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Water quality guidelines and monitoring requirements for paper mill boilers operating with softened makeup water

Scope

Many paper mill boilers operate with softened water as the primary feedwater makeup source. The guidelines applicable to water treatment programs for paper mill boilers with softened water makeup are provided. Monitoring and sampling procedures to assure maximum reliability are also provided.

Definitions

Feedwater is the water fed to boilers for the purpose of generating steam.

Condensate is the pure water returning from the condensation of steam. It is a portion of the boiler feedwater.

Makeup is the softened water provided to supplement the condensate and provide feedwater to the boiler.

Attemperating water is pure water that is sprayed into superheated steam to control the steam temperature.

Safety precautions

Sampling pressurized process streams such as steam and condensate can be dangerous. Caution is required due to the pressure as well as the high temperatures that may be present in various areas of the boiler feedwater, steam, and condensate systems. Properly designed sample coolers should be employed at all times when sampling pressurized or hot streams.

Introduction

Although most paper mill boilers require high-purity feedwater, a considerable number of systems use softened water as makeup. These systems are primarily systems with boiler operating pressures below 6,895 kPa (1,000 psig) and predominantly below 4,137 kPa (600 psig). For these systems, the makeup water is softened rather than demineralized. This TIP is an adjunct to TIP 0416-03 “Water Quality and Monitoring Requirements for Paper Mill Boilers Operating on High Purity Water” (1).

It is beyond the scope of the paper to specify equipment. However, it should be noted that softened makeup water is normally produced by sodium cycle ion exchange. Precipitation softening followed by sodium cycle ion exchange softening may be used to reduce silica and alkalinity. On occasion, softening followed by reverse osmosis may be used to provide the feedwater quality required (2,3).

The paper recommends water quality guidelines for the various streams found in the boiler area. Considerable attention is given to identifying process sample points for control testing. Monitoring requirements provide the basis for designing and controlling water treatment processes associated with boilers using softened makeup water. Note

TIP Category: Automatically Periodically Reviewed (Five-year review)



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that the specific prescription for a boiler system is dependent upon many variables beyond those presented. The input of a water treatment chemical supplier or consultant is required when establishing monitoring and control practices for a particular boiler system.

Sampling and monitoring water quality

Sampling and monitoring water quality is necessary to confirm system control. This helps to ensure that mill personnel will not discover damage when they inspect equipment. The two primary methods used to monitor water quality are continuous analysis (using continuous analyzer equipment) and grab sample analysis. Continuous analyzers are commonly used to aid in the supervision of utility systems. The coverage provided by continuous analyzers, 24 hours a day/seven days a week, represents a tremendous advantage over grab analysis. Continuous analyzer data can be studied to establish the duration of operation outside control limit specifications. This information can then be used to estimate any damage that may have occurred during the upset condition.

Continuous analyzers do not eliminate the need for grab sample analysis. Grab samples are collected manually and are used to perform bench tests. These bench tests verify the accuracy of the continuous analyzers, which must be calibrated regularly. Finally, grab sample analysis provides useful troubleshooting information when out-of-limit conditions exist.

Selecting sample points

Fig. 1 depicts a typical boiler system using softened makeup water. Suggested sample points are noted. Those sample points where continuous analysis is recommended are differentiated from the locations suggested for grab analysis. It should be noted that sample points recommended for continuous analysis are also subject to grab analysis.

