MODEL CB

15 - 100 HP
Steam and Hot Water
Dryback Integral Burner

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FEATURES AND BENEFITS

In addition to the features provided on all Cleaver-Brooks Firetube Boilers, the following features apply specifically to Model CB Firetube Boilers. The CB four-pass dryback boiler is the premium firetube boiler design available.

Four-Pass Dryback Design:

- Four-pass design provides high flue gas velocities and low stack temperature for guaranteed maximum efficiency.
- Dryback design provides full access to boiler tubes, tube sheet, and furnace for ease of maintenance.
- Dryback design includes single rear tube sheet construction, providing reduced tube sheet stresses.

Five Square Feet of Heating Surface per Boiler hp:

- Maximum heat transfer with minimum thermal stresses provide guaranteed efficiency and long boiler life.
- Highest guaranteed fuel-to-steam efficiencies.

Low Furnace Location

- Furnace located well below water level with generous clearance from bottom of boiler, allowing proper circulation.
- Low furnace provides additional safety margin between furnace and water level.
- Reduces water carryover, producing drier steam.

Hinged or Davited Front and Rear Doors:

- Provides full access to front and rear tube sheet and furnace.
- Reduces maintenance costs.

High Turndown Burner:

- 4:1 turndown (gas and oil) is standard.
- Advanced burner design provides maximum combustion efficiencies and high turndown.
- Reduced boiler cycling and maintenance.
- Boiler stays on line during low load conditions for optimum efficiency and performance.

Gas, No. 2 Oil, No. 6 Oil, and Combination Gas and Oil Burners Available:

- High radiant multi-port gas burner designed for high gas velocities and complete fuel/air mixing, providing maximum combustion efficiencies.
- Air atomizing oil burner available for proper oil atomization, maximum combustion efficiency, and low maintenance requirements.
- Air atomizing compressor provided with the boiler package for clean oil burning and ease of maintenance.
- Combination gas/oil burners provide quick fuel changeover without re- adjustment of the burner.
- Fuel oil controller eliminates the need for over 40 connections, combining gauges, valves, and regulators into a single casting.
- Retractable oil nozzle provides easy access and cleaning and eliminates coking of oil and nozzle tip when firing gas.

PRODUCT OFFERING

Model CB Firetube Boilers are available in low pressure steam, high pressure steam, and hot water designs. Burners are available to fire natural gas, light oil, heavy oil, or a combination of oil and gas. Optional alternate fuel burners are also available.

Model CB Boilers include:

- Four-pass dryback design.
- 15 hp through 100 hp.
- 150 psig - 350 psig high pressure steam.
- 15 psig low pressure steam.
- 30 psig or 125 psig hot water.
- Natural gas, light oil, or heavy oil firing.

The Model CB Boiler is the premium firetube product offering providing maximum boiler efficiency, the widest range of size and pressures, and premium control packages.

Available options: For option details, contact your Cleaver-Brooks authorized representative. Options include the following:

Boiler Options

- Auxiliary low water cut-off (standard on steam boilers).
- Drain valves.
- Additional screwed or flanged tappings.
- Special design pressures.
- Surge load baffles.
- Seismic design.
- Internal hot water coils.
- Blowdown valves.
- Non-return valves.
- Feedwater valves and regulators.
- Special doors, davited, hinged, left swing.
- Special base rails.
- Surface blowdown systems.
- Combustion relief door.
- Weather-proofing.
- Blend pump.

Burner/Control Options

- Special modulation controls.
- Optional flame safeguard controller.
- Lead/lag system.
- High altitude design, up to 12,000 ft.
- Special insurance and code requirements (e.g. FM, ASME CSD-1).
- Alarm bell/silence switch.

- Special motor requirements (TEFC, high efficiency).
- Remote contacts.
- Special purpose indicator lights.
- Main disconnect.
- Elapsed time meter.
- Voltmeter/micro-ammeter.
- NEMA enclosures.
- Low fire hold controls.
- Remote emergency shut-off (115V).
- Circuit breaker.
- Day/night controls.
- Special power requirements.

Fuel Options

- Automatic fuel changeover.
- Special gas pressure regulator.
- Oversized/undersized gas trains.
- Gas strainer.
- Special fuel shut-off valves.
- Special pilot.
- Alternate fuel firing (propane, digester gas, etc.).
- Special oil pumps.

DIMENSIONS AND RATINGS

- Dimensions and ratings for the Model CB boilers are shown in the following tables and illustrations:
- Table A6-1. Model CB Steam Boiler Ratings (15 thru 100 hp)
- Table A6-2. Model CB Hot Water Boiler Ratings (15 thru 100 hp)
- Table A6-3. Safety Valve Openings
- Table A6-4. Relief Valve Openings
- Figure A6-1. Model CB Steam Boiler Dimensions (15 and 150 lb design pressure) (15 thru 100 hp)
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Table A6-1. Model CB Steam Boiler Ratings (15 - 100 hp)

BOILER HP	15[C]	20[C]	30[C]	40[C]	50	60	70	80	100
RATINGS - SEA LEVEL TO 3000 FT									
Rated Cap. (lbs steam/hr @212°F) Btu Output (1000 Btu/hr)	518 502	690 670	1035 1004	1380 1339	1725 1674	2070 2009	2415 2343	2760 2678	3450 3348
APPROXIMATE FUEL CONSUMPTION AT RATED CAPACITY									
Light Oil (gph)[A]	4.5	6.0	9.0	12.0	14.9	17.9	20.9	23.9	29.9
Heavy Oil (gph)[B]	-	-	-	-	13.9	16.7	19.5	22.3	27.9
Gas (cfh) 1000 Btu-Nat Gas (Therm/hr)	628 6.3	837 8.4	1255 12.6	1674 16.7	2092 20.9	2511 25.1	2929 29.3	3348 33.5	4184 41.8
POWER REQUIREMENTS - SEA LEVEL TO 3000 FT, 60 HZ									
Blower Motor hp (except gas)	1	1	1-1/2	2	2	2	2	2[D]	3
Gas Models (only)	1	1	1-1/2	2	2	2	2	2[D]	3
Oil Pump Motor, hp No. 2 Oil	Belt-Driven From Blower				1/3	1/3	1/3	1/3	1/3
Oil Pump Motor, hp No. 6 Oil	-	-	-	-	1/3	1/3	1/3	1/3	1/3
Oil Heater kW No. 6 Oil	-	-	-	-	5	5	5	5	5
Air Compressor Motor hp (Oil firing Only)	Air Compressor Belt-Driven from Blower Motor				2	2	2	2	2

NOTES:
1. For altitudes above 3000 ft, contact your local Cleaver-Brooks authorized representative for verification of blower motor hp.
A. Based on 140,000 Btu/gal.
B. Based on 150,000 Btu/gal.
C. No. 6 Oil not available in 15-40 hp range.
D. 3 hp above 2000 ft.

Table A6-2. Model CB Hot Water Boiler Ratings (15 - 100 hp)

BOILER HP	15[c]	20[c]	30[c]	40[c]	50	60	70	80	100
RATINGS - SEA LEVEL TO 3000 FT									
Rated Cap Btu Output (1000 Btu/hr)	502	670	1004	1339	1674	2009	2343	2678	3348
APPROXIMATE FUEL CONSUMPTION AT RATED CAPCITY									
Light Oil (gph)[A]	4.5	6.0	9.0	12.0	14.9	17.9	20.9	23.9	29.9
Heavy Oil (gph)[B]	-	-	-	-	13.9	16.7	19.5	22.3	27.9
Gas (cfh)MBtu- nat Gas (Therm/hr)	628 6.3	837 8.4	1255 12.6	1674 16.7	2092 20.9	2511 25.1	2929 29.3	3348 33.5	4184 41.8
POWER REQUIREMENTS - SEA LEVEL TO 3000 FT, 60 HZ									
Blower Motor hp (except gas)	1	1	1-1/2	2	2	2	2	2[D]	3
Gas Models (only)	1	1	1-1/2	2	2	2	2	2[D]	3
Oil Pump Motor, hp No. 2 Oil	Belt-Driven From Blower				1/3	1/3	1/3	1/3	1/3
Oil Pump Motor, hp No. 6 Oil	-	-	-	-	1/3	1/3	1/3	1/3	1/3
Oil Heater kW No. 6 Oil	-	-	-	-	5	5	5	5	5
Air Compressor Motor hp (Oil firing Only)	Air Compressor Belt-Driven from Blower Motor				2	2	2	2	2

NOTES:
1. For altitudes above 3000 ft, contact your local Cleaver-Brooks authorized representative for verification of blower motor hp.
A. Based on 140,000 Btu/gal.
B. Based on 150,000 Btu/gal.
C. No. 6 Oil not available in 15-40 hp range.
D. 3 hp above 2000 ft.

Table A6-3. Steam Boiler Safety Valve Openings

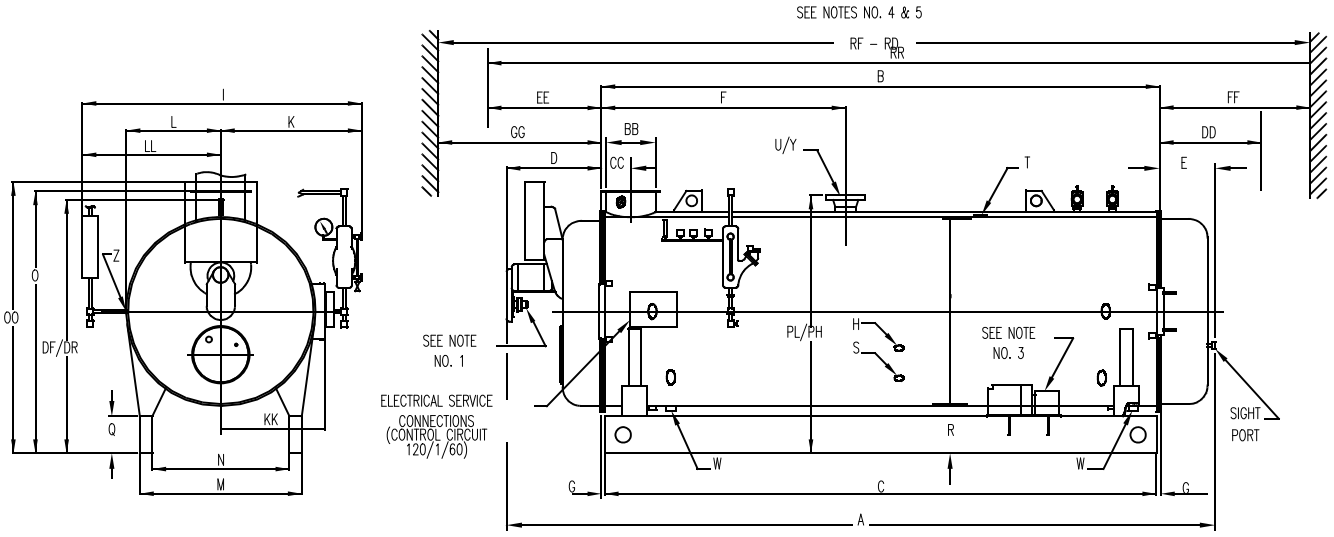
VALVE SETTING	15 PSIG STEAM		100 PSIG STEAM		125 PSIG STEAM		150 PSIG STEAM		200 PSIG STEAM		250 PSIG STEAM	
BOILER HP	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)
15	1	1-1/2	1	1	1	3/4	1	3/4	1	3/4	1	3/4
20	1	1-1/2	1	1	1	3/4	1	3/4	1	3/4	1	3/4
25	1	2	1	1	1	1	1	1	1	3/4	1	3/4
30	1	2	1	1-1/4	1	1	1	1	1	3/4	1	3/4
40	1	2-1/2	1	1-1/4	1	1-1/4	1	1	1	1	1	1
50	1	2-1/2	1	1-1/2	1	1-1/4	1	1-1/4	1	1	1	1
60	1	2	1	1-1/2	1	1-1/4	1	1-1/4	1	1	1	1
70	1	2	1	2	1	1-1/2	1	1-1/2	1	1-1/4	1	1
80	1	2-1/2	1	2	1	1-1/2	1	1-1/2	1	1-1/4	1	1-1/4
100	1	2-1/2	1	2	1	1-1/2	1	1-1/2	1	1-1/2	1	1-1/4

Table revised 04/2012

Table A6-4. Hot Water Boiler Relief Valve Openings

VALVE SETTING	30 PSIG HW		60 PSIG HW		100 PSIG HW		125 PSIG HW	
BOILER HP	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)
15	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1
25	1	1-1/4	1	1	1	1	1	1
30	1	1-1/4	1	1	1	1	1	1
40	1	1-1/4	1	1	1	1	1	1
50	1	2	1	1-1/4	1	1	1	1
60	1	2	1	1-1/4	1	1	1	1
70	1	2	1	2	1	1-1/4	1	1
80	1	2	1	2	1	1-1/4	1	1-1/4
100	1	2-1/2	1	2	1	1-1/4	1	1-1/4

NOTES:
1.Hot water relief valves are Kunkle #537.
2. BHP followed by "A" designates hot water boilers furnished in a smaller vessel size with additional tubes in the upper portion of the vessel.



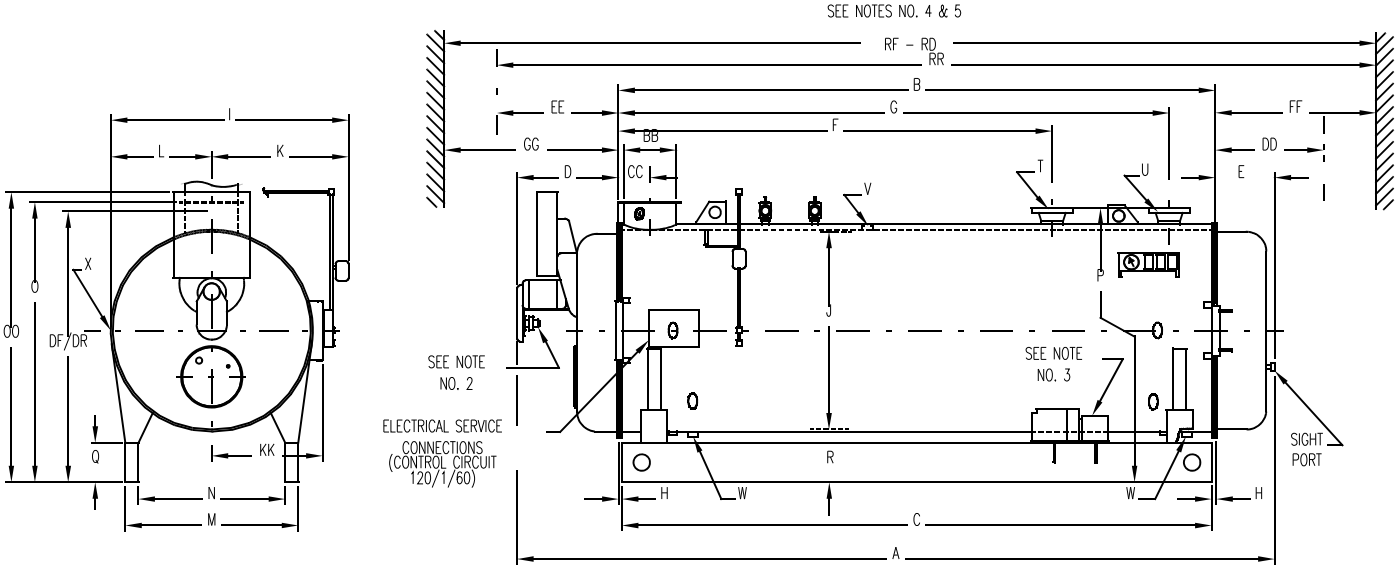
BOILER HP	DIM	15	20	30	40	50	60	70	80	100
LENGTHS										
Overall	A	96-5/8	96-5/8	114-5/8	140-5/8	129	129	168	168	187
Shell	B	62-5/8	62-5/8	80-5/8	106-5/8	92	92	131	131	150
Base Frame	C	59	59	77	103	91	91	130	130	148
Front Head Extension	D	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2
Rear Head Extension	E	15-1/2	15-1/2	15-1/2	15-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2
Front Ring Flange to Nozzle - 15 psig	F	36	36	45	57	46	46	65-1/2	65-1/2	75
Front Ring Flange to Nozzle - 150 psig	F	36	36	45	57	46	46	72-1/2	72-1/2	82
Ring Flange to Base	G	1-13/16	1-13/16	1-13/16	1-13/16	5/8	1/2	1/2	1/2	1/2
WIDTHS										
Overall	I	61	61	61	61	73	73	73	73	73
ID, Boiler	J	36	36	36	36	48	48	48	48	48
Center to Water Column	K	33	33	33	33	39	39	39	39	39
Center to Outside Hinge	KK	22	22	22	22	29	29	29	29	29
Center to Lagging	L	20	20	20	20	27	27	27	27	27
Center to Auxiliary LWCO	LL	28	28	28	28	34	34	34	34	34
Base, Outside	M	28	28	28	28	37-5/8	37-5/8	37-5/8	37-5/8	37-5/8
Base, Inside	N	22	22	22	22	29-5/8	29-5/8	29-5/8	29-5/8	29-5/8

