BOILER WATER TREATMENT AND CONDENSATE RETURN LINE PROTECTION

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We could spend several days discussing the fine points of boiler water treatment, and the protection of condensate return lines. There are a number of different chemicals which are used and many ideas about how and where these chemicals should be added. However, the purpose of this discussion is not to explore all of these details, but rather to present the fundamentals of good chemical treatment.

Before discussing the internal boiler water chemicals however, we should point out that there are several ways of partially removing harmful materials from water before it is pumped into a boiler. These harmful materials are, of course, the dissolved minerals in the water, and especially the calcium and magnesium minerals. The calcium and magnesium salts make up the hardness and are also primarily responsible for the formation of scale on the water side surfaces of boilers.

These two minerals can be removed, to a great extent, outside the boiler. This is normally accomplished by means of a hot process lime-soda softener or a sodium zeolite softener. These may be used either singularly or in combination with one another. In a hot process unit, lime (calcium hydroxide) and soda ash (sodium carbonate) are added to the water which has been heated to 215 degrees - 225 degrees F. The calcium and magnesium salts are precipitated and the effluent hardnes is about 1 grain per gallon (gpg), or 17.1 parts per million (ppm). Oxygen is also removed during the heating process in a softener of this type. Steam is used for heating.

Zeolite is a common term covering a variety of iron exchange materials. There are four main types used for water softening. One occurs naturally and is referred to as natural green sand. The other three are synthetic and are called resins. These materials have the ability to exchange ions, taking one kind out of the water and releasing a different kind in its place.

A solution of sodium chloride (common salt)) is first passed over the resin, and the resin particles become saturated with sodium ions. The zeolite is then said to be regenerated. Now, when hard water passes over the resin it takes calcium and magnesium ions out of the water and releases sodium ions in their place. There is no other change. The effluent from a well operated zeolite softener will average about 1-2ppm hardness. This means then that the bulk of the scale forming minerals can be removed from the water ahead of the boiler. Such a process materially reduces the amount of chemicals required to keep the boiler free of scale.

There is no mystery to maintaining the water surfaces of boilers free of scale and corrosion. It is based on well established and well understood chemical reactions and depends primarily on three classes of chemicals.

The first of these is phosphate. There are many different types of phosphate chemicals which can be and are used. However, whichever one is used, it is used for one primary purpose and that is to supply phosphate to the boiler water. The amount of phosphate per pound of material is then of economical importance. The amount of phosphate present is expressed as a percentage of phosphorus pentoxide or P2 O5, and varies from 10-15% up to 67%.

The action of the phosphate is to combine with the calcium in the water. It forms calcium phosphate which precipitates as a sludge. With the proper boiler water alkilinity this sludge will not be adherent and will be easily removed through blowdown.

The magnesium in the water will combine with the silica which is naturally present in the water, to precipitate as magnesium silicate, also a nonadherent sludge. In cases where there is insufficient silica naturally occurring, the addition of silica has proved quite successful. On the other hand, if the magnesium does not precipitate as magnesium silicate it usually combines with the phosphate to form a sticky magnesium phosphate sludge. It is then necessary to use some type of organic dispersive to keep this sludge from adhering to the internal boiler surfaces.

The second class of chemicals supply alkalinity to the boiler water. Soda ash (sodium carbonate) and caustic soda, (sodium hydroxide) are used for this purpose. Some types of phosphates also add some alkalinity. Alkalinity in the boiler water has a three fold purpose. First, sufficient alkalinity is required to insure that the calcium phosphate is precipitated as a non-adherent sludge. Next, the alkaline materials prevent the water from dissolving the boiler metal. This is of course, a very slow process; however, it proceeds at its slowest pace at a pH of 10.2. Most boiler water treatments are slightly above that point. Finally, sufficient alkalinity is needed to keep excess silica in solution, where this material is high in the raw water.

Although caustic may be somewhat more dangerous to handle, it has one big advantage over soda ash. This is in the field of condensate return line corrosion, and will be covered later.

The third primary chemical is sodium sulfite. Sodium sulfite is an oxygen scavenger. It reacts with oxygen in the feed water and thus prevents oxygen corrosion of the boiler metal. Sodium sulfite should be fed to the boiler feed water, or to the storage space of the deairating heater.

These then are the three basic chemicals used in internal boiler water treatment; phospate, caustic soda, and sodium sulfite. There is no mystery about what they do, or how they work. Most often these are the only chemicals required for clean boilers, year after year.

