WATER TREATMENT

BOILERS

A boiler is a tank in which water is converted to steam for heating buildings and for any of the many operations that require heat or steam.

There are basically two types of boilers:

A. **WATER TUBE** (20% of boilers in use) - Water is fed through a bundle of tubes inside the boiler, and heat is applied to the outside of the tubes to heat the water.

B. **FIRE TUBE** (80% of boilers in use) - Heat travels through a bundle of tubes inside the boiler to heat the water surrounding the tubes.

The bundle of tubes which carries water in the Water Tube Boiler and heat in the Fire Tube Boiler is called the Heat Transfer Surface.

Both the Water Tube and the Fire Tube Boiler have the following components:

HEAT SOURCE - A gas, oil, or coal burner heats the water in the oiler.

WATER SOURCE - The makeup water entering the boiler from the local water supply is the water source. It may be preheated (in large systems it is nearly always preheated) to drive off dissolved oxygen and carbon dioxide gases before the water enters the boiler. Since these gases dissolve more readily in cold water, preheating helps to eliminate them. Dissolved gases cause corrosion in the boiler.

The makeup water is often held in a tank (Condensate Receiver). Here it is combined with hot condensate. Scale and corrosion prevention chemicals are added at the receiver to condition the water before it enters the boiler.

FEED WATER PUMP - When heated water from the boiler is given off as steam, the pump draws feed water into the boiler from the condensate receiver. The feed water pump must generate sufficient pressure to overcome the pressure in the boiler.

BLOWDOWN VALVE - This valve allows some of the water carrying accumulated solids ("sludge") in the boiler to drain into the sewer. The act of removing water and sludge from the boiler is called "blowdown."

WATER LEVEL CONTROL - The Water Level Control maintains the proper water level inside the boiler. This water level can be visually checked at the sight glass,

The boiler tubes will become overheated if the water level is too low to keep the heat transfer surface covered. Low water level will cause excessive stress to the boiler. High water level will allow water to get into the steam lines, reducing the efficiency of the boiler system.

SAFETY VALVES - These valves automatically releases any excess pressure that builds up in the boiler. Every boiler has several safety mechanisms that will shut it off in the event of malfunction.

Natural water can damage a boiler by producing: 1) scale and 2) corrosion.

Water always contains some impurities in the form of dissolved solids and gases. The solids are calcium, magnesium, and other salts that form scale; the dissolved oxygen and carbon dioxide gases cause corrosion of metal.

1. SCALE

As water flows over rock formations and through the earth, it picks up and dissolves calcium and other metallic salts. When water enters a boiler, where it is heated to produce steam, these dissolved solids precipitate out of solution. The precipitates are left behind in the boiler water--they do not travel with the steam. If they are allowed to accumulate, they will settle out as scale on the boiler metal. This is what happens when water in a pan on the stove is allowed to boil dry, or when water in a glass is allowed to evaporate completely. A residue of salts will be left, which is scale. The amount of scale depends on the amount of dissolved solids in the water. If water is added, the scale residue will not go back into solution. The U.S. Bureau of Mines has determined that only 1/9" scale in a boiler increases fuel bills 16%. When chemical treatment is not used, scale forms in a boiler. If scale is allowed to build up, it reduces the heating efficiency of the boiler. A heavily scaled boiler heats water to steam at a slower rate, because the scale acts as an insulator. This increases operating costs.

TREATMENT FOR SCALE PREVENTION

Milanco Boilertreat 1000, 1000S, 1000HP and 1000 HPS all prevent scale formation by causing dissolved solids to precipitate as light, fluffy sediment which settles to the bottom of the boiler. This sediment will not form a hard scale, and is easily flushed away in the blowdown.

2. CORROSION

Gases in the air are soluble in water. Two that cause the most problems are oxygen and carbon dioxide.

