

Condensate Systems

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Condensate is steam that has condensed as a result of doing work and liberating heat. Being condensed water vapor (steam) and relatively pure compared to most well and surface waters, condensate is an excellent source of feedwater. Since condensate is typically of better quality than normal make-up sources boiler water cycles of concentrations can be increased and blowdown amounts can be reduced with its use. This results in a reduction of heat loss through blowdown, which reduces the amount of heat (fuel) required to maintain operating pressures. Another important aspect of condensate is its heat content. Again less heat (fuel) is required to maintain operating pressures when the feedwater temperatures are elevated. Finally, because condensate is water that a plant has already treated, (pretreatment, scale/corrosion inhibitors, oxygen removed, pumped and evaporated to steam) it represents a valuable investment that can be utilized over if treated properly. Therefore, recovering and reusing condensate whenever possible is good management.

While recovering and reusing condensate can be advantageous for a plant, if not treated properly condensate can become a maintenance nightmare. The most common problem associated with condensate is corrosion of the piping that returns it to the feedwater system and ultimately the boiler. Almost all problems associated with condensate corrosion can be trace to two gases: carbon dioxide and oxygen.

CARBON DIOXIDE

Alkalinity, in the form of carbonate and bicarbonate ions, naturally occurs in water. Under the pressures and temperatures found in boilers, a portion of this alkalinity breaks down to form carbon dioxide:



The first reaction usually achieves 100% completion. The second typically achieves 80% or more completion at pressures over 150 psig; between 50 and 150 psig completion varies from 30-80%; between 15 and 50 psig completion varies from 10-30%. Load factor also has an effect on these

reactions. Higher load factors will result in lower conversion rates.

Other sources of CO₂ are free carbon dioxide in raw water (typically well water), use of soda ash as an alkalinity builder for internal boiler treatment, process contamination and decomposition of some organic compounds. Carbon dioxide, which again is a gas, is carried out with the steam. After the steam has done its work and condenses, some if not all, of the carbon dioxide will dissolve in the condensate. This results in the formation of carbonic acid:



Dissolved carbon dioxide in the condensate can accelerate corrosion in several ways. Carbonic acid lowers condensate pH and causes corrosion. This low pH leads to corrosion of ferrous metals and ultimately to the formation of ferrous oxide precipitates.

Carbonic acid corrosion typically manifest itself as a general thinning of the metal, often causing initial failures in areas where system metals are already thin, ie; pipe threads, etc.

The thinning of condensate piping typically leads to high iron content in boiler feedwater. The result is boiler tube failures as the iron precipitates out onto the tubes once it reaches the elevated temperatures and pH's of the boiler water. This deposition can cause galvanic as well as under deposit corrosion, accelerating the corrosion rates to the point of failure.

The proper approach to reducing carbon dioxide attack is determined by a number of factors that include: complexity, size and age of the system, the quantity and source of condensate returned and the raw water characteristics. Various mechanical means of reducing carbon dioxide attack are available that include: hot or cold process softening, ion-exchange of various types and degasification, demineralization and deaeration of feedwater.

Other considerations to reducing carbon dioxide attack would include: severity and location of the corrosion in the systems, pressures and reducing stations, the feasibility of remote feeding, the nature of the process as well as any government restrictions and regulations.

OXYGEN

Oxygen can be introduced to a condensate system in a number of ways: by improper operation of a deaerating heater, disruption of feeding an oxygen scavenger, process contamination, in-leakage during shut-down/cool-down times, vacuum pumps, vented condensate receivers, leaking pump glands, etc.

Whatever the cause, oxygen corrosion in condensate is typically rapid and terminal to the system. The severity of oxygen attack depends of the concentration of dissolved oxygen, the pH and the temperature.

One of the most severe aspects of oxygen corrosion is that it occurs as pitting. A pit is a concentration of corrosion in a small area of metal surface. This type of corrosion can cause total failure of equipment even though the amount of metal loss is relatively small.

The influence of temperature in condensate as well as other areas of the boiler system is particularly important. Corrosion rates are accelerated as the temperature increases in the presence of oxygen. Since temperature is a driving force in oxygen corrosion even small quantities of dissolved oxygen in condensate can cause severe corrosion.

Oxygen removal in the condensate system is determined by the source. If oxygen is flashing with the steam from the boiler, use or repair of a deaerating heater could help eliminate this. If oxygen is a result of in-leakage due to faulty seals, etc. certain repairs can be made to repair these. Often times oxygen in-leakage into a condensate system is a situation that cannot totally be eliminated and therefore must be dealt with in the most economical manner.

TREATMENT

Most often, condensate corrosion, whether from carbon dioxide or oxygen attack, is dealt with through the use of two basic types of chemicals: neutralizing amines and filming amines.

NEUTRALIZING AMINES

Neutralizing amines do just as their names imply; they neutralize the carbonic acid formed in condensate thereby reducing the potential for low pH attack. Neutralizing amines are typically classified by their vapor/liquid distribution ratio. This vapor/liquid ratio refers to the amount of amine

present in the steam phase (vapor) vs. the liquid phase (condensate). Vapor/liquid ratios are temperature and pressure dependent. Various amines will stay in the vapor phase longer in a system than another amine will and could leave certain areas unprotected. Generally speaking, one amine will not offer protection to an entire system. It is important to select an amine or combination of amines that will protect the total system. With this in mind testing should be performed at various locations throughout the system to insure the overall protection of equipment.

Common neutralizing amines include, but are not limited to: morpholine, cyclohexylamine, diethylaminoethanol (DEAE), dimethylpropanolamine (DMPA) and 2-amino-2-methyl-1-propanol (AMP-95).

Selection of one or more of these amines must be based upon system pressures, temperatures, complexity, types of equipment used, and their ability to retard corrosion rates.

FILMING AMINES

Filming amines are typically used to counter the effects of oxygen corrosion. They function by laying down a monomolecular film on metal surfaces which aids in the protection of condensate piping and steam equipment. Filming amines will also provide protection against carbonic acid attack.

The two most common filming amines are octadecylamine (ODA), and ethoxylated soya amine (ESA). In order for filming amines to work, condensate pH must be high enough for the film to form (- 6.0 pH or above).

Care must be taken with the feeding of either neutralizing or filming amines. Overfeed of either to a system that has experienced corrosion in the past can lead to rapid removal of iron oxide deposits. Sloughed off iron oxide deposits can cause blockage of traps and valves in the condensate system and in the deaerating heater.

Returning condensate represents a valuable heat source and has the potential of reducing boiler operating costs. This potential may incur cost penalties in terms of repairs to damaged piping and or equipment, increased energy costs due to steam leaks, etc, if not treated properly. The largest expensive however; is not the expense to replace and repair equipment, but the financial loss of production during the down time.