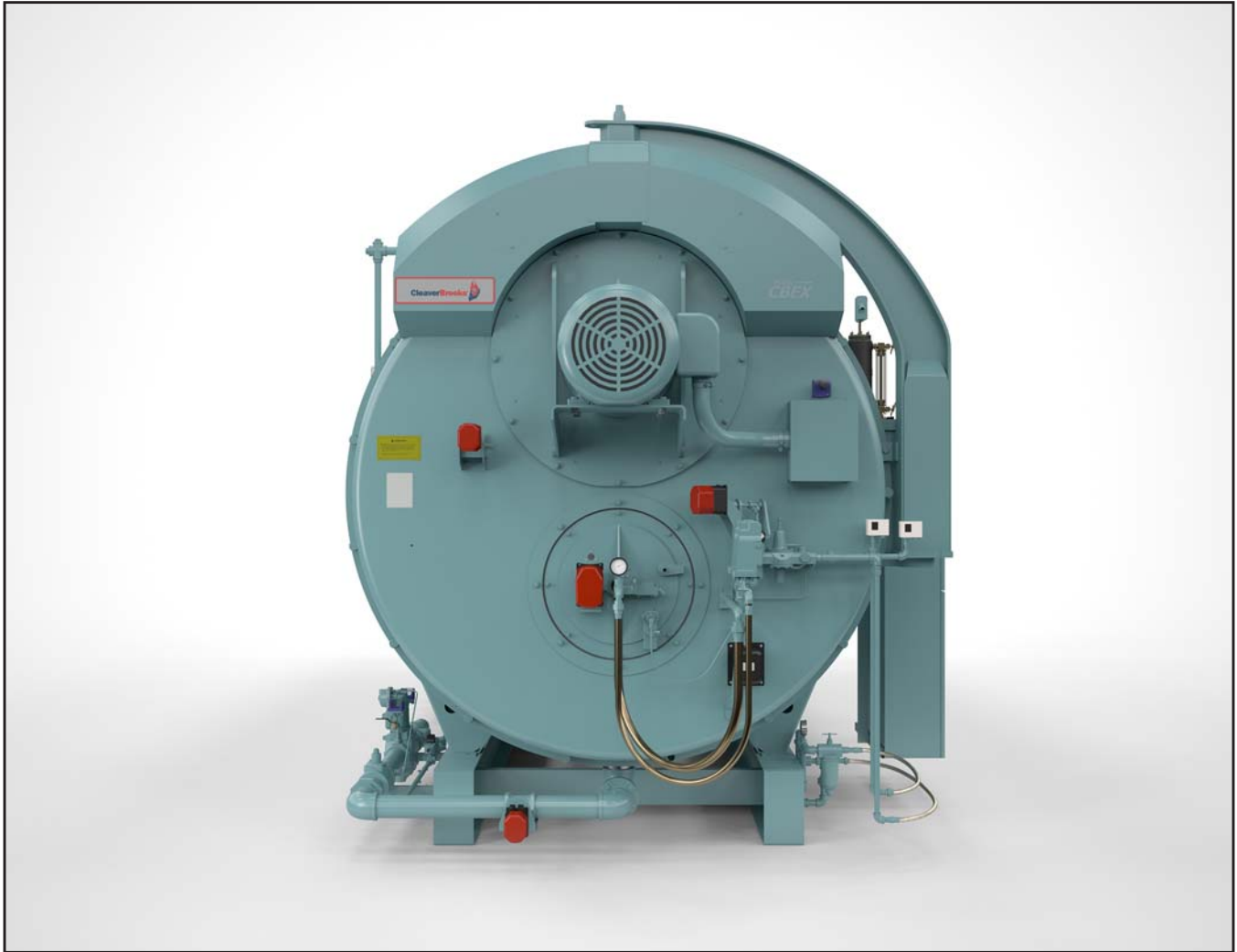


CBEX-DE



250-800 HP

Boiler Book
09/2017



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The Cleaver-Brooks CBEX-DE Dryback Elite is a two-pass dryback firetube boiler with integral burner design, available in sizes from 250 to 800 boiler horsepower. All units are factory fire tested and shipped as a package, ready for installation.