Dissolved oxygen in water entering the boiler causes corrosion, which will pit and weaken the boiler. Rust is formed as a by-product. Rust deposits interfere with the boiler's heating efficiency. This slower heating ability increases the boiler's operating cost.

Carbon dioxide corrosion occurs in the condensate return system. Carbon dioxide is released as a gas when water is converted to steam. This gas travels with the steam. When steam liquefies and enters the condensate return lines, the carbon dioxide gas is absorbed in the condensate water, forming a weak acid which will eventually "groove" or wear away the metal.

CORROSION PREVENTION

Milanco Boilertreat 1000 and Boilertreat 1000 HP contain oxygen scavengers to inhibit the corrosive action of the dissolved oxygen. Boilertreat 1000 is recommended for boilers that operate under 75 psig. Boilertreat 1000 HP is recommended for boilers that operate at pressures between 75 psig and 300 psig.

Boilertreat 1000S and 1000Hps has a neutralizing amine that increases the pH of the water to an alkaline level, from 7 to 8.2 (explained later). This also will neutralize the corrosive acid formed by carbon dioxide.

TREATING THE WATER

Natural water is not pure. Rain water is contaminated by airborne dust particles. Water passing through soil and over rocks picks up minerals. Even mountain spring water derives its good taste from the minerals it contains. These same minerals cause scale in boilers--consequently, all boiler feed water requires treatment.

We said in an earlier part that water contains various impurities in an infinite variety of combinations and amounts. Water from different locations, then, will differ in the amount of chemical treatment needed to prevent scaling and corrosion. We must run tests on the water at each location to determine how much treatment should be used. The tests we use are as follows: (Detailed Test Instructions are included in the #1900 Test Kit).

1. HARDNESS TEST - Hardness is a word used to describe dissolved calcium and magnesium salts in water. We can determine the amount of these salts in water by simple titration; that is, adding chemical Hardness indicators to a sample of water.

Hardness is expressed in ppm, which stands for parts per million. Let's say the result of the Hardness test is 20 ppm. This means that for every 1 million pounds of water, there are 20 pounds of Hardness salts (dissolved calcium and magnesium).

Hardness in ppm may be converted to grains per gallon by dividing the ppm reading by 17.

$$\frac{\text{Hardness ppm}}{17} = \text{Hardness grains per gallon.}$$

Example: Water Hardness of 170 ppm is converted to 10 grains per gallon.

170 divided 17 = 10 grains per gallon

Conversely, to convert from grains to ppm, multiply the value in grains by 17. Hardness grains per gallon x 17 = hardness ppm.

Example: 10 grains = 170 ppm hardness.

Hardness must be precipitated out of water so that scale does not form. When high alkalinity is present in the water, the Hardness is precipitated as soft sludge that is held in suspension by either the Boilertreat 1000 series of chemicals until blowdown. When low alkalinity is present in the raw water, the alkaline builders in these products provide the alkalinity necessary to precipitate the Hardness as soft sludge. A smaller dosage will be used if the makeup water is highly alkaline. The amount of alkalinity in the raw water is determined by the "M" Alkalinity test.

2. "M" ALKALINITY TEST - This is used to determine the Total Alkalinity of the raw water in ppm. The result of the "M" Alkalinity test is used to determine how much Boilertreat 1000 to use. Subtract the "M" Alkalinity in ppm from the Hardness in ppm and divide by 20 to get the dosage of Boilertreat 1000.

Hardness - "M" Alkalinity = pints of Boilertreat 1000 to use for each 1000 gallons 20 of makeup water.

Example: If Hardness is 140 ppm and "M" Alkalinity is 80 ppm, then H minus M = 60 ppm divided by 20 = 3 pints of Boilertreat 1000 for 1000 gallons of makeup water.

3. SULFITE TEST - This test indicates the amount of Sulfite in the water. Sulfite and oxygen cannot coexist; therefore, by keeping an excess of sulfite in the boiler water, we can be sure there is no oxygen is present. If no oxygen is present, no acid can be formed and there will be no corrosion.