Figure A6-1. Model CB Steam Boiler Dimensions and Weights (15 and 150 psig Design Pressure - 15 to 100 hp) Sheet 1 of 2

BOILER HP	DIM	15	20	30	40	50	60	70	80	100
HEIGHTS										
Base to Steam Outlet (15 psig only)	PL	50-1/4	50-1/4	50-1/4	50-1/4	70-1/2	70-1/2	70-1/2	70-1/2	70-1/2
Overall	OO	66	66	66	66	78-3/4	78-3/4	78-3/4	78-3/4	78-3/4
Base to Vent Outlet	O	53-1/2	53-1/2	53-1/2	53-1/2	70	70	70	70	70
Base to Steam Outlet (150 psig only)	PH	50-1/4	50-1/4	50-1/4	50-1/4	66-1/2	66-1/2	66-1/2	66-1/2	70-5/16
Height of Base	Q	8	8	8	8	12	12	12	12	12
Base to Bottom of Boiler	R	12	12	12	12	16	16	16	16	16
BOILER CONNECTIONS										
Chemical Feed	H	1	1	1	1	1	1	1	1	1
Feedwater, Right and Left	S	1	1	1	1	1-1/4	1-1/4	1-1/4	1-1/4	1-1/4
Low Pressure (15 psig only) Steam Nozzle Drain, Front and Rear	 U W	 4 1	 4 1	 4 1	 6[A] 1-1/4	 6[A] 1-1/4	 6[A] 1-1/4	 6[A] 1-1/2	 6[A] 1-1/2	 8[A] 1-1/2
High Pressure (150 psig only) Surface Blowoff, Top C_L Steam Nozzle Blowdown, Front and Rear	 T Y W	 1 1-1/2 1	 1 1-1/2 1	 1 2 1	 1 2 1	 1 3 1-1/4	 1 3 1-1/4	 1 3 1-1/4	 1 3 1-1/4	 1 4[B] 1-1/4
VENT STACK										
Diameter (flgd connection)	BB	6	6	8	8	10	10	12	12	12
Front Ring Flange to Vent C_L	CC	4	4	5	5	6	6	7	7	7
MINIMUM CLEARANCES										
Rear Door Swing[C]	DD	44	44	44	44	55	55	55	55	55
Front Door Swing[C]	EE	44	44	44	44	55	55	55	55	55
Tube Removal, Rear	FF	56	56	74	100	84	84	123	123	142
Tube Removal, Front	GG	46	46	64	90	74	74	113	113	132
MINIMUM BOILER ROOM LENGTH ALLOWING FOR DOOR SWING AND TUBE REMOVAL FROM:										
Rear of Boiler	RR	163	163	199	251	231	231	309	309	347
Front of Boiler	RF	153	153	189	241	221	221	299	299	337
Thru Window or Doorway	RD	151	151	169	195	202	202	241	241	260
WEIGHT IN LBS										
Normal Water Capacity		1340	1300	1710	2290	3130	2920	4620	4460	5088
Approx. Ship Wgt - 15 psig		3000	3100	3650	4350	6900	7000	8100	8200	9000
Approx. Ship Wgt - 150 psig		3100	3200	3800	4500	7000	7200	8800	9000	9500
Approx. Ship Wgt - 200 psig		3300	3400	4100	4700	7400	7600	9300	9500	10000

NOTES:
1. Air compressor belt driven from blower motor on sizes 15 thru 40
2. Air compressor module on sizes 50 thru 100 hp.
3. Accompanying dimensions, while sufficiently accurate for layout purposes, must be confirmed for construction by certified dimension prints.
A. ANSI 150 psig flange.
B. ANSI 300 psig flange.
C. 15 thru 100 hp standard hinged door.

Figure A6-1. Model CB Steam Boiler Dimensions and Weights (15 and 150 psig Design Pressure - 15 to 100 hp) Sheet 2 of 2



BOILER HP	DIM	15	20	30	40	50	60	70	80	100
LENGTHS										
Overall	A	97	97	114-5/8	140-5/8	129	129	168	168	187
Shell	B	62-5/8	62-5/8	80-5/8	106-5/8	92	92	131	131	150
Base Frame	C	59	59	77	103	91	91	130	130	148
Front Head Ext.	D	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2
Rear Head Ext.	E	15-1/2	15-1/2	15-1/2	15-1/2	18-1/2	18-1/2	18-1/2	18-1/2	18-1/2
Front Ring Flange to Return	F	43-5/8	43-5/8	62	81	69	69	108	108	127
Front Ring Flange to Outlet	G	55-1/8	55-1/8	73-1/8	98-1/2	84-5/8	84-5/8	123-5/8	123-5/8	142-5/8
Ring Flange to Base	H	1-13/16	1-13/16	1-13/16	1-13/16	5/8	5/8	5/8	5/8	1
WIDTHS										
Overall	I	48-3/4	48-3/4	48-3/4	48-3/4	63	63	63	63	63
ID, Boiler	J	36	36	36	36	48	48	48	48	48
Center to Entrance Box	K	28-3/4	28-3/4	28-3/4	28-3/4	36	36	36	36	36
Center to Outside Hinge	KK	22	22	22	22	29	29	29	29	29
Center to Lagging	L	20	20	20	20	27	27	27	27	27
Base, Outside	M	28	28	28	28	37-5/8	37-5/8	37-5/8	37-5/8	37-5/8
Base, Inside	N	22	22	22	22	29-5/8	29-5/8	29-5/8	29-5/8	29-5/8

Figure A6-2. Model CB Hot Water Boiler Dimensions (30 psig and 125 psig Design Press. - 15 to 100 hp) Sheet 1 of 2

BOILER HP	DIM	15	20	30	40	50	60	70	80	100
HEIGHTS										
Overall	OO	66	66	66	66	72-5/8	72-5/8	72-5/8	72-5/8	72-5/8
Base to Vent Outlet	O	53-1/2	53-1/2	53-1/2	53-1/2	70	70	70	70	70
Base to Return and outlet	P	50	50	50	50	70-1/2	70-1/2	70-1/2	70-1/2	70-1/2
Davit (Front)	DF	-	-	-	-	-	-	-	-	-
Davit (Rear)	DR	-	-	-	-	-	-	-	-	-
Height of Base	Q	8	8	8	8	12	12	12	12	12
Base to bottom of boiler	R	12	12	12	12	16	16	16	16	16
BOILER CONNECTION										
Water Return[A]	T	2-1/2	2-1/2	3	3	4	4	4	4	4
Water Outlet[A] -dip tube included	U	2-1/2	2-1/2	3	3	4	4	4	4	4
Air Vent	v	1	1	1	1	1-1/4	1-1/4	1-1/4	1-1/4	1-1/4
Drain, Front and Rear	W	1	1	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	1-1/2
Auxiliary Connection	X	1	1	1	1	1	1	1	1	1
VENT STACK										
Diameter (flgd. connection)	BB	6	6	8	8	10	10	12	12	12
Front Ring Flange to vent C_L	CC	4	4	5	5	6	6	7	7	7
MINIMUM CLEARANCES										
Rear Door Swing	DD	44	44	44	44	55	55	55	55	55
Front Door Swing	EE	44	44	44	44	55	55	55	55	55
Tube Removal, Rear	FF	56	56	74	100	84	84	123	123	142
Tube, Removal, Front	GG	46	46	64	90	74	74	113	113	132
MINIMUM BOLER ROOM LENGTH ALLOWING FOR DOOR SWING AND TUBE REMOVAL FROM:										
Rear of Boiler	RR	163	163	199	251	231	231	309	309	347
Front of Boiler	RF	153	153	189	241	221	221	299	299	337
Thru Window or Doorway	RD	151	151	169	195	202	202	241	241	260
WEIGHT IN LBS										
Water Capacity Flooded		1500	1460	1915	2585	3665	3500	5420	5250	5960
Approx. Ship. Wgt. – 30 psig Approx. Ship. Wgt. – 125 psig		3000 3300	3100 3400	3650 3880	4350 4580	6800 7100	7000 7300	8000 8350	8100 8450	8800 9150

NOTES:

1. Accompanying dimensions and ratings while sufficiently accurate for layout purposes, must be confirmed for construction by certified dimension prints.
2. Air compressor belt driven from blower motor on sizes 15 thru 40 hp.
3. Air compressor module on sizes 50 thru 100 hp.
4. 15 - 100 hp, hinged door standard.
5. Add 370 lbs to the 80 hp ship weight for 100A and 485 lbs to the 100 hp ship weight for the 125A.

A. 15-40 HP are threaded connection; 50-100 HP are 150# flange.

Figure A6-2. Model CB Hot Water Boiler Dimensions (30 psig Design Pressure - 15 to 100 hp) - Sheet 2 of 2

BOILER HP	DIMENSION (INCHES)				
	A	B	C	D	E
15 - 40	20	36	28	45	20
50 - 100	27	48	38	60	26

NOTE:

1. Dimensions in inches.
2. 15 - 100 hp (100A & 125A) boilers are standardly equipped with hinges. Davit available as an option.

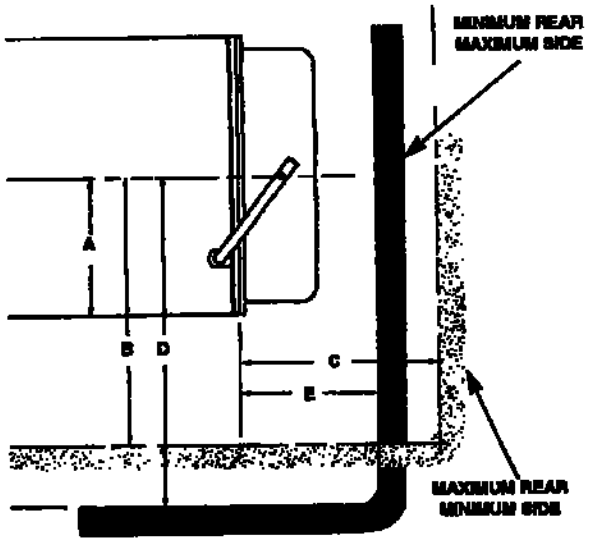
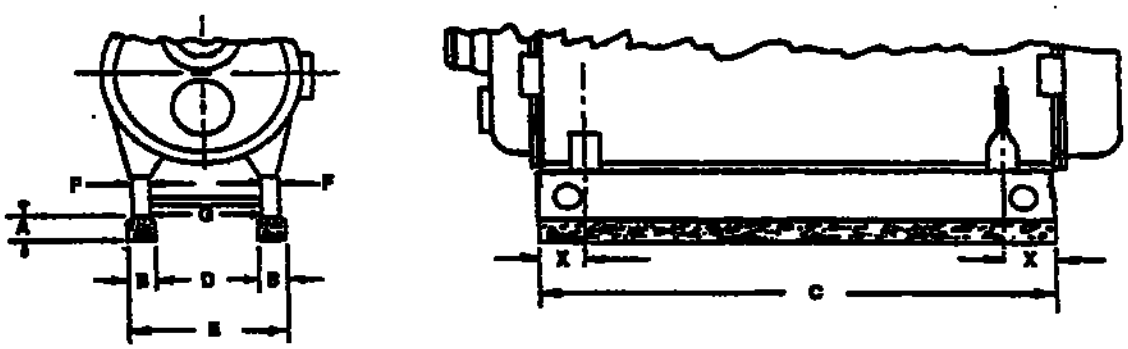


Figure A6-3. Space Required to Open Rear Head on Model CB Boilers Equipped with Davits

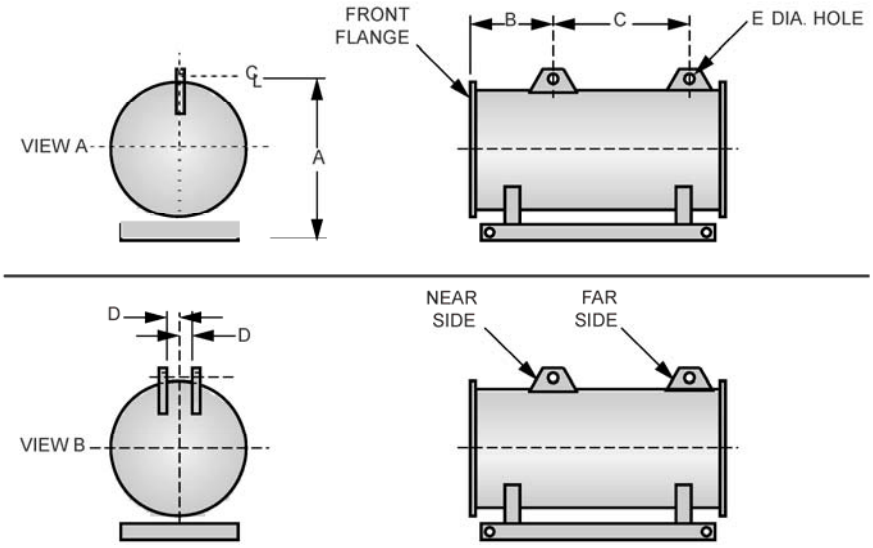


BOILER HP	A	B	C	D	E	F	G	X1	X2
15-20	6	8	59	17	33	3	22	9-3/4	9-3/4
25-30	6	8	77	17	33	3	22	9-3/4	9-3/4
40	6	8	103	17	33	3	22	9-3/4	9-3/4
50-60	6	8	91	26	42	4	29-5/8	8-1/4	8-1/4
70-80	6	8	130	26	42	4	29-5/8	8-1/4	8-1/4
100	6	8	148	26	42	4	29-5/8	8-1/4	8-1/4

NOTE:

1. All numbers in table are in inches.
2. 6-inch high mounting piers recommended for use beneath the boiler base frame. The use of these piers provides increased inspection accessibility to the piping beneath the boiler and added height for washing down the area beneath the boiler.

Figure A6-4. Model CB Boiler Mounting Piers



BOILER HP		VIEW	ALL DIMENSIONS IN INCHES				
			A	B	C	D	E
15	Steam	A	51-3/4	12	38-3/4	-	2-1/2
	Hot Water	B	50-1/2	12	38-3/4	6	2-1/2
20	Steam	A	51-3/4	12	38-3/4	-	2-1/2
	Hot Water	B	50-1/2	12	38-3/4	6	2-1/2
25	Steam	A	51-3/4	12	56-3/4	-	2-1/2
	Hot Water	B	50-1/2	12	56-3/4	6	2-1/2
30	Steam	A	51-3/4	12	56-3/4	-	2-1/2
	Hot Water	B	50-1/2	12	56-3/4	6	2-1/2
40	Steam	A	51-3/4	12	82-3/4	-	2-1/2
	Hot Water	B	50-1/2	12	82-3/4	6	2-1/2
50	All	B	68	18	57	10	2-1/2
60	All	B	68	18	57	10	2-1/2
70	All	B	68	27	67	10	2-1/2
80	All	B	68	27	67	10	2-1/2
100	All	B	68	27	86	10	2-1/2

NOTE:

1. A, B and C Dimensions may vary by 1/2 inch.

2. BHP followed by “A” designates hot water boilers furnished in a smaller vessel size with additional tubes in upper portion of vessel.