FEATURES AND BENEFITS

- EX technology
 - Advanced heat transfer tubes
 - Simplified 2-pass vessel
 - Optimized furnace geometry for near-perfect combustion
- Integral burner specifically designed and tested for the boiler
- Removable head for ease of maintenance and inspection
- Hawk 1000 control system standard; optional Hawk 4000
- LevelMaster low water cutoff standard on steam boilers
- Quiet operation
- Smaller footprint and lower weight than comparable traditional firetube boilers
- Front and rear access

PRODUCT OFFERING

- 250-800 HP
- cULus labeled as a package
- 30 ppm standard; 60 ppm available for 700/800 HP
- Combination gas & #2 oil firing
- Steam and Hot Water
 - Low & High Pressure Steam: 15#, 150-300#
 - 30 and 125 psig hot water
- Full modulation, all sizes
- Boiler options:
 - Additional screwed or flanged tappings
 - Blowdown valves
 - Non-return valves
 - Feedwater valves and regulators
 - Surface blowdown systems
 - Surge load baffles
 - Seismic design
 - Flow meters for fuel, water or steam
 - Economizer support
- Burner/Control Options:
 - O2 trim
 - Flame safeguard controllers
 - Lead/lag system
 - Special insurance and code requirements (e.g. FM, NFPA85)
 - Alarm bell/silence switch

Special motor requirements (TEFC, high efficiency)

Special indicating lights

Main disconnect

NEMA enclosures.

Remote emergency shut-off (115V)

Circuit breakers

Day/night controls

Special power requirements

- Fuel Options:

Gas strainer

Gas pressure gauge

Future oil conversion

Future low NOx conversion

Oversized/undersized gas trains

Optional Oil Pumps

BOILER RATINGS**Table 1: CBEX-DE Ratings 250-800 HP**

Boiler Output, HP	250	300	350	400	500	600	700	800
Firing Rate, BTU/h	10,205,793	12,246,951	14,288,110	16,329,268	20,411,585	24,493,902	28,576,220	32,658,537
Shell Diameter, in.	67	67	67	78	83	83	83	83

Motor Size (60 PPM system)	-	-	-	-	-	-	40	60
Motor Size (30 PPM system)	15	20	30	25	30	50	50	75
Oil Pump Motor HP (No. 2 Oil only)	1/2	3/4	3/4	3/4	3/4	3/4	1	1
Air Compressor Motor HP (No. 2 Oil only)	5	5	5	5	7 1/2	7 1/2	7 1/2	7 1/2

Boiler Ratings

Rated Capacity (lb-steam/hr at 212F)	8,625	10,350	12,075	13,800	17,250	20,700	24,150	27,600
Btu Output (1000 BTU/hr)	8,369	10,043	11,716	13,390	16,738	20,085	23,433	26,780
Light Oil gph (140,000 BTU/gal)	72.9	87.5	102.1	116.6	145.8	175.0	204.1	233.3
Gas CFH (1000 BTU)	10,206	12,247	14,288	16,329	20,412	24,494	28,576	32,659
Gas Therm (therm/hr)	102.1	122.5	142.9	163.3	204.1	244.9	285.8	326.6
Heating Surface sq-ft (fireside)	814	859	1121	1244	1650	1876	2375	2466

ENGINEERING DATA

Table 2: Model CBEX-DE Steam Volume and Disengaging Areas

BOILER HP	STEAM VOLUME CU-FT	STEAM RELIEVING AREA SQ-IN
250	61.6	9173
300	65.1	9706
350	69.0	10282
400	78.0	11722
500	114.4	13018
600	130.5	14832
700	131.8	14976
800	136.9	15566

NOTE:

Based on normal water level average between pump on and off.

Table 3: Model CBEX-DE Recommended Steam Nozzle Size

OPERATING PRESSURE PSIG								
	250	300	350	400	500	600	700	800
15	10	12	12	12	12	12	12	12
30	8	8	10	10	10	12	12	12
40	8	8	8	10	10	10	12	12
50	6	8	8	8	8	10	10	12
75	6	6	8	8	8	8	10	10
100	6	6	6	6	8	8	8	10
125	6	6	6	6	8	8	8	8
150	4	6	6	6	6	6	8	8
200	4	4	4	6	6	6	6	6
250	4	4	4	4	6	6	6	6

NOTES:

1. Steam nozzle sizes given in inches.
2. Recommended steam nozzle sizes based on 4000 to 5000 fpm steam velocity.

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.

The table below lists the approximate quantity of water represented by 4 inches of water at normal operating level for Cleaver-Brooks CBEX Boilers.

