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A REVIEW OF OPERATIONS MANAGEMENT IN TREATMENT PLANT MATERIALS

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DECLARATION

This work is the result of my own except for summaries and references that each of them I have explained the source.

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ABSTRACT

A review of Operations Management in Treatment Plant materials to control the water systems that is very important to the overall operation of the powerhouse and to the success of the chemical treatment program. Proper control results in a clean boiler, and a clean boiler improves energy efficiency and boiler reliability. Good control saves money, conserves energy. The steam produced in the boilers must be of acceptable quality, as dictated by the operations for which it is intended.

The first support system is the pre-treatment system. As the name implies, water is first treated before it reaches the boiler. The general purpose of pre-treatment is to remove both suspended and soluble solids that, if not removed, could lead to boiler deposits and poor steam quality. These problems, in turn, could lead to inefficient boiler operation and ultimately to boiler and/or plant shutdown.

The second boiler support system is the feed-water system. Feed-water system is basically the final stream of the water that enters the boiler. It is composed of water from the pre-treatment system plus any water from the condensate system can result. The third support is chemical treatment. Good monitoring of chemical reserve and right practice can prevent the corrosion and scaling tendency.

It is imperative that each support system be at its best if the entire boiler system is to operate efficiently. Otherwise, maintenance costs and process inefficiency, and ultimately a plant or process shutdown could occur.

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INTRODUCTION

1.0 Overview

At Nalco, we've built our business on boilers. Over 75 years ago, Nalco began treating boilers for railroads and industry. Our long-term commitment is to provide the most innovative boiler treatment programs and services that build value for our customers by improving system reliability, optimizing total cost of operation, and minimizing safety risks. Many customers will lose more money from a single day of lost steam production than they spend with Nalco for boiler treatment in a year or two. Although the direct costs for our boiler water treatment programs might not significantly impact their bottom line, our results do. That is why we are so passionate about the reliable, safe, and cost-effective production of steam. Successful boiler system operation requires a total system approach to:

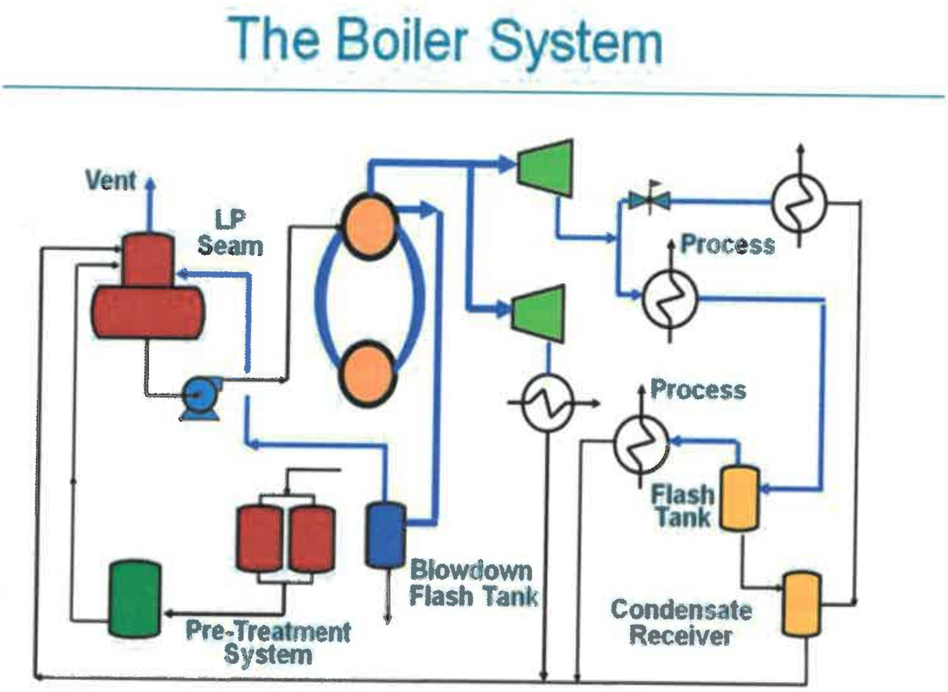
- Prepare makeup water to meet system requirements before it goes to the boiler
- Provide pre-boiler, boiler, and post-boiler corrosion protection
- Maintain clean internal boiler surfaces
- Maximize system availability and extend boiler system life
- Ensure reliable steam production acceptable for the intended use
- • Protect production processes and equipment
- Maximize the value of condensate return
- Optimize energy efficiency
- Assure safety and regulatory compliance

1.1 Background of the study

A review of operation management in treatment plant material have plays an important roles in produce steam especially for the boiler system, which in turn is used for a variety of operations, including electrical power generation via turbines, chemical processing, and numerous heating applications. The steam produced in the boilers must be of acceptable purity, as dictated by the operation for which it is intended. The purity of the steam produced and the efficiency of the boiler depend upon the manner in which the boiler support systems are operated. The support systems are those operations that either produce water that is used in the boiler or return used steam to the boiler for reprocessing. The three support systems are: pretreatment, feed-water, and condensate. Figure 1 illustrates a typical industrial boiler system. The first support system is the pretreatment system. As the name implies, water is first treated before it reaches the boiler. The general purpose of pretreatment is to remove both suspended and soluble solids that, if not removed, could lead to boiler deposits and poor steam purity. These problems, in turn, could lead to inefficient boiler operation and ultimately to boiler and plant shutdown. The pretreatment system usually consists of one or more of the following operations:

