing contractor into the stack.
   - J. The complete vessel is fully insulated [2" fiberglass blanket] under a preformed, sectional steel jacket.
   - K. Factory painted using hard-finish enamel.

2. Forced Draft Burner

A. The burner is of the forced draft design and provided with a UL/cUL fuel burning system in full accordance with the requirements of state, provincial and local codes, and other applicable regulatory bodies.

B. Burner shall be equipped to burn Natural Gas and shall be the high radiant surface combustion pre mix design.

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

D. Responding to system demand from the drum mounted sensor the burner operates in the full modulation firing mode. Ultra-violet [UV] flame scanner is provided for flame presence during firing.

E. An Ignition transformer is provided.

F. Pilot is spark ignited gas.

G. 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.
- 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. A.S.M.E. safety relief valves relative to boiler design pressure.

B. Pressure gauge with inspectors test cock and connection for steam boiler.

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

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

E. Primary low water cutoff internal probe type with manual reset for hot water boilers.

F. Auxiliary Low Water Cutoff, manual reset type, standard for steam boilers, optional for hot water boilers.

G. Controls:

- Operating Limit.
- Excess Pressure [High Limit], manual reset for steam boiler.
- Excess Temp [High Limit], manual reset for hot water boiler.
- Burner firing rate.

H. Boiler water circulating pump for hot water boilers.

4. Burner Control Panel and Controls

A. The control panel is a NEMA 1A Rated enclosure, mounted on the boiler above the burner at approximately eye level height. This panel may be located on the boiler side relative to additional electrical control options.

B. Mounted within or on the control panel box are the controls noted in the Control Panel Figure:

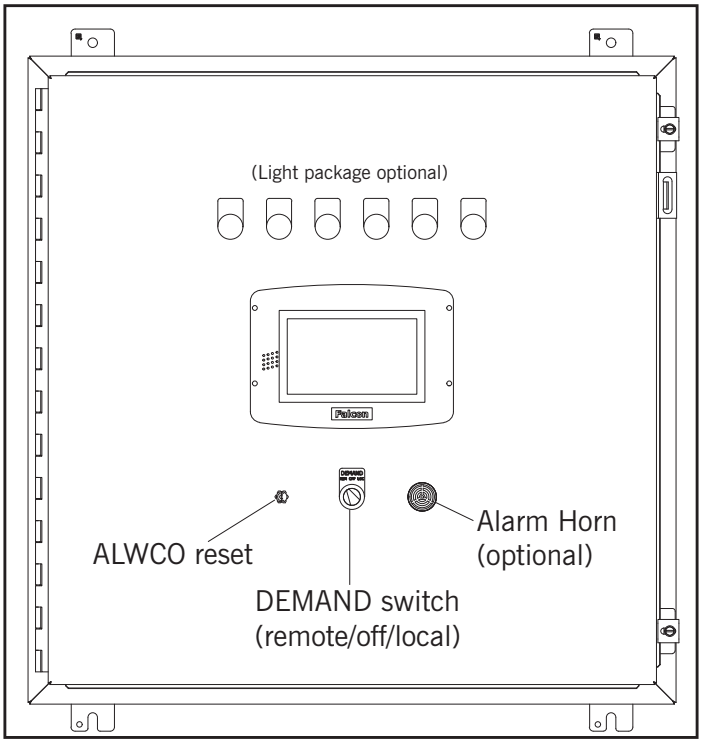

Figure 1. Control Panel

Optional Equipment

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

- 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.
- TDS control.
- Feedwater Stop and Check Valves.
- Steam Stop Valve.
- ASME Hydro Test of Valves and Valve Piping.
- Design pressures above 150 PSIG to 600 PSIG.
- Lead/Lag Control.
- Alarm with silence switch.
- Additional Indicator Lights.
- Main Power Disconnect.
- Optional NEMA Enclosures.
- Stack economizer
- Packaged skid systems available

Insurance/Codes

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

1. 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 M5M boiler is UL listed and labeled.

2. 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.
3. 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.

DIMENSIONS AND RATINGS

For layout purposes, the nominal dimensions and connections for the Model M5M are shown in Figures 2 and 3 and Tables 1, 2, 4 and 5. Ratings of each boiler size are noted in Tables 3 and 6. Additional information is shown in the following tables.