Figure A6-5. Lifting Lug Locations, Model CB Boilers

PERFORMANCE DATA

Efficiency

Tables A6-5 through A6-10 show predicted fuel-to-steam efficiencies (including radiation and convection losses) for Cleaver-Brooks Model CB Firetube boilers. For specific efficiencies on firetube boiler offerings not listed here, contact your local Cleaver-Brooks authorized representative.

Cleaver-Brooks offers an industry leading fuel-to-steam boiler efficiency guarantee for Model CB Firetube Boilers. The guarantee is based on the fuel-to-steam efficiencies shown in the efficiency tables and the following conditions. The efficiency percent number is only meaningful if the specific conditions of the efficiency calculations are clearly stated in the specification (see Cleaver-Brooks publication CB-7768 for a detailed description of efficiency calculations).

The boiler manufacturer shall guarantee that, at the time of startup, the boiler will achieve fuel-to-steam efficiency (as shown in the tables listed above) at 100% firing rate (add efficiency guarantees at 25%, 50%, and 75% of rating, if required). If the boiler(s) fail to achieve the corresponding guaranteed efficiency as published, the boiler manufacturer will rebate, to the ultimate boiler owner, five thousand dollars ($5,000) for every full efficiency point (1.0%) that the actual efficiency is below the guaranteed level. The specified boiler efficiency is based on the following conditions.

1. Fuel specification used to determine boiler efficiency:
   - Natural Gas

     Carbon, % (wt) = 69.98

     Hydrogen, % (wt) = 22.31

     Sulfur, % (wt) = 0.0

     Heating value, Btu/lb = 21,830
   - No. 2 Oil

     Carbon, % (wt) = 85.8

     Hydrogen, % (wt) = 12.7

     Sulfur, % (wt) = 0.2

     Heating value, Btu/lb = 19,420
   - No. 6 Oil

     Carbon, % (wt) = 86.6

     Hydrogen, % (wt) = 10.9

     Sulfur, % (wt) = 2.09

     Heating value, Btu/lb = 18,830
2. Efficiencies are based on ambient air temperature of 80 °F, relative humidity of 30%, and 15% excess air in the exhaust flue gas.
3. Efficiencies are based on manufacturer's published radiation and convection losses. (For Cleaver-Brooks radiation and convection losses, see Boiler Efficiency Facts Guide, publication number CB-7767).
4. Any efficiency verification testing will be based on the stack loss method.

When specifying the efficiencies in the tables, be sure to include the specific guarantee conditions to maximize the effectiveness of your efficiency specification. If you have any questions regarding the efficiency specifications, please contact your local Cleaver-Brooks authorized representative. For efficiencies and stack temperatures at operating pressures not listed, follow these procedures:

When the operating steam pressure is between 10 psig and 125 psig, interpolate the values from the efficiency tables.

When the operating steam pressure is above 125 psig, estimated efficiency can be calculated as follows:

Example:

Boiler: 100 hp.

Fuel: natural gas.

Operating steam pressure: 200 psig.

Find the fuel-to-steam efficiency at 100% firing rate. From Figure A6-6 for a 100 hp boiler operating at 100% firing rate and an operating steam pressure of 125 psig, the efficiency is 88.0%.

Using Figure A6-6, note that the stack temperature increases 36 °F at the higher operating pressure. To estimate boiler efficiency, use this rule of thumb: For every 40 °F increase in stack temperature, efficiency decreases by 1%. Since the stack temperature rise is 36 °F, the decrease in the boiler efficiency at 200 psig operating pressure is calculated as follows: 36/40 = .9%. Therefore, the boiler efficiency at 200 psig operating pressure is 82.5 - .9 = 81.6%.

Emissions

The emission data included in this section consists of typical uncontrolled emission levels for Cleaver-Brooks Model CB Firetube Boilers.

Notice

The data in Table A6-11 represents typical emission levels only. Guaranteed emission levels are available from your local Cleaver-Brooks authorized representative.

Table A6-5. Predicted Fuel-to-Steam Efficiencies (%), Model CB Boilers - 10 psig, Natural Gas

BOILER HP	FIRING RATE (%)			
	25	50	75	100
50	83.0	83.2	82.9	82.4
60	82.9	83.1	82.7	82.3
70	84.5	84.7	84.3	83.9
80	84.6	84.8	84.5	84.0
100	84.4	85.0	84.8	84.4

Table A6-6. Predicted Fuel-to-Steam Efficiencies (%), Model CB Boilers - 125 psig, Natural Gas

BOILER HP	FIRING RATE (%)			
	25	50	75	100
50	80.2	81.9	80.4	80.1
60	80.1	80.4	80.3	80.1
70	81.7	82.0	81.9	81.7
80	81.8	82.1	82.0	81.8
100	81.5	82.4	82.3	82.2

Table A6-7. Predicted Fuel-to-Steam Efficiencies (%), Model CB Boilers - 10 psig, No. 6 Oil

BOILER HP	FIRING RATE (%)			
	25	50	75	100
50	86.8	87.0	86.6	86.1
60	86.7	86.9	86.5	86.0
70	88.4	88.6	88.2	87.7
80	88.5	88.7	88.3	87.8
100	88.2	88.5	88.3	88.0

Table A6-8. Predicted Fuel-to-Steam Efficiencies (%), Model CB Boilers - 125 psig, No 6 Oil

BOILER HP	FIRING RATE (%)			
	25	50	75	100
50	83.9	84.2	84.0	83.8
60	83.8	84.1	83.9	83.8
70	85.5	85.8	85.6	85.4
80	85.6	85.9	85.7	85.6
100	84.6	85.8	85.9	85.8

Table A6-9. Predicted Fuel-to-Steam Efficiencies (%), Model CB Boilers - 10 psig, No. 2 Oil

BOILER HP	FIRING RATE (%)			
	25	50	75	100
50	86.5	86.7	86.3	85.8
60	86.3	86.6	86.2	85.7
70	87.9	88.2	87.8	87.3
80	88.1	88.3	87.9	87.4
100	87.8	88.4	88.1	87.7

Table A6-10. Predicted Fuel-to-Steam Efficiencies (%), Model CB Boilers - 125 psig, No 2 Oil

BOILER HP	FIRING RATE (%)			
	25	50	75	100
50	83.6	84.0	83.8	83.5
60	83.5	83.8	83.7	83.5
70	85.1	85.4	85.3	85.1
80	85.2	85.6	85.4	85.3
100	84.8	85.7	85.6	85.5

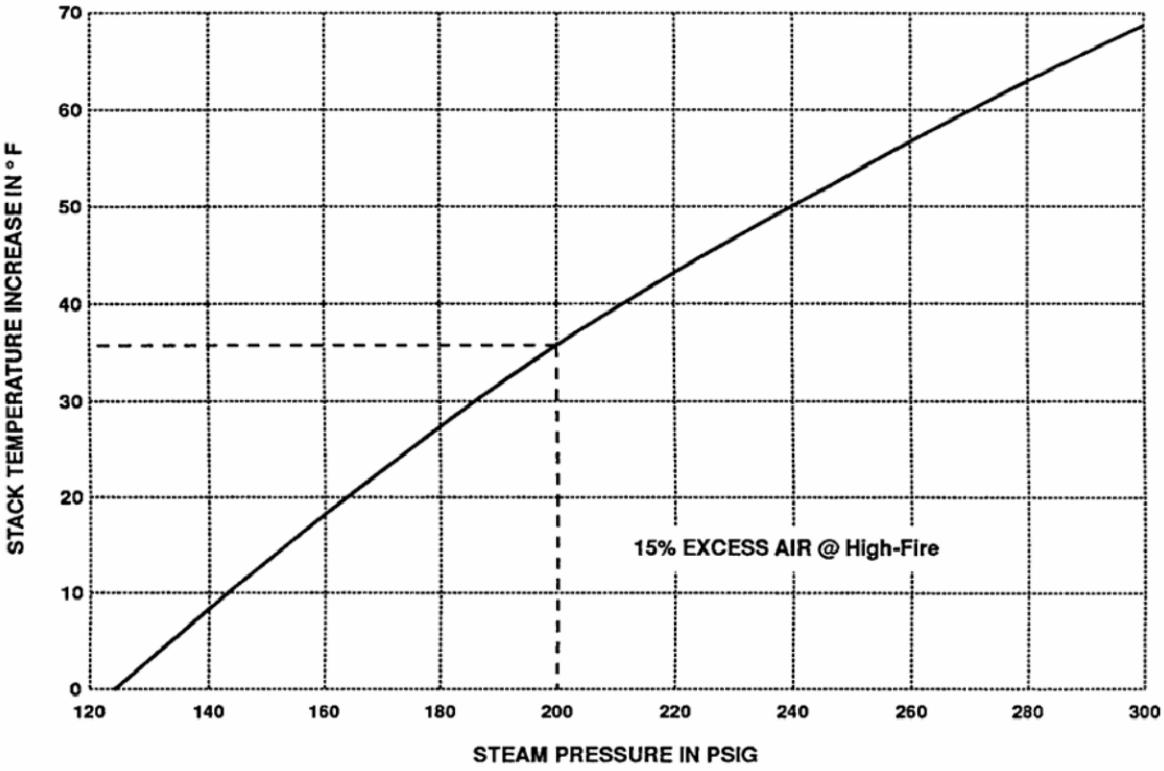


Figure A6-6. Predicted Stack Temperature Increase for Pressure Greater Than 125 psig

Table A6-11. Model CB Boiler Emission Data

POLLUTANT		ESTIMATED LEVELS - UNCONTROLLED		
		NATURAL GAS	NO. 2 OIL[B]	NO. 6 OIL[C]
CO	ppm[A]	200	90	95
	Lb/MMBtu	0.15	0.07	0.075
NOx	ppm[A]	100	185	502
	Lb/MMBtu	0.12	0.25	0.67
SOx	ppm[A]	1	278	278
	Lb/MMbtu	0.001	0.52	0.52
HC/VOCs	ppm[A]	40	50	70
	Lb/MMBtu	0.016	0.025	0.035
PM	ppm[A]	-	- -	
	Lb/MMBtu	0.01	0.025	0.160

NOTES:

Refer to Section E for detailed emission information.

A. ppm levels corrected to 3% O_2, dry basis.

B. Based on fuel constituent levels of:
Fuel-bound nitrogen content = 0.015% by weight
Sulfur content = 0.5% by weight
Ash content = 0.01% by weight

C. Based on fuel constituent levels of:
Fuel-bound nitrogen content = 0.7% by weight
Sulfur content = 0.5% by weight
Ash content = 0.1% by weight
Conradson carbon residue = 16% by weight

Table A6-12. Heating Surface, Model CB Boilers

BOILER HP	HEATING SURFACE (SQ-FT)	
	FIRESIDE	WATERSIDE
15	75	85
20	100	109
25	125	144
30	150	162
40	200	219
50	250	266
60	300	323
70	350	388
80	400	441
100	500	544

ENGINEERING DATA

The following engineering information is provided for Model CB Firetube Boilers. Additional detail is available from your local Cleaver-Brooks authorized representative.

Blowdown Water Requirements

Some local codes require blowdown tanks to be constructed in accordance with recommendations of the National Board of Boiler and Pressure Vessel Inspectors.

The National Board's recommendations base the size of the blowdown tank on the removal of at least 4 inches of water from the boiler.

Sound Level

Table A6-17 summarizes predicted sound pressure levels for Model CB Boilers.

Table A6-18 and A6-19 give detailed octave band sound pressure levels for each boiler. These values are based on standard motors. Optional motor types and altitude conditions can increase sound levels.

Units

The units for the sound level tables are dBA (decibels, measured on the A-weighted scale) in reference to 0.0002 microbars (20 micro-Newtons per square meter). They are standardly referenced in specifying and reporting sound pressure levels on industrial equipment.

Table A6-13. Steam Volume and Disengaging Area

BOILER HP	STEAM VOLUME CU-FT		STEAM RELIEVING AREA, SQ-IN	
	HIGH PRESSURE[A]	LOW PRESSURE[B]	HIGH PRESSURE[A]	LOW PRESSURE[B]
15	2.9	5.9	1356	1637
20	2.9	5.9	1356	1637
25 & 30	3.9	7.9	1817	2195
40	5.3	10.8	2485	2999
50	9.7	16.0	2959	3372
60	9.7	16.0	2959	3372
70	14.3	23.7	4367	4975
80	14.3	23.7	4367	4975
100	16.6	27.4	5053	5757

NOTE: Based on normal water level.

A. Based on 150 psig design pressure.

B. Based on 15 psig design pressure.

Table A6-14. Water Circulation Rate and Temperature Drop for Hot Water Boiler

BOILER HP	BOILER OUTPUT (1000) BTU/HR	SYSTEM TEMPERATURE DROP - DEGREES F									
		10	20	30	40	50	60	70	80	90	100
		MAXIMUM CIRCULATING RATE - GPM									
15	500	100	50	33	25	20	17	14	12	11	10
20	670	134	67	45	33	27	22	19	17	15	13
30	1005	200	100	67	50	40	33	29	25	22	20
40	1340	268	134	89	67	54	45	38	33	30	27
50	1675	335	168	112	84	67	56	48	42	37	33
60	2010	402	201	134	101	80	67	58	50	45	40
70	2345	470	235	157	118	94	78	67	59	52	47
80	2680	536	268	179	134	107	90	77	67	60	54
100	3350	670	335	223	168	134	112	96	84	75	67

NOTES:

1. Minimum recommended return water temperature is 150 °F. Minimum recommended outlet temperature for Model CB Hot Water Boilers is 170 °F. Contact your local Cleaver-Brooks authorized representative for special hot water application information.

2. See Section H2 for over-pressure requirements.

Table A6-15. Recommended Steam Nozzle Size (To Maintain 4000 to 5000 fpm Nozzle Velocity)

BOILER HP										
OPERATING PRESSURE PSIG	15	20	25	30	40	50	60	70	80	100
15	4	4	4	4 6		6	6	6	6	8
30	2	2	2.5	2.5	3	4	4	4	4	6
40	2	2	2.5	2.5	3	3	4	4	4	6
50	1.5	2	2	2.5	2.5	3	3	4	4	4
75	1.5	2	2	2	2.5	3	3	3	4	4
100	1.5	1.5	2	2 2		3	3	3	3	4
125	1.5	1.5	2	2 2		3	3	3	3	4
150	1.5	1.5	2	2 2		2.5	2.5	2.5	2.5	2.5
200	1.5	1.5	2	2 2		2.5	2.5	2.5	2.5	2.5
250	1.5	1.5	2	2 2		2	2	2	2	2

NOTES:

1. Steam nozzle sizes given in inches.

2. Recommended steam nozzle sizes based on 4000 to 5000 fpm steam velocity. Spool pieces (300 lb flanges) are available in the following sizes (in inches): 3x2-1/2x30, 4x3x30, 6x4x36, 8x6x48, 10x8x48, and 12x8x48.

3. All standard steam nozzle sizes for 150 psig design pressure or greater are the same as 125 psig operating pressure on the above table. To increase or decrease the standard size, request the change with your local Cleaver-Brooks authorized representative.

Table A6-16. Model CB Blowdown Tank Sizing Information

BOILER HP	WATER (GAL.)
15-20	26
25-30	34
40	47
50-60	55
70-80	80
100	93

NOTE: Quantity of water removed from boiler by lowering normal water line 4".

Table A6-17. Sound Pressure Level Summary (50-100 hp)

BOILER HP	50	60	70	80	100
HFO, dBA	79	79	79	79	81
LFO, dBA	78	78	78	78	79
HFG, dBA	77	77	78	78	78
LFG, dBA	72	73	74	75	75

NOTES:

1. Boiler No. followed by an “a” designates hot water boilers furnished in a smaller vessel size with additional tubes in the upper portion of the vessel.

