Remediation: Air, Water and Soil

EBD WATER TREATMENT FOR WATER BOILERS AND COOLING TOWERS

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Remediation: Air, Water and Soil

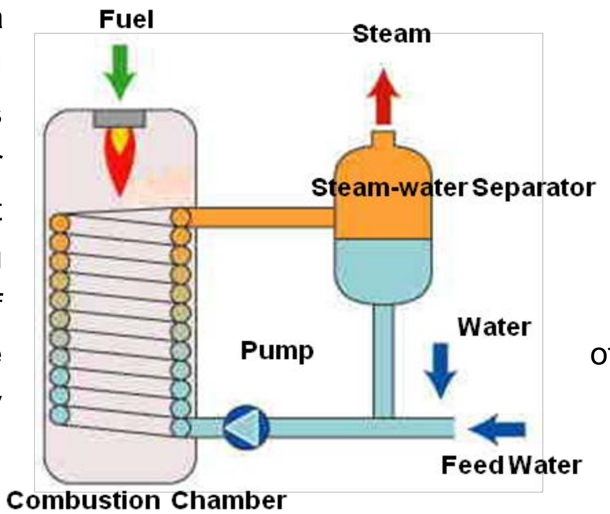
Environmental Balance Devices (EBD) technology significantly improves boiler and cooling tower operation efficiencies. EBD systems eliminate water circulation line obstructions and thus reduce operational costs associated with maintenance, replacements as well as consumables.

1. Heat Exchange Equipment Summary: BOILERS

A boiler is a closed vessel in which water is heated. The heated or vaporized fluid within the boiler is used for various processes or heat applications including; water heating, central heating, boiler-based power generation for thermal power plants as well as in large ships. Boilers for hot water production and water heat purposes are sometimes classified as “low pressure boilers”.

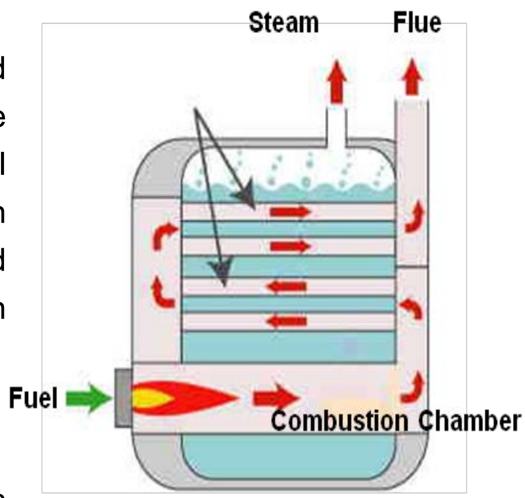
A. Once Through Boiler

These boilers are characterized by having continuous flow paths from the evaporator inlet to the super heater outlet, without a separation drum in the circuit. They are used for supercritical boilers which do not have a significant gravity variation between water and steam. They are also used for small-type boilers which require quick starting. Retained water volume is small and thus they have excellent starting properties as well as low-load following capability. In order to stabilize the quantity of steam production and its temperature, a balance of input water, output steam, and thermal energy supply is important; along with highly advanced technology and high water purity implementation.