Tables 7 & 8 - Gas Line Capacity
Table 9 - Hot Water Flow Rate and Pressure Drop
Table 10 - Hot Water Maximum Circulating Rates
Table 11 - Feedwater Make-up Rates
Table 12 - Feedwater Quality
Table 13 - Natural Gas Pressure Requirements, standard gas train size.

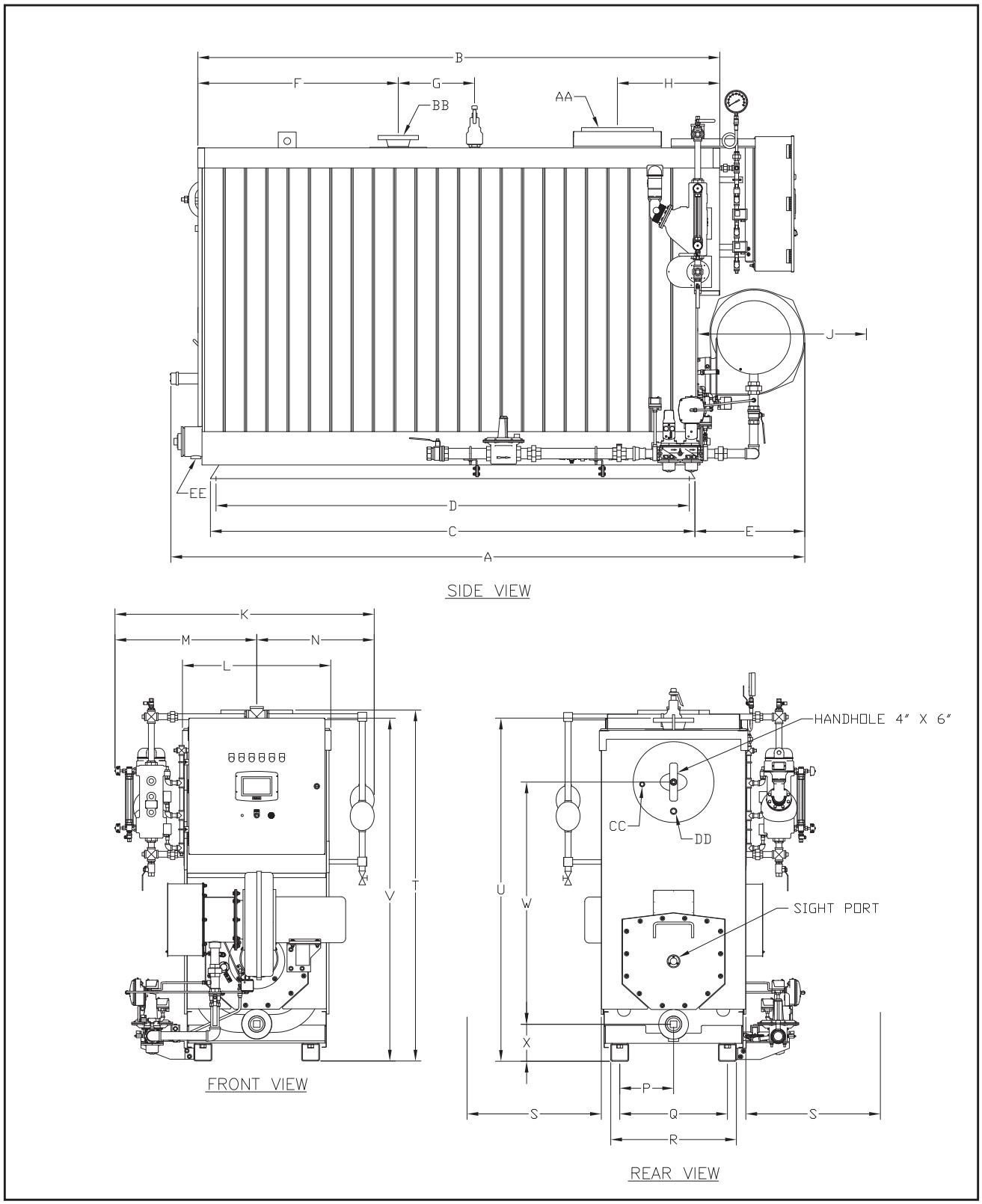

Figure 2. M5M Dimension Diagram - Steam

Table 1. M5M Steam Dimensions Inches

		Boiler Size							
	DIMENSIONS (inches)	2000	2500	3000	3500	4000	4500	5000	6000
	Lengths								
A	Overall	79	94.5	94.5	110	110	126	126	141.5
B	Pressure Vessel w/casing	52.25	68.38	68.38	84	84	100.63	100.63	116.25
C	Base Frame	45.5	61.13	61.13	76.75	76.75	92.38	92.38	108
D	Base Frame Anchor Holes	43	58.5	58.5	74.5	74.5	90	90	105.5
E	Blower Extension	19	19	20.5	20.5	24.5	24.5	24.5	24.5
F	Rear Casing to Steam Nozzle	16.38	24.38	24.38	30.13	30.13	36.75	36.75	44.63
G	Steam Nozzle to Safety Valve 15#	7	12	12	11.5	11.5	17	17	17
	Steam Nozzle to Safety Valve 150#	8	12	12	17	17	13	13	17
H	Front Casing to Stack Connection	18.19	18.69	18.69	18.69	18.69	22.81	22.81	22.81
J	Front Clearance for Burner Removal	20	20	24.5	24.5	30.5	30.5	39	39
	Widths								
K	Overall	57.5	57.5	57.5	57.5	57.5	57.5	57.5	57.5
L	Casing	33	33	33	33	33	33	33	33
M	Center to water Column	33	33	33	33	33	33	33	33
N	Center to Aux. Water Column	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5
P	Boiler Centerline to Base Centerline	12	12	12	12	12	12	12	12
Q	Base Frame Anchor Holes	24	24	24	24	24	24	24	24
R	Base Frame Outside	28	28	28	28	28	28	28	28
S	Tube Removal Each Side	30	30	30	30	30	30	30	30
	Heights								
T	Overall Base to Stack Connection	78.25	78.25	78.25	78.25	78.25	78.25	78.25	78.25
U	Base to Steam Nozzle 15#	73.5	73.5	73.5	76.5	76.5	76.5	76.5	76.5
	Base to Steam Nozzle 150#	73.5	73.5	73.5	73.5	73.5	76.5	76.5	76.5
V	Base to Top of Control Panel	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5
W	Drum Centerline Spacing	54	54	54	54	54	54	54	54
X	Base to Lower Drum Center	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25
	Connections								
