POWER PLANT

WATER CHEMISTRY

A PRACTICAL GUIDE

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PennWell®

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Chapter 2 Condensate/ Feedwater Chemistry

Introduction

The preboiler system of a typical utility steam generating unit (Fig. 2–1) includes a steam surface condenser, several closed tube-in-shell feedwater heaters, a deaerating feedwater heater, and sometimes an economizer. For industrial systems, feedwater heaters, with the exception of the deaerator, are often omitted unless the steam drives a turbine. The preboiler circuit condenses the turbine exhaust steam and prepares the condensate for return to the boiler. The condensation process significantly improves the efficiency of a unit, as is outlined in greater detail in Supplement 2–1 at the end of this chapter.

The potential for contaminant introduction to a steam generating plant is greatest in the preboiler system, especially at the condenser or via condensate return from an industrial process. This makes chemistry control and monitoring of condensate and feedwater extremely important.

601-750 (4.15-5.17)	751-900 (5.18-6.21)	901-1000 (6.22-6.89)	1001-1500 (6.90-10.34)	1501-2000 (10.35-13.79)
<0.007	<0.007	<0.007	<0.007	<0.007
≤0.025	≤0.02	≤0.02	≤0.01	≤0.01
≤0.02	≤0.015	≤0.01	≤0.01	≤0.01
≤0.2	≤0.1	≤0.05	ND	ND
8.3-10.0	8.3-10.0	8.8-9.6	8.8-9.6	8.8-9.6
NS	NS	VAM	VAM	VAM
<0.5	<0.5	<0.2	<0.2	<0.2
<0.5	<0.5	<0.2	<0.2	<0.2
≤30	≤20	≤8	≤2	≤1
<200(3)	<150(3)	<100(3)	NS(4)	NS(4)
NS	NS	NS	ND(4)	ND(4)
1500-300(5)	1200-200(5)	1000-200(5)	≤150	≤80
0.5-0.1	0.5-0.1	0.5-0.1	0.1	0.1

```
160 QCWL=(QFWGPM*NAFW)/(NACW-NAFW)
170 PRINT  "THE RATE OF COOLING WATER FLOW INTO THE CONDENSER = ";:PRINT
USING "###.##";QCWL;:PRINT  " GPM"
```

Case History 2-1

Conditions: Two-pass condenser
Copper-nickel tubing

I had been performing thrice-weekly cleanliness factor analyses on the condenser. The values remained very steady in the mid-70% range for several months, but suddenly within two days dropped to 45%. Waterside fouling does not occur nearly this rapidly. Such changes are more indicative of air inleakage and accumulation of gasses on the steam-side condenser tube surfaces. The maintenance staff was so notified. When the maintenance crew inspected the condenser, they quickly discovered a crack in the condenser shell where a heater drip line entered. Once they welded this crack, the cleanliness factors returned to previous values, where they remained for another two months until suddenly dropping again. The weld had failed. The maintenance crew then welded a collar to the shell, which totally sealed the crack. This cured the problem.

Case History 2-2

Conditions: Two-pass condenser
Admiralty tubing

I had been collecting thrice-weekly cleanliness factor readings on this condenser as well. Rather suddenly, the condenser began performing erratically. At high unit loads, the cleanliness factor ranged between 70% to 75%, but at low unit loads it sometimes dropped as low as 18%. Again, such fluctuations could not have been the result of waterside tube fouling. All evidence pointed to air inleakage, but the source could not be located. Utility managers brought in a leak detection firm, whose personnel used helium leak detection to completely check the condenser and turbine. They classified leaks as large, medium, and small, and found well over a dozen leaks including two large ones, one of which was at the expansion joint between the turbine and the condenser. All leaks were repaired by plant maintenance crews, but this did not solve the problem. Finally, an operator discovered that a trap on the condensate return line from the gland steam exhauster was sticking open at low loads. The trap and line were designed to return condensed gland steam from the subcooler to the condenser, but allow

Supplement 3-1

BASIC Program for Calculating Sodium-to-Phosphate Ratios of Boiler Water

Sodium-to-phosphate ratio monitoring is very important for boilers that are treated with coordinated or congruent phosphate. Chemists must maintain the ratios within relatively narrow guidelines to properly control the boiler water chemistry. The BASIC program on page 77 provides a simple and efficient method for determining these ratios. The only inputs needed are pH and phosphate concentrations (ppm), however, ammonia may significantly affect the calculations.

The calculations first appeared in the November 1986 issue of ***Power Engineering*** magazine, and the computer program then appeared in the May 1992 issue of this magazine. Since the publication of these two articles, utility personnel and researchers have become much more aware of the effect of ammonia on boiler water pH. At the 1996 International Water Conference, George Verib of Ohio Edison presented an excellent paper on boiler water treatment, part of which discussed ammonia and its relation to sodium/phosphate ratios. Ammonia can have a very significant effect on the calculations, especially in higher pressure units where the sodium-phosphate concentrations are low. Ohio inspection. The edges of the turbine blades exhibit an abraded pattern. This problem can become more acute in cycling units because frequent startups, shutdowns, or load changes impart additional stress to the tubes.