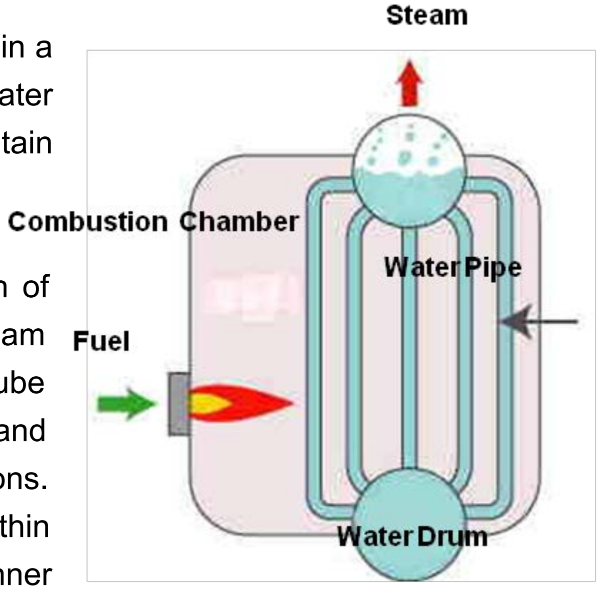


B. Fire Tube boiler

There are two types of fire tube boilers – flue boilers and smoke tube boilers. They are usually cylindrical in shape to promote energy efficiency and generally have small footprints. Fire Tube boilers are primarily utilized in industrial applications, large buildings and were also used on stream ships in the past. They used to have high ventilation resistance and complex structuring, making them difficult to clean and service. With the advent of improved water treatment equipment, electric ventilation systems, automatic controllers etc., such modern boilers are much easier to maintain.



C. Water Tube Boiler



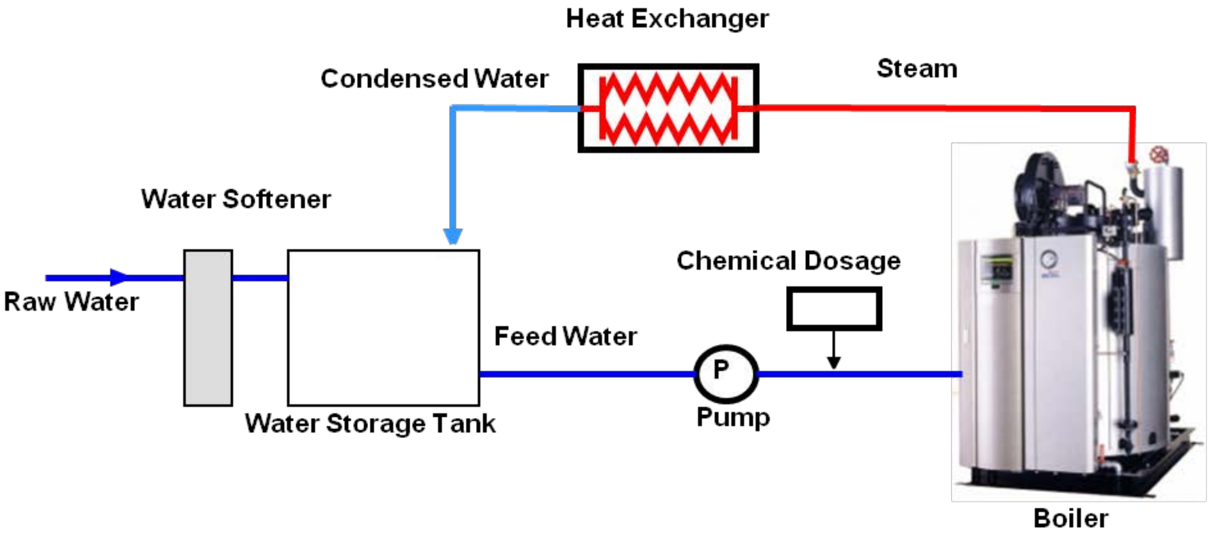
Tubes filled with water are arranged within a furnace in a number of varying configurations. Usually, the water pipes connect to large drums; the lower drums contain water and the upper drums contain steam and water. With other models, such as with mono-tube boilers, water is circulated by a pump through a succession of coils. This type of boiler generally generates high steam production rates, but less storage capacity. Water tube boilers can be designed to exploit any heat source and are generally preferred in high-pressure applications. Since the high-pressure water/steam is contained within smaller diameter pipes, such pipes can have thinner walls.

