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AN OVERVIEW OF STEAM BOILERS CHEMICAL TREATMENT STRATEGIES

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Abstract— **The Feed water usage in Boiler has the limitation for Iron, Copper, Total hardness Silica and dissolved solids. The operation of the Boiler will be affected due to the presence of Calcium and Magnesium salts in the water. The presence of excess Oxygen and Carbon dioxide in Boiler feed water tend to make corrosion in the Boiler parts. The use of chemicals in treating Boiler water tend to improve the Boiler efficiency, reduced maintenance cost, increased Equipment life, reduce the Fuel cost and minimize the water usage. When the Boiler water becomes steam which leaves the impurities like salts of calcium and Magnesium and the same impurities shall be removed from the Boiler by blowdown and addition of makeup water. This paper outlines detrimental effects of dissolved salts, ions and gases present in the Boiler feed water and condensate water and remedial solution such as chemical treatment strategies which eventually increases the life of the Boiler system.**

I. INTRODUCTION

This is brief write up on the steam boiler water treatment. The Boiler operators require effective Boiler feed water treatment system to maintain the Boiler. The main objective of this write up is to provide the Boiler users to operate and maintain the boiler in a efficient way to improve the efficiency and ways to prevent the boiler from any mishappening.

The impurities exists in water are of three types and can cause multiple problems in boilers. These impurities are

1. Suspended solids
2. Dissolved solids
3. Dissolved gasses.

Impurities present in the water can be treated by usually physical or mechanical methods. Chemical treatment is to clean up the remaining traces left after physical treatment. The pre-treatment (Physical or Mechanical) minimize chemical costs.

Faulty water chemistry results in Corrosion in tubes and pipes, Scale formation in Tubes and Carry over impurities. These needs to be taken care while required high performance.

Scaling is formed by salts in water. These salts reach a deposit site and precipitate when concentrated by increase in temperature in Boilers. Common impurities that can form scale shall be Magnesium, calcium, iron, copper and silica. The deposits formed by the following ways:

- scale that deposited onto tube surfaces
- sludge which were carried away by water to the metal surface

Some common scales in Boiler water systems are:

- calcium carbonate
- calcium phosphate
- magnesium silicate
- silica

As per ASME/ABMA (American Boiler Manufacturers Association):

Boiler Feed water Quality shall be as follows:

Table 1:

Boiler Operating pressure(bar)	Total dissolived solids (ppm)	Total Alkailinity (ppm)	Total Suspended Solids (ppm)
0-3.5	2500	500	-
3.5-20	3500	700	15
20-30	3000	600	10
30-40	2500	500	8
40-50	1000	200	3
50-60	750	150	2
60-70	625	125	1

Boiler water quality after Dearator:

Table 2:

Drum Design pressure (psig)	Dissolved oxygen (ppm)	Toal Iron (ppm)	Total copper(ppm)	Total hardness (ppm)	pH	Non voltaile TOC (ppm)	Oily matter (ppm)
0-300	<0.007	≤0.1	≤0.05	≤0.3	8.3-10	<1	<1
301-450	<0.007	≤0.05	≤0.025	≤0.3	8.3-10	<1	<1
451-600	<0.007	≤0.03	≤0.02	≤0.2	8.3-10	<0.5	<0.5
601-750	<0.007	≤0.025	≤0.02	≤0.2	8.3-10	<0.5	<0.5
751-900	<0.007	≤0.02	≤0.015	≤0.1	8.3-10	<0.5	<0.5
901-1000	<0.007	≤0.02	≤0.01	≤0.05	8.8-9.6	<0.2	<0.2
1001-1500	<0.007	≤0.01	≤0.01	≤0.05	8.8-9.6	<0.2	<0.2
1501-2000	<0.007	≤0.01	≤0.01	≤0.05	8.8-9.6	<0.2	<0.2

Boiler Feedwater-Maximum Allowable impurities

Table 3:

Chemical	Symbol	Maximum concentration (ppm)
Sodium Sulphite	Na_2So_3	1
Sodium Chloride	NaCl	10
Sodium Phosphate	Na_3Po_4	25
Sodium Sulphate	Na_2So_4	25
Silica Oxide	SiO_2	0.2

II. CHEMICAL DOSING REQUIREMENT

Because of water hardness and its composition interactions with treatment chemicals and other impurities it is very hard to determine the true concentrations of many impurities in the boiler water.

Chlorides, which are relatively unaffected by other materials in the boiler. When compared to the makeup water chloride concentration, boiler water chloride concentration will show the cycles of concentration of a boiler Feed water. In Boiler Blowdown in based on the composition of chlorides present in the water. If “N” of cycles of concentration is advised for a given boiler, then the concentration of chlorides should never exceed “N” times that of the makeup water. For example, the makeup water chloride concentration is 6 ppm so the boiler chloride concentration must never exceed 36 ppm.