2. Sound Pressure levels measured on boilers operating in various locations and expressed in dBA are as follows:

NOTE: ABBREVIATIONS: HF = High Fire LF = Low Fire O = Oil G = Gas

Table A6-18. Model CB Boiler Sound Pressure Level Details (40 hp)

FIRING RATE FUEL	SOUND LEVEL dBA	OCTAVE BAND SOUND PRESSURE LEVELS IN dB RE .0002 MICROBAR									
		31Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	16kHz
40HP[A]											
LFG	76	73	75	72	74	76	70	67	68	64	57
LFO	77	73	75	75	76	75	72	67	66	66	58
HFG	79	81	78	74	80	78	71	69	68	64	58
HFO	79	72	77	77	81	78	73	69	66	66	58

A. The data shown above was taken on the 40 hp. Since the highest Sound Level is below 80 dBA, no additional 36" diameter Firetubes were tested. If Sound Level predictions are required for the 15 thru 30 hp, use the values shown for the 40 hp.

NOTE: ABBREVIATIONS: HF = High Fire LF = Low Fire O = Oil G = Gas

Table A6-19. Model CB Boiler Sound Pressure Level Details (50 - 100 hp)

FIRING RATE FUEL	SOUND LEVEL dBA	OCTAVE BAND SOUND PRESSURE LEVELS IN dB RE .0002 MICROBAR									
		31Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	16kHz
50 HP											
LFG	72	71	65	71	71	70	68	63	60	53	46
LFO	78	71	76	78	73	72	72	76	61	56	54
HFG	77	72	68	75	76	74	74	66	61	54	47
HFO	79	72	70	75	75	77	77	70	63	56	54
60 HP											
LFG	73	70	75	72	72	73	68	61	56	50	45
LFO	78	68	77	74	74	75	74	71	58	53	48
HFG	77	73	75	72	72	75	76	63	55	50	44
HFO	79	75	75	75	75	77	77	72	59	52	45
70 HP											
LFG	74	70	70	75	74	73	71	62	56	51	46
LFO	78	70	73	77	74	75	74	70	59	53	57
HFG	78	72	72	77	78	75	76	68	58	52	57
HFO	79	73	73	80	77	77	76	70	60	54	48
80 HP											
LFG	75	70	75	75	73	75	76	66	62	62	53
LFO	78	69	77	76	74	76	74	73	63	62	57
HFG	78	72	74	78	75	75	76	57	61	59	52
HFO	79	75	75	75	74	76	75	69	62	59	54
100 HP											
LFG	75	69	69	75	76	73	71	65	63	59	50
LFO	79	68	73	78	78	75	79	76	63	59	54
HFG	78	69	70	77	77	74	74	69	63	59	50
HFO	81	68	70	77	78	78	77	71	64	59	57

NOTES: ABBREVIATIONS: HF = High Fire LF = Low Fire O = Oil G = Gas

Boiler HP followed by an “A” designates hot water boilers furnished in a smaller vessel size with additional tubes in the upper portion of the vessel.

Test Method

The sound pressure levels in the above tables were obtained from tests in accordance with the "ABMA Test Code for the Measurement of Sound from Packages Boilers." In accordance with this code, the sound pressure levels reported were measured on the boiler centerline 4-1/2 feet vertically above the bottom of the base rails and 3 feet horizontally in front of the end of the blower motor or front surface of the electrical cabinet.

Sound Level Meter

The sound level meter used complies with ANSI S1.4, Type 1 (Precision). The readings are taken with the meter set for slow response.

Sound Pressure

On large size boilers, the need for auxiliary equipment, and the necessary interconnecting piping, make it impractical (and sometimes impossible) to provide a boiler testing environment that is suitable for obtaining the data needed to develop Sound Pressure Power levels.

Typical Values

Sound pressure levels (dBA) for identical boilers will vary between boiler rooms. In addition, variations will occur between different people using different sound meters on the same boiler. And finally, no two boilers can be expected to give precisely the same sound levels. For these reasons, we can only predict, but not guarantee, sound levels (dBA).

Octave Band

When predicting sound pressures in octave bands (e.g., dB at 125 Hz), even greater variations between boilers, between sound meters, and between operators can be expected. These larger variations in the low and high frequencies make octave band levels a less reliable method of reporting than A-scale sound levels. (Since A-scale sound levels are dominated by mid-frequency sounds, the A-scale sound levels between two boilers can be in reasonable agreement even though the low and high frequencies of octave band measurement do not closely correspond).

Gas-Fired Burners

Table A6-20 shows minimum gas pressure requirements for Model CB Boilers.

Table A6-21 shows minimum required gas pressure altitude conversion.

Table A6-22 shows maximum gas consumption for natural gas and propane vapor.

Figure A6-7 shows standard gas train sizes and locations for Model CB Firetube Boilers.

Figure A6-8 shows typical gas train piping layouts for multiple boiler applications.

Figure A6-9 shows gas train components.

Oil-Fired Burners

Fuel oil consumption information is shown on the boiler rating sheets in the Dimensions and Rating Section.

Figure A6-10 shows the oil connection sizes and locations for Model CB Boilers firing No. 2 oil.

Figure A6-11 shows the oil connection sizes and locations for Model CB Boilers firing No. 5 and No. 6 oil.

Figure A6-12 through Figure A6-14 show typical oil systems and layouts.

Figure A6-15 shows the detail of an oil transfer tank (day tank) typically utilized to provide a storage reservoir between the oil system supply pump and the boiler oil pump.

No. 6 Oil Piping, Storage Tank Heating

If the oil viscosity exceeds 4,000 SSU at the pumping temperature, tank preheating is required.

Based on the climate conditions for the job location, the minimum pumping temperature can be predicted, and the viscosity for the particular oil at this pumping temperature can be determined.

It is recommended to provide for tank and/or line heating on all No. 6 oil installations to ensure against high viscosities at decreased pumping temperatures. The following are two common methods:

1. Provide a tank suction heater and bundling the steam or water lines to the heater with the oil lines.
2. Provide electric heating equipment on the oil lines and/or in the storage tank.

Notice

The temperature in the oil suction line should not exceed 130 °F as higher temperatures could cause vapor binding of the oil pump and decreased oil flow.

See Figure A6-16 for an example of tank heating method.

Table A6-20. Minimum required gas pressure at entrance to gas train

Boiler Hp	Train Size	Gas Supply Pressure Less Then 27" W.C.		Gas Supply Pressure Up To 10 Psi	
		Regulator Model*	Min. Supply Press "W.C.	Regulator Model*	Min. Supply Press "W.C.
15	1-1/4	Maxitrol 1-1/4", RV-61	4	Maxitrol 1-1/4", 210-D	4
20	1-1/4	Maxitrol 1-1/4", RV-61	7	Maxitrol 1-1/4", 210-D	7
30	1-1/2	Maxitrol 1-1/2", RV-81	6	Maxitrol 1-1/2", 210-D	7
40	1-1/2	Maxitrol 1-1/2", RV-81	9	Maxitrol 1-1/2", 210-D	10
50	2	Maxitrol 2", RV-91	6	Maxitrol 2", 210-E	7
60	2	Maxitrol 2", RV-91	7	Maxitrol 2", 210-E	8
70	2	Maxitrol 2", RV-91	10	Maxitrol 2", 210-E	11
80	2	Maxitrol 2", RV-91	12	Maxitrol 2", 210-E	14
100	2	Maxitrol 2", RV-91	12	Maxitrol 2", 210-E	15
*Maxitrol RV series is standard; 210 series is optional					

ALTITUDE (FT)	CORRECTION FACTOR	ALTITUDE (FT)	CORRECTION FACTOR
1000	1.04	6000	1.25
2000	1.07	7000	1.30
3000	1.11	8000	1.35
4000	1.16	9000	1.40
5000	1.21	-	-

To obtain minimum required gas pressure at altitudes above 700 feet, multiply the pressure by the listed factors:
Inches WC x 0.577 = oz/sq-in.
Oz/sq-in x 1.732 = Inches WC.
Inches WC x 0.0361= psig.
Oz/sq-in x 0.0625 = psig.
Psig x 27.71 = Inches WC.
Psig x 16.0 = Oz/sq-in.

Table A6-21. Minimum required gas pressure altitude conversion

Table A6-22. Maximum Gas Consumption (CFH) for Natural Gas and Propane Vapor

BOILER HP	TYPE OF GAS AND HEAT CONTENT	
	NATURAL GAS 1000 (Btu/cu-ft)	PROPANE GAS 2550 (Btu/cu-ft)
15	625	245
20	835	330
25	1045	410
30	1255	490
40	1675	655
50	2095	820
60	2510	985
70	2930	1150
80	3350	1315
100	4185	1640

NOTES:

BHP followed by “A” designates hot water boilers furnished in a smaller vessel size with additional tubes in upper portion of vessel.

Table A6-23. Gas Pilot Data

BHP	Connection (inches) NPT	Min. Required Gas Pressure (Up to 700) Inches WC	Max. Permissible Gas Pressure (psig)
50-100	1/2	4	5

BHP	Manufactured 500 Btu/Cu. Ft	Natural 1000 Btu/ Cu. Ft	Propane 2500 Btu/Cu Ft
50-100	120	60	25

Approximate Gas Usage:

1. Multiply the CFH rate by 0.007 to obtain the number of cu. ft of gas used in 25 sec. (Length of (1) light off).
2. Multiply the number of cu. ft/light (item 1) by the estimated number of lights/hour or per day to obtain the approximate usage in cu. ft/hour or cu. ft/day.

BOILER HP	MODEL CB	
	CONNECTION SIZE (IN.) (NPT)	LOCATION DIMENSION “A” (IN.)
15, 20	1-1/4	65-1/2
30	1-1/2	68
40, 50A	1-1/2	68
50	2	74
60, 70, 80	2	74
100A, 100	2	74

NOTE: BHP followed by “A” designates hot water boiler furnished in a smaller vessel size with additional tubes in upper portion of vessel.

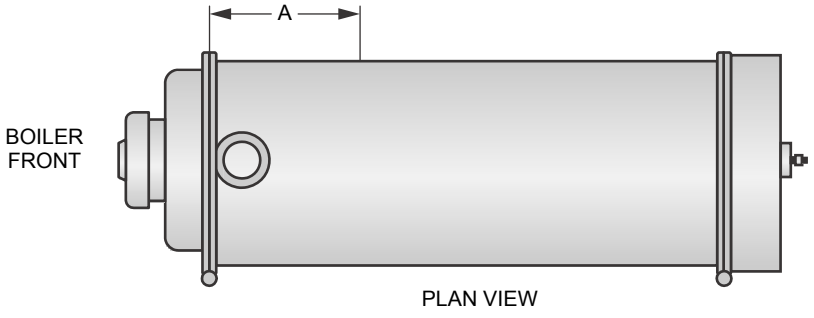
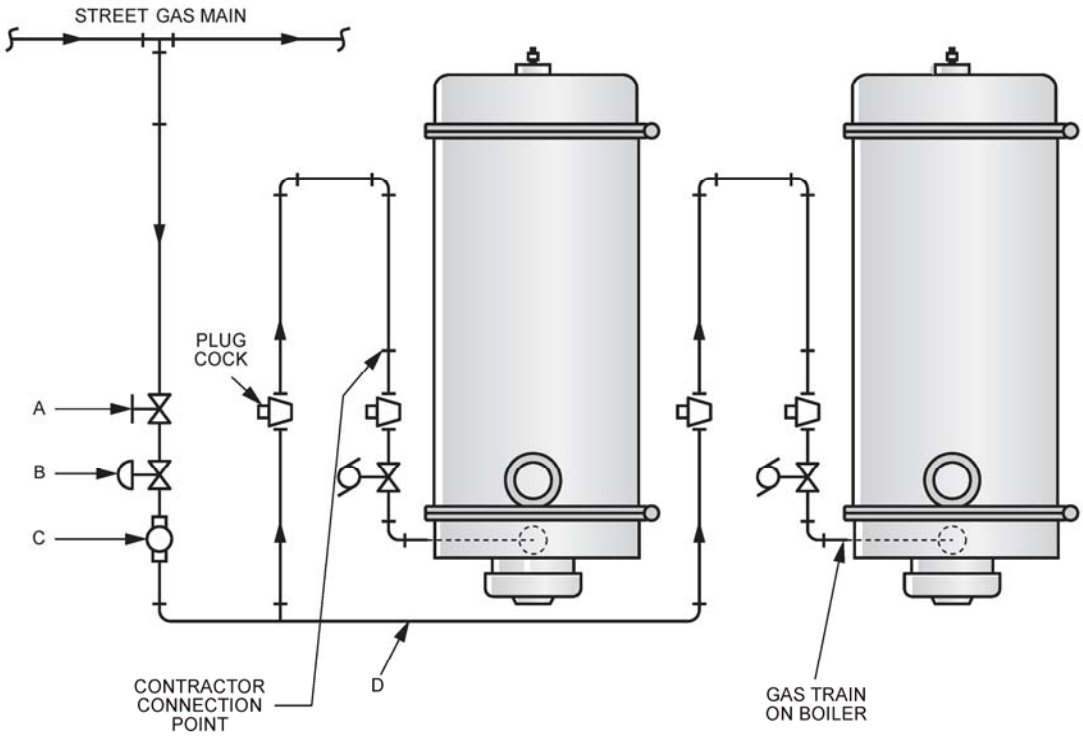


Figure A6-7. Standard Gas Train Connection Size and Location

This figure illustrates the basic gas valve arrangement on Cleaver-Brooks Model CB Boiler and shows the contractor's connection point. The valves and controls between the contractor connection point and the gas main in the street are representative of a typical installation. Actual requirements may vary depending on local codes or local gas company requirements which should be investigated prior to preparation of specifications and prior to construction.



A. Utilities service valve.

B. Utilities service regulator.

C. Gas meter.

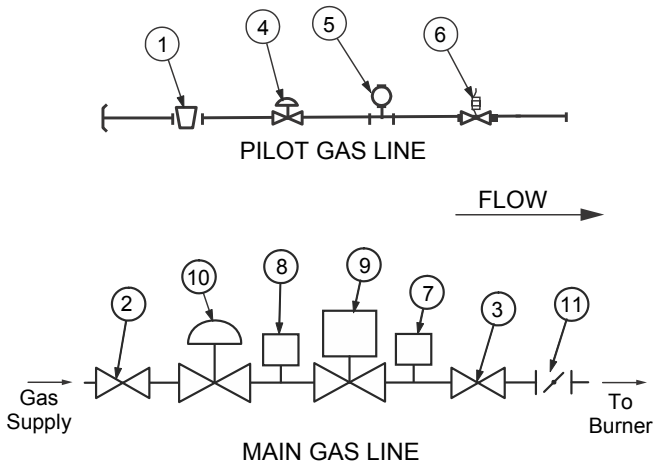
D. Piping from meter to boiler.

The size of the gas line from the meter to the gas pressure regulator at the boiler can be very important if gas pressures are marginal. The gas line sizing is dependent on:

1. Gas pressure at outlet of gas meter (C)
2. Rate of gas flow required, CFH
3. Length of pipe run (D)
4. Pressure required at contractor connection point.

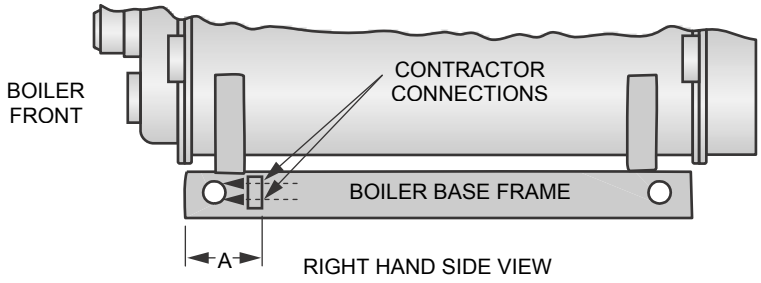
The local gas utility will advise the pressure that is available at the outlet of their meter.