AA	O.D. Stack Sleeve Connection	12	12	12	12	12	16	16	16
BB	Steam Nozzle 15#	4	4	4	6	6	6	6	6
	Steam Nozzle 150#	2 1/2	3	3	3	3	4	4	4
CC	Surface Blowoff	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4
DD	Feedwater	1	1	1	1	1	1	1	1
EE	Bottom Blowdown 15#	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
	Bottom Blowdown 150#	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4

Table 2. M5M Steam Dimensions Millimeters

		Boiler Size							
	DIMENSIONS (millimeters)	2000	2500	3000	3500	4000	4500	5000	6000
	Lengths								
A	Overall	2007	2400	2400	2794	2794	3200	3200	3594
B	Pressure Vessel w/casing	1327	1737	1737	2134	2134	2556	2556	2953
C	Base Frame	1156	1553	1553	1949	1949	2346	2346	2743
D	Base Frame Anchor Holes	1092	1486	1486	1892	1892	2286	2286	2680
E	Blower Extension	483	483	521	521	622	622	622	622
F	Rear Casing to Steam Nozzle	416	619	619	765	765	933	933	1134
G	Steam Nozzle to Safety Valve 15#	178	305	305	292	292	432	432	432
	Steam Nozzle to Safety Valve 150#	203	305	305	432	432	330	330	432
H	Front Casing to Stack Connection	462	475	475	475	475	579	579	579
J	Front Clearance for Burner Removal	508	508	622	622	775	775	991	991
	Widths								
K	Overall	1461	1461	1461	1461	1461	1461	1461	1461
L	Casing	838	838	838	838	838	838	838	838
M	Center to water Column	838	838	838	838	838	838	838	838
N	Center to Aux. Water Column	622	622	622	622	622	622	622	622
P	Boiler Centerline to Base Centerline	305	305	305	305	305	305	305	305
Q	Base Frame Anchor Holes	610	610	610	610	610	610	610	610
R	Base Frame Outside	711	711	711	711	711	711	711	711
S	Tube Removal Each Side	762	762	762	762	762	762	762	762
	Heights								
T	Overall Base to Stack Connection	1988	1988	1988	1988	1988	1988	1988	1988
U	Base to Steam Nozzle 15#	1867	1867	1867	1943	1943	1943	1943	1943
	Base to Steam Nozzle 150#	1867	1867	1867	1867	1867	1943	1943	1943
V	Base to Top of Control Panel	1943	1943	1943	1943	1943	1943	1943	1943
W	Drum Centerline Spacing	1372	1372	1372	1372	1372	1372	1372	1372
X	Base to Lower Drum Center	210	210	210	210	210	210	210	210