Superheater/reheater exfoliation is mostly a mechanical phenomenon, and a chemical cleaning of the tubes may be necessary to remove the fractured magnetite layers. Superheater chemical cleaning is not simple, and requires temporary piping, well thought out procedures, and the services of a reliable chemical cleaning firm. However, superheater/reheater cleaning may still be cost effective if SPE is a severe problem. For boilers with drainable superheaters, it is possible to remove some of the exfoliated material by water washing.

Steam Chemistry Monitoring

Steam chemistry monitoring and sample analyses are quite important. Prime sample locations include reheat steam (or main steam for boilers without reheaters) and saturated steam. The former sample allows the plant chemist to monitor steam conditions after the attemperator. The appropriate parameters for analysis include those constituents outlined in Table 4-2. On-line analyses are recommended for sodium, cation conductivity, silica, and possibly chloride, with grab sample analyses for sulfate and TOC. Continuous sampling of saturated steam serves as a good backup to the main/reheat sample, and is the primary sample when main or reheat sampling is unavailable.

Steam Chemistry Issues at Industrial Plants without Turbines

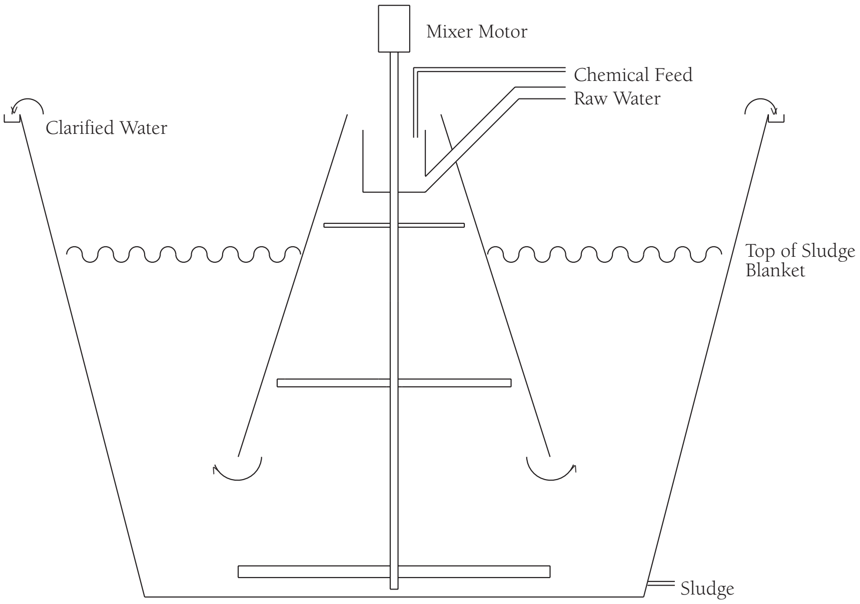
Where steam is used for industrial processes without driving turbines, carryover issues are still important, but may be influenced by somewhat different factors than those for utility units. Many of these have been discussed in chapter 2. Boiler water and steam chemistry monitoring are still important, especially for boilers with superheaters. Carryover can easily cause severe deposition in the superheaters with resulting tube failures. The ASME guidelines outlined previously in Tables 2–3 through 2–5 provide good guidelines for feedwater and boiler water chemistry. Monitoring should at least include on-line sodium or degassed cation conductivity. Proper training is also important. I have been to facilities where the operators knew how to perform standard chemical tests, but did not know what the results indicated. Steam chemistry was a mess, but the operators were taking accurate readings! Training must not only include the "how" of water chemistry monitoring, but also the "why."

One of the most important issues regarding industrial steam generation is the effect of steam purity on condensate produced later on in the process. Boilers lent chlorine scavenger, but if the system contains no carbon filters, some other method of oxidant removal is required. Most commonly, a dehalogenating or reducing agent (sodium sulfite or sodium bisulfite) is injected ahead of the demineralizer or reverse osmosis unit to protect the equipment.

Clarification and Softening

Clarification and softening are often carried out in a single process unit, and Figure 5-2 outlines a simplified version of a common clarifier configuration. The water may first be allowed to pass through a grit or settling chamber to allow large particles to settle on their own. Many particles, however, are truly suspended and will stay in the water indefinitely. These particles tend to develop a negative electrical charge, which keeps the solids separated and in suspension. A two-stage process, coagulation-flocculation, is employed in the clarifier to bring the particles together in a settleable solid. In the first step, a coagulant is added for charge neutralization. The coagulant may be an inorganic salt such as aluminum sulfate [$Al_2(SO_4)_3 \bullet 18H_2O$], sodium aluminate ($Na_2Al_2O_4$), ferrous sulfate [$Fe_2(SO_4) \bullet 9H_2O$], or ferric chloride ($FeCl_3$). These salts dissolve in water to produce positively charged cations that neutralize the negative charge on the suspended solids and allow them to draw together. Cationic organic polymers,

Figure 5-2



Simplified Clarifier Design.