Table 4: Model CBEX-DE Blowdown Tank Sizing Information

BOILER HP	WATER (GAL)
250	159
300	168
350	178
400	203
500	225
600	257
700	259
800	270

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

Burner Characteristics

Note that altitude correction and burner changes are required for higher altitudes which may alter dimensions, motor hp and gas pressures. Also 50 Hz applications and low NOx options should be reviewed by the Cleaver-Brooks authorized representative.

Fuel Connections - Gas

The local gas company should be consulted for requirements and authorization for installation and inspection of gas supply piping. Installation of gas supply piping and venting must be in accordance with all applicable engineering guidelines and regulatory codes. All connections made to the boiler should be arranged so that all components remain accessible for inspection, cleaning and maintenance.

A drip leg should be installed in the supply piping before all fuel train components. The drip leg and strainer should be at least as large as the inlet fitting supplied with the boiler. Consideration must be given to both volume and pressure requirements when choosing gas supply piping size. Refer to the boiler dimension diagram provided by Cleaver-Brooks for the particular installation. Connections to the burner gas train should be made with a union, so that gas train components or the burner may be easily disconnected for inspection or service. Upon completion of the gas piping installation, the system should be checked for gas leakage and tight shutoff of all valves.

Fuel Connections - Oil

Oil-fired burners may be equipped with an oil pump, which draws fuel from a storage tank or circulating loop and supplies pressurized oil to the burner nozzle(s). The burner supply oil pump has a greater capacity than the burner requires for the maximum firing rate. Fuel not delivered to the nozzle is returned to the storage tank. A two-pipe (supply and return) oil system is recommended for all installations. Oil lines must be sized for the burner and burner supply oil pump capacities.

The burner supply oil pump suction should not exceed 10" Hg. If a transfer pump is used, it must

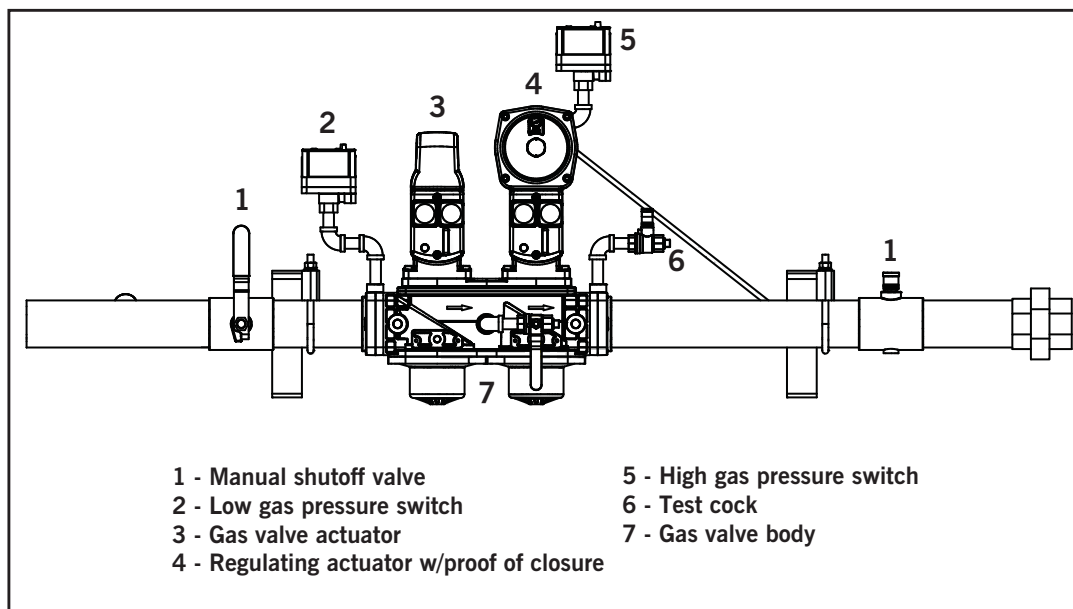
have a pumping capacity at least equal to that of the burner pump(s). Supply pressure to the burner pump should not exceed 3 psig.

A strainer must be installed in the supply piping upstream of the burner supply pump in order to prevent entry of foreign material into the pump, fuel control valves, or burner nozzle(s). The strainer must be sized for the burner supply pump capacity. A strainer mesh of 150 microns (0.005") is recommended.

Install a check valve in the line to prevent draining of the oil suction line when the burner is not in operation. Location of the check valve varies with the system, but usually it is located as close as possible to the storage tank.

Installation of a vacuum gauge in the burner supply line between the burner oil pump and the strainer is recommended. Regular observation and recording of the gauge indication will assist in determining when the strainer needs servicing.

