Cannonball
Water Group

Steam Locomotive - Operating Boiler Treatment Guidelines

The treatment of steam locomotive boilers is virtually the same in scope and means as the principles of good industrial boiler treatment. To protect the boiler, the objectives are:

- Prevent hard scale deposit on the tubes in the boiler
- Prevent low pH, high temperature corrosion of the boiler
- Stop oxygen corrosion in the tender tank, feedwater lines and the boiler
- Keep excessive boiler foaming from causing carryover of boiler water into the steam

However, steam locomotives have specific unique characteristics that not all industrial boilers share. For example, riveted plate boilers are common in locomotives and would exclude the use of chelants (i.e. EDTA) that would cause serious corrosion in & around riveted plates, stay bolts, etc. Also, high hardness (in fact varying hardness) waters are often used as make up in locomotives, uncommon in industrial boilers. It is critical to consider these special needs when developing a steam locomotive boiler treatment program.

1. Scale:

Scale is generally caused by dissolved hardness in the water becoming insoluble at the elevated temperatures and forming a hard, tight scale on the boiler tubes. Whenever possible, soft water should be used as make up, either from a softener or collected rain water. If soft water is used all deposition can be chemically controlled.   If hard water is used, some deposition may occur but the objective will be to condition the sludge so that is low in adherence and does not form a tight, hard scale. This kind of sludge can be easily removed from the boiler without causing boiler damage.

The molecules used to control scale in the 21st century are sophisticated chemical polymers. There are many polymers and each has its own strengths and weakness. While a ***residual*** of 10 ppm of each polymer is generally the target, all are difficult to test for and generally are controlled by testing for another component of a blended product. In some cases, a direct polymer test may exist and if so, that polymer should be the preferred choice.

1. Low pH Corrosion:

At elevated temperatures in the boiler, the pH of water will often be lower than the same water at ambient temperatures. Measurement of boiler water pH at operating temperatures is difficult, so a direct and reliable method is to measure the OH (hydrate) alkalinity in the boiler water. The easiest & best method is to run a P alkalinity and an M (or T) alkalinity then use the following equation to calculate OH:

$$2xP - M = OH$$

The OH alkalinity level should be maintained between **100 ppm - 300 ppm.** If the OH is too low, corrosion may result. Also, scale control will not be as effective. If the level is too high it will cause foaming and carryover of boiler water into the steam. Naturally occurring alkalinity

May provide more than enough OH. If supplemental OH is needed, NaOH (caustic soda) is added, again frequently as one component of the treatment formulation.

Note that the normal precipitation of hardness salts in the boiler at operating temperatures will also reduce boiler water alkalinity and require addition alkalinity supplement addition.

Occasionally, P alkalinity along with pH can be used to control boiler alkalinity. If this is desired, contact Cannonball Water for specific recommendations.

2. Oxygen Corrosion:

Oxygen dissolved in water will cause corrosion of steel and cast iron. As the water temperature increases, the oxygen corrosion accelerates. Oxygen can be chemically removed with a variety of molecules but the most common used is sodium sulfite. It chemical reacts with the oxygen to form sulfate, which is inert in the boiler water environment. *(Other molecules, like DEHA and erythorbate will also remove feedwater oxygen, as well as convert feedwater steel from (red) hematite iron oxide to corrosion resistant (black) magnetite iron oxide. Little residual protection is provided by these during outages).*

During operation, a sulfite residual should be maintained in the boiler between **30 ppm – 60 ppm**. Low residual may allow corrosion, high level wastes chemical. If the boiler will be idled wet, the sulfite level should be run up to at least 100 ppm just prior to shut down to protect the boiler while cold.

3. Boiler Foam Control:

High dissolved solids, suspended solids and high OH alkalinity will all cause foaming in the boiler water and carryover of boiler water into the steam. Foaming can also cause level control problems in the boiler. All 3 contaminants are reduced by blowdown – removing water from the boiler and replacing with fresh water.

OH alkalinity control was discussed in section 2 above. Dissolved solids can be indirectly measured by measuring the conductivity of the boiler water. As more minerals dissolve in water, the ability to conduct an electrical current increases. Generally, at pressures under 300 psig, the boiler water un-neutralized conductivity should be maintained below **6000 µS/ cm (µmho/cm).** If the water is high in suspended solids (sludge) then the target conductivity may need to be lowered to prevent foaming and deposition from the excessive sludge. If foaming is observed, additional blowdown is needed.

Low boiler conductivity (below **1000 µS/ cm**) will make control of other chemicals difficult and waste water and fuel.

4. Control Range Summary (cycled up boiler water)

- Sulfite: 30 – 60 ppm (operating)
- OH alkalinity: 100 – 300 ppm
- Conductivity: 3000 – 5000 µS/ cm
- Polymers: 10 ppm residual
- pH: 11.0 – 12.5

5. Boiler Layup:

Most corrosion damage to boilers occurs when the boiler is idle. As the boiler cools, steam in the unit condenses and creates a partial vacuum. Since pressure gaskets are positive PRESSURE gaskets they can not adequately prevent air leakage into the unit when cooling & condensation occurs. Oxygen corrosion will then proceed in the unit, causing permanent damage.

To properly protect the boiler, there are 2 primary methods of layup that should be used:

Wet Layup

This method should be used only for short periods – ideally 2 weeks or less and for a maximum of 1 month. The required steps are:

a. Increase sulfite residual, using Cannonball Water **OxyGon (**or **BoilerSave)**, to 100 ppm or more during operation.

b. Make sure the OH alkalinity is at least 150 ppm prior to shutdown – add Cannonball Water **ALK+ (**or **BoilerSave)** as needed to increase.

c. Test boiler sulfite level once/ week to insure that a minimum residual of 40 ppm is maintained. If level drops too low, **OxyGon (**or **BoilerSave)** must be added to increase sulfite residual.

Dry Layup

The best method for extended boiler protection is to layup the boiler dry. The proper steps are:

a. Drain boiler water while the unit is still warm and open the hand hole immediately. This will allow the residual heat to force evaporation of residual water and dry the boiler.

b. Blow dry air (warmer the better) into the boiler until completely dry.

c. Spray VCI corrosion inhibitor into the boiler and seal.

d. On start up, refill boiler and blowdown the boiler frequently for the first few hours of low heat operation.