For connection sizes (inches) see Table 1

Table 3. M5M Ratings Steam

		Boiler Size							
Description	Units	2000	2500	3000	3500	4000	4500	5000	6000
Input Max.	BTU/Hr.	2,000,000	2,500,000	3,000,000	3,500,000	4,000,000	4,500,000	5,000,000	6,000,000
	KCAL/Hr.	504,000	630,000	756,000	882,000	1,008,000	1,134,000	1,260,000	1,512,000
Natural Gas (1000 Btu/ft3)	FT3/Hr	2000	2500	3000	3500	4000	4500	5000	6000
Natural Gas	M3/Hr	57	71	85	99	113	127	142	170
Output at 100% Firing	BTU/Hr.	1,600,000	2,000,000	2,400,000	2,800,000	3,200,000	3,600,000	4,000,000	4,800,000
	KCAL/Hr.	403,200	504,000	604,800	705,600	806,400	907,200	1,008,000	1,209,600
	BHP	48	60	72	84	96	108	119	143
	KW	469	586	703	821	938	1055	1172	1407
Steam Capacity (from and at 212 deg F)	lb/hr	1656	2070	2484	2898	3312	3726	4105	4933
	kg/hr	751	939	1127	1315	1502	1690	1862	2238
MAWP	PSI	15/150	15/150	15/150	15/150	15/150	15/150	15/150	15/150
	BAR	1.0/10.3	1.0/10.3	1.0/10.3	1.0/10.3	1.0/10.3	1.0/10.3	1.0/10.3	1.0/10.3
Water Content (Standard)	Gallons (U.S.)	65.3	90.0	90.0	112.9	112.9	139.4	139.4	163.0
	Gallons (Imp.)	54.4	74.9	74.9	94.0	94.0	116.1	116.1	135.7
	Liters	247.3	340.5	340.5	427.3	427.3	527.8	527.8	616.9
Water Content (Low Water Volume)	Gallons (U.S.)	31.9	43.8	43.8	54.6	54.6	68.0	68.0	74.7
	Gallons (Imp.)	26.6	36.5	36.5	45.5	45.5	56.6	56.6	62.2
	Liters	120.9	165.9	165.9	206.8	206.8	257.3	257.3	282.8
Weight w/o Water (Shipping)	Pounds	3,100	3,700	3,700	4,100	4,100	4,700	4,700	5,400
	Kg	1406	1678	1678	1860	1860	2132	2132	2449
Operating Weight (Standard)	Pounds	3,644	4,450	4,450	5,041	5,041	5,862	5,862	6,758
	Kg	1653	2018	2018	2287	2287	2659	2659	3066
Operating Weight (Low Water Volume)	Pounds	3,366	4,065	4,065	4,555	4,555	5,266	5,266	6,023
	Kg	1527	1844	1844	2066	2066	2389	2389	2732
Fan Motor Size	HP	2	2	3	3	5	5	5	7.5
Operating Voltage, Fan	Volts/Ph/Hz	460/3/60	460/3/60	460/3/60	460/3/60	460/3/60	460/3/60	460/3/60	460/3/60
Control Circuit	Volts/Ph/Hz	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60
Flue Gas Mass Flow @ 100% Firing (Natural Gas)	lb/hr	2266	2832.5	3399	3965.5	4532	5098.5	5665	6798
	kg/h	1028	1285	1542	1799	2056	2313	2570	3084