2. Why Water Treatment is Required

Boilers are usually made of carbon steel. Optimally, calcium, magnesium and sodium should be ionized and removed from raw water prior to boiling using deaerators, but in many applications, they are not used and thus scaling and corrosion problems usually arise. Scale build-up in heat exchange tubes can cause pipes to bulge and burst, and this leads to an increase in fuel consumption. Boiler corrosion also damages pipes and other related equipment often leading to energy loss in the form of steam leaks.

The study of corrosion involves analyzing pH levels, carbon dioxides, types and densities of dissolved salts, temperature, as well as flow rates. The flow chart included below, depicts a typical boiler facility. There are three main locations where corrosions occurs; 1) at the water supply pipe, 2) within the boiler body itself, and 3) the heat exchanger. The primary cause for corrosion in the water supply is dissolved oxygen. It can be treated using membrane deaeration devices which are sometimes used in small size once-through boilers but most boilers however, do not employ them. Water cleaning agents can be effective in preventing corrosion but too much cleaning agent or prolonged use of said agents, can also cause water supply damage. Generally speaking, the best known methods for preventing corrosion, consist of using deaeration devices together with cleaning agents in boilers made out of corrosion resistant materials lined with protective coatings.

When oxygen gets inside of boilers, corrosion takes place in the main body of the boiler as well as in the steam pipes. This can, and often does, lead to costly damage such as steam leakage and having to replace damaged and burst piping. Corrosion prevention methods for the body of the boilers, include the implementation of water softening devices, nitrogen type anti oxidation apparatuses, de-aeration agents or the use of film-forming agents instead of de-aeration apparatuses. Hydrazine was formerly used in boilers to eliminate dissolved oxygen from feeding water and to remove minute amounts of remaining oxygen after the deaeration process. Due to recent growing interest in environmental safety however, hydrazine-free agents have been implemented instead. All corrosion prevention methods require regular maintenance and repair and it is, therefore, difficult to achieve significant cost reductions in boiler operations.



3. Problems Caused By Water Circulation In Boilers

□ **Scale Accumulation Problems**

The primary factor for causing scaling is the combination of hardening components (e.g. calcium and magnesium) in water and carbonate ions, which produce calcium carbonate and magnesium carbonate. In addition, when silica exceeds its solubility limit and comes into contact with hardening components, silicate components accumulate in the water circuit as silica; which is difficult to eliminate. Metal ions (e.g. iron and copper), and metal oxide (e.g. iron oxide, zinc, and copper) bulge on the bottom of the scale.

□ **Corrosion Problems**

Corrosion occurs when dissolved oxygen and refined iron react. If the pH level is low, iron is eluted and corrodes further. If the pH level is high, it causes alkali corrosion. When the amount of corrosive anion (e.g. ion sulfate and chloride ion) increases, this causes additional corrosion.

□ **Carryover**

“Carryover with steam”, refers to the transport of moisture and impurities in steam. Priming with rapid increases in loading, mixing of fats and oils, excessive amounts of alkaline and foam creation containing high salinity levels leads to equipment deterioration.

4. Problems Caused by Water Circulation in Cooling Towers

□ Corrosion **Problems**

Dissolved oxygen, pH levels, chloride ions, and ammonium ions cause corrosion. Heat exchanger corrosion can, and often does, lead to cracks and holes forming in piping equipment.