Upon completion of the oil piping installation, the system should be checked for oil or air leakage and tight shutoff of all valves.



Gas train, typical*

*Gas train configuration may vary based on insurance and boiler/site requirements

Table 5: CBEX-DE Gas Train Sizes and Inlet Pressure Requirements

BOILER HP	EMISSIONS ppm	GAS TRAIN SIZE inches	INLET PRESSURE inches W.C.	
			minimum	maximum
250	30	1.5 - 2.0	64	138
250	30	2.0	53	64
250	30	2.5	38	53
250	30	3.0	33	38
300	30	1.5 - 2.0	80	181
300	30	2.0	65	80
300	30	2.5	43	65
300	30	3.0	36	43
350	30	1.5 - 2.0	100	227
350	30	2.0	79	100
350	30	2.5	50	79
350	30	3.0	41	50
400	30	1.5 - 2.0	124	276
400	30	2.0	98	124
400	30	2.5	60	98
400	30	3.0	48	60
500	30	1.5 - 2.5	171	360
500	30	2.0 - 2.5	133	171
500	30	2.5	77	133
500	30	3.0	59	77
500	30	4.0	48	59
600	30	2.0 - 3.0	166	361
600	30	2.5 - 3.0	95	166
600	30	3.0	75	95
600	30	4.0	60	75
700	30	2.0 - 3.0	212	415.5
700	30	2.5 - 3.0	117	212
700	30	3.0	91	117
700	30	4.0	71	91
700	60	2.0 - 3.0	213	415.5
700	60	2.5 - 3.0	118	213
700	60	3.0	92	118
700	60	4.0	72	92
800	30	2.0 - 3.0	268	415.5
800	30	2.5 - 3.0	150	268
800	30	3.0	118	150
800	30	4.0	93	118
800	60	2.0 - 3.0	267	415.5
800	60	2.5 - 3.0	148	267
800	60	3.0	115	148
800	60	4.0	90	115

NOTES:

On standard gas trains, manual shutoff valve is a butterball type valve for connection sizes up to and including 2 inches. Larger than 2 inch connections use a plug cock type valve. If upgrading to a plug cock valve for a 2 inch or smaller connection, pressure requirements may change. Contact C-B.

Table 6: Altitude Correction for Gas

ALTITUDE (FT)	CORRECTION FACTOR	ALTITUDE (FT)	CORRECTION FACTOR
1000	1.04	6000	1.25
2000	1.07	7000	1.3
3000	1.11	8000	1.35
4000	1.16	9000	1.4
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 7: Model CBEX-DE Steam Boiler Safety Valve Outlet Size

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
250	2	2-1/2	2	2	2	(1) 1-1/2 (1) 2	2	(1) 2 (1) 1-1/2	2	(1) 1-1/4 (1) 1-1/2	2	(1) 1-1/4 (1) 1-1/2
300	2	(1) 2-1/2 (1) 3	2	(1) 2 (1) 2-1/2	2	2	2	(1) 2 (1) 1-1/2	2	1-1/2	2	(1) 1-1/4 (1) 1-1/2
350	2	3	2	2-1/2	2	(1) 2-1/2 (1) 2	2	2	2	(1) 1-1/2 (1) 2	2	1-1/2
400	2	3	2	2-1/2	2	(1) 2-1/2 (1) 2	2	(1) 2-1/2 (1) 2	2	(1) 1-1/2 (1) 2	2	(1) 1-1/2 (1) 2
500	3	(1) 2-1/2 (2) 3	3	(1) 2 (2) 2-1/2	2	2-1/2	2	(1) 2-1/2 (1) 2	2	(1) 2-1/2 (1) 2	2	(1) 1-1/2 (1) 2
600	3	3	3	2-1/2	3	(2) 2-1/2 (1) 2	2	2-1/2	2	(1) 2-1/2 (1) 2	2	2
700	4	(1) 2-1/2 (3) 3	4	(1) 2 (3) 2-1/2	3	2-1/2	3	(2) 2-1/2 (1) 2	2	2-1/2	2	(1) 2-1/2 (1) 2
800	4	3	4	2-1/2	4	(3) 2-1/2 (1) 2	3	(2) 2-1/2 (1) 2	2	2-1/2	2	(1) 2-1/2 (1) 2

NOTE: Valve manufacturers are Kunkle, Consolidated or Conbraco, depending on availability.