The way to reduce the cycles of concentration in boilers is to blow down some of the highly concentrated boiler water. Makeup water replaces the blow down and dilutes the remaining boiler water. Blow down is performed two ways.

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1. Surface blowdown and
2. Bottom blowdown.

Surface blowdown normally controls through the manual valve. This process can also be automated by use of a conductivity sensor, motorized valve, and controller. This method will control water quality through the automated valve as needed.

Bottom blowdown is typically performed every shift on each blowdown connection. Bottom blowdown removes the boiler of sludge and sediment at the bottom of the boiler. This makes it imperative that each boiler blowdown connection is used to prevent accumulation of sludge and solids in that part of the boiler. Considering the boiler load profile, water quality, and the chemical treatment program, the frequency and duration of bottom blowdown can be calculated.

The blow down should be done based on the water quality and the steam quality. If the entire blow down is done manually, as with bottom blow down, it is important that operators monitor cycles closely and adjust frequency and length of time of blow down accordingly. This manual action is hard one to control cycles of concentration. surface blow down is used to control the cycle of centration of salts in water through blow down.

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If the chloride level is higher than the recommended one, more blow down is needed. If it is low, excess blow down will result in wasted chemicals in water. In some cases, the chloride level never approaches the recommended maximum, even if little or no blowdown is being done.
With the blow down rate established, chemical feed can be done by dosing pump setting changes to bring residual chemical concentrations to the required level. Standard boiler chemical programs include

a. Sodium hydroxide (caustic soda) for alkalinity
b. Sodium sulfite for oxygen scavenging
c. Phosphate for scale prevention
d. Amines for return condensate treatment, which prevent condensate line corrosion and sludge deposition in the boiler.

The one of the parameters should be tested to maintain good boiler chemistry control is conductivity. The more materials are dissolved in the water, the higher its conductivity. As a boiler approaches its maximum allowable cycles, it will also approach its maximum allowable conductivity, Carryover resulting in excess fuel consumption and reduced efficiency. Measuring condensate and boiler water conductivities are important for ensuring good steam quality and can expose mechanical problems with boiler operation.

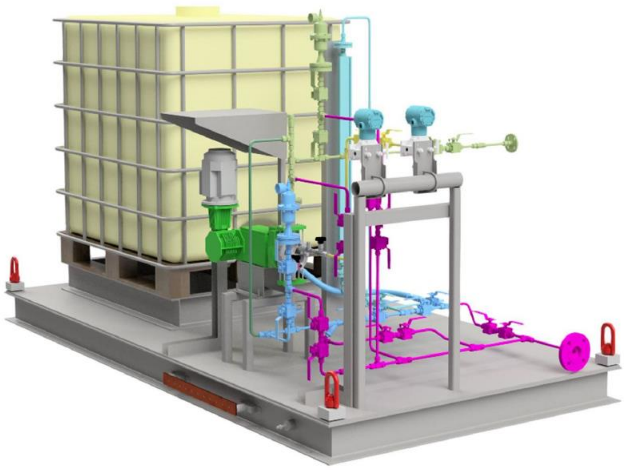
III. CHEMICAL DOSING

SODIUM HYDROXIDE DOSING:
The sodium Hydroxide dosing is done in the boiler in order to provide high alkaline environment in the Boiler. This is added to Boiler feed water to prevent the acidic corrosion. Normally high temperature magnifies the corrosion in the boiler system since it speed up the chemical reaction. This dosing is used to increase the pH of the water.

SODIUM SULPHITE OR HYDRAZINE DOSING:
The boiler tubes gets damaged due to the concentration of oxygen in the water by tube pitting. Cold water holds more air. A deaerator can be used to heat the water with steam to remove oxygen, Normally Sodium Sulphite is used as a dosing chemical to remove the Oxygen
This chemical dosing is otherwise called as LP Dosing (Low Pressure Dosing). This dosing is used to remove the dissolved oxygen from the water. This chemical is added to the Low pressure side of the Boiler water system.
LP dosing is normally dosed in Deaerator or in the Boiler Feedwater pump suction line. Oxygen present in boiler feed water will erode tubes of a boiler. Water contains many elements that can either accumulate or erode the metal surfaces inside the boiler.
When water contains the dissolved Oxygen heated, the corrosive nature of these dissolved gases increases. As the temperature (and operating pressure) of a boiler increases, the destructive ability of O2 increases.
Corrosion due to Oxygen causes severe metallic breakdown. Dissolved oxygen present in water and steam results in pitting of boiler.
Usually there are two chemicals used in LP dosing. One is Sodium Sulphite (Na_2So_3) and another one is Hydrazine(N_2H_4).

$$Na_2So_3 + 1/_2O_2 \longrightarrow Na_2So_4$$
$$N_2H_4 + O_2 \longrightarrow N_2 + 2H_2O$$

Sodium Sulphite dosing is used for the low pressure Boilers as it increases the TDS of the water whereas Hydrazine is used in low pressure dosing for High pressure Boilers.