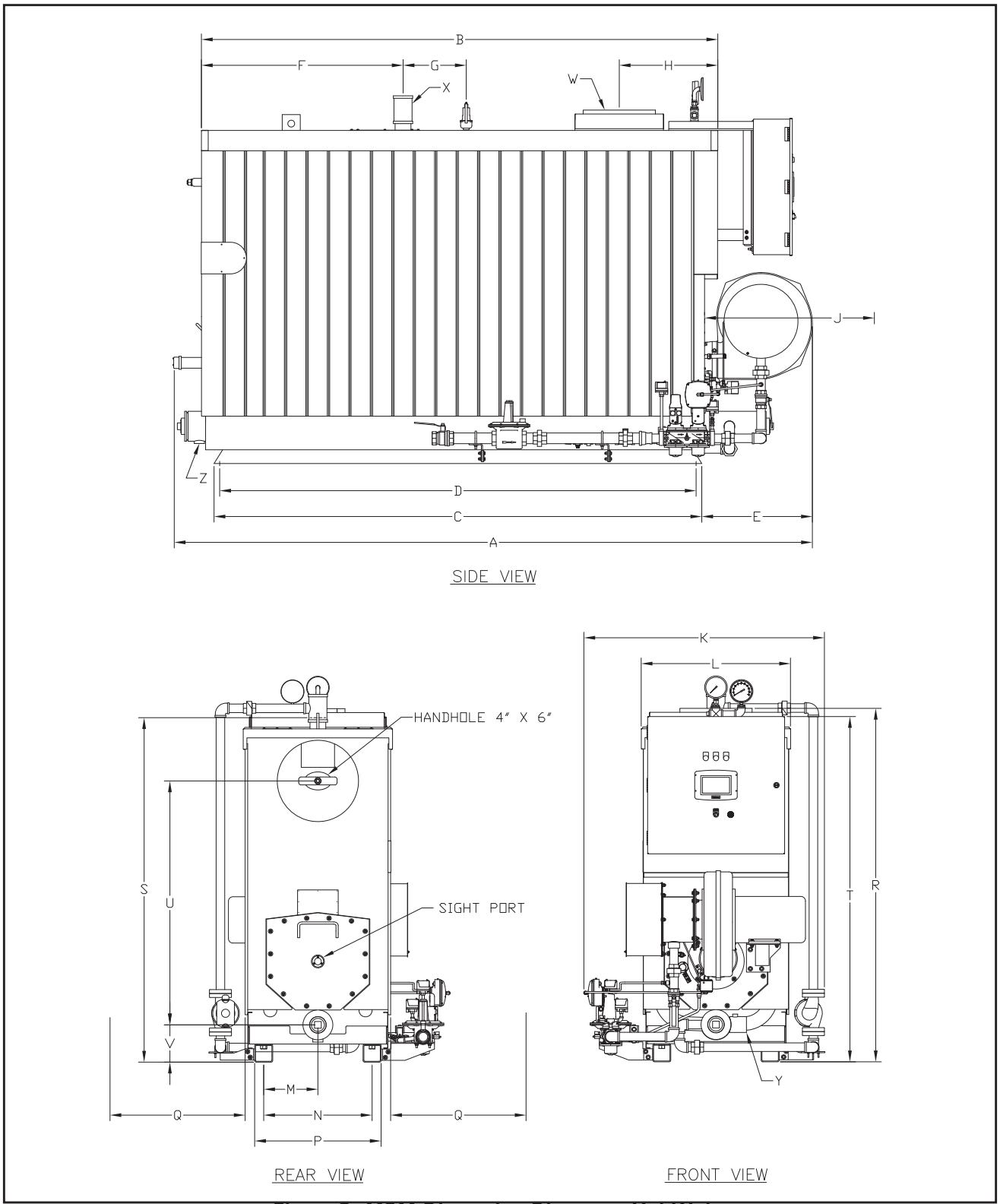

Figure 3. M5M Dimension Diagram - Hot Water

Table 4. M5M Hot Water Dimensions Inches

		Boiler Size							
	DIMENSIONS (inches)	2000	2500	3000	3500	4000	4500	5000	6000
	Lengths								
A	Overall	79	94.5	94.5	110	110	126	126	141.5
B	Pressure Vessel w/casing	51.25	67.38	67.38	83	83	99.63	99.63	115.25
C	Base Frame	45.5	61.13	61.13	76.75	76.75	92.38	92.38	108
D	Base Frame Anchor Holes	43	58.5	58.5	74.5	74.5	90	90	105.5
E	Blower Extension	19	19	20.5	20.5	24.5	24.5	24.5	24.5
F	Rear Casing to Supply Nozzle	16.38	24.38	24.38	30.13	30.13	36.75	36.75	44.63
G	Supply Nozzle to Relief Valve	7	12	12	10.75	10.75	13	13	14
H	Front Casing to Stack Connection	17.19	17.69	17.69	17.69	17.69	21.81	21.81	21.81
J	Front Clearance for Burner Removal	20	20	24.5	24.5	30.5	30.5	39	39
	Widths								
K	Overall	50	50	50	54	54	54	54	54
L	Casing	33	33	33	33	33	33	33	33
M	Boiler Centerline to Base Centerline	12	12	12	12	12	12	12	12
N	Base Frame Anchor Holes	24	24	24	24	24	24	24	24
P	Base Frame Outside	28	28	28	28	28	28	28	28
Q	Tube Removal Each Side	30	30	30	30	30	30	30	30
	Heights								
R	Overall Base to Stack Connection	78.25	78.25	78.25	78.25	78.25	78.25	78.25	78.25
S	Base to Supply Nozzle	76.25	76.25	76.25	76.25	76.25	76.25	76.25	76.25
T	Base to Top of Control Panel	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5
U	Drum Centerline Spacing	54	54	54	54	54	54	54	54
V	Base to Lower Drum Center	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25
	Connections								
W	O.D. Stack Sleeve Connection	12	12	12	12	12	16	16	16
X	Supply Nozzle	3	3	3	4	4	4	4	4
Y	Return Nozzle	3	3	3	4	4	4	4	4
Z	Drain	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2