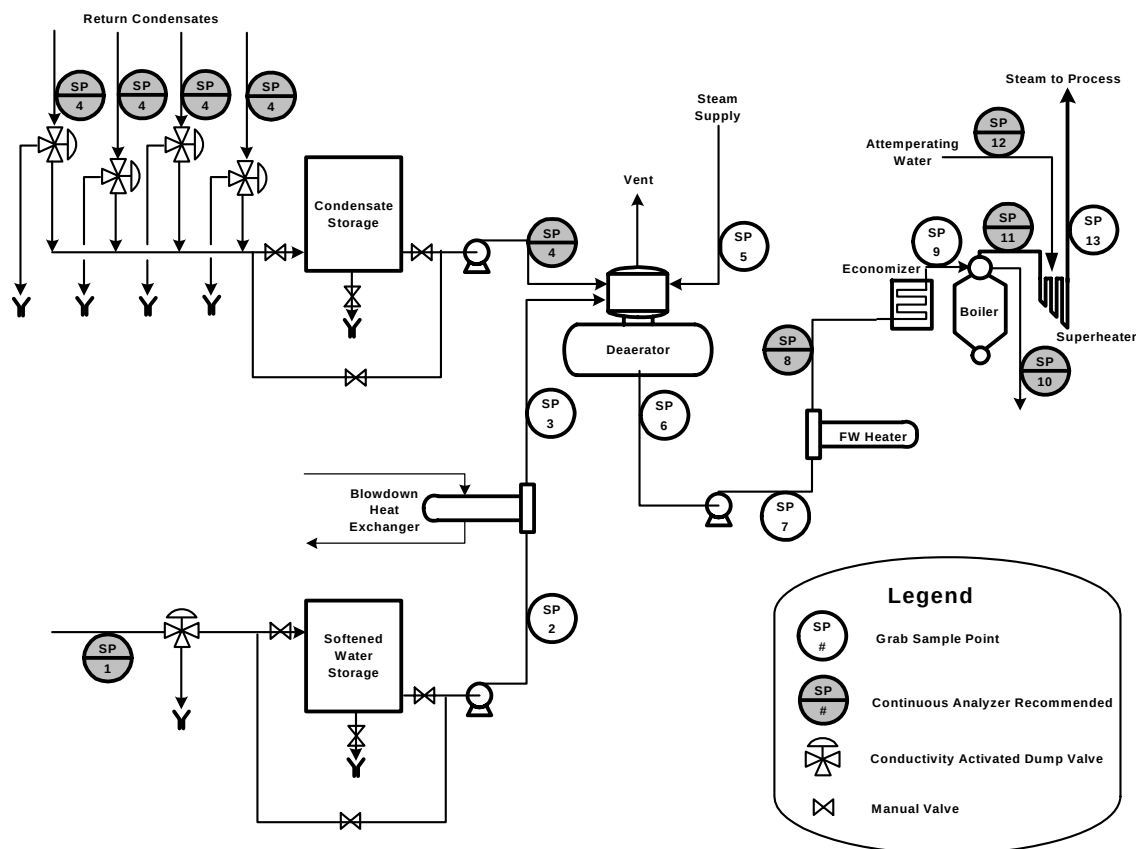


Fig. 1. Typical boiler system with suggested sample points noted

Monitoring sample points

All samples should be collected from continuously flowing streams. This is necessary for the continuous analyzers and is suggested for the grab sample points to ensure accurate representation of the stream being sampled. The sample points shown in Fig. 1, which are needed to accurately ascertain the quality of the feedwater, are:

1. Softened makeup water to storage
2. Softened makeup water from storage
3. Softened makeup water after blowdown heat exchanger
4. Individual and combined return condensate streams
5. Deaerator steam
6. Deaerator storage tank outlet
7. Feedwater after the feedwater pump(s)
8. Feedwater after any closed feedwater heaters and prior to the boiler economizer
9. Boiler economizer outlet
10. Boiler continuous blowdown
11. Saturated steam
12. Attemperating water
13. Superheated steam

Sample points 1, 4, 8, 10, 11, and 12 should be considered for continuous analysis. The results of this continuous analysis should be associated with a data accumulation device, and in most instances, audible alarms should be placed in occupied areas to warn of out-of-limit conditions. Suggested frequencies for grab sampling at sample points recommended for continuous analysis are provided in Table 1.