Figure A6-8. Typical Gas Piping Layout



ITEM	DESCRIPTION	INS	UL			FM		CSD-1		
		BOILER HP	15-20	30-50	60-100	15-20	30-100	15-20	30-50	60-100
1	Pilot Shut Off Cock		x	x	x	x	x	x	x	x
2	Manual Shut Off Valve		x	x	x	x	x	x	x	x
3	Manual Shut Off Valve		x	x	x	x	x	x	x	x
4	Pilot Pressure Regulator		x	x	x	x	x	x	x	x
5	Pilot Pressure Gauge		x	x	x	x	x	x	x	x
6	Gas Pilot Valve		x	x	x	x	x	x	x	x
7	High Gas Pressure Switch				x	x	x			x
8	Low Gas Pressure Switch				x	x	x			x
9	Main Gas Valve with POC		x	x	x	x	x	x	x	x
10	Main Gas Regulator		x	x	x	x	x	x	x	x
11	Butterfly Valve			x	x		x		x	x

Figure A6-9. Model CB Gas Train Components



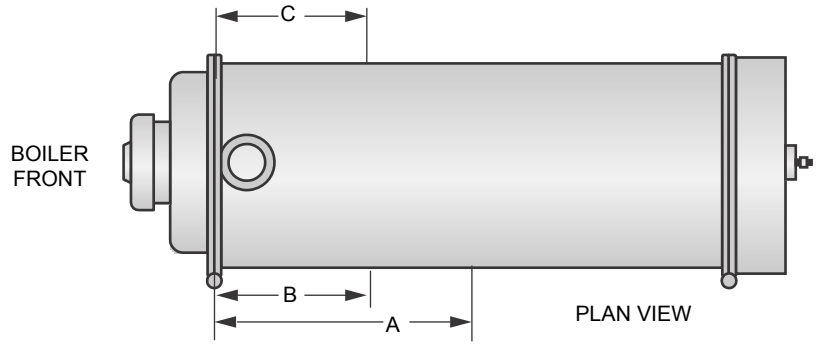
BOILER HP	MODEL CB				
	SUPPLY AND RETURN CONN SIZES (IN.) (NPT)	DIM. A (IN.)	RECOMMENDED OIL LINE[A] SIZES (STANDARD PIPE) (IN.)		
			STORAGE TANK TO BOILER OR PUMP CONNECT	PUMP TO BOILER	RETURN LINE TO TANK
15, 20	3/4	8-1/4	3/4	NONE	3/4
30, 40	3/4	8-1/4	3/4	NONE	3/4
50, 60	3/4	11-1/2	3/4	1	3/4
70, 80	3/4	11-1/2	3/4	1	3/4
100	3/4	11-1/2	1	1	1

NOTE: See No. 2 Oil Line Sizing Instruction for systems with other conditions.

A. For suction line condition with a maximum of 10 Feet of lift and a total of 100 equivalent feet of suction line.

B. This table is based on a single boiler installation.

Figure A6-10. No. 2 Oil Connection Size, Location and Recommended Line Sizes



BOILER HP	SUPPLY CONNECTION		RETURN CONNECTION		RECOMMENDED OIL LINE SIZES (STANDARD PIPE) (IN.)		
	SIZE (IN.) (NPT)	A (IN.)	SIZE (IN.) (NPT)	B (IN.)	STORAGE TANK TO PUMP	PUMP TO BOILER	RETURN LINE TO TANK
50, 60, 70, 80, 100	1-1/4	27-3/4	3/4	19-3/4	2	1-1/4	1-1/4

NOTES:

1. All dimensions in inches.
2. For suction lines with a maximum of 10 feet of lift and a total of 100 equivalent feet of suction line.
3. This table is based on a single boiler installation.

Figure A6-11. No. 6 Oil Connection Size, Location and Recommended Line Sizes, Model CB Boiler

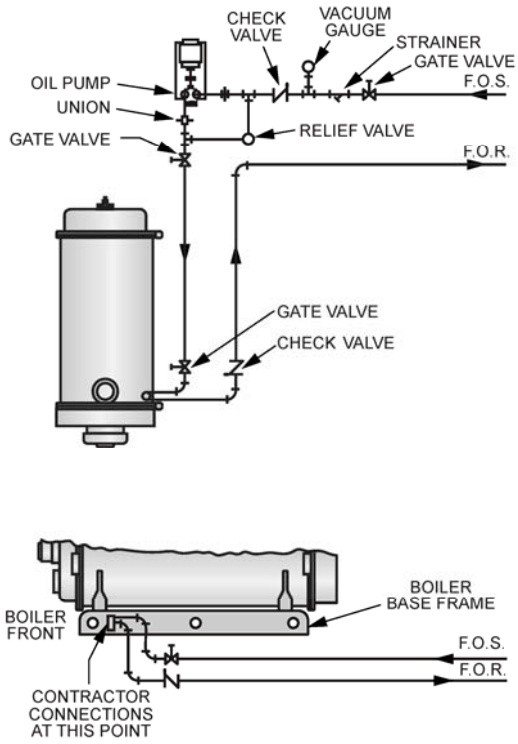


Figure A6-12. No. 2 Oil Piping, Single Boiler Installation, Remote Oil Pump

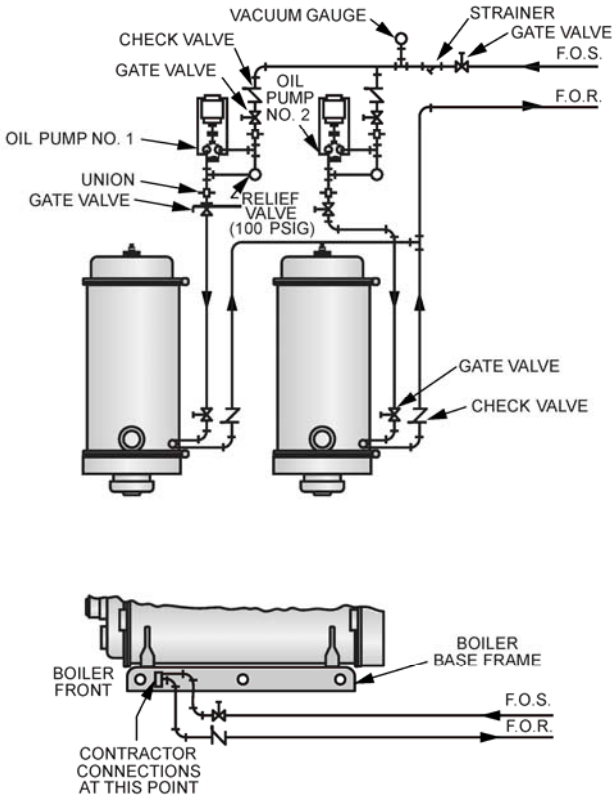


Figure A6-13. No. 2 Oil Piping, Multiple Boiler Installation, Remote Oil Pumps

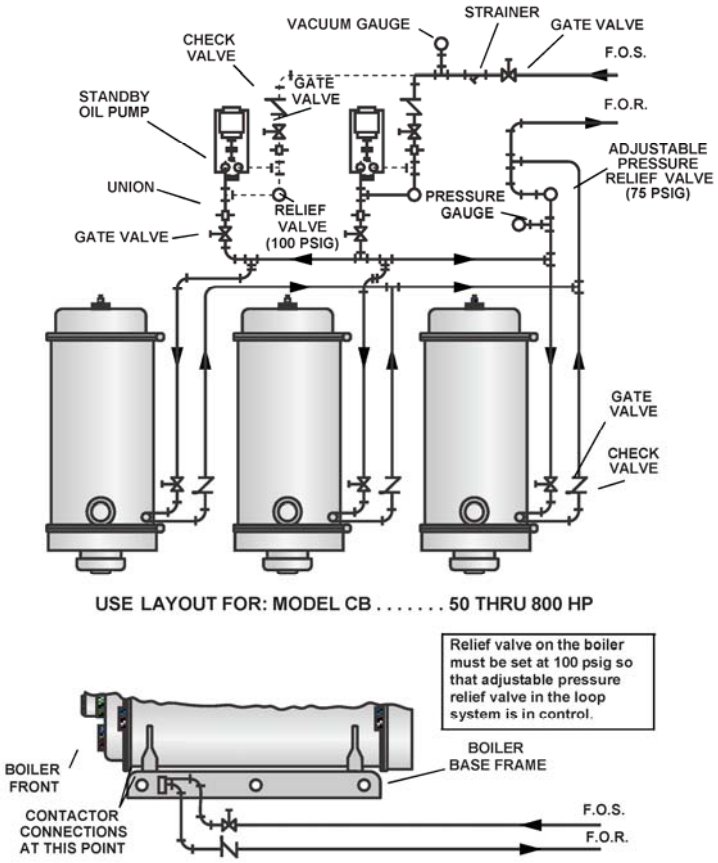


Figure A6-14. No. 2 Oil Piping, Multiple Boiler Installation

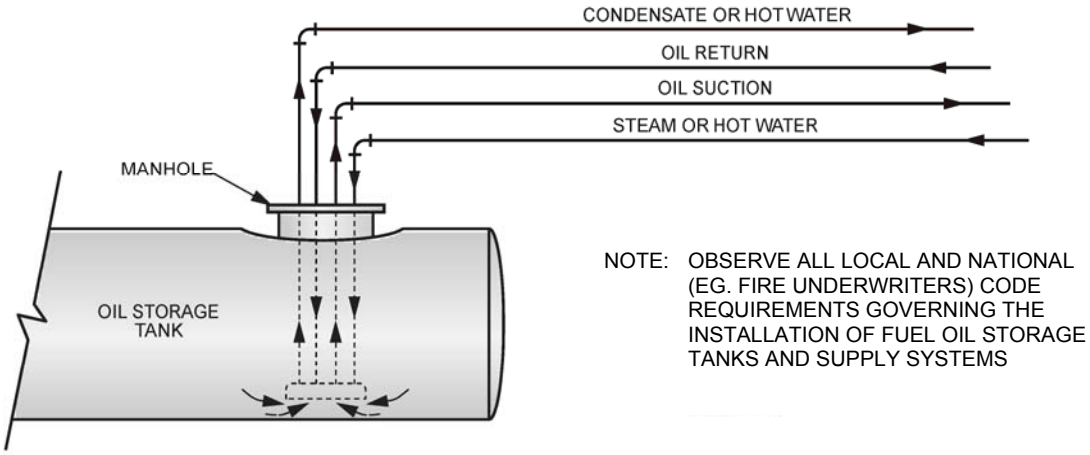


Figure A6-15. Typical Fuel Storage Tank Arrangement

Boiler Room Information

Figure A6-17 shows typical boiler room length requirements.

Figure A6-18 shows typical boiler room width requirements.

Figure A6-19 shows typical breeching arrangements.

Stack Support Capabilities

Cleaver-Brooks Firetube Boilers 15 hp through 100 hp can support up to 1,000 lbs without additional support. Firetube boilers 125 hp through 800 hp can support up to 2,000 lbs without additional support.

Firetube sizes 250 hp through 800 hp can be reinforced to support 3,000 lbs.

Stack/Breeching Size Criteria

The design of the stack and breeching must provide the required draft at each boiler flue gas outlet. Proper draft is critical to burner performance.

Although constant pressure at the flue gas outlet of the Model CB is not required, it is necessary to size the stack/breeching to limit flue gas pressure variation. For boiler sizes 50 – 800 horsepower, the allowable pressure range is –0.5" W.C. to

+0.5" W.C. The maximum pressure variation at any firing rate for the boiler is 0.5" W.C. For boiler sizes 15 – 40 horsepower, the allowable pressure range is –0.25" W.C. to +0.25" W.C.

For additional information, please review Section I4, General Engineering Data (Stacks) and Section F, Stacks. Stack and breeching sizes should always be provided by a reputable stack supplier who will design the stack and breeching system based on the above criteria. Your local Cleaver-Brooks authorized representative is capable of assisting in your evaluation of the stack/breeching design.

Boiler Room Combustion Air

When determining boiler room air requirements, the size of the room, air flow, and velocity of air must be reviewed as follows:

1. Size (area) and location of air supply openings in boiler room.
   A. Two (2) 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.
   B. Air supply openings can be louvered for weather protection, but they should not be covered with fine mesh wire, as this type of covering has poor air flow qualities and is subject to clogging by dust or dirt.
   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 unsatisfactory burner performance.
   D. Under no condition should the total area of the air supply openings be less than (1) square foot.
   E. Size the openings by using the formula:

      Area (sq-ft) = cfm/fpm

2. Amount of air required (cfm).
   A. Combustion Air = Rated bhp x 8 cfm/bhp.
   B. Ventilation Air = Maximum bhp x 2 cfm/bhp

C. Total recommended air, 10 cfm/bhp - up to 1000 feet elevation. Add 3 percent more per 1000 feet of added elevation.

3. Acceptable air velocity in boiler room (fpm).

   A. From floor to (7) foot height - 250 fpm.

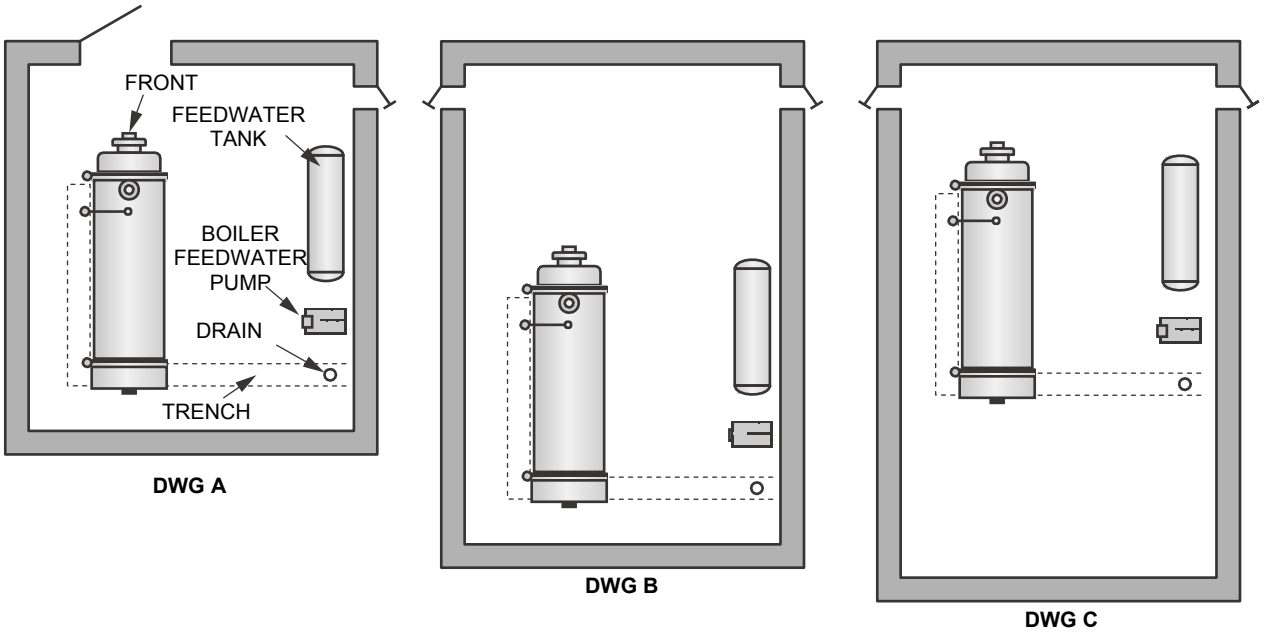
   B. Above (7) foot height - 500 fpm.

   Example: Determine the area of the boiler room air supply openings for (1) 300 hp boiler at 800 feet altitude. The air openings are to be 5 feet above floor level.

   - Air required: 300 x 10 = 3000 cfm (from 2B above).
   - Air velocity: Up to 7 feet = 250 fpm (from 3 above).
   - Area Required: Area = cfm = 3000/250 = 12 Sq-ft total.
   - Area/Opening: 12/2 = 6 sq-ft/opening (2 required).

Notice

Consult local codes, which may supersede these requirements.



1. Shortest boiler room length (Dwg A) is obtained by allowing for possible future tube replacement (from front or rear of boiler) through a window or doorway. Allowance is only made for minimum door swing at each end of the boiler. This arrangement provides sufficient aisle space at the front of the boiler but a "tight" space condition at the rear.

