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CTP Technical Resource - 1200.3 – Boiler Water Chemistry

Very seldom is water treated because of the pump which handles it. In nearly all cases it is treated because of other equipment in the cycle such as the boiler, heaters, etc. The pump has to handle it "as is" and the pump must be of the proper materials for the job. This section covers the basic facts of water treatment and in general the methods most commonly used. The subject is a large one, and no attempt will be made here to go into great detail.

There are two basic kinds of hardness. Temporary hardness consists of bicarbonates of calcium and magnesium, $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$. It is called temporary hardness because when heated, the bicarbonates break down into CO_2 and the carbonates, $CaCO_3$ and $MgCO_3$. The carbonates will collect in the mud drum or lower tubes of a boiler and must be blown out regularly.

Permanent hardness is caused by the sulphates, chlorides and nitrates of calcium and magnesium. These compounds do not affect the pH of the water, are not precipitated by heat, and form a hard scale when water is evaporated. An example is the scale formed in a tea kettle.

The type of water treatment used depends upon what is in the water. In addition to the salts causing hardness which are mentioned above, raw water may also contain silica, sodium and potassium salts, iron, manganese, carbon dioxide, oxygen, nitrogen and others.

Softening or removal of these salts is usually done in one of three ways or a combination of two of them:

1. Hot process chemical
2. Ion exchanger
3. Evaporator

The hot process chemical softening is done by adding lime, $Ca(OH)_2$, soda ash, Na_2CO_3, or caustic, Na OH or a combination of the three to hot water and then filtering the water. The chemical used and the quantity are determined by the hardness of the water.

The ion exchanger is essentially the same machine as the water softener. Ion exchange material (often called Zeolite) has the ability to exchange one ion for another, hold it temporarily in chemical combination, and give it up to a strong re-generating solution. As in the hot process system, the arrangement of ion exchangers is governed by the material to be removed from the water.

An evaporator is merely a device for boiling the water to be softened and then condensing the vapor. The evaporator is usually used in series with either a hot process softener or an ion exchanger, since if it is used on raw water there is a great deal of scale which forms on the evaporator tubes.

Small power plants may use only a hot process softener or an ion exchanger, but the larger plants nearly always have an evaporator in the cycle.

Even though the water has been softened, it still may contain CO_2, O_2 or other gases. For that reason a power plant has a deaerator in the system to remove all gases.

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Since the feed water is treated for equipment other than the pump, a treatment system which may be perfectly satisfactory for the boiler, heaters and piping, may be death on the boiler feed pumps or the heater drain pumps. In a central station, for example, carbon steel is satisfactory for piping, valves and boiler tubes, but is no good for feed pump parts.

Boiler feed water is described as stabilized or unstabilized depending on the concentration of salts dissolved in the water. Stabilizing chemicals have the effect of reducing the rate of attack of feedwater on cast iron in the pH range of 7.0 to 11.0.

The amount of salts in the water is expressed as "total solids in parts per million" (ppm). Water having 5 grams of salt in 1,000,000 grams of water (about 265 gallons) would have 5 ppm total solids. Waters having less than 5 ppm (such as typical condensate or evaporated make-up) may be considered unstabilized.

Stabilizing salts may enter the feedwater through raw or treated make-up water, from recirculation of boiler salines, or from direct addition of chemicals on the suction side of the pump. The ppm of solids in the make-up must be multiplied by the percentage of make-up to arrive at the net effect on the feedwater. For example, 10% make-up containing 20 ppm solids will add only 2 ppm to the feedwater.

The minimum amount of stabilizing required for the protection of cast iron and steel casings will depend on the pH value and temperature, and can be determined by referring to the chart below.

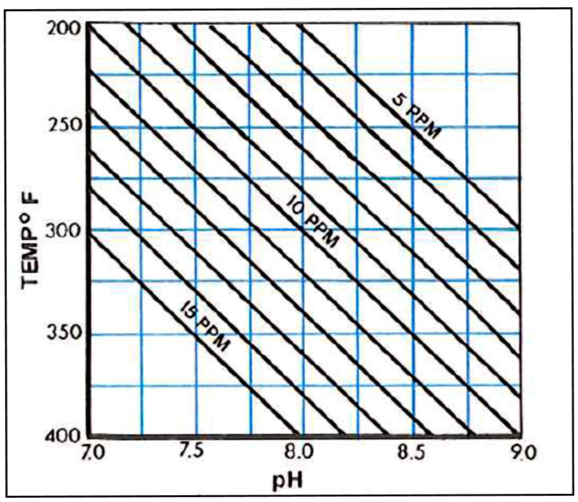

Figure 1200.7
Stabilizing salts concentrations for various
pH and temperature values.

Solids under 5 ppm classify the water as insufficiently stabilized at any practical pH value and require corrosion-resistant casing and fittings. For a pH above 9.0, the pH value is the determining factor for material selection, provided solids exceed 10 ppm. Amines or ammonia are sometimes used to control the pH value of unstabilized feedwater, usually at about pH 9.0. Because amines or ammonia do not increase the solids content, an unstabilized feedwater remains unstabilized requiring a corrosion-resistant casing and fittings. If the pH is above 9.0, fittings of chromium, 0.5% molybdenum steel are required.

BOILER FEED PUMP MATERIAL

Class I. In stabilized water (feedwaters containing solids in excess of the minimum values of the chart) - material selection will depend on pH range, in accordance with the recommendations below:

If the pH range is from 7.0 to 8.5, bronze fittings and a cast iron casing are satisfactory. If a steel casing must be used for strength, a 5% chromium, 0.5% molybdenum steel (ASTM-A217 grade) is required.

If the pH range is from 7.0 to 11.0, a cast iron casing is satisfactory, but corrosion resistant fittings should be used. If a steel casing must be used for strength, a 5% chromium, 0.5% molybdenum steel (ASTM-A grade) is required.

If the pH range is from 8.5 to 11.0, cast iron or steel fittings and a cast iron casing are satisfactory but the use of hardened stainless steel wearing rings is recommended for pumps which develop large (approximately 100 psi or over) differential pressures per stage. If a steel casing is required for strength, carbon steel is satisfactory.

NOTE: If stabilizing is not continuous and there are periods when water is not stabilized, the feedwater is Class II and materials should be selected accordingly.

Class II. Unstabilized or insufficiently stabilized water (feedwaters containing less solids than the minimum values of the chart) – Corrosion-resistant casing and fittings are required.

Class III. Special Cases (feedwaters not covered by range of chart) - These cases will be frequent and must be considered special.

DISSOLVED OXYGEN

At temperatures over 200° F, in any pH range, dissolved oxygen in concentrations greater than .03 cc per liter will accelerate corrosion of cast iron, carbon steel, and 5% chromium 0.5% molybdenum steel materials. The exception is: if the pH is over 9.0 and dissolved solids are 10 ppm or more, dissolved oxygen in concentrations greater than .03 cc can generally be tolerated

For dissolved oxygen concentrations exceeding .03 cc, 13% chrome stainless steel materials (ASTM-A296, CA-15 and AISI Type 416) are suitable for the entire pH range of 7.0 to 11.0. Bronze is also suitable for pH ranges of 7.0 to 8.5, provided the mechanical requirements are such that bronze can be used.