□ **Slime Problems**

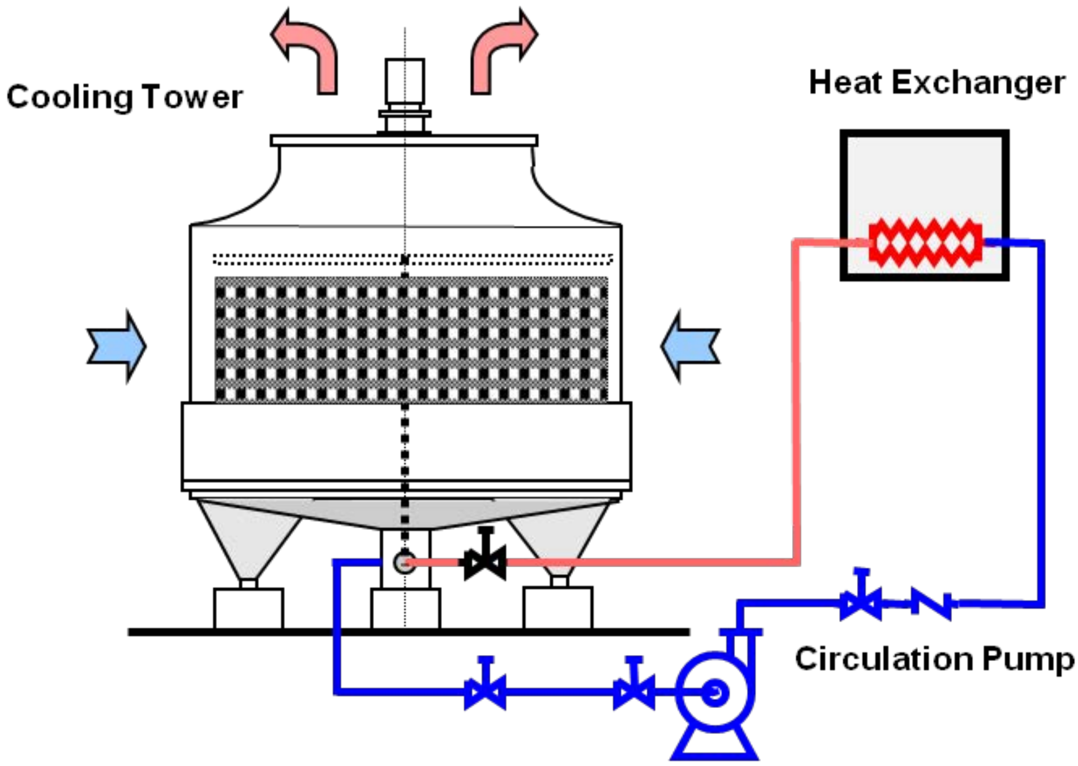
Water circulating in cooling towers is a perfect breeding ground for microorganisms such as algae, bacillus (bacteria) and fungus. The propagation of such type of microorganisms combined with the secretions of viscous organisms, cause slime to form. Algae and slime propagation leads to equipment clogging problems which also leads to foul odors and related human health problems.

□ **Scale Accumulation Problems**

Scale accumulation occurs when insoluble substances adhere and accumulate in piping. Scale is comprised mainly of inorganic substances such as calcium, silica, and iron rust which cause corrosion if not adequately treated. In addition, if these substances spread to the heat exchange piping of the heat exchangers, heat exchange efficiency decreases and this in turn, increases operational costs.

□ **Legionella Pneumophila Propagation**

Organic substances are always present in cooling water tower operations and facilities. This phenomenon leads to the propagation of bacteria including Legionella Pneumophila which gets dispersed into the atmosphere. EBD systems combat Legionella infectious disease concentrations.



5. Environmental Balance Device (EBD) Technical Summary

1) Boiler Circuits:

□ Scale Accumulation Problems

Boilers are refined fuel-burning apparatuses for heating water. Refined fuels are derived from crude oil and gas originally drilled from below ground resources which contain highly concentrated negative ultra-particles. These particle concentrations increase during the fuel combustion process resulting in large amounts of active oxygen (O) forming around the boilers and water circuits. Active oxygen which has a strong oxidation function, combines with inorganic substances resulting in scale accumulation in water. The body of a boiler is made of steel derived from iron which also contains high concentrations of ultra-elementary particles. These particles absorb scale resulting in increased adhesion of inorganic substances. De-aeration devices and/or chemical agents are commonly used to counteract scale accumulation but such methods are reactive in nature and do not constitute a permanent solution to this costly problem.