4. DROP TEST FOR pH LEVEL CONTROL - Phenolphthalein is an indicator which is colorless below and pink above a pH of 8.2. When the pH of the condensate is higher than 8.2, pink indicates that corrosion is being prevented effectively. A red color indicates excess chemical is being used; therefore, the feed rate should be reduced.

5. CHLORIDE TEST - When water is converted to steam, the dissolved solids do not travel with the steam, but are left behind in the boiler water. Water enters the boiler to replace the amount lost through steam evaporation. When this new water is converted to steam, more solids are left behind. As steam is continually produced, evaporated, and replaced with new water, the amount of solids in the boiler continues to increase.

For every pound of steam generated, a pound of water must be replaced. The amount of solids in the water will have doubled when the amount of new water that has entered the boiler is equal to the amount of water that was used to originally fill the boiler. When the amount of solids has doubled, there are 2 cycles of concentration in the water; when the amount of solids has tripled, there are 3 cycles of concentration. Cycles of concentration is an indicator of the amount of solids buildup in the water.

Chloride is chosen as the indicator for cycles of concentration because, 1) it is always present in the makeup water, 2) it does not change character when heated, 3) it is not affected by chemical treatment, and 4) like the other dissolved solids, it does not leave the water in the boiler when steam is produced. If the Chloride in the water doubles, all the solids have doubled.

The Chloride Test is run on a sample of the raw water and on a sample of the water from the boiler sight glass. When the Chloride reading of the boiler water is 6 times the Chloride reading of the raw water, there are 6 cycles of concentration.

To select the "maximum allowable" cycles of concentration, divide the raw water hardness into 1000.

Examples:

$$\frac{1000}{\text{Makeup water Hardness of 100 ppm}} = 10 \text{ Cycles of Concentration}$$

Blowdown should occur at 10 Cycles of Concentration or before.

$$\frac{1000}{200 \text{ ppm H}} = \text{Cycles of Concentration}$$

Blowdown should occur at 5 Cycles of Concentration or before.

The boiler should never be operated over 10 Cycles of Concentration.

At this point, you are ready to learn how to apply the information from earlier parts to make cost estimates and proposals for customers with large or small boiler systems using hard or soft water.

1. **Selecting the Right Milanco Product** - Since waters in every part of the country contain some Hardness, you will use the Boilertreat 1000 series of chemicals as the scale prevention product for most boilers. There are All-In-One chemistries, and component packages to use that reduce the overall cost if the Boiler system is large enough. Boilertreat 1000 Series of chemicals can treat hard or soft water supplies.

2. **Determining the Dosage Rate of Boilertreat 1000** - Most boiler operators are accustomed to using water treatment in "pints per 1000 gallons." To figure the dosage of Boilertreat 1000 in pints per 1000 gallons, use this formula:

Hardness (in ppm) - "M" Alkalinity (in ppm) divided by 20 = dosage in pints/1000 gallons

Or, to state it more simply: H - M divided by 20 = pints/1000 gallons

Example: Hardness = 190; "M" Alkalinity = 130 ppm: 190 - 130 = 60 divided by 20 = 3 pints/1000 gallons

3. **<u>Estimating Gallons of Makeup Water per hour</u>** - To use the following chart, find out the following:

a. The size of the boiler in Horsepower.

b. The percent of Condensate Return.
If you do not know the percent of Condensate Return, use 50%.

To determine gallons of makeup per hour, refer to the line in the chart listing the Horsepower of your boiler, then refer to the correct % Condensate Return Column for the amount of gallons.

<u>Example:</u> A 125 HP boiler with 40% Condensate Return will use a maximum of 300 gallons of makeup water per hour.