Table 5. M5M Hot Water Dimensions Millimeters

		Boiler Size							
	DIMENSIONS (millimeters)	2000	2500	3000	3500	4000	4500	5000	6000
	Lengths								
A	Overall	2007	2400	2400	2794	2794	3200	3200	3594
B	Pressure Vessel w/casing	1302	1711	1711	2108	2108	2531	2531	2927
C	Base Frame	1156	1553	1553	1949	1949	2346	2346	2743
D	Base Frame Anchor Holes	1092	1486	1486	1892	1892	2286	2286	2680
E	Blower Extension	483	483	521	521	622	622	622	622
F	Rear Casing to Supply Nozzle	416	619	619	765	765	933	933	1134
G	Supply Nozzle to Relief Valve	178	305	305	273	273	330	330	356
H	Front Casing to Stack Connection	437	449	449	449	449	554	554	554
J	Front Clearance for Burner Removal	508	508	622	622	775	775	991	991
	Widths								
K	Overall	1270	1270	1270	1372	1372	1372	1372	1372
L	Casing	838	838	838	838	838	838	838	838
M	Boiler Centerline to Base Centerline	305	305	305	305	305	305	305	305
N	Base Frame Anchor Holes	610	610	610	610	610	610	610	610
P	Base Frame Outside	711	711	711	711	711	711	711	711
Q	Tube Removal Each Side	762	762	762	762	762	762	762	762
	Heights								
R	Overall Base to Stack Connection	1988	1988	1988	1988	1988	1988	1988	1988
S	Base to Supply Nozzle	1937	1937	1937	1937	1937	1937	1937	1937
T	Base to Top of Control Panel	1943	1943	1943	1943	1943	1943	1943	1943
U	Drum Centerline Spacing	1372	1372	1372	1372	1372	1372	1372	1372
V	Base to Lower Drum Center	210	210	210	210	210	210	210	210

For connection sizes (inches) see Table 4

Table 6. M5M Ratings Hot Water

		Boiler Size							
Description	Units	2000	2500	3000	3500	4000	4500	5000	6000
Input Max.	BTU/Hr.	2,000,000	2,500,000	3,000,000	3,500,000	4,000,000	4,500,000	5,000,000	6,000,000
	KCAL/Hr.	504,000	630,000	756,000	882,000	1,008,000	1,134,000	1,260,000	1,512,000
Natural Gas (1000 Btu/ft3)	FT3/Hr	2000	2500	3000	3500	4000	4500	5000	6000
Natural Gas	M3/Hr	57	71	85	99	113	127	142	170
Output 100% Firing	BTU/Hr.	1,630,000	2,037,500	2,445,000	2,852,500	3,260,000	3,667,500	4,075,000	4,890,000
	KCAL/Hr.	410,760	513,450	616,140	718,830	821,520	924,210	1,026,900	1,232,280
MAWP	PSI	140	140	140	140	140	140	140	140
	BAR	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
Operating Temp., Max.	°F	250	250	250	250	250	250	250	250
	°C	121	121	121	121	121	121	121	121
Water Content	Gallons (U.S.)	96	131	131	163	163	200	200	233
	Gallons (Imp.)	79.94	109.08	109.08	135.70	135.70	166.50	166.50	194.01
	Liters	363.4	495.9	495.9	616.9	616.9	756.9	756.9	882.0
Weight w/o Water (Shipping)	Pounds	3,100	3,700	3,700	4,100	4,100	4,700	4,700	5,400
	Kg	1406	1678	1678	1860	1860	2132	2132	2449
Operating Weight	Pounds	3,900	4,792	4,792	5,458	5,458	6,366	6,366	7,342
	Kg	1769	2174	2174	2476	2476	2888	2888	3330
Standby Heat Loss	BTU/Hr	4,000	5,000	6,000	7,000	8,000	9,000	10,000	12,000
	Watts	1172	1465	1758	2051	2344	2637	2930	3516
Fan Motor Size	HP	2	2	3	3	5	5	5	7.5
Operating Voltage, Fan	Volts/Ph/Hz	460/3/60	460/3/60	460/3/60	460/3/60	460/3/60	460/3/60	460/3/60	460/3/60
Control Circuit	Volts/Ph/Hz	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60
Flue Gas Mass Flow @ 100% Firing (Natural Gas)	lb/hr	2266	2832.5	3399	3965.5	4532	5098.5	5665	6798
	kg/h	1028	1285	1542	1799	2056	2313	2570	3084