□ Corrosion Problems

It is generally thought that corrosion occurs when dissolved oxygen in water reacts with materials made of iron and steel resulting iron elution. Actually corrosive active oxygen (O) is the primary cause for corrosion and not oxygen (O2). By eliminating active oxygen, iron oxidation is thereby significantly reduced resulting in extended boiler and piping equipment service life and decreased operational costs.

2) Cooling Tower Circuit

□ Corrosion Problems

It is not well known that high volumes of active oxygen are present in water circulating in cooling towers. Corrosion occurs inside piping, due to the oxidizing effects of active oxygen. Many microorganisms exist in the atmosphere as well as in water including iron bacteria which secrete corrosive enzymes. Corrosion is prevented by impeding specific harmful microorganism propagation and by reducing active oxygen levels.

□ Slime Problems

Ideal conditions exist in cooling towers for microbial propagation including iron bacteria, algae, bacillus (bacteria) and fungus. In order to prevent these types of bacteria from replicating exponentially, beneficial microorganism propagation is required. Bacillus and fungus contain high concentrations of negative ultra-elementary particles but can be held in check by creating a balanced state in the cooling tower. An EBD created balanced state will enable indigenous beneficial microorganisms to propagate and they will decompose algae, fungus and organic substance contamination.

□ Scale accumulation Problems

Scale develops from active oxygen oxidation of insoluble inorganic substances. Inorganic substances such as calcium, silica and iron rust which cause scale will decompose by activating indigenous beneficial microorganisms.

□ Propagation of Legionella Pneumophila

Organic substances accumulate in water during the water cooling process. This phenomenon leads to the propagation of bacteria including Legionella Pneumophila which disperses into the atmosphere. Achieving a balanced state is critical to combat Legionella infectious disease

Boiler & Cooling Tower Water Quality Verification

Table-1 below, reflects the water quality standards during boiler operations. **Table-2** below, reflects the water quality standards for **cooling tower** feed and circulation water. EBD type and number of units is listed thereafter based on the values of these standards

Table-1 Water Quality Standards for Boilers.

Maximum Working Pressure (Mpa)	7.5~10		10~15		15~20		20～	
Treatment Method	AVT	CWT	AVT	CWT	AVT	CWT	AVT	CWT
pH(25°C)	8.5~9.6	6.5~9.3	8.5~9.6	6.5~9.3	8.5~9.6	6.5~9.3	8.5~9.6	6.5~9.3
Electrical Conductivity (mS/m)	0.03	0.02	0.03	0.02	0.03	0.02	0.025	0.02
Dissolved Oxygen (μgO/L)	<7	20~200	<7	20~200	<7	20~200	<7	20~200
Iron (μgFe/L)	<30	<20	<20	<20	<10	<10	<10	<10
Copper (μgCu/L)	<10	<10	<5	<10	<3	<5	<2	<2
Hydrazine (μgN2H4/L)	>30		>10		>10		>10	
Silica (μgSoO2/L)	<40	<20	<30	<20	<20	<20	<20	<20

AVT: All Volatile Treatment CWT: Combined Water Treatment

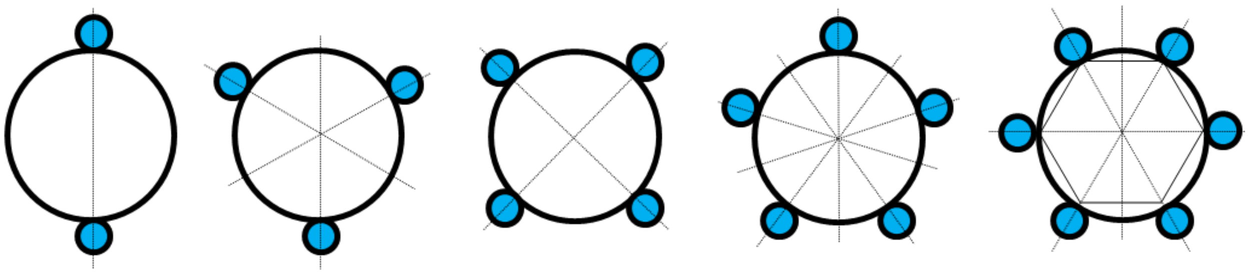
Table-2 Water Quality Standards for Cooling Towers