GALLONS OF MAKEUP WATER PER HOUR
AS RELATED TO HORSEPOWER AND CONDENSATE RETURN
PERCENT OF CONDENSATE RETURN

Boiler Horse Power	0%	10%	20%	30%	40%	50%	60%	70%	
40	160	144	128	112	96	80	64	48	
60	240	216	192	168	144	120	96	72	
80	320	288	256	224	192	160	128	96	
100	400	360	320	280	240	200	160	120	
125	500	450	400	350	300	250	200	150	
150	600	540	480	420	360	300	240	180	
200	800	720	640	560	480	400	320	240	
250	1000	900	800	700	600	500	400	300	

If this chart is not available, figure the gallons of makeup per hour using one of the following formulas:

a. If there is no Condensate Return

A boiler uses a maximum of 4 gallons of water per hour per Horsepower:
amount of Horsepower x 4 = gallons of makeup water per hour

Example: A 100 HP boiler with no condensate return uses a maximum of 400 gallons of water per hour (100 x 4 = 400).

b. If there is Condensate Return

Figure 4 gallons of water per hour per Horsepower, less % of Condensate Return.
Amount of HP x 4 - % Condensate Return = gal. makeup water per hour (gph)

Example: A 100 HP boiler with 10% Condensate Return would be 400 gph less 40 gallons (10%), or 360 gallons per hour, 100 HP x 4 = 400 gph - 40 (10% of 400) = 360 gph.

4. **Calculating Price** - When estimating the cost of Water Treatment products for the amount of water you will be treating, follow these two guidelines:

a. Round off estimate to nearest even number when quoting dosage rate per 1000 gallons of water.

b. Recommend "X" number of pints of treatment per 1000 gallons of makeup water (a pint is equal to a pound), quote cost in price per pound.

To figure price per pound (pint), use this formula:

Hardness in ppm less "M" Alkalinity in ppm divided by 20 = pints per 1000 gallons x price per pound of product = cost per 1000 gallons.

H -"M" divided by 20 = pints/1000 gallons x price/lb. = cost/1000 gallons.

Example: Hardness = 160 ppm; "M" Alkalinity = 70 ppm

160 - 70 = 90 divided by 20 = 4.5 pints (pounds), rounded off to 5 pints or 5 pounds x price per pound = cost per 1000 gallons.

To figure cost of treatment per day, use this formula:

Cost per 1000 gallons x gallons makeup water per hour x hours of operation per day = cost per day.

CONDENSED VERSION

Determining Dosage Rate of Boilertreat Chemistry

Hardness (in ppm) less "M" Alkalinity (in ppm) divided by 20 = Dosage in pints/1000 gallons.

Estimating Gallons of Makeup water/hour

(a) No Condensate return
Boiler Horsepower (HP) x 4 = gallons of makeup water per hour.

(b) With Condensate return
Boiler HP x 4 - condensate return = gallons of makeup water/hour. Multiply either A or B by number of pints of treatment per 1000 gallons of makeup water.

Figuring Cost per 1000 Gallons

Hardness (in ppm) less "M" Alkalinity divided by 20 = pints per 1000 gal. Pints/1000 gal. x price per pound of Boilertreat 1000 = Cost per 1000 gal.

Cost of Treatment Per Day

Cost per 1000 gallons x gallons of makeup water per hour x hours of operation per day Cost per day.

5. Determining the Blowdown Schedule

As you will recall, 1000 divided by Hardness in ppm = maximum cycles of concentration.

Example: 1000 divided by 180 ppm Hardness = 5 Concentrations.

This figure is the maximum allowable cycles of concentration. This does not mean that you must or should allow this many cycles. Running the boiler at this maximum or critical limit may result in more frequent need for service on your part. Therefore, it may be desirable for you to run the boiler at 3 cycles instead of 5 as in the example above. This determination will hinge upon your judgment of the reliability of the boiler operators in following your recommendations during your absence.

The decision can also be based on the figures revealed by your competitor's log sheet. If his instructions have been consistently ignored, your chance of success at maximum allowable concentrations is not good.