APPLICATION DATA

The following information is provided for the Model M5M boiler. Additional information may be obtained from your local Cleaver-Brooks authorized representative.

Emissions

Controlled emissions shall be <20 PPM NOx and <50 PPM CO for natural gas fuel operation without the use of FGR [Flue Gas Recirculation].

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 9 depicts the rate of make-up required and Table 10 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.

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 M5M 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 are employed or unusually high stacks. 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 M5M 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 - An adequate volume of uncontaminated air to support proper combustion and equipment ventilation must be supplied. 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:

1. 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.
2. 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.
3. 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.
4. It is forbidden to have the total area of the air supply openings at less than one square foot.
5. Size the openings by using the formula (Area in ft2 = cfma/fpma), where cfma = cubic feet per minute of air; fpma = feet per minute of air.
6. Amount of air required (cfm):
   A. Combustion Air = Maximum boiler horsepower (bhp) times 8 cfm.
   B. Ventilation Air = Maximum boiler horsepower (bhp) times 2 cfm.
   C. Total Air = 10 cfm per bhp (up to 1000 feet elevation, add 3% more per 1000 feet of added elevation).
7. Acceptable air velocity in the boiler room (fpm):
   A. From floor to 7 feet high = 250 fpm.
   B. 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 M5M 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 (6.C.) above, total air required = 214 bhp x 10 = 2140 cfm.

Air Velocity: From (7.A.) above = 250 fpm.

Area required: From the formula in (5) above, 2140 cfm/250 fpm = 8.56 square feet total.

Area opening: 8.56 divided by 2 = 4.28 ft2 per opening (2 required).

Notice

Consult local codes, which may supersede these requirements.

Gas Piping

General - The Model M5M 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 M5M 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 M5M boiler requires a stable gas pressure supply. The pressure requirements are listed in the gas pressure table.

Gas Piping - Model M5M units are standardly equipped with a gas pressure regulator. If upstream pressure to the standard regulator will be greater than 3 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 block 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 7 and 8 should be used. The data in these tables is from the NFPA source book, 2006 edition.

Table 7. 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 8. 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							

Hot Water

For hydronic heating, maximum circulating rates are shown in Table 9 & 10 relative to system temperature drop. To prevent the heated water from flashing to steam, minimum overpressure is noted in Table 10A below. As a recommendation, a low boiler water pressure control can be provided to alert the boiler room attendant that overpressure of the boiler has decreased below the minimum setting.

Table 9. Model M5M Hot Water – Pressure Drop and Maximum Flow Rate

MODEL NO.	Delta T = 20° F		Delta T = 30° F		Delta T = 40° F		Delta T = 50° F	
	ΔP	GPM	ΔP	GPM	ΔP	GPM	ΔP	GPM
2000	0.96	165.2	0.43	110	0.24	83	0.16	66
2500	1.49	206.5	0.67	138	0.38	103	0.24	83
3000	2.13	247.6	0.95	165	0.54	124	0.34	99
3500	1.32	289	0.59	193	0.34	145	0.22	116
4000	1.72	330.8	0.77	220	0.44	166	0.28	132
4500	2.18	372.1	0.97	248	0.55	186	0.35	149
5000	2.68	413.4	1.20	276	0.68	207	0.43	166
6000	3.86	496	1.72	331	0.97	248	0.63	199

NOTE: Return water temperature must be >140F.