Table 1. Sample point testing frequency

Sample Point	Sample Identification	Point	Test Parameter	Grab Sample Testing Frequency
1	Softened makeup water to storage		- Total hardness, ppm as CaCO_3 - Conductivity, micromhos	- Every 4 hours - Every 8 hours
4	Individual and combined return condensate streams		- Total hardness, ppm as CaCO_3 - Conductivity, micromhos - Total iron, ppm as Fe	- Every 4 hours - Every 4 hours - Every 24 hours
8	Feedwater after any closed feedwater heaters and prior to the boiler economizer		- Total hardness, ppm as CaCO_3 - Silica, ppm as SiO_2 - Conductivity, micromhos - Total iron, ppm as Fe - pH, units - Oxygen, ppb as O_2	- Every 4 hours - Every 24 hours - Every 8 hours - Every 8 hours - Every 8 hours - Every 8 hours
10	Boiler continuous blowdown		- Total alkalinity, ppm as CaCO_3 - Silica, ppm as SiO_2 - Oxygen scavenger ⁽¹⁾ - Neutralized conductivity, micromhos - Internal treatment ⁽²⁾	- Every 8 hours - Every 8 hours - As prescribed - Every 8 hours - As prescribed
11	Saturated steam		- Sodium, ppm as Na ⁽³⁾ - Conductivity, micromhos	- As prescribed - Every 8 hours
12	Attemperating water		- Sodium, ppm as Na ⁽³⁾ - Conductivity, micromhos	- As prescribed - Every 8 hours

Notes:

- (1) The water treatment chemical supplier or consultant should prescribe the oxygen scavenger and appropriate residual test frequency.
- (2) The water treatment chemical supplier or consultant should prescribe the internal boiler water treatment and the appropriate residual test frequency.
- (3) The water treatment chemical supplier or consultant should provide guidance regarding the necessity and frequency for sodium analysis. The presence of steam turbine generators would suggest that testing is necessary.

Sample points 2, 3, 5, 6, 7, 9, and 13 are all grab sample points. Justification for monitoring these sample points is presented in Table 2.

Table 2. Justification for monitoring grab sample points

Sample point ...	Is used ...
2. Softened makeup water from storage	to confirm no extraneous streams have been introduced into the softened water storage tank.
3. Softened makeup water after blowdown heat exchanger	as a troubleshooting aid to eliminate leaking blowdown heat exchangers as a possible contamination source.
5. Deaerator steam	to eliminate contaminated steam as a source of boiler feedwater contamination. This is a particularly important sample point if deaerator steam is supplied from a boiler blowdown flash tank that could carryover into the flash steam during excessive boiler blowdown periods.
6. Deaerator storage tank outlet	to troubleshoot deaerator performance and to define oxygen scavenger efficiency.
7. Feedwater after the feedwater pump(s)	to identify any air or cooling water ingress associated with the boiler feedwater pumps. (Use in conjunction with sample point 6.)
9. Boiler economizer outlet	to monitor final feedwater quality prior to introduction into the boiler. This sample point is particularly useful to quantify corrosion products entering the boiler and to aid in troubleshooting contaminant rejection from the boiler via boiler blowdown.
13. Superheated steam	to monitor final steam purity prior to any steam turbine generator or sensitive process user

To achieve accurate test results, bench tests on grab samples must be conducted in an appropriate, controlled environment. Continuous analyzers also require adequate protection for reliable service. Proper control of factors such as temperature and humidity along with housekeeping practices, including cleaning glassware and other equipment, cannot be overemphasized.

Sampling methods

Sample collection techniques vary according to conditions and parameters to be monitored. Sample collection equipment is described in the following American Society for Testing and Materials (ASTM) standards:

- D1192-98 Standard Guide for Equipment for Sampling Water and Steam in Closed Conduits
- D1066-97(2001) Standard Practice for Sampling Steam
- D3370-95a(1999)e1 Standard Practices for Sampling Water from Closed Conduits

Copies of these standards are available from ASTM.

Samples must be representative of the system being monitored. To accomplish this goal, the following general recommendations are provided:

- Sample flow should be continuous and cooled to $25^{\circ}\text{C} \pm 1^{\circ}$ ($77^{\circ}\text{F} \pm 2^{\circ}$) when necessary.
- Testing should be conducted as soon as possible after collection.
- Sample lines should be as short as possible, minimizing any lag between a process change and a reflective sample change.
- Sample lines and cooling devices should be constructed of 18-8 stainless steel or a suitable non-reactive substitute.
- Sample line internal diameter should be minimized.
- Sample velocity should be maintained in the range of 1.5 to 2.1 m/s (5 to 7 ft/s).
- When sampling pressurized streams continuously, sample conditioning should include pressure control to maintain steady sample flows.
- When sampling saturated or superheated steam for purity monitoring, special equipment is required. The details of design and installation of this special equipment is presented in ASTM standard D1066-97(2001).