6. For example: A boiler is rated at 150 Hp, with estimated 20% Condensate Return.

a. Test the raw makeup water with the following results: Hardness - 140 ppm; "M" Alkalinity - 80 ppm.

b. Figure the product dosage.
H - M divided by 20 = pints per 1000 gallons dosage.
140 ppm - 80 ppm = 60 ppm divided by 20 = 3 pints per 1000 gallons.

c. Since the water contains Hardness, choose the product.

d. Use the chart to determine gallons of makeup water per hour, or figure it this way:
150 HP x 4 gal. per HP = 600 gallons per hour, less 120 gals. (20% Condensate Return) = 480 gallons of makeup water per hour.

e. As determined above, the dosage will be 3 pints per 1000 gallons. Since the boiler is using 480 gallons per hour, you will be using about 1.5 pints (1.5 lbs.) of Boilertreat 1000 per hour. The cost per hour of operation will then be 1.5 lbs. x price per pound (price x 1.5).

f. Allow a maximum of 7 cycles of concentration (1000 divided by 140 ppm Hardness = 7), but you would probably do better to operate at 5 cycles.

This is enough information to get the boiler operating properly. See that the Control Tests are made regularly, and that blowdown is not neglected.

CLOSED SYSTEMS

Previous subjects have directed your attention to steam boiler systems in which some of the steam is consumed in food preparation, sterilization, and steam cleaning and "process" work. The condensate developed at these points of steam use is seldom returned to the boiler on a 100% basis. The steam that is intentionally lost in this manner must be replaced with new makeup water. Previous lessons have explained how this water exchange continually brings new Hardness into the system, which, in turn, requires continuous chemical injections.

Heating boilers continually recirculate the same water. Condensate return is theoretically 100%, but in practice, some small amounts of water are lost by occasional blowdown and pipe leaks in the system. This is a closed system because it loses no steam and takes on no new water.

Since new water does not enter the system, there is no concentration of the scale-forming nature of makeup water. Our treatment program is, therefore, directed to the prevention of corrosion in the closed system. Use Closed System CT to apply a protective inhibitor film on the metal surfaces. This film prevents contact between the metal and the water containing dissolved oxygen, which, as you have learned, is the source of corrosion. Our concern is to maintain an adequate level of Closed System CT to preserve this inhibitor film. We have no need to test the water for Hardness in order to make the product installation.

1. The start-up charge of Closed System CT is slug fed into the top hand hole of the boiler, using enough to bring the Closed System CT content up to the rate of 1 gallon to each 250 gallons of water. The capacity of the boiler can be determined by asking the operator for his estimate, or by multiplying the rated HP by 10.

Example: 100 HP = 1000 gallons

2. Unless some unforeseen accident occurs, the original chemical level will be retained indefinitely and will only need additions once or twice a year to compensate for leaks or other unintentional losses. Constant call-backs, Service Reports, and other nonproductive customer relationships are eliminated.

3. Following the original installation, no chemical expertise is needed to make the additions of chemical that may be required several times each season. Closed System CT is added through a by-pass feeder which is installed in the boiler feed water line. A test to determine the amount of inhibitor in the system is performed on a monthly basis. If there is addition of equipment, draining of the system for maintenance, or inspection of the boiler, the system should be checked and recharged to the proper inhibitor concentration once the water levels have been refilled. After the initial charge, and each addition, the water should be checked for inhibitor concentration within a week.

4. Dirty or cloudy water in the system means that there is contamination in the system (oil, dirt, or corrosion). It must be determined if there is contamination being introduced into the system, or if there are deposits being removed by the Milanco chemistry. Milanco's products have some detergency in them to remove contaminants found on the interior surfaces of the system and to keep them clean. This is important, because the metal surfaces need the chemistry in direct contact to deposit the protective film that is needed for protection. Sometimes if may be necessary to dump or bleed the water out of the system in order to remove the contaminants which may be loosened by the chemistry.