Table 8: Model CBEX-DE Hot Water Boiler Relief Valve Outlet Size

VALVE SETTING BOILER HP	30 PSIG HW		125 PSIG HW	
	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)	NO. OF VALVES REQ'D	OUTLET SIZE (IN.)
250	2	(1) 1-1/4 (1) 2-1/2	1	2
300	2	(1) 2 (1) 2-1/2	1	2
350	2	(2) 2-1/2	1	2-1/2
400	3	(1) 1 (2) 2-1/2	1	2-1/2
500	3	(1) 2 (2) 2-1/2	1	2-1/2
600	3	(3) 2-1/2	2	(1) 1 (1) 2-1/2
700	4	(1) 2 (3) 2-1/2	2	(1) 1 (1) 2-1/2
800	4	(4) 2-1/2	2	(1) 2 (1) 2-1/2

NOTE: Relief valve is Kunkle #537 for 30# & 125# (Section IV) boiler and Kunkle #927 for 150# HTHW (Section I) boiler.

Table 9: Rear Door Swing

	Dimensions (inches)				
	A	B	C	D	E
250-350 HP	36.5	65	51	83	35
400 HP	42	73	56	96	44
500-800 HP	44.5	86	64	99	57

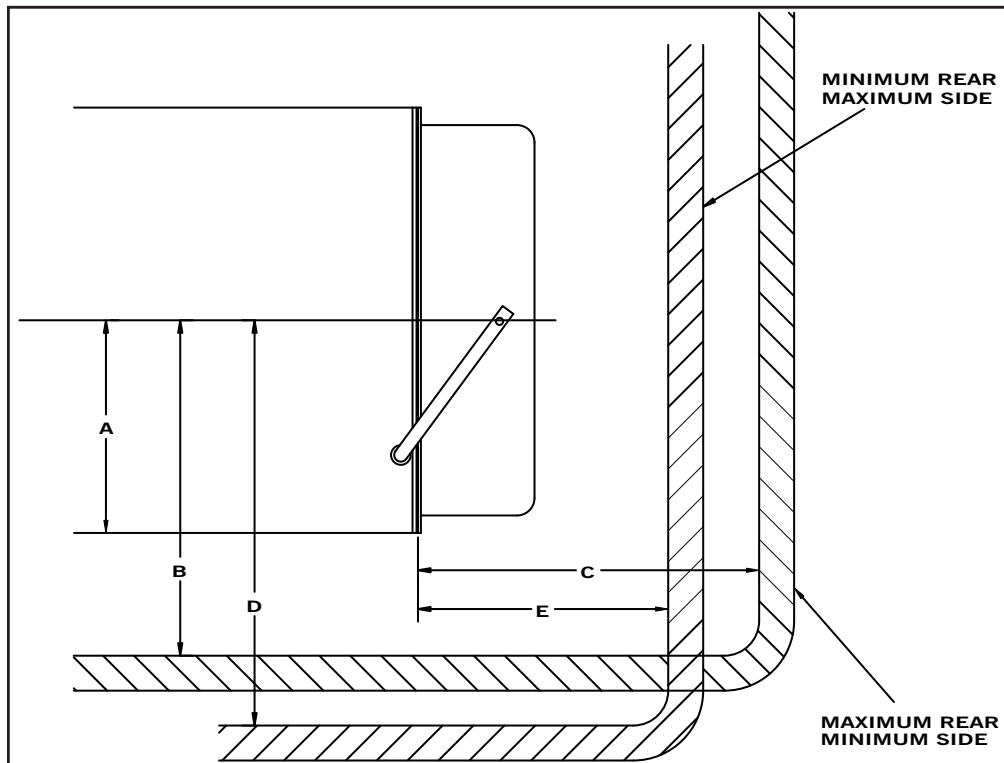


Table 10: Model CBEX-DE Boilers Lifting Lug Location

BOILER HP	ALL DIMENSIONS IN INCHES				
	A	B	C	D	E
250	88	36	102	10	3
300	88	36	111	10	3
350	88	36	120	10	3
400	98.5	36	128	10	3
500	102.5	37	127	10	3
600	102.5	37	152	10	3
700	102.5	37	154	10	3
800	102.5	37	162	10	3

NOTE: Dimensions A, B, and C may vary by 1 inch.