Classification	Feed Water	Cooling Water	Problem	
Parameter			Corrosion	Scale
pH	6.0-8.0 (25°C)	6.0-8.0 (25°C)		
Electrical Conductivity mg/l	50	200		
Sulfate Ions mg/l	50	200		
Calcium carbonate ($CaCO_3$) mg/l	50	100		
Total Hardness (TH) mg/l	70	200		
Ionic Silica mg/l	30	50		
Iron (Fe) mg/l	0.3	1		
Copper (Cu) mg/l	0.1	0.3		

6. EBD Device Selection

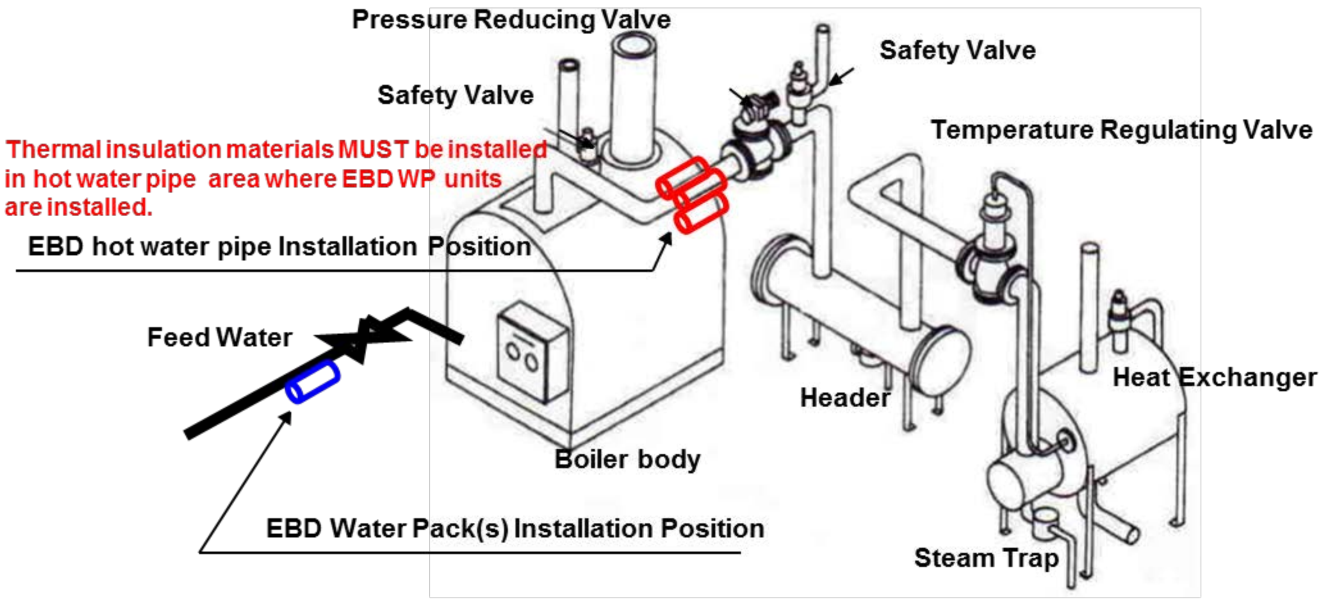
Pipe Dimensions in mm (A)	Pipe Dimensions in inches B)	Number of Required EBD WP Units for 80 ℃ (176 Degree Fahrenheit) water and below	Number of Required EBD WP Units for 80 ℃ (176 Degree Fahrenheit) water and above.
25	1	1	2
30	1×1/4	1	2
40	1×3/4	1	2
50	2	1	2
65	2×1/2	1	2
80	3	1	2
90	3×1/2	1	2
100	4	2	4
125	5	2	4
150	6	3	6
175	7	3	6
200	8	4	8
225	9	4	8
250	10	4	8
300	12	5	10