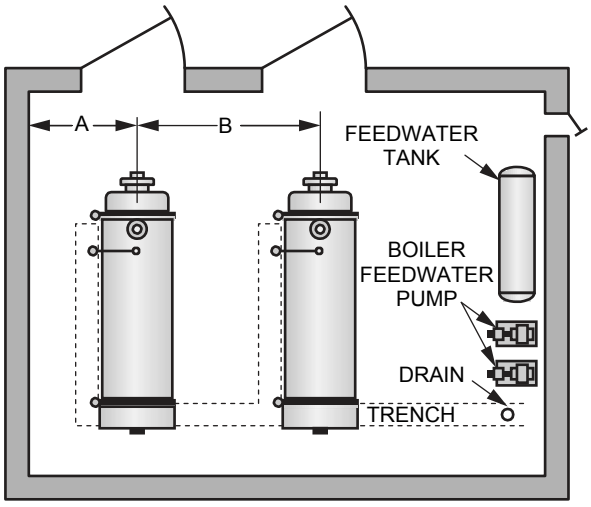
If space permits, approximately 1.5 additional feet should be allowed at the rear for additional aisle and working space.

2. Next shortest boiler room length (Dwg B) is obtained by allowing for possible future tube replacement from the front of the boiler. Allowance is only made for minimum door swing at the rear.

If space permits, approximately 1.5 additional feet should be allowed at the rear for additional aisle and working space.

3. A slightly longer boiler room (Dwg C) is obtained by allowing for possible future tube replacement from the rear of the boiler. Allowance for door swing at the front provides sufficient aisle and working space at the front.

Figure A6-16. Boiler Room Length (Typical Layout)

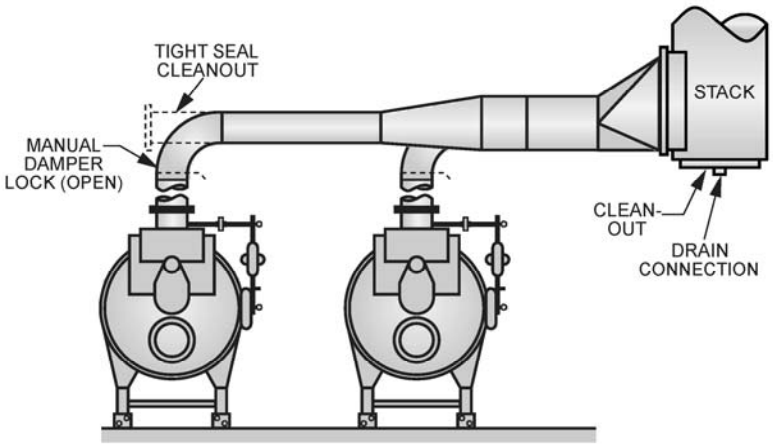


BOILER HP	15-40	50-100
Dimension A	75"	81"
Dimension B	103"	115"

NOTES:

1. Recommended Minimum Distance Between Boiler and Wall. Dimension "A" allows for a "clear" 42" aisle between the water column on the boiler and the wall. If space permits, this aisle should be widened.
2. Recommended Minimum Distance Between Boilers. Dimension "B" between boilers allows for a "clear" aisle of: 42" - 15-100 hp
   If space permits, this aisle should be widened.

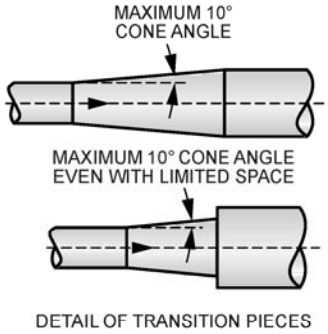
Figure A6-17. Boiler Room Width (Typical Layout)



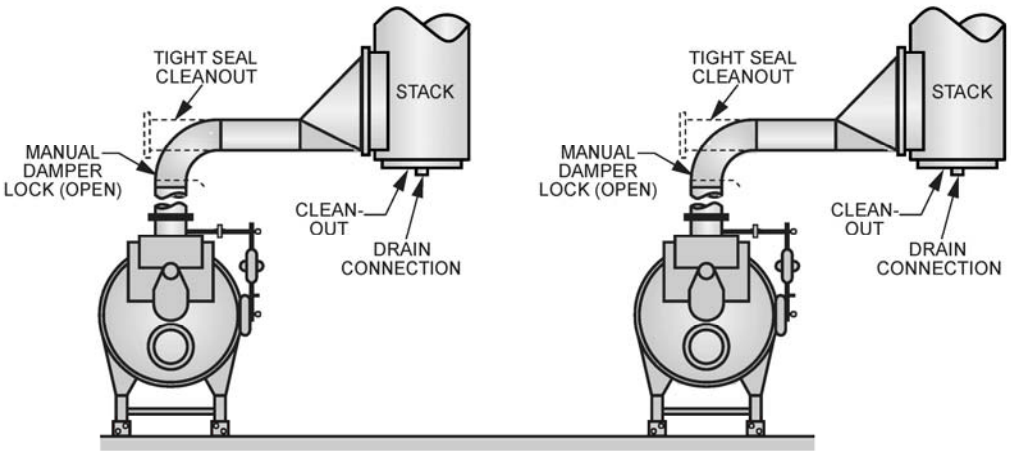
MULTIPLE BOILERS WITH A COMMON STACK

NOTE: These stack breeching arrangements for multiple boilers are typical and not intended for your specific design requirements. For additional information, review Section F, Stacks.

Stack and breeching sizes should always be provided by a reputable stack supplier who will design the stack and breeching system based on your specific criteria. Your local Cleaver-Brooks authorized representative is capable of assisting in your evaluation of stack and breeching design.



DETAIL OF TRANSITION PIECES



MULTIPLE BOILERS WITH INDIVIDUAL STACKS

Figure A6-18. Breeching Arrangement

Notes

SECTION A6
MODEL CB 15-100 HP

SAMPLE SPECIFICATIONS - STEAM

1.01 Boiler Characteristics (Steam) A6-36
1.02 General Boiler Design A6-36
1.03 Steam Boiler Trim A6-37
1.04 Burner and Controls A6-38
1.05 Efficiency Guarantee A6-44
1.06 Warranty A6-45
1.07 Shop Tests A6-45
1.08 Start-up Service A6-45

MODEL CB 15-100 HP
MODEL CB STEAM BOILER (15-100 HP, STEAM 15-350 PSIG)

The following sample specification is provided by Cleaver-Brooks to assist you in meeting your customer's specific needs and application.

A separate specification for steam boilers and hot water boilers is provided. Burner specifications and detailed control specifications for CB 780 Flame Safeguard control and the CB-HAWK Flame Safeguard control are included. See Section D, Controls, for additional information on control options.

The Sample Specifications are typically utilized as the base template for the complete boiler specification. Contact your local Cleaver-Brooks authorized representative for information on special insurance requirements, special code requirements, optional equipment, or general assistance in completing the specification.

1.01 Boiler Characteristics (Steam)

A. The Steam Boiler shall be Cleaver-Brooks Model CB, Fuel Series _____ (100, 200, 400, 600, 700), _____ hp designed for _____ psig (15, 150, 200, or other psig steam). The maximum operating pressure shall be _____ psig.

B. The boiler shall have a maximum output of _____ Btu/hr, or _____ horsepower when fired with CS 12-48 _____ oil and/or natural gas, _____ Btu/cu-ft. Electrical power available will be _____ Volt _____ Phase _____ Cycle.

1.02 General Boiler Design

A. The boiler shall be a four pass horizontal firetube updraft boiler with five (5) square feet of heating surface per rated boiler horsepower. It shall be mounted on a heavy steel frame with integral forced draft burner and burner controls.

The complete package boiler shall be approved as a unit by Underwriters Laboratories and shall bear the UL/ULC label, except in the case where 50 Hz has been selected.

1. The boiler shall be completely preassembled and fire tested at the factory.

   The unit shall be ready for immediate mounting on floor or simple foundation and ready for attachment of water, steam, fuel, electrical, vent and blowdown connections.

2. The boiler shall be built to comply with the following insurance and codes _____ (Factory Mutual, ASME CSD-1).

B. Boiler Shell (Steam)

1. The boiler shell must be constructed in accordance with ASME Boiler Code and must receive authorized boiler inspection prior to shipment. A copy of the inspection report shall be furnished to the purchaser.

2. Two lifting eyes shall be located on top of the boiler.

3. Front and rear doors on the boiler shall be hinged or davited. Doors are to be sealed with fiberglass tadpole gaskets and fastened tightly using heavy capscrews that thread into replaceable brass nuts.

4. Rear refractory and insulation shall be contained in the formed door, which must swing open for inspection of brick work.
5. The boiler tubes shall not include turbulators, swirlers or other add-on appurtenances.
6. Front and rear tube sheets and all flues must be fully accessible for inspection and cleaning when the doors are swung open. The boiler shall be furnished with adequate handholes to facilitate boiler inspection and cleaning.
7. The exhaust gas vent shall be located near the front of the boiler on the top center line and shall be capable of supporting:
   - 15-100 hp. 1000 lbs and shall contain a stack thermometer
8. The boiler shell shall contain a chemical feed connection.

C. Observation ports for the inspection of flame conditions shall be provided at each end of the boiler.

D. The boiler insulation shall consist of a 2 inch blanket under a sectional preformed sheet metal lagging. This insulation must be readily removable and capable of being reinstalled, if required.

E. The entire boiler base frame and other components shall be factory painted before shipment using a hard finish enamel coating.

1.03 Steam Boiler Trim

A. Water Column
A water column shall be located on the right hand side of the boiler complete with gauge glass set and water column blowdown valves.

1. Feedwater Pump Control
   The boiler feedwater pump control shall be included as an integral part of the water column to automatically actuate a motor driven feed water pump maintaining the boiler water level within normal limits.
2. Low Water Cutoff

   The low water cutoff shall be included as an integral part of the boiler feedwater control wired into the burner control circuit to prevent burner operation if the boiler water level falls below a safe level.

B. Auxiliary Low Water Cutoff
Auxiliary low water cutoff manual reset shall be included, piped to the vessel, and wired to the burner control circuit. A manual reset device shall be used on this control.

C. Steam Pressure Gauge
The steam pressure gauge shall be located at the front of the boiler and include cock and test connection.

D. Safety Valves
Safety valves of a type and size to comply with ASME Code requirements shall be shipped loose.

E. Steam Pressure Controls
The steam pressure controls to regulate burner operation shall be mounted near the water column. Controls shall be a high limit (manual reset), operating limit (auto reset), and firing rate control (30-100 hp).

1.04 Burner and Controls

A. Mode of Operation
Select one of the following:

- 15 and 20 hp. Burner operation shall be on-off principle.
- 30 and 40 hp. Burner operation shall be high-low-off principle. The burner shall always return to low fire position for ignition.
- 50 - 100 hp. Burner operation shall be full modulation principle. The burner shall always return to low fire position for ignition.

B. Blower

1. Air for combustion shall be supplied by a forced draft blower mounted in the front boiler door, above the burner, to eliminate vibration and reduce noise level.
2. Maximum sound level of the boiler/burner package shall not exceed _____ dbA (when measured in accordance with ABMA Sound Test Standards).
3. The impeller shall be cast aluminum, radial blade, carefully balanced, and directly connected to the blower motor shaft.

C. Combustion Air Control
Select one of the following:

- 15 and 20 hp. Combustion air damper shall be manually set for proper air-fuel ratios.
- 30 and 40 hp. Combustion air damper shall be linked to damper motor. Auxiliary switch on the damper motor shall control high or low firing rate.
- 50 - 100 hp. Combustion air damper and cam operated fuel metering valves shall be operated by a single damper control motor that regulates the fire according to load demand. Potentiometer type position controls shall be provided to regulate operation of the damper control motor.

D. Fuel Specification and Piping
Select one of the following fuel types:

- Fuel series 700 - Gas fired (4.4.1).
- Fuel series 100 - Light oil (No. 2) fired (4.4.2).
- Fuel series 200 - Light oil or gas fired (4.4.3).
- Fuel series 600 - No. 6 oil fired (4.4.4).
- Fuel series 400 - No. oil or gas fired (4.4.5).

1. Fuel Series 700 - Gas Fired

a. Burner Type - The burner shall be integral with the front head of the boiler and of high radiant multi-port type for gas. The burner shall be approved for operation on natural gas fuel.

b. Gas Pilot - The gas pilot shall be a premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary gas valve cannot open until pilot flame has been established. The pilot train shall include two manual shut-off valves, solenoid valve, pressure regulator and pressure gauge.

c. Gas Burner Piping - Gas burner piping on all units shall include pressure regulator, primary gas shutoff valve, motor operated with proof of closure switch and plugged leakage test connection. The main gas valve(s) shall be wired to close automatically in the event of power failure, flame failure, low

water or any safety shutdown condition. A lubricating plug cock or butterfly shutoff valve shall be provided as a means for a tightness check of the primary shut off valve. An additional plug cock on butterfly valve shall be furnished at entrance to gas train. Select one of the following:

1) 15-50 hp. Burners equipped as shown above.

2) 60-100 hp. High and low gas pressure switches shall be provided.

d. Burner Turndown - Select one of the following:

1) 15 and 20 hp. Burner shall operate on the on/off principle.

2) 30 and 40 hp. Burner shall operate on the high-low-off principle with a turndown of 3:1 when firing natural gas.

3) 50-100 hp. Turndown range of burner shall be 4:1 when firing natural gas.

2. Fuel Series 100 - Light Oil Fired

a. Burner Type - The burner shall be integral with the front head of the boiler, and shall be a low pressure air atomizing type approved for operation with CS12-48, Commercial No. 2 oil.

3. Oil Pilot - The oil pilot shall be air atomizing type with automatic electric ignition and include oil solenoid valve. An electronic detector shall monitor the pilot so that the primary oil valve cannot open until flame has been established.

4. Oil Pump - An oil pump with a capacity of approximately twice the maximum burning rate shall be included. Select one of the following:

- 15 hp through 40 hp. The oil pump shall be integral with the burner and belt driven from the blower motor.
- 50 hp through 100 hp. Separate motor driven pump set, shipped loose to be installed in a location favorable to the oil storage tank, shall be provided.

5. Oil Burner Piping - Fuel oil piping on the unit shall include oil pressure regulating devices, oil metering controls, solenoid shutoff valves, pressure gauges and fuel strainer, all integrally mounted on the unit. Select one of the following:

- 50 hp through 100 hp. A fuel oil controller shall be provided to combine all of the fuel oil controls into a single casting which is mounted on the front door of the unit. A single tip retractable nozzle shall be used for the low pressure air atomizing burner.
- 70 hp through 100 hp. A low oil pressure switch shall be included in the oil piping.

6. Low Pressure Air Atomizing - Select one of the following:

- 15 hp through 40 hp. Belt driven air compressor, lubricating oil tank, oil level indicator, inlet air filter, air pressure gauge, and low atomizing air pressure switch.
- 50 hp through 100 hp. Separate air compressor module mounted on boiler base rail with low atomizing air pressure switch.

7. Burner Turndown - Select one of the following:

- 15 and 20 hp. Burner shall operate on the on/off principle.
- 30 and 40 hp. Burner shall operate on the high-low-off principle with a turndown of 3:1 when firing No. 2 oil.

- 50 hp through 100 hp. Turndown range shall be 4:1 when firing No. 2 oil.