- Hot or cold lime softening
- Filtration
- Ion exchange softening
- De-alkalization
- Demineralization
- Reverse osmosis

Figure 1.1: A Typical Boiler System



Source: Nalco Manual

Selection of the appropriate pretreatment system is dictated primarily by the chemical composition of the supply water and by boiler requirements. The second boiler support system is the feed-water system. Feed-water is the final stream of water that enters the boiler. It is composed of water from the pretreatment system plus any water returned from the condensate system. These combined streams first pass through a deaerator, which preheats the feed-water and, by virtue of its temperature, removes gases (most importantly oxygen) from the water before it enters the boiler. If oxygen is not efficiently removed, severe corrosion of the rest of the feed-water system as well as the boiler and condensate system can result.

In a literal sense, the deaerator is considered a feed-water heater. Other heaters or heat exchangers, such as blowdown heat exchangers, feed-water heaters, and economizers, may also be present. The boiler's third support system is the condensate system. It is here that condensed steam, after the steam has been used for its intended purpose, is collected and returned to the boiler for reprocessing. Condensate is a valuable component of feed-water. It is of high purity and contains a significant amount of heat. The more condensate that can be returned to the feed water tank and it can support for the less fuel that needs to be consumed, and generally the less makeup water that is required from pretreatment. Just as makeup water from pretreatment must meet certain criteria, so must condensate.

Corrosion products or contamination from a process can lead to severe problems and inefficiency throughout the rest of the boiler system. It is imperative that each support system is at its best, if the entire boiler system is to operate efficiently. Otherwise, maintenance costs and process inefficiency will increase, and ultimately, a plant or process shutdown could occur. Hardness leakage and oxygen dissolved in boiler will focus in order to prevent the corrosion and scaling tendency. A method of Prof. Dr. Kaoru Ishikawa(1968) will be use for the studies in order to Review of Operations Management in Treatment Plant Material.

1.2 Statement of the Problem

Boiler scale and iron deposit and the various concepts and practices associated with boiler cycle chemistry will be approached here from a problem and solution standpoint. The boiler cycle is defined as all the contributing components of the system, from the feed-water to the condensate. The pretreatment and chemicals are all used in the cycle to avoid or eliminate problems associated with dissolved or suspended solids and gases in feed-water. These constituents, if left unchecked, may cause considerable damage throughout a steam-using process

1.2.1 Hardness Scale

The primary reason scale form is that the solubility of the scale-forming salts in water decreases as the temperature and concentration.

Table 1.1: Common Problem and Affected Areas in Boilers

Major Problem	Deaerator	Feedwater System	LP Boiler	HP Boiler	Superheater/ Reheater	Turbine	Steam-Using Equipment	Condensate System
Scale								
Hardness		X	X					
Silica			X	X		X		
Iron	X	X	X	X	X			X
Corrosion								
Oxygen	X	X	X	X	X		X	X
Alkalinity/CO_2				X		X	X	X
Ammonia		X					X	X
Chelate		X	X					
Deposits								
Metal oxides	X	X	X	X	X			X
Organics		X	X	X				
Carryover								
Entrained liquids			X	X	X	X	X	
TDS			X	X	X	X	X	

Source : Nalco Manual

When feed-water is elevated to boiler water temperature and concentration of the scale-forming salts exceeds its solubility, the salts precipitate and scale forms.

Table1.2: Solubility of Chemical Compounds

Compound	Solubility (ppm as $CaCO_3$) 32°F (0°C)	212°F (100°C)
Calcium		
Bicarbonate	1620	decomposes
Carbonate	15	13
Sulfate	1290	1250
Magnesium		
Bicarbonate	37100	decomposes
Carbonate	101	75
Sulfate	170000	356000
Sodium		
Bicarbonate	38700	decomposes
Carbonate	61400	290000
Chloride	225000	243000
Hydroxide	370000	970000
Sulfate	33600	210000

Source: Nalco manual

Scale forms in improperly treated boiler water systems by one or both of the following mechanisms:

1. The precipitation of relatively insoluble feed-water hardness compounds. Calcium

Carbonate precipitation at the metal surface is one example.

2. The supersaturation or crystallization of dissolved solids (such as CaSO4 and SiO2) in water that contacts heat transfer surfaces. The thin viscous film of boiler water immediately adjacent to the heating surface tends to become more concentrated than the main body of boiler water. As the steam bubbles are formed, they depart from the metal surface, leaving behind a circular deposit (Table 1.1). Eventually, the circular formation is completely filled in with scale (Table 1.2). This may occur even though the concentration throughout the main body of the solution does not exceed the solubility limit. Even the most soluble sodium salts may deposit if

water in a tube is allowed to evaporate to dryness due to plugging, poor circulation, or excessive heat transfer rates. Scale rarely exists in the pure compound form; it is generally found as complex molecules or as a mixture of compounds within any given sample.

