Steam/Condensate Treatment

An Overview of Monitoring and Treatment

A White Paper Prepared for
P.C.I. Controls and Instrumentation
August 1995 Seminar

By
John J. Baum
Craft Products Company, Inc.

Steam/Condensate Treatment

Introduction

In the production of steam, even high quality/purity steam, contaminants are introduced which require monitoring and treatment in order to maximize the useful life of steam use and/or steam/condensate transport equipment and piping. Further, contamination of condensate at use points is also a concern which is best handled through regular monitoring of contaminant levels. Refer to Table 1.

Contaminant Removal

When returning Condensate is found to contain contamination that is detrimental to the system, removal or treatment is usually indicated. Treatment is usually introduced when the contamination is dissolved, particularly dissolved gases. If suspended, removal could be achieved through mechanical separation (filtration). Note that suspension could also refer to the contamination of steam with boiler water and the resulting impurities. This would also be removed by separation, with the use of internal or external steam separators being the predominant method (assuming other factors have been eliminated - refer to Steam Quality/Purity Paper).

Other contaminants, particularly in gross amounts (such as dissolved copper from extremely large distribution systems), might necessitate the use of "Condensate Polishing" equipment. This is usually a water treatment feature unto itself, predominantly softening, deionization or other means of chemical removal.

hi some cases gross contamination, whether dissolved or suspended, the condensate must be dumped to prevent damage to system components. As mentioned previously, regular monitoring of system parameters *is* the best preventative for damage due to steam/condensate contamination.

Condensate Treatment

The predominant term for the use of pH adjusting treatments is "Condensate Treatment" which refers to the addition of chemicals to the steam (through either the boiler water or direct injection to the Steam Header) to prevent steam/condensate line corrosion due to the acidic nature of Carbon Dioxide contaminated steam. The Carbon Dioxide is a normal by-product of the breakdown of Boiler Water Alkalinity, and occurs in most boilers to varying degrees. The Carbon Dioxide, upon dissolution in condensate forms Carbonic Acid, which can dissolve metal rapidly. In systems where oxygen inleakage also occurs, metal dissolution can occur at a rate ten times that of a system with only one or the other contaminant

Neutralizing Amines

The most commonly used material for Condensate pH conditioning is the family of volatile amines known as "neutralizing amines". These materials are volatilized into the steam and by their alkaline nature re-dissolve in the condensate to effectively neutralize the effects of carbonic acid There are a number of important features of these materials that need to be known in order to select the proper one(s) for a given application. These are outlined for the most commonly utilized products in Table 2.

The Vapor/Liquid Distribution Ratio refers to the tendency for a given amine to be in the vapor phase (steam) or liquid phase (boiler water or condensate). For example, Cyclohexylamine with a Vapor/Liquid Ratio of 4.7:1 will place 4.7 times the material in the vapor phase as in the water phase. Stated differently, for every 5.7 pounds of amine in the operating boiler, 4.7 pounds will be evaporated with the steam while 1 pound will remain in the boiler water. These ratios are most commonly used to predict the performance of a product in a specific system: A higher ratio means the amine is more likely to stay with the steam in a distribution system, while an amine with a lower ratio will condense at the earliest possible time. This means that the higher ratio product is best suited to a larger system while a lower ratio product is best for a smaller system.

Control of the feed of these products is critical to their proper application, as underfeed results in acid corrosion of system metals and overfeed could result in caustic corrosion as well as possible health hazards. Obviously, it is in the interest of the user of these materials to ensure the skill level of the entity recommending and/or supervising the application of these materials. In addition to the need for skill due to effectiveness issues, there are economic concerns which are directly effected by the skill of application.

Filming Amines

Another class of amines have proven valuable in treating to prevent deterioration of system piping due to dissolved gases. Referred to as "Filming Amines", these form a hydroscopic layer on wetted system components, thus protecting them from attack by dissolved gases. As a result of their physical and chemical characteristics, they are most often injected into the steam header. Maintenance of the monomolecular hydrophobic coating is achieved through constant feed of the filmer, with initial dosage based on system size (square footage) and experience with the specific product

This type of treatment, while effective in preventing corrosion due to all dissolved gases, is not generally suggested for old systems or when feed the feed point must be the boiler and the Boiler Water contains copious amounts of sludge. The reason is that this material is surface active, and sees sludge and rough surface as a location on which to act Action cm non-smooth surfaces can break them loose and/or cause them to agglomerate, forming sludge masses which can plug equipment orifices and fittings. When treating anything other than a smooth, new system, it is suggested that material be fed in minute amounts initially and increased gradually, working up to the expected required feed rate over a period of time determined by the age and size of the system, and the degree to which it has deteriorated

Table 1

Steam/Condensate Parameters to Monitor

General Parameters
- Specific Conductivity
- pH
- Amine (if used)

Contaminants
- Sludge
- Iron
- Copper
- Hardness
- Other Contaminants
  - Oil (Terminal)
  - Milk (Dairy)
  - Process Fluids

Table 2

Select Amine Data

	Cyclohexyl	DEAE	Morpholine	AMP
Vapor/Liquid Distribution Ratio	4.7:1	1.7:1	0.4 :1	0.3 :1
FDA Limits (NOTE: Total NTE 25 ppm)	10 ppm	15 ppm	10 ppm	N.E.
Boiling Point (Amme/Water Mix)	205°F	210°F	Does Not Form Azeotrope	
Boiling Point (Amine Only)	273°F	325°F	264°F	329°F

Amine Blends

Often the best treatment for an individual system is not an off-the-shelf product but a Mend of amines from the categories mentioned above. Most of these can be blended together, though this must be done carefully in view of the range of physical and chemical characteristics that are represented by this family of materials.

Optimizing Material Usage

Because the costs associated with the use of organic amines are relatively high, there is usually motivation for optimizing the use of products containing them. The first step is the examination of point of feed The reasoning has to do with examining the characteristics and how they fit with the application. For example, if one were feeding Moipholine to the Boiler Feedwater, the distribution ratio indicates that for every 1.4 pounds fed, 0.4 pounds goes with the steam and 1 pound stays in the Boiler Water. Assuming blowdown is 10%, that would put 0.1 pounds down the drain, meaning that 20% of the amount leaving the boiler is being wasted!

In any case, it *is* generally accepted that the ideal feed point for amines is into the steam flow at a point somewhere prior to the condensation point This would bee immediately after the boiler if the entire system is being treated or at a convenient header location if steam to a specific piece of equipment or plant section is the treatment goal.

Further, a single amine most likely does not give the ideal distribution within a system. It is likely that a blend of at least two different amines will give the best overall neutralization performance. The actual blend can likely be deduced by experience with similar systems, but can be confirmed only through a trial-and-error test using actual operational condensate samples from points throughout the distribution system(s). The benefit of this procedure is that a single amine will provide best protection to only a portion of the plant system, and when fed to properly adj ust the 1*1 at that point, pH levels at other points in the system will either be higher or lower than ideal.

Ideal Control Limits

What control limits should be used is a point of debate within the field of treatment. While some adhere to the "theoretical" point at which Caibonic Acid ceases to exist in its free form (pH = 8.3, the endpoint for OH alkalinity existence), others prefer additional cushion. Obviously one would not want to approach a pH of 9, where free causticity could strip light allow metals. The author points out that in the process of optimization, a fine tuning point for any system might be the marriage of acceptable pH and corrosion levels. This optimization would involve the relationship between condensate pH and iron and/or copper levels. In some systems where steam quality is very good and Boiler Water Alkalinity low, a much lower pH, approaching conventional neutrality (pH = 7.0), could provide excellent results without excessive amine feed.