E. Fuel Series 200 - Light Oil or Gas Fired

1. Burner Type - The burner, integral with the front head of the boiler, shall be a combination of the low pressure air atomizing type for oil and high radiant multi-port type for gas. The burner shall be approved for operation with either CS12-48 Commercial No. 2 Oil or natural gas.
2. Gas Pilot - The gas pilot shall be premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary fuel valve cannot open until flame has been established. The pilot train shall include two manual shut-off valves, solenoid valve, pressure regulator and pressure gauge.
3. Oil Burner
   a. Oil Pump - An oil pump with a capacity of approximately twice the maximum burning rate shall be included. Select one of the following:
      1) 15 hp through 40 hp. The oil pump shall be integral with the burner and belt driven from the blower motor.
      2) 50 hp through 100 hp. Separate motor driven pump set, shipped loose, to be installed in a location favorable to the oil storage tank, shall be provided.
4. Oil Burner Piping - Fuel oil piping on the unit shall include oil pressure regulating devices, oil metering controls, solenoid shutoff valves, pressure gauges and fuel strainer, all integrally mounted on the unit. Select one of the following:
   a. 50 hp through 100 hp. A fuel oil controller shall be provided to combine all of the fuel oil controls into a single casting which is mounted on the front door of the unit. A single tip retractable nozzle shall be used for the low pressure air atomizing burner.
   b. 70 hp through 100 hp. A low oil pressure switch shall be included in the oil piping.
5. Low pressure air atomizing. Select one of the following:
   a. 15 hp through 40 hp. Belt driven air compressor, lubricating oil tank, oil level indicator, inlet air filter, air pressure gauge and low atomizing air pressure switch.
   b. 50 hp through 100 hp. Separate air compressor module mounted on boiler base rail with low atomizing air pressure switch.
6. Gas Burner
   a. Gas Burner Piping - gas burner piping on all units shall include pressure regulator, primary gas shutoff valve, motor operated with proof of closure switch and plugged leakage test connection. The main gas valve(s) shall be wired to close automatically in the event of power failure, flame failure, low water or any safety shutdown condition. A lubricating plug cock or butterfly shutoff valve shall be provided as a means for a tightness check of the primary shut off valve. An additional plug cock or butterfly valve shall be furnished at entrance to gas train. Select one of the following:
      1) 15-50 hp. Burners equipped as shown above.
      2) 60-100 hp. High and low gas pressure switches shall be provided.
7. Burner Turndown
   Select one of the following:

- 15 and 20 hp. Burner shall operate on the on/off principle.
- 30 and 40 hp. Burner shall operate on the high-low-off principle with a turndown of 3:1
- 50-100 hp. Turndown range of the burner shall be 4:1.

F. Fuel Series 600 - No. 6 Oil Fired

1. Burner Type - The burner shall be integral with the front head of the boiler and low pressure air atomizing type approved for operation with CS12-48, Commercial No. 6 Oil.
2. Gas Pilot - The gas pilot shall be a premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary oil valve cannot open until pilot flame has been established. The pilot train shall include two manual shut-off valves, solenoid valve, pressure regulator and pressure gauge.
3. Oil Pump - An oil pump set with a capacity of approximately twice the maximum burning rate shall be included.

   A separate motor driven pump set shall be included shipped loose for location favorable to the oil storage tank.
4. Oil Burner Piping - A fuel oil controller combining all of the fuel oil controls into a single casing shall be provided. Oil pressure regulating devices, oil metering controls, solenoid shutoff valves, high and low oil temperature switches and necessary pressure and temperature gauges shall be included in this packaged assembly mounted on the front door of the boiler. A fuel strainer shall also be provided, mounted to the boiler. A single tip retractable nozzle shall be used for the low pressure air atomizing burner. Flexible hoses shall be provided to allow easy removal of the nozzle for inspection when it is placed in the vice jaws located on the front door of the boiler.

   The metering valve shall permit circulation of hot oil to the burner at all times. The burner drawer oil piping and nozzle shall be purged of oil on each shutdown.

   For 70 through 100 hp, a low oil pressure switch shall be included in the oil piping.
5. Low Pressure Air Atomizing - Select one of the following:

   a. 50 through 100 hp. Separate air compressor module mounted on boiler base rail with low atomizing air pressure switch.
6. Oil Preheat
   The oil shall be preheated by a steam heater and electric heater, each with thermostatic control. Both heaters shall be installed in a single compact shell mounted, piped, and wired on the boiler. The thermostatic controls shall be set to cut-out the electric heater when steam is available. Select one of the following:

   a. 50 through 100 hp. Electric preheater size shall be 5 kW.

G. Fuel Series 400 - No. 6 Oil or Gas Fired

1. Burner Type - The burner shall be integral with the front head of the boiler and shall be a combination of the low pressure atomizing type for oil and high radiant multi-port type for gas. The burner shall be approved for operation with either CS12-48 Commercial No. 6 oil or natural gas.
2. Gas Pilot - The gas pilot shall be a premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary oil valve cannot open until pilot flame has been established. The pilot train shall include two manual shut-off valves, solenoid valve, pressure regulator and pressure gauge.

3. Oil Burner

   a. Oil Pump - An oil pump set with a capacity of approximately twice the maximum burning rate shall be included.

   b. Oil Burner Piping - A fuel oil controller combining all of the fuel oil controls into a single casing shall be provided. Oil pressure regulating devices, oil metering controls, solenoid shutoff valves, high and low oil temperature switches, and the necessary pressure and temperature gauges shall be included in this packaged assembly mounted on the front door of the boiler. A fuel strainer shall also be provided, mounted to the boiler. A single tip retractable nozzle shall be used for the low pressure air atomizing burner. Flexible hoses shall be provided to allow easy removal of the nozzle for inspection when it is placed in the vice jaws located on the front door of the boiler. The metering valve shall permit circulation of hot oil to the burner at all times. The burner drawer oil piping and nozzle shall be purged of oil at each shutdown.

      For 70 through 100 hp, a low oil pressure switch shall be included in the oil piping.

1. Low Pressure Air Atomizing - Select one of the following:

   a. 50 through 100 hp. Separate air compressor module mounted on boiler base rail with low atomizing air pressure switch.

2. Oil Preheat
   The oil shall be preheated by a steam heater and electric heater, each with thermostatic control. Both heaters shall be installed in a single compact shell mounted, piped, and wired on the boiler. The thermostatic controls shall be set to cut-out the electric heater when steam is available.

   a. 50 through 100 hp. Electric preheater size shall be 5 kW.

3. Gas Burner

   a. Gas Burner Piping - Gas burner piping on all units shall include pressure regulator, primary gas shutoff valve, motor operated with proof of closure switch and plugged leakage test connection. The main gas valve(s) shall be wired to close automatically in the event of power failure, flame failure, low water or any safety shutdown condition. A lubricating plug cock or butterfly shutoff valve shall be provided as means for a tightness check of the primary shutoff valve. An additional plug cock or butterfly valve shall be furnished at entrance to gas train. Select one of the following:

      1) 50 hp. Burner equipped as shown above.

      2) 60 through 100 hp. High and low gas pressure switches shall be provided.

   b. Burner Turndown - Turndown shall be 4:1.

H. Boiler Flame Safeguard Controller and Control Panel

1. CB780E Flame Safeguard

   a. Boilers with CB780E Control - Each boiler shall be factory equipped with flame safeguard controller providing technology and functions equal to the Cleaver-Brooks Model CB780E.

      Controller shall be computerized solid state having sequence and flame-on lights and alpha- numeric “first out” fault indications of flame safeguard trip functions. It shall include dynamic self-check logic. The controller 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.

Controller shall be the non-recycle type for maximum safety that shall shutdown the burner and indicate as a minimum the following trip functions: pilot and main flame failure, high and low fire proving switch faults, locking interlocks open, false flame signal and fuel valve open (when proof of closure switch is furnished).

The controller shall have a run/test switch. It shall allow interruptions to sequence just after pre-purge, during pilot ignition trial and run cycles for adjustments to firing rate motor, damper linkages and pilot flame for minimum turndown tests.

b. Control Panel - The control panel shall be mounted on the front door of the boiler in a location convenient to the operator. The hinged metal cabinet will have NEMA 1A rating that includes a neoprene dust seal and a Yale cabinet key type lock.

   The panel shall contain the boiler flame safeguard controller, blower motor starter, indicating lights and selector switches.

   The panel shall have a removable sub-base for mounting the flame safeguard controller, blower motor starter, and terminal blocks. For combination gas-oil and heavy oil fired boilers the panel will contain the fuel selector and/or oil heater selector switch.

   The panel shall contain the following lights and switches:

   Lights

   - White - load demanded.
   - White - fuel valve open.
   - Red - low water.
   - Red - flame failure.

   Control Switches

   - Burner On-Off.
   - Manual-Automatic.
   - Manual Firing Rate Control.

2. Oil, heat and moisture resistant wire shall be used and identified with circuit numbers corresponding to the electrical wiring diagram.
3. All electrical equipment and wiring shall be in conformance with Underwriters Laboratories requirements.
4. Boiler to be supplied with a control circuit transformer and fuse protection for the control circuit.
5. Control Panel: The control panel shall be mounted on the front door of the boiler in a location convenient to the operator. The hinged metal cabinet will have NEMA 1A rating that includes a neoprene dust seal and a Yale cabinet key type lock.

   The panel shall contain the boiler flame safeguard controller, indicating lights and selector switches.

Panel shall have a removable sub-base for mounting the flame safeguard controller, and terminal blocks. For combination gas-oil and heavy oil fired boilers the panel will contain the fuel selector and/or oil heater selector switch.

6. Oil, heat, and moisture resistant wire shall be used and identified with circuit numbers corresponding to the electrical wiring diagram.
7. All electrical equipment and wiring shall be in conformance with Underwriters Laboratories requirements.
8. Boiler to be supplied with a control circuit transformer and fuse protection for the control circuit.

1.05 Efficiency Guarantee

The boiler manufacturer shall guarantee that, at the time of startup, the boiler will achieve _____ fuel-to-steam efficiency at 100% firing rate when burning natural gas and _____ fuel-to-steam efficiency at 100% firing rate when burning oil (add efficiency guarantees at 25%, 50%, and 75% of rating, if required). If the boiler(s) fail to achieve the corresponding guaranteed efficiency as published, the boiler manufacturer will rebate, to the ultimate boiler owner, five thousand dollars ($5,000) for every full efficiency point (1.0%) that the actual efficiency is below the guaranteed level.

The specified boiler efficiency is based on the following conditions.

A. Fuel specification used to determine boiler efficiency:

1. Natural Gas

   Carbon, % (wt) = 69.98

   Hydrogen, % (wt) = 22.31

   Sulfur, % (wt) = 0.0

   Heating value, Btu/lb = 21,830

2. No. 2 Oil

   Carbon, % (wt) = 85.8

   Hydrogen, % (wt) = 12.7

   Sulfur, % (wt) = 0.2

   Heating value, Btu/lb = 19,420

3. No. 6 Oil

   Carbon, % (wt) = 86.6

   Hydrogen, % (wt) = 10.9

   Sulfur, % (wt) = 2.09

   Heating value, Btu/lb = 18,830

B. Efficiencies are based on ambient air temperature of 80 °F, relative humidity of 30%, and 15% excess air in the exhaust flue gas.

C. Efficiencies are based on manufacturer's published radiation and convection losses. (For Cleaver-Brooks radiation and convection losses, see Boiler Efficiency Facts Guide, publication number CB-7767).

D. Any efficiency verification testing will be based on the stack loss method.

EXECUTION

1.06 Warranty

A. All equipment is to be guaranteed against defects in materials and/or workmanship for a period of 12 months from date of start-up or 18 months from date of shipment, whichever comes first.

1.07 Shop Tests

A. The packaged boiler must receive factory tests to check the construction, controls, and operation of the unit. All tests may be witnessed by the purchaser, if desired.

1.08 Start-up Service

After boiler installation is completed, the manufacturer shall provide the services of a field representative for starting the unit and training the operator at no additional costs.

A. A factory approved and authorized start-up report shall be submitted to the customer/user at the time of start-up.

Notes

SECTION A6
MODEL CB 15-100 HP

SAMPLE SPECIFICATIONS - HOT WATER

1.01 Boiler Characteristics (Hot Water) A6-48
1.02 General Boiler Design A6-48
1.03 Hot Water Boiler Trim A6-49
1.04 Burner and Controls A6-49
1.05 Blower A6-49
1.06 Combustion Air Control A6-50
1.07 Fuel Specification and Piping A6-50
1.08 Efficiency Guarantee A6-56
1.09 Warranty A6-56
2.01 Shop Tests A6-57

MODEL CB HOT WATER BOILER (15-100 HP, 30 PSIG, 125 PSIG)

1.01 Boiler Characteristics (Hot Water)

A. The Hot Water Boiler shall be Cleaver-Brooks Model CB, Fuel Series _____ (100, 200, 400, 600, 700), _____ hp designed for _____ psig (30, 125, or other psig hot water). The maximum water temperature will be _____ degree F, and the maximum system temperature drop will be _____ degree F.

B. The boiler shall have a maximum output of _____ Btu/hr, or _____ horsepower when fired with CS 12-48 _____ oil and/or natural gas, _____ Btu/cu-ft. Electrical power available will be _____ Volt _____ Phase _____ Cycle.

1.02 General Boiler Design

A. The boiler shall be a four pass horizontal firetube updraft boiler with five (5) square feet of heating surface per rated boiler horsepower. It shall be mounted on a heavy steel frame with integral forced draft burner and burner controls. The complete package boiler shall be approved as a unit by Underwriters Laboratories and shall bear the UL/ULC label.

1. The boiler shall be completely preassembled and fire tested at the factory.

   The unit shall be ready for immediate mounting on floor or simple foundation and ready for attachment of water, steam, fuel, electrical, vent and blowdown connections.

2. The boiler shall be built to comply with the following insurance and codes _____ (Factory Mutual, ASME CSD-1).

B. Boiler Shell (Hot Water)

1. The boiler shell must be constructed in accordance with ASME Boiler Code and must receive authorized boiler inspection prior to shipment. A copy of the inspection report shall be furnished to the purchaser.
2. The hot water return and outlet connections shall be located on the top center line of the boiler. The boiler shall be designated to rapidly mix the return water with the boiler water. Forced internal circulation shall be used.
3. A dip tube shall be included as an integral part of the water outlet.
4. Two lifting eyes shall be located on top of the boiler.
5. Front and rear doors on the boiler shall be hinged or davited. Doors are to be sealed with fiberglass tadpole gaskets and fastened tightly using heavy capscrews that thread into replaceable brass nuts.
6. Rear refractory and insulation shall be contained in the formed door, which must swing open for inspection of brick work.
7. The boiler tubes shall not include turbulators, swirlers or other add-on appurtenances.
8. Front and rear tube sheets and all flues must be fully accessible for inspection and cleaning when the doors are swung open. The shell must be furnished with adequate handholes to facilitate boiler inspection and cleaning.

9. The exhaust gas vent shall be located near the front of the boiler on the top center line and shall be capable of supporting 1000 lbs and shall contain a stack thermometer

C. Observation ports for the inspection of flame conditions shall be provided at each end of the boiler.

D. The boiler insulation shall consist of a 2 inch blanket under a sectional preformed sheet metal lagging. This insulation must be readily removable and capable of being reinstalled, if required.

E. The entire boiler based frame and other components shall be factory painted before shipment using a hard finish enamel coating.

1.03 Hot Water Boiler Trim

A. Low Water Cutoff
A low water cutoff control (manual reset) shall be mounted on the top centerline of the boiler wired into the burner control circuit to prevent burner operation if boiler water falls below a safe level.

B. Pressure and Temperature Gauges
Pressure and temperature gauges shall be mounted on the boiler with temperature sensing element located adjacent to the hot water outlet.

C. Relief Valves
Water relief valves of a type and size to comply with ASME Code requirements shall be shipped loose.

D. Temperature Controls
Temperature controls to regulate burner operation shall be mounted on the unit with temperature sensing elements located adjacent to the hot water outlet. Controls shall be high limit (manual reset), operating limit (auto reset), and firing rate control (30-100 hp).

1.04 Burner and Controls

A. Mode of Operation
Select one of the following:

- 15 and 20 hp. Burner operation shall be on-off principle.
- 30 and 40 hp. Burner operation shall be high-low-off principle. The burner shall always return to low fire position for ignition.
- 50 - 100 hp. Burner operation shall be full modulation principle. The burner shall always return to low fire position for ignition.

1.05 Blower

A. Air for combustion shall be supplied by a forced draft blower mounted in the front boiler door, above the burner, to eliminate vibration and reduce noise level.

B. Maximum sound level of the boiler/burner package shall not exceed _____ dbA (when measured in accordance with ABMA Sound Test Standards).

C. The impeller shall be cast aluminum, radial blade, carefully balanced, and directly connected to the blower motor shaft.