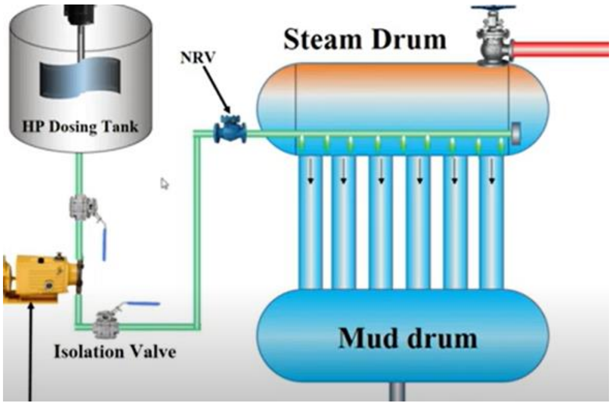
PHOSPHATE DOSING:
In order to remove the residual hardness and prevent scale formation due to accumulation of salts in the form of Calcium Chloride and Magnesium sulphate in the Boiler drum Phosphate Solution dosing is preferred.
Normally Tri sodium phosphate is dosed in the high pressure side of the Boiler. If the pH of water is less than 9.0 the calcium salts will not precipitate in the water. In order maintain the pH more than 9 and to make the calcium and magnesium salts to precipitate the Trisodium phosphate is dosed which are more Alkaline in nature. Tri sodium phosphate solution is prepared in the separate tank by mixing the Trisodium phosphate with the water and agitated with the Agitator for thorough mixing. After mixing with the water the Phosphate solution is dosed into the Steam drum by using the high pressure dosing pump. This Phosphate dosing is also called as high pressure dosing (HP dosing) as this dosing is done at the Boiler Drum which is at high pressure.

$$Na_3Po_4 + H_2O \longrightarrow NaOH_2 \uparrow + Na_2HPO_4$$
$$2Na_3Po_4 + 3CaCl_2 \longrightarrow Ca_3(Po_4)_2 + 6NaCl$$
$$Na_3Po_4 + 3MgSo_4 \longrightarrow Mg_3Po_4 + 3NaSo_4$$

Phosphate hide out:
if the temperature of the boiler water increases beyond the limit the Solubility of Phosphate in the water decreases and deposited in the water tubes and performance of the boiler is less. If the temperature of the boiler water is in the allowable

range(200-350°C) and Phosphate will again reappear & Solubility of the Phosphate in water is optimum. This disappearing and appearing of Phosphate is termed as Phosphate hide out.

There is a relation between the Boiler load, pH and Phosphate. If the Boiler load increases the pH will increase and Residual Phosphate presence in water will be reduced. If the Boiler load decreases the pH will reduce and the Phosphate presence in water will increase and come to normal.



AMINE DOSING:

Most of the combined carbon dioxide is released with steam in the boiler and subsequently dissolves in the condensate, frequently causing corrosion problems.

Boiler corrosion occurs due to the presence and reaction of oxygen and carbon dioxide with iron in the boiler water system. This carbonic acid corrosion shall be rectified by Amine dosing.

CO_2 is dissolved in water in condensate to form carbonic acid (H_2CO_3). This carbonic acid reacts with steels and low alloys steels to form an iron carbonate scale. CO_2 corrosion is most typically found in condensate return systems.

The rate of corrosion in materials affected by CO_2 corrosion is dependent on several factors such as the concentration of CO_2 in the environment, the operating pressure sand temperature, and the material composition.

Amine is dosed in the Condensate return line to increase the pH of the water. These condensate lines are of acidic in nature and cause Carbonic acid corrosion. In order to remove the carbonic acid Corrosion these amines are added to make water neutral or slightly alkaline.

IV.CONCLUSION

The boiler Chemical dosing system is a must require in overcoming the Boiler material failure from Scale, Sludge and Corrosion. From the above, it is clearly understood that the treatment of boiler feed water, Boiler water and Condensate water shall increase the life of the Boiler.

The addition of boiler chemical dosing and water treatment such as deaeration will ensure good operation and long life for boiler systems and its components. By maintaining optimal boiler water chemistry and preventing scale and corrosion, these chemicals contribute to improved efficiency and reduced maintenance costs.

V. REFERENCE

[1] ASME/ABMA (American Boiler Manufacturers Association)

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