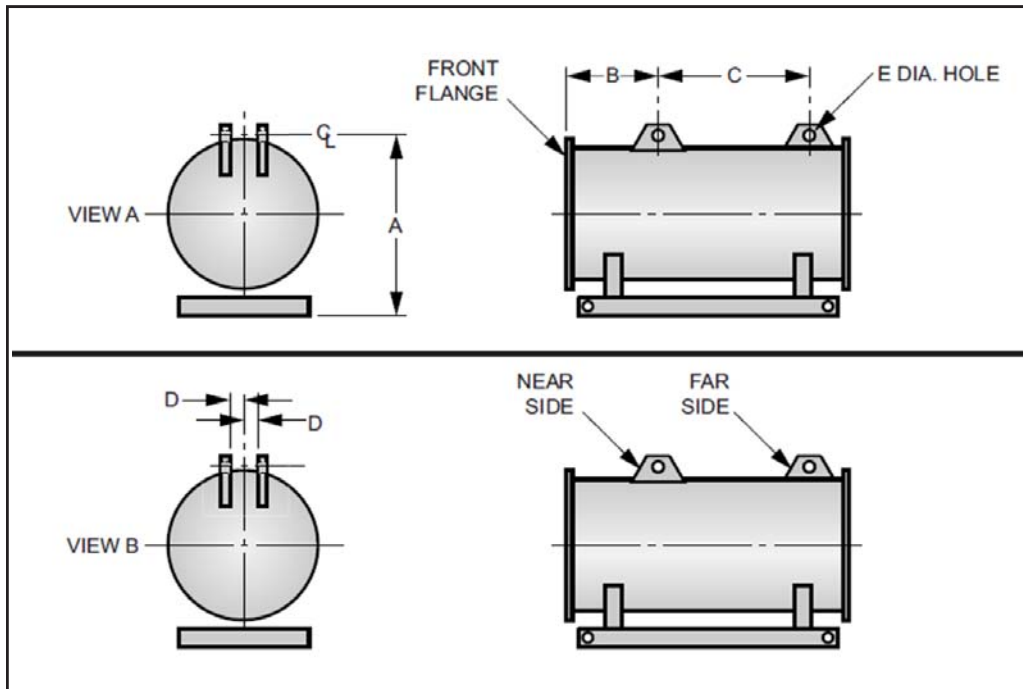


Table 11: Model CBEX-DE Boiler Mounting Piers

BOILER HP	ALL DIMENSIONS IN INCHES								
	A	B	C	D	E	F	G	X1	X2
250	6	9	176.5	38	56	4	43	12.25	15.25
300	6	9	185.5	38	56	4	43	12.25	15.25
350	6	9	195.5	38	56	4	43	12.25	15.25
400	6	9	200.5	51	72	4	56	15.5	14
500	6	12	196.5	41.5	65.5	6.5	47	12.5	16.5
600	6	12	221.5	41.5	65.5	6.5	47	12.5	16.5
700	6	12	223.5	49.5	73.5	6.5	47	13.5	16.5
800	6	12	232.5	49.5	73.5	6.5	57	13.5	16.5

NOTE:

6-inch high mounting piers recommended for use beneath the boiler base frame. The use of these piers provides increased inspection accessibility to the boiler and added height for washing down the area beneath the boiler.

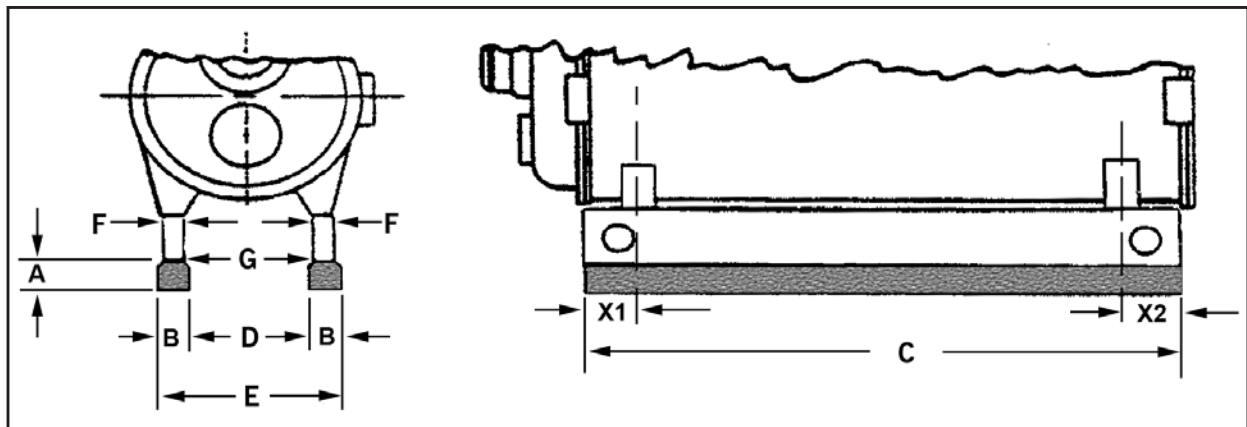


Table 12: Boiler Room Width (Typical Layout) - Model CBEX-DE

BOILER HP	250-350	400	500-800
DIM. "A"	99	104	119
DIM. "B"	144	153	172

NOTES:

1. Recommended Minimum Distance Between Boiler and Wall. Dimension "A" allows for a clear 42" aisle between the face of the control panel and the wall. If space permits, this aisle should be widened.