1.06 Combustion Air Control

Select one of the following:

- 15 and 20 hp. Combustion air damper shall be manually set for proper air-fuel ratios.
- 30 and 40 hp. Combustion air damper shall be linked to damper motor. Auxiliary switch on the damper motor shall control high or low firing rate.
- 50 - 100 hp. Combustion air damper and cam operated fuel metering valves shall be operated by a single damper control motor that regulates the fire according to load demand. Potentiometer type position controls shall be provided to regulate operation of the damper control motor (remove this sentence when a CB-HAWK Flame Safeguard is used).

1.07 Fuel Specification and Piping

Select one of the following fuel types:

- Fuel series 700 - Gas fired (4.4.1).
- Fuel series 100 - Light oil (No. 2) fired (4.4.2).
- Fuel series 200 - Light oil or gas fired (4.4.3).
- Fuel series 600 - No. 6 oil fired (4.4.4).
- Fuel series 400 - No. oil or gas fired (4.4.5).

A. Fuel Series 700 - Gas Fired

1. Burner Type - The burner shall be integral with the front head of the boiler and of high radiant multi-port type for gas. The burner shall be approved for operation on natural gas fuel.
2. Gas Pilot - The gas pilot shall be a premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary gas valve cannot open until pilot flame has been established. The pilot train shall include two manual shut-off valves, solenoid valve, pressure regulator and pressure gauge.
3. Gas Burner Piping - Gas burner piping on all units shall include pressure regulator, primary gas shutoff valve, motor operated with proof of closure switch and plugged leakage test connection. The main gas valve(s) shall be wired to close automatically in the event of power failure, flame failure, low water or any safety shutdown condition. A lubricating plug cock or butterfly shutoff valve shall be provided as a means for a tightness check of the primary shut off valve. An additional plug cock on butterfly valve shall be furnished at entrance to gas train. Select one of the following:
   a. 15-50 hp. Burners equipped as shown above.
   b. 60-100 hp. High and low gas pressure switches shall be provided.
4. Burner Turndown - Select one of the following:
   a. 15 and 20 hp. Burner shall operate on the on/off principle.
   b. 30 and 40 hp. Burner shall operate on the high-low-off principle with a turndown of 3:1 when firing natural gas.
   c. 50-100 hp. Turndown range of burner shall be 4:1 when firing natural gas.

B. Fuel Series 100 - Light Oil Fired

1. Burner Type - The burner shall be integral with the front head of the boiler, and shall be a low pressure air atomizing type approved for operation with CS12-48, Commercial No. 2 oil.
2. Oil Pilot - The oil pilot shall be air atomizing type with automatic electric ignition and include oil solenoid valve. An electronic detector shall monitor the pilot so that the primary oil valve cannot open until flame has been established.
3. Oil Pump - An oil pump with a capacity of approximately twice the maximum burning rate shall be included. Select one of the following:
   a. 15 hp through 40 hp. The oil pump shall be integral with the burner and belt driven from the blower motor.
   b. 50 hp through 100 hp. Separate motor driven pump set, shipped loose to be installed in a location favorable to the oil storage tank, shall be provided.
4. Oil Burner Piping - Fuel oil piping on the unit shall include oil pressure regulating devices, oil metering controls, solenoid shutoff valves, pressure gauges and fuel strainer, all integrally mounted on the unit. Select one of the following:
   a. 50 hp through 100 hp. A fuel oil controller shall be provided to combine all of the fuel oil controls into a single casting which is mounted on the front door of the unit. A single tip retractable nozzle shall be used for the low pressure air atomizing burner.
   b. 70 hp through 100 hp. A low oil pressure switch shall be included in the oil piping.
5. Low Pressure Air Atomizing - Select one of the following:
   - 15 hp through 40 hp. Belt driven air compressor, lubricating oil tank, oil level indicator, inlet air filter, air pressure gauge, and low atomizing air pressure switch.
   - 50 hp through 100 hp. Separate air compressor module mounted on boiler base rail with low atomizing air pressure switch.
6. Burner Turndown - Turndown range of the burner shall be 4:1 when firing No. 2 oil. Select one of the following:
   - 15 and 20 hp. Burner shall operate on the on/off principle.
   - 30 and 40 hp. Burner shall operate on the high-low-off principle with a turndown of 3:1 when firing No. 2 oil.
   - 50 hp through 100 hp. Turndown range shall be 4:1 when firing No. 2 oil.

C. Fuel Series 200 - Light Oil or Gas Fired
1. Burner Type - The burner, integral with the front head of the boiler, shall be a combination of the low pressure air atomizing type for oil and high radiant multi-port type for gas. The burner shall be approved for operation with either CS12-48 Commercial No. 2 Oil or natural gas.
2. Gas Pilot - The gas pilot shall be premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary fuel valve cannot open until flame has been established. The pilot train shall include two manual shut-off valves, solenoid valve, pressure regulator and pressure gauge.
3. Oil Burner
   a. Oil Pump - An oil pump with a capacity of approximately twice the maximum burning rate shall be included. Select one of the following:

1) 15 hp through 40 hp. The oil pump shall be integral with the burner and belt driven from the blower motor.

2) 50 hp through 100 hp. Separate motor driven pump set, shipped loose, to be installed in a location favorable to the oil storage tank, shall be provided.

b. Oil Burner Piping - Fuel oil piping on the unit shall include oil pressure regulating devices, oil metering controls, solenoid shutoff valves, pressure gauges and fuel strainer, all integrally mounted on the unit. Select one of the following:

1) 50 hp through 100 hp. A fuel oil controller shall be provided to combine all of the fuel oil controls into a single casting which is mounted on the front door of the unit. A single tip retractable nozzle shall be used for the low pressure air atomizing burner.

2) 70 hp through 100 hp. A low oil pressure switch shall be included in the oil piping.

3) Low pressure air atomizing - Select one of the following:

- 15 hp through 40 hp. Belt driven air compressor, lubricating oil tank, oil level indicator, inlet air filter, air pressure gauge and low atomizing air pressure switch.
- 50 hp through 100 hp. Separate air compressor module mounted on boiler base rail with low atomizing air pressure switch.

4. Gas Burner

a. Gas Burner Piping - gas burner piping on all units shall include pressure regulator, primary gas shutoff valve, motor operated with proof of closure switch and plugged leakage test connection. The main gas valve(s) shall be wired to close automatically in the event of power failure, flame failure, low water or any safety shutdown condition. A lubricating plug cock or butterfly shutoff valve shall be provided as a means for a tightness check of the primary shut off valve. An additional plug cock or butterfly valve shall be furnished at entrance to gas train.

Select one of the following:

- 15-50 hp. Burners equipped as shown above.
- 60-100 hp. High and low gas pressure switches shall be provided.

5. Burner Turndown - Select one of the following:

- 15 and 20 hp. Burner shall operate on the on/off principle.
- 30 and 40 hp. Burner shall operate on the high-low-off principle with a turndown of 3:1
- 50-100 hp. Turndown range of the burner shall be 4:1.

6. Fuel Series 600 - No. 6 Oil Fired

a. Burner Type - The burner shall be integral with the front head of the boiler and low pressure air atomizing type approved for operation with CS12-48, Commercial No. 6 Oil.

b. Gas Pilot - The gas pilot shall be a premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary oil valve cannot open until pilot flame has been established. The pilot train shall

include two manual shut-off valves, solenoid valve, pressure regulator and pressure gauge.

c. Oil Pump - An oil pump set with a capacity of approximately twice the maximum burning rate shall be included.

A separate motor driven pump set shall be included shipped loose for location favorable to the oil storage tank.

d. Oil Burner Piping - A fuel oil controller combining all of the fuel oil controls into a single casing shall be provided. Oil pressure regulating devices, oil metering controls, solenoid shutoff valves, high and low oil temperature switches and necessary pressure and temperature gauges shall be included in this packaged assembly mounted on the front door of the boiler. A fuel strainer shall also be provided, mounted to the boiler. A single tip retractable nozzle shall be used for the low pressure air atomizing burner. Flexible hoses shall be provided to allow easy removal of the nozzle for inspection when it is placed in the vice jaws located on the front door of the boiler.

The metering valve shall permit circulation of hot oil to the burner at all times. The burner drawer oil piping and nozzle shall be purged of oil on each shutdown.

For 70 through 100 hp, a low oil pressure switch shall be included in the oil piping.

e. Low Pressure Air Atomizing

1) 50 through 100 hp. Separate air compressor module mounted on boiler base rail with low atomizing air pressure switch.

f. Oil Preheat
The oil shall be preheated by a safety type water-to-water-to-oil preheating system in conjunction with an electric preheater, each with thermostatic control. Both heaters shall be mounted, piped, and wired on the boiler.

1) 50 through 100 hp. Electric preheater size shall be 5 kW.

7. Fuel Series 400 - No. 6 Oil or Gas Fired

a. Burner Type - The burner shall be integral with the front head of the boiler and shall be a combination of the low pressure atomizing type for oil and high radiant multi-port type for gas. The burner shall be approved for operation with either CS12-48 Commercial No. 6 oil or natural gas.

b. Gas Pilot - The gas pilot shall be a premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary oil valve cannot open until pilot flame has been established. The pilot train shall include two manual shut-off valves, solenoid valve, pressure regulator and pressure gauge.

8. Oil Burner

a. Oil Pump - An oil pump set with a capacity of approximately twice the maximum burning rate shall be included.

b. Oil Burner Piping - A fuel oil controller combining all of the fuel oil controls into a single casing shall be provided. Oil pressure regulating devices, oil metering controls, solenoid shutoff valves, high and low oil temperature switches, and the necessary pressure and temperature gauges shall be included in this packaged assembly mounted on the front door of the boiler. A fuel strainer shall also be provided, mounted to the boiler. A single tip retractable nozzle shall be used for the low pressure air atomizing burner.

Flexible hoses shall be provided to allow easy removal of the nozzle for inspection when it is placed in the vice jaws located on the front door of the boiler. The metering valve shall permit circulation of hot oil to the burner at all times. The burner drawer oil piping and nozzle shall be purged of oil at each shutdown.

For 70 through 100 hp, a low oil pressure switch shall be included in the oil piping.

9. Low Pressure Air Atomizing
    a. 50 through 100 hp. Separate air compressor module mounted on boiler base rail with low atomizing air pressure switch.
10. Oil Preheat
    The oil shall be preheated by a safety type water-to-water-to-oil preheating system in conjunction with an electric preheater, each with thermostatic control. Both heaters shall be mounted, piped, and wired on the boiler. Select one of the following:
    a. 50 through 100 hp. Electric preheater size shall be 5 kW.
11. Gas Burner
    a. Gas Burner Piping - Gas burner piping on all units shall include pressure regulator, primary gas shutoff valve, motor operated with proof of closure switch and plugged leakage test connection. The main gas valve(s) shall be wired to close automatically in the event of power failure, flame failure, low water or any safety shutdown condition. A lubricating plug cock or butterfly shutoff valve shall be provided as means for a tightness check of the primary shutoff valve. An additional plug cock or butterfly valve shall be furnished at entrance to gas train. Select one of the following:
        1) 50 hp. Burner equipped as shown above.
        2) 60 through 100 hp. High and low gas pressure switches shall be provided.
        3) Burner Turndown - Turndown shall be 4:1.

D. Boiler Flame Safeguard Controller and Control Panel
    1. CB780E Flame Safeguard
    2. 4.5.1.1 Boilers with CB780E Control - Each boiler shall be factory equipped with flame safeguard controller providing technology and functions equal to the Cleaver-Brooks Model CB780E.

    Controller shall be computerized solid state having sequence and flame-on lights and digital “first out” fault code indications of flame safeguard trip functions. It shall include dynamic self-check logic. The controller 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.

    Controller shall be the non-recycle type for maximum safety that shall shutdown the burner and indicate as a minimum the following trip functions: pilot and main flame failure, high and low fire proving switch faults, running interlocks open, false flame signal and fuel valve open (when proof of closure switch is furnished).

    The controller shall have a run/test switch. It shall allow interruptions to sequence just after pre- purge, during pilot ignition trial and run cycles for adjustments to firing rate motor, damper linkages and pilot flame for minimum turndown tests.

3. Control Panel: The control panel shall be mounted on the front door of the boiler in a location convenient to the operator. The hinged metal cabinet will have NEMA 1A rating that includes a neoprene dust seal and a Yale cabinet key type lock.

   The panel shall contain the boiler flame safeguard controller, blower motor starter, indicating lights and selector switches.

   The panel shall have a removable sub-base for mounting the flame safeguard controller, blower motor starter, and terminal blocks. For combination gas-oil and heavy oil fired boilers the panel will contain the fuel selector and/or oil heater selector switch.

   The panel shall contain the following lights and switches:

   a. Lights
      - White - load demanded.
      - White - fuel valve open.
      - Red - low water.
      - Red - flame failure.

   b. Control Switches
      - Burner On-Off.
      - Manual-Automatic.
      - Manual Firing Rate Control.

4. Oil, heat and moisture resistant wire shall be used and identified with circuit numbers corresponding to the electrical wiring diagram.
5. All electrical equipment and wiring shall be in conformance with Underwriters Laboratories requirements.
6. Boiler to be supplied with a control circuit transformer and fuse protection for the control circuit.
7. Control Panel: The control panel shall be mounted on the front door of the boiler in a location convenient to the operator. The hinged metal cabinet will have NEMA 1A rating that includes a neoprene dust seal and a Yale cabinet key type lock.

   The panel shall contain the boiler flame safeguard controller, indicating lights and selector switches.

   Panel shall have a removable sub-base for mounting the flame safeguard controller, and terminal blocks. For combination gas-oil and heavy oil fired boilers the panel will contain the fuel selector and/or oil heater selector switch.

8. Oil, heat, and moisture resistant wire shall be used and identified with circuit numbers corresponding to the electrical wiring diagram.
9. All electrical equipment and wiring shall be in conformance with Underwriters Laboratories requirements.
10. Boiler to be supplied with a control circuit transformer and fuse protection for the control circuit.

1.08 Efficiency Guarantee

The boiler manufacturer shall guarantee that, at the time of startup, the boiler will achieve _____ fuel-to-steam efficiency at 100% firing rate when burning natural gas and _____ fuel-to-steam efficiency at 100% firing rate when burning oil (add efficiency guarantees at 25%,

50%, and 75% of rating, if required). If the boiler(s) fail to achieve the corresponding guaranteed efficiency as published, the boiler manufacturer will rebate, to the ultimate boiler owner, five thousand dollars ($5,000) for every full efficiency point (1.0%) that the actual efficiency is below the guaranteed level.

The specified boiler efficiency is based on the following conditions.

A. Fuel specification used to determine boiler efficiency:

1. Natural Gas

   Carbon, % (wt) = 69.98

   Hydrogen, % (wt) = 22.31

   Sulfur, % (wt) = 0.0

   Heating value, Btu/lb = 21,830

2. No. 2 Oil

   Carbon, % (wt) = 85.8

   Hydrogen, % (wt) = 12.7

   Sulfur, % (wt) = 0.2

   Heating value, Btu/lb = 19,420

3. No. 6 Oil

   Carbon, % (wt) = 86.6

   Hydrogen, % (wt) = 10.9

   Sulfur, % (wt) = 2.09

   Heating value, Btu/lb = 18,830

B. Efficiencies are based on ambient air temperature of 80 °F, relative humidity of 30%, and 15% excess air in the exhaust flue gas.

C. Efficiencies are based on manufacturer's published radiation and convection losses. (For Cleaver-Brooks radiation and convection losses, see Boiler Efficiency Facts Guide, publication number CB-7767).

D. Any efficiency verification testing will be based on the stack loss method.

1.09 Warranty

A. All equipment is to be guaranteed against defects in materials and/or workmanship for a period of 12 months from date of start-up or 18 months from date of shipment, whichever comes first.

EXECUTION

2.01 Shop Tests

A. The packaged boiler must receive factory tests to check the construction, controls, and operation of the unit. All tests may be witnessed by the purchaser, if desired.

B. Start-up Service

1. After boiler installation is completed, the manufacturer shall provide the services of a field representative for starting the unit and training the operator at no additional costs.

a. A factory approved and authorized start-up report shall be submitted to the customer/user at the time of start-up.

Notes