Table 10. Model M5M Hot Water – Maximum Circulating Rate/Temperature Drop

MODEL NO. (HP)	SYSTEM TEMPERATURE DROP [0 F]									
	10	20	30	40	50	60	70	80	90	100
	MAXIMUM CIRCULATING RATE - GPM									
2000 (47)	330	165	110	83	66	55	47	41	37	33
2500 (59)	413	206	138	103	83	69	59	52	46	41
3000 (71)	494	248	165	124	99	83	71	62	55	50
3500 (83)	578	289	193	145	116	97	83	72	64	58
4000 (95)	661	331	220	166	132	110	95	83	74	66
4500 (107)	740	372	248	186	149	124	106	93	83	74
5000 (119)	826	413	275	207	165	138	118	103	92	83
6000 (143)	992	496	330	248	198	166	142	124	110	99

NOTE: Return water temperature must be >140F.
HP = Horsepower

Table 10A. Boiler Operating temperature and minimum overpressure

Outlet Water Temperature Degrees F (C)	Minimum System Operating Pressure	Boiler Design Pressure
160 – 180 (71 – 82)	12 (0.83)	160 (11.03)*
181 – 185 (83 – 85)	15 (1.03)	160 (11.03)*
186 – 195 (86 – 91)	18 (1.24)	160 (11.03)*
196 – 210 (92 – 99)	20 (1.38)	160 (11.03)*
211 – 220 (100 – 104)	22 (1.52)	160 (11.03)*
221 – 230 (105 – 110)	25 (1.72)	160 (11.03)*
231 – 240 (111 – 115)	30 (2.07)	160 (11.03)*
241 – 250 (116 – 121)	43 (2.96)	160 (11.03)*
251 – 260 (122 – 126)	55 (3.79)	200 (13.79)**
261 – 270 (127 – 132)	70 (4.83)	200 (13.79)**
271 – 280 (133 – 137)	82 (5.65)	200 (13.79)**
281 – 290 (138 – 143)	100 (6.9)	200 (13.79)**
291 – 300 (144 – 149)	112 (7.72)	200 (13.79)**
301 – 310 (150 – 154)	124 (8.55)	200 (13.79)**
311 – 320 (155 – 160)	140 (9.65)	200 (13.79)**
321 – 330 (161 – 165)	160 11.03)	200 (13.79)**
331- 340 (166 – 171)	170 (11.72)	250 (17.24)**
341 – 350 (172 – 176)	180 (12.41)	250 (17.24)**
355 (179)	190 (13.10)	250 (17.24)**

*Boiler built per ASME Code Section IV For Heating Boilers bearing the “H” Stamp
**Boiler built per ASME Code Section I For Power Boilers bearing the “S” Stamp.

Table 11. Model M5M Steam Boiler Water Make-up Rates

Boiler Model (HP)	Gallons per Minute [GPM] at full steaming capacity
2000 (47)	3.3
2500 (59)	4.1
3000 (71)	5.0
3500 (83)	5.8
4000 (95)	6.6
4500 (107)	7.5
5000 (119)	8.3
6000 (143)	9.9

Table 12. Model M5M Boiler Water Quality Requirements

Parameter	Boiler Water Limit
pH	8.5 - 10.5
Iron	0.1 ppm
Oxyen	0.007 mg/liter
Silica	< 200 ppm
Specific Conductivity	3500 umho/cm
Total Dissolved Solids	2500
Suspended Solids	15 ppm
Total Alkalinity	300 ppm as CaCO3

Table 13. Model M5M required Natural Gas pressure*

BOILER SIZE	Customer connection pipe size	PRESSURE REQUIRED		Firing Rate	
		Min. (“W.C.)	Max. (“W.C.)	Min	Max
2000	1.5	17	**	500	2000
2500	1.5	17	**	500	2500
3000	1.5	17	**	600	3000
3500	1.5	21	**	700	3500
4000	1.5	21	**	800	4000
4500	1.5	24	**	900	4500
5000	1.5	28	**	1000	5000
6000	1.5	28	**	1200	6000

****At entrance to the standard UL, cUL, FM & XL GAP gas trains (upstream of gas pressure regulator).***

**Gas train components are rated for maximum of 3 psig with the gas pressure regulator capable of 10 psig inlet pressure. However, when the incoming pressure is greater than 3 psig, an upstream pressure relief device must be installed.

Note: For altitude above 2000 Feet, contact your local Cleaver-Brooks representative.