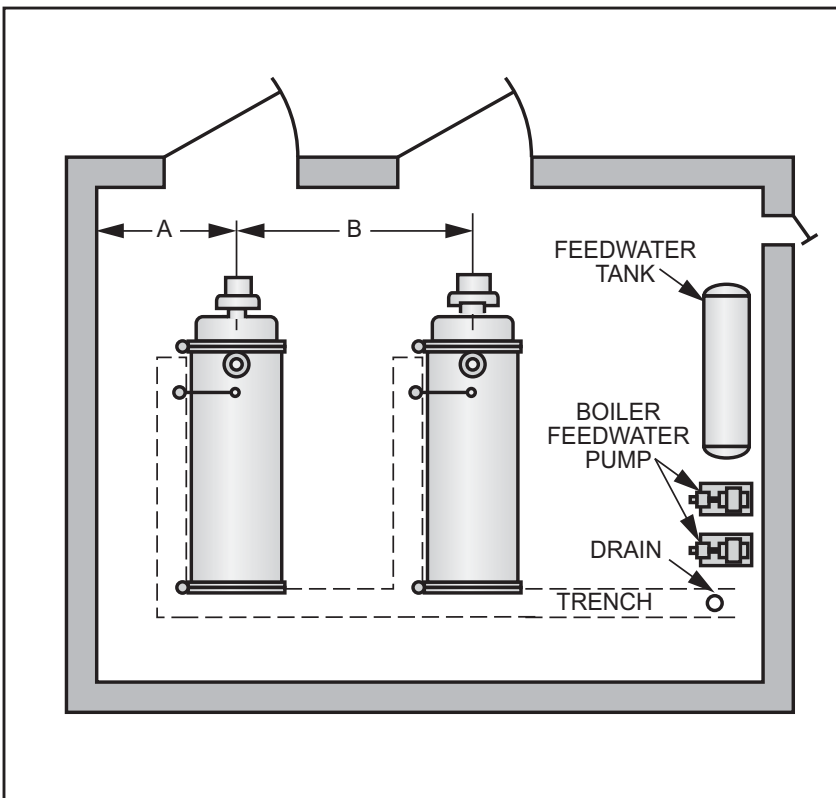
2. Recommended Minimum Distance Between Boilers.

Dimension "B" between boilers allows for a clear aisle of:

48" - 250-400 HP

60" - 500-800 HP

If space permits, this aisle should be widened.



Stack Support Capabilities

CBEX boilers can support up to 2000 lbs. without additional support.

CBEX boilers can be reinforced to support up to 3000 lbs.

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.

Two (2) permanent air supply openings in the outer walls of the boiler room are recommended. Locate one (1) at each end of the boiler room, preferably below a height of 7 feet. This allows air to sweep the length of the boiler.

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.

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.

Under no condition should the total area of the air supply openings be less than one (1) square foot.

Size the openings by using the formula:

$$\text{Area (sq-ft)} = \text{CFM/FPM}$$

2. Amount of air required (cfm).

Combustion Air = Rated bhp x 8 cfm/bhp.

Ventilation Air = Maximum bhp x 2 cfm/bhp or a total of 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).

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

Above (7) foot height - 500 fpm.

Example: Determine the area of the boiler room air supply openings for (1) 1000 hp boiler at 800 feet altitude. The air openings are to be 5 feet above floor level.

Air required: $1000 \times 10 = 10000$ cfm (from 2B above).

Air velocity: Up to 7 feet = 250 fpm (from 3 above).

Area Required: $\text{Area} = \text{cfm/fpm} = 10000/250 = 40$ Sq-ft total.

Area/Opening: $40/2 = 20$ sq-ft/opening (2 required).

NOTE: Consult local codes, which may supersede these requirements.