There is, of course, one further step for complete control over boiler water conditions, and that is blowdown. This simply means that the dissolved and suspended solids are not allowed to concentrate beyond some maximum value. The upper limit depends on the pressure at which the boilers operate, however, 3500 ppm of total solids is the maximum allowed by the American Boiler Makers Association code.

There are other materials added to boilers also. They are primarily anti-foams and dispersives. These two materials are highly overworked. They are good tools, and quite valuable when correctly applied. However, we do not beleive they should be used as a crutch to support poor engineering and poorly designed treatment. They may even be introduced simply to increase the revenue of the vendor. Why, for example, should it be necessary to use a dispersive, as sludge conditioner in a boiler with zeolite softened make up water? With this type of make up water there will be little or no sludge to condition.

So far we have discussed only boiler water treatment whereas your problem is actually two-fold. You have not only the boiler water treatment to consider, but also the question of condensate return line corrosion. This corrosion can occur either as carbon dioxide or acid corrosion, or as oxygen corrosion.

The carbon dioxide corrosion appears as grooves worn in the pipe just where the condensate flows. It may also appear as general pipe thinning, and shows up particularly at threads. Oxygen corrosion occurs as tubercles or barnicles as rust inside the return lines. A combination of carbon dioxide and oxygen corrosion is characterized by pits and grooves in the metal.

There are two different materials on the market today which are being used with good results. These are the neutralizing amines, and the filming amines.

The neutralizing amines are volatile alkaline materials. They are primarily effective against carbon dioxide corrosion, but have very little value in combating oxygen corrosion. In your raw water are naturally occuring bicarbonates. As these pass through the heater and into the boiler they are converted to caustic soda. Carbon dioxide gas is given off as a result of this conversion and it passes out of the boiler with the steam. Carbon dioxide is an acid and it dissolves in the condensate as it is formed. This lowers the pH of the condensate to a point where actual acid attack of the pipe occurs. The neutralizing amines simply neutralize this acid.

If soda ash is used for boiler water treatment it too breaks down in the boiler to form caustic soda and carbon dioxide. This simply increases the corrosion problem, and, if you are using a neutralizing amine it increases your cost. Inasmuch as caustic soda is already reverted to the final product, no carbon dioxide is given off in the boiler. This is of course the advantage of caustic over soda ash.

Filming amines actually protect the pipe by forming a thin, non-wetable coating on the surface. This separates the pipe from the corrosive condensate and offers excellent protection from both carbon dioxide and/or oxygen corrosion. The filming amines represent a far better material in almost every case. Not only do they provide better protection, they usually cost less as well!

The fliming amines cannot be mixed with other chemicals, and pure condensate must be used to prepare the feeding solution. However, the filming amines can be fed to the boiler by means of the boiler feed water. It is not necessary to feed it into the steam line.

The filming amines have a strong affinity for iron. Therefore they will clean off all of the corrosion products, dirt, and oil that might be inside your condensate return system. This may give some trouble with plugged traps and strainers until the system is cleaned out.

There is one further point that you should consider, and that is in regard to protecting your equipment from corrosion while it is in standby.

If a boiler is to be in standby for an extended period, it should be drained and dried out. Pans of quick lime or silica gel should be put into the boiler and it should then be closed up. Of course, the feed water must be shut off tight as well as the main steam valve and blow down valves. This is called "dry standby".

If the unit is to be in standby for a short period, "wet" standby will be adequate. To achieve this, the boiler should be completely filled with treated water which contains 350-400 ppm of caustic soda, and 120-150 ppm of sodium sulfite. These chemicals must be thoroughly circulated so that all parts are protected. The water should be tested frequently enough to insure that these limits are maintained.

In order to protect a condensate system while in standby, three times the usual feed rate of filming amines should be fed for about two weeks before the system is to be taken out of service.

As a brief review, let us say that there are two ways that the scale forming minerals, as hardness, can be reduced before pumping the water into a boiler. These are the hot process lime-soda softener and the zeolite softener. Each has its advantages and disadvantages.

The internal treatment for the prevention of scale and corrosion depends on three classes of chemicals; phosphate, alkali, and sodium sulfite, an oxygen scavenger.

Both neutralizing amines and filming amines are used to prevent condensate return line corrosion. The filming amines represent the better corrosive inhibitors.

The filming amine is also used to prevent standby corrosion of condensate systems. Boilers can be protected in standby by either the "wet" or the "dry" method.

Of course, there are many details which we have not covered. Each problem requires a somewhat different solution depending on the conditions in each plant. However, the purpose of this discussion was not to investigate details, but rather to present a clear cut picture of the fundamentals of good boiler water treatment.