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## Response to contamination of high purity boiler feedwater

### Scope

Demineralized water is widely used as makeup to boiler feedwater in the pulp and paper industry. The high purity of demineralized water makes it well suited for steam generation, especially in boilers with operating pressures that exceed 6.4 Mpa [900 psig]. However, because the water is so pure, small amounts of contamination may significantly affect its characteristics and threaten the operating reliability of the steam system. Consequently, operators should be trained to take action in response to feedwater contamination before significant damage occurs.

To aid in this training, the Water Treatment Subcommittee of the TAPPI Steam and Power Committee published “recommended actions” for common water chemistry conditions that require immediate response. The water chemistry conditions covered were high and low boiler water pH, silica intrusion, black liquor contamination, and feedwater hardness excursions. This paper updates those recommendations and includes new recommendations for feedwater iron contamination.

The needs of each pulp and paper mill are different. Consequently, these recommendations should be adapted to each individual mill situation. In all cases, when a deviation from normal water quality occurs, operators should notify their management.

This paper deals with response to contamination of high purity boiler feedwater. Obviously, preventing contamination is the best operating mode. To that end, the Water Treatment Subcommittee of the TAPPI Steam and Power committee has published a paper entitled “Water Quality and Monitoring Requirements for Paper Mill Boilers Operating on High Purity Water.” Plants that experience episodes of contamination should adopt the recommendations in that document.

### Safety precautions

Whenever people are working with hot and/or acidic or caustic solutions, extreme care must be taken to avoid direct contact with the skin or eyes.

### Definitions

**Buffer** – A buffer is a substance that accepts either hydrogen ions [acids] or hydroxyl ions [bases] minimizing pH changes. For example, the bicarbonate ion buffers the pH of sodium zeolite softened make up boiler water.

**Congruent phosphate – pH treatment** (Sometimes referred to as coordinated phosphate-pH treatment) - A congruent phosphate-pH treatment program maintains a phosphate-pH relationship that limits the free hydroxide or acid

generation in the water of 10.65 MPa [1500 psig] and lower pressure boilers. The purpose is to prevent significant pH excursions in the event of low level contamination or localized concentration of the boiler water.

Colloidal silica – Colloidal silica is a term applied to very small particles of silica. These particles are not removed in the some filtration processes, and may pass through ion exchange resin beds and contaminate boiler feedwater. Because typical silica testing does not indicate colloidal silica, it is not detected until it reaches the boiler and decomposes. At that time, it can be detected by testing processes, and may exceed target limits.

## Content

This section discusses the problems caused by various types of boiler water contamination, the potential sources of this contamination and recommended actions for responding to the contamination.

## High and Low Boiler Water pH

### Background

Either high or low boiler water pH can cause corrosion in the steam generating sections of the boiler. This effect could be magnified beneath deposits or in areas of steam blanketing. These same boiler water pH conditions can lead to corrosion in superheaters and turbines when these contaminants reach the steam system.

Problems with boiler water pH excursions are rarely encountered in boilers provided with softened makeup water, except for those systems with black liquor contamination. The boiler water alkalinity typically associated with softened water systems acts as a buffer, limiting the pH changes caused by feedwater contaminants

Demineralized water has little buffering capacity. Where a congruent phosphate - pH treatment program is being used, the phosphate provides the buffering, however it is limited and the ability to maintain pH can be overcome by moderate amounts of contaminants.

### Potential Contaminants That Produce High Boiler Water pH

There are a number of potential feedwater contaminants that can produce high boiler water pH, including :

- Caustic in the Demineralized Water
  - Caustic from the demineralizer regeneration system can contaminate the demineralized water. If the service water valve fails to close during regeneration, caustic can enter the demineralizer system product water.
  - Increased sodium leakage from the demineralizer is essentially caustic in that water. Small amounts are typical , but large amounts can lead to boiler pH control problems. Changes in the raw water supply, poor regeneration of the cation resin, cation resin bed exhaustion, the presence of cation resin in the anion bed, or organic fouling of the anion resin can lead to this problem. .
- Black Liquor in the Condensate – Caustic-containing black liquor can contaminate the condensate due to leaks in digester heaters, evaporators, liquor concentrators, and other liquor heaters.
- Overfeed of Caustic to the Boiler – Caustic is often fed to the boiler to maintain the desired pH level. Overfeed of this caustic causes high boiler water pH. Caustic may come from treatment blends used in the program.
- Caustic from a Condensate Polisher – Exchange of the condensate treatment chemical (ammonia and/or amines ) on to a sodium-regenerated cation condensate polisher introduces sodium into the condensate (as sodium hydroxide or other sodium salts).