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 CBEX is not required, it is necessary to size the stack/breeching to limit flue gas pressure variation. The allowable pressure range is $-0.25''$ W.C. to $+0.25''$ W.C. The maximum pressure variation at any firing rate for the boiler is $0.25''$ W.C.

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.

PERFORMANCE DATA

Table 13: Model CBEX-DE Boilers: Natural Gas, Estimated Emission Levels

POLLUTANT	UNITS	60 PPM SYSTEM	30 PPM SYSTEM
CO	ppm ^A	10 ^B	10 ^B
	lb/MMBtu	0.0075	0.0075
NOx	ppm ^A	60	30
	lb/MMBtu	0.07	0.035
SOx	ppm ^A	1	1
	lb/MMBtu	0.001	0.001
HC/VOC	ppm ^A	8	8
	lb/MMBtu	0.0032	0.0032
PM	ppm ^A	-	-
	lb/MMBtu	0.01	0.01

A. ppm levels are given on a dry volume basis and corrected to 3% oxygen (15% excess air)

B. 50 ppm CO at below 50% and 10 ppm above 50% rate

Table 14: Model CBEX-DE Boilers: No. 2 Oil, Estimated Emission Levels

POLLUTANT	UNITS	60 PPM SYSTEM	30 PPM SYSTEM
CO	ppm ^A	10	10
	lb/MMBtu	0.008	0.008
NOx	ppm ^A	120	90
	lb/MMBtu	0.16	0.12
SOx	ppm ^A	55	55
	lb/MMBtu	0.1	0.1
HC/VOC	ppm ^A	4	4
	lb/MMBtu	0.002	0.002
PM	ppm ^A	-	-
	lb/MMBtu	0.025	0.025

A. ppm levels are given on a dry volume basis and corrected to 3% oxygen (15% excess air)

BASED ON THE FOLLOWING CONSTITUENT LEVELS:

Fuel-bound Nitrogen content = 0.015% or less by weight.

Sulfur content = 0.1% by weight.

Ash content = 0.01% by weight.

Table 15: Model CBEX-DE Boilers: Predicted Sound Levels (30 or 60 ppm NO_x systems) at High Fire

BHP	Sound Level dbA	
	30 PPM	60 PPM
250	82	
300	83	
350	85	
400	84	
500	85	
600	85	
700	86	86
800	88	87

Efficiency

The tables below show predicted fuel-to-steam efficiencies (including radiation and convection losses) for CBEX-DE boilers (30 ppm). Cleaver-Brooks offers an industry leading fuel-to-steam boiler efficiency guarantee for CBEX Firetube Boilers. The guarantee is based on the fuel-to-steam efficiencies shown in the efficiency tables and on the conditions stated below. 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-7767 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, ten thousand dollars (\$10,000) 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	• No. 2 Oil
Carbon,% (wt) = 69.98	Carbon,% (wt) = 85.8
Hydrogen,% (wt) = 22.31	Hydrogen,% (wt) = 12.7
Sulfur,% (wt) = 0.0	Sulfur,% (wt) = 0.2
Heating value, Btu/lb = 21,830	Heating value, Btu/lb = 19,420

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 the following radiation and convection losses. Firing rate of 25% - 1.2%, 50% - 0.6%, 75% - 0.4%, and 100% - 0.3%.

Table 16: Model CBEX-DE Boilers: Predicted Fuel-to-Steam Efficiencies-Natural Gas

BHP	OPERATING PRESSURE = 125 psig				
	% OF LOAD				
	10%	25%	50%	75%	100%
250	79.3	81.8	82.1	81.8	81.4
300	79.3	81.8	82.1	81.9	81.5
350	79.4	82.0	82.4	82.2	82.0
400	79.4	82.0	82.5	82.3	82.1
500	79.4	82.0	82.5	82.3	82.1
600	79.4	82.2	82.7	82.7	82.5
700	79.5	82.3	82.9	82.7	82.6
800	79.5	82.3	82.9	82.7	82.6

Table 17: Model CBEX-DE Boilers: Predicted Fuel-to-Steam Efficiencies-No. 2 Oil

BHP	OPERATING PRESSURE = 125 psig			
	% OF LOAD			
	25%	50%	75%	100%
250	84.6	85.1	84.7	84.1
300	84.6	85.1	84.8	84.2
350	84.9	85.5	85.3	84.9
400	84.9	85.7	85.4	85.1
500	84.9	85.7	85.4	85.1
600	85.2	85.9	86.0	85.7
700	85.4	86.2	86.0	85.8
800	85.4	86.2	86.0	85.8



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