EBD Water Pack (WP) System Installation Cross Section Diagram

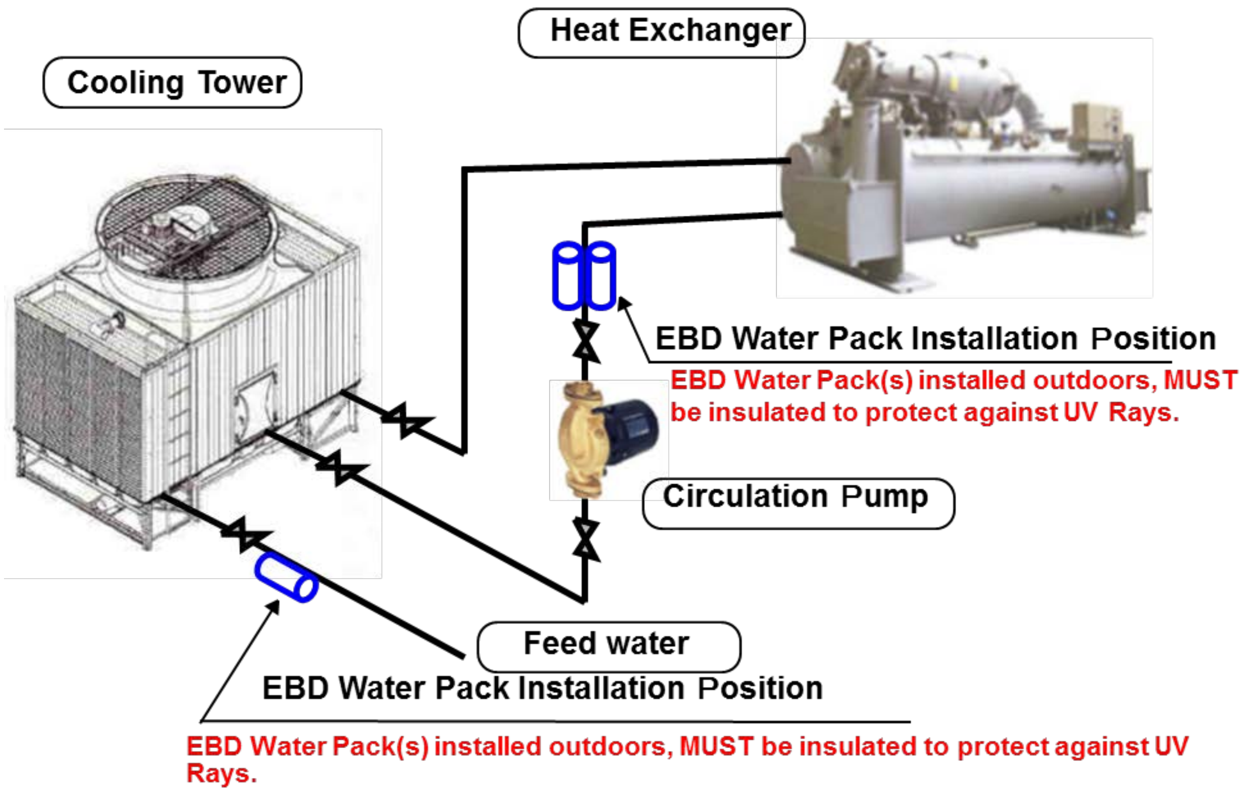


[2 WP Installation] [3 WP Installation] [4 WP Installation] [5 WP Installation] [6 WP Installation]