### Recommended Actions

Recommended actions for responding to high boiler water pH for boilers operating on congruent chemistry are presented in Table 1.

### Potential Feedwater Contaminants That Produce Low Boiler Water pH

There are a number of potential feedwater contaminants that can produce low boiler water pH, including:

- Feedwater Hardness – Feedwater hardness contamination can cause the pH of a lightly buffered boiler water to drop due to alkalinity consumption in the hardness precipitation mechanism. Sources of feedwater hardness include condenser leaks, mill water heat exchangers, condensate and feedwater pump seal water hardness leakage from the demineralizer system, and emergency raw water connections.

- Demineralizer Regenerant – Sulfuric or hydrochloric acid is used to regenerate the cation resins in the demineralizer or mixed bed demineralizer system. The regenerant can enter the boiler feedwater when demineralizer valves do not close properly during regeneration.
- Black Liquor – Black liquor contamination usually produces high pH in a boiler but occasionally low pH occurs. This can occur when a system has amine-regenerated polishers and the sodium form the liquor is exchanged for amine. The amine does not remain in the boiler to buffer the contamination and pH depression may result.
- Colloidal Silica – The present of colloidal silica in the feedwater may consume hydroxide alkalinity in the boiler, resulting in a depression of boiler water pH.
- Treatment products designed with a low Na:PO<sub>4</sub> for boiler chemistry control can also drive pH down if overfed..

### Recommended Actions

The actions recommended for responding to low boiler water pH are presented in Table 2.

### Silica Intrusion

#### Background

Silica can form troublesome deposits in boilers, turbines, and desuperheating stations. Silica deposits are difficult to remove which makes silica deposit control extremely important to power house operation.

A major source of concern is turbine silica deposition. Boiler water silica exhibits significant volatility at operating pressures of 600 psig and above. The degree of volatility is a function of boiler pressure and boiler water pH. The silica that is vaporized in the boiler passes through the superheater and enters the turbine as a gas. The steam cools as it expands through the turbine and the silica solidifies. When the concentration of silica vapor in the steam is too high, as the silica solidifies, deposits are formed on the turbine blades. Silica deposits formed in this manner can reduce both turbine capacity and efficiency.

#### Potential Sources of High Silica

Soluble silica can enter the boiler water in any, or all, of the streams making up the boiler feedwater. Common sources of feedwater silica contamination are:

- Demineralized Water – Small amounts of silica are typically present in demineralized water, however large amounts can occur during the service cycle and also if the anion unit is operated past exhaustion. High silica levels during the service cycle may be associated increases in raw water silica, poor anion regeneration practice, degraded anion resin, or high cation unit sodium levels ( which causes high pH in the anion leading to higher silica leakage).
- Mill Water Contamination – Contamination of mill water into a system will bring silica along with any other species in the mill water (such as hardness). Pump seals and heat exchanger leaks are typical sources. Leaking emergency feedwater supply valves can also cause mill water contamination of the boiler feedwater. [Double block valves with an intermediate bleed are recommended to avoid this problem.]
- Attemperation Water Contamination – because attemperation water is injected directly into the superheated steam, high silica concentrations in the attemperation water will cause high silica concentrations in the steam.
- Colloidal silica] can also enter the boiler through the makeup water system. Because typical silica testing does not indicate colloidal silica, it is not detected until it reaches the boiler and decomposes. Troubleshooting sources can be a challenge due to this analytical limitation. Colloidal silica can be a seasonal issue, especially in colder climates when the river turns over.

Streams sampled for silica, including steam, condensate, and demineralized water should flow continuously. When initiating a sample point, it should be flushed for at least one week prior to collecting samples for analysis.

### Recommended Actions

The actions recommended for responding to high boiler water silica are presented in Table 3.