1.2.2 Silica Scale

Silica-based deposits are found primarily in lower pressure systems (less than 1000 psig [6.9 MPag]). Where the pretreatment system is not designed for silica removal, i.e., sodium zeolite softening or where the boiler is operated at excessive cycles of concentration. Although uncommon, silica-based deposits can also be found in high-pressure systems where silica leakage through the anion unit(s) has been a problem. Silica-based deposits become more serious as silica levels increase and as the hydrate alkalinity decreases.

Table 1.3: Constituents Found in Boiler Deposit

Name	Formula
Acmite	$Na_2O \cdot Fe_2O_3 \cdot 4SiO_2$
Analcite	$Na_2O \cdot Al_2O_3 \cdot 4SiO_2 \cdot 2H_2O$
Anhydrite	$CaSO_4$
Aragonite	$CaCO_3$ (gamma form)
Basic magnesium phosphate	$Mg_3(PO_4)_2$ $Mg(OH)_2$
Brucite	$Mg(OH)_2$
Calcium hydroxide	$Ca(OH)_2$
Calcite	$CaCO_3$ (beta form)
Copper	Cu
Cuprite	Cu_2O
Ferrous oxide	FeO
Goethite	$Fe_2O_3 \cdot H_2O$ (alpha form)
Gypsum	$CaSO_4 \cdot 2H_2O$
Hematite	Fe_2O_3
Hydroxyapatite	$Ca_{10}(PO_4)_6(OH)_2$
Magnetite	Fe_3O_4
Serpentine (magnesium silicate)	$3MgO\ SiO_2 \cdot 2H_2O$
Sodium ferrous phosphate	$NaFePO_4$
Tenorite	CuO
Thenardite	Na_2SO_4
Xonotlite	$5CaO \cdot 5SiO_2 \cdot H_2O$

Source: Nalco Manual

Silica, in addition to forming boiler deposits, can vaporize from the boiler and will be carried with the steam as silicic acid. When the steam containing vaporous silicic acid performs work and has some of the heat content reduced, such as going through a turbine, the silica precipitates on the metal surfaces, causing deposits. This can be a major problem on turbine blades. This deposit will reduce the efficiency of the turbine and can result in an imbalance of the turbine wheel.

1.2.3 Iron Deposit

Iron oxides present in boiler water have caused problems. However, in the beginning, iron deposits were not the major problem or root cause of most boiler tube failures, as were hardness scale deposits. As the design of boilers evolved from low-pressure riveted drum-type boilers to today's modern high-pressure, high heat flux, thin-walled water-tube boilers, the requirement for higher purity boiler feed-water also occurred. The effective removal of calcium and magnesium from boiler feed-water by pretreatment techniques such as lime softening, sodium zeolite softening, ion exchange demineralization, and reverse osmosis (RO) has shifted the cause for boiler tube failures to be predominately due to iron deposits on the heat transfer surface. These deposits cause under-deposit corrosion problems and act as insulators, impairing heat transfer, which cause the boiler tube to overheat and ultimately rupture.

Both soluble and insoluble iron (particulate and colloidal) can be present in boiler feed water and boiler water. Boiler water iron will deposit on the steam generating surfaces of the boiler and cause under-deposit corrosion and overheating problems. Iron deposits on the heat transfer surfaces are typically hard, dense, and porous. The porosity of the deposits allow wick boiling to occur, which provides a mechanism for concentrating and trapping corrosive chemistries such as caustic, acid phosphates, sulfates, and chlorides inside the deposit. In addition, the insulating property of the deposit impairs heat transfer and causes the temperature of the boiler tube to increase.

Table 1.4: Thermal Conductivity of Typical Boiler Deposits

Compound	Thermal Conductivity	
	Btu/h•ft^2°F/in.	W/m^{2}K/mm
Calcium Phosphate	25	3600
Magnetite	20	2900
Magnesium Phosphate	14.8	2100
Calcium Sulfate	9	1300
Serpentine	7	1000
Calcium Carbonate	6.4	920
Hematite	4.1	590
Carbon Steel	320	46000

Source: Nalco Manual

1.3 Objectives of the Studies

The objectives of the studies are to prevent scaling and corrosion tendency to the boiler that can interrupt the operations system. In order to make that, it is important to make sure that all the practice should be as below:-

1. Incoming water supply and this is referring to water source. It is important to know the water chemistry are meet the requirements spec that can use for the boiler.
2. Water source that contain of hardness and silica will be recommend to install Softener, DI or Silica removal in order for soft water supply that can reduce the problem or tendency scaling to the boiler.
3. To maintain clean internal boiler surfaces without corrosion and scales that can interrupt steam produce for operation process.
4. Maximize system availability meaning that the boiler can run full capacity without interruption.
5. To make sure that steam production acceptable for the intended use and more purity of steam.
6. To extent boiler system life that can use for many years without interruptions. Annual inspection by DOSH officers will involve for annual inspection
7. To make sure that production processes and equipment are protect and good well control.