7. EBD Device Installation for Boilers



8. EBD Installation for Cooling Towers - Diagram



9. Required Number of EBD Devices for Boilers and Cooling Towers

	Facility	Type	Size (Tones)	Quantity	Estimated Pump Discharge Pipe Diameter in Inches	Estimated Feed Water Line Diameter in Inches	Required Number of EBD Devices
1	144	Steam Boiler	60	2	Boiler specifications required		
2	804	Cooling Tower	600	1	10	2	5 WP-L
3	912	Steam Boiler	250	1	Boiler specifications required		
4	1090	Cooling Tower	116	1	5	3/4	3 WP-L
5	1410	Cooling Tower	1000	5	12	3	5×6=30 WP-L
6	1469	Cooling Tower	50	2	4	1	2×6=30 WP-L
7	322	Steam Boiler	75	1	Boiler specifications required		
8	403	Steam Boiler	75	1	Boiler specifications required		
9	856	Cooling Tower	200	2	5	1×1/4	2×3=6 WP-L

10. Installation Instructions

□ Steam pipes will exceed over **100 degrees Celsius (212 degrees Fahrenheit)** in temperature, therefore, the precise steam pipe areas where the EBD units are to be installed, should first be well insulated using high quality thermal materials. EBD maximum operating temperature should **never exceed 70 degrees Celsius (158 degrees Fahrenheit)**.

□ If the EBD Water Pack(s) (WP) units will be exposed to direct sunlight (ultraviolet (UV) rays), it/they should also be covered and protected by high quality thermal insulation materials.

□ **EACH** EBD Water Pack (WP) unit, must be installed around the pipe, in a cylindrical /circular fashion. **DO NOT INSTALL LENGTHWISE ALONG THE LENGTH OF THE PIPE**. Please see EBD Water Pack (WP) system installation cross section diagram located below Table 2.

□ **EACH** EBD Water Pack (WP) unit, must be installed on the pump discharge pipe. **DO NOT INSTALL ON THE SUCTION END OF THE PUMP.** Please see EBD WP unit positioning diagram in Section 8 above.

□ The EBD Water Pack (WP) pipe grouping configuration is effective up to 6,561 feet (2,000 meters) downstream as well as upstream of its piping installation location. If water storage tank(s) is/are installed in the water circulation circuit(s) and water is exposed to ambient air, active oxygen will be absorbed into the water circulation circuit(s) and additional EBD units will be required and installed around the base of such tank(s).

□ The EBD WP units come with installation brackets. Strong duct tape may be used instead.

□ If the EBD units have to be removed for plant repairs and/or piping replacement, they should be reinstalled as soon as such repairs are completed. Approximately three months will be required for producing an EBD induced balanced state for newly installed equipment and/or parts. EBD units prevent the accumulation of scale and/or rust on an ongoing, continuous basis.

11. Important EBD Installation Recommendations

□ A balanced state between the airspace and earth's crust can be produced within 3 days of EBD device installation.

□ Microorganism activation will become significant once a balanced environment is produced.

□ The microorganism propagation cycle is biweekly. Water samples should be taken and analyzed every two weeks.

□ The required treatment period can be calculated and established based on the history of the facility in question. For example, if 10 years represents one unit of ongoing operation, three months will be required to improve water quality by achieving the maximum indigenous microbial propagation.

□ Environmental factors which greatly affect microorganism activity, are temperature, oxygen density, active oxygen volumes, nutritive salt, moisture and pH levels.

□ Active oxygen which is present in the facility environment, will begin bonding with free electrons which are also present in the surrounding atmosphere. Active oxygen (O) will be converted to stable oxygen form (O_2).

- □ Rust prevention will lead to quantifiable prolonged piping service life. This in turn leads to energy savings and reduced capital investment requirements.
- □ Chemicals dosages should be reduced or altogether eliminated after EBD system installation. This is recommended since such chemical substances contain high concentrations of negative ultra elementary particles which partially limits EBD functions.
- □ Cooling tower cleaning is recommended prior to EBD system installation.
- □ Regular water testing and analysis should be conducted after EBD installation since water quality changes take place during plant expansions, repairs, new equipment installation etc.

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