

Nitrogen Sparging and Blanketing of Water Storage Tanks

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In many industrial processes, including most utility and industrial steam systems, good deaerated makeup and condensate water is stored in open-to-air storage tanks where it is contaminated by oxygen, carbon dioxide (CO₂), and dirt before it is used. This contamination can be prevented by nitrogen sparging and blanketing of storage tanks.

To protect steam generation and other water and steam-handling equipment against corrosion,¹⁻⁷ the concentration of corrosive impurities must be low.

Two frequent cycle contaminants are oxygen and carbonates (including carbonic acid [H₂CO₃]); only low ppb concentrations can be tolerated. High oxygen causes general and pitting corrosion of carbon and low-alloy steels and copper alloys and—in interaction with chlorides—pitting, stress corrosion, and corrosion fatigue of stainless steels (SS). Carbonates contribute to the corrosion and, by reducing pH, can cause erosion-corrosion.

Currently, after outages, many boilers and preboilers, and other industrial systems, are filled with aerated water. During operation, aerated makeup water is added to the condenser, to the deaerator, or elsewhere. This water,

which is exposed to air in vented storage tanks, contains high concentrations of carbon dioxide (CO₂), carbonates, and oxygen. At equilibrium with air at room temperature there are ppm concentrations of CO₂ (that depend on pH) and 8 ppm of oxygen in the water.

Dosing the tanks with ammonia (NH₃) and hydrazine (H₂NNH₂) may reduce the oxygen concentration, but it increases ~10-fold the concentration of carbonate, because it leads to formation of ammonium carbonate in this ammoniated water. When this water is pumped into the system and heated during startups the ammonium carbonate breaks down, elevating the concentration of H₂CO₃ and reducing the pH of the feedwater, boiler water, and steam condensate. In room-temperature laboratory samples, an alkaline pH is misleading because it does not represent the actual pH at the temperatures and the two-phase conditions of the cycles. These problems have been recognized for some time⁸⁻⁹ but, except for nuclear units, little has been done to fix them.

Filling the Boiler and Preboiler

Filling the boiler and preboiler with aerated water results in large changes in pH and oxygen concentration and increased corrosion. The altered pH and oxygen concentration influence the solubility of iron and copper oxides. Solubility is high at low pH_i (pH at temperature) and low at high pH_i. During startup and normal operation, CO₂ is driven out. The oxides that dissolved after the boiler fill and warm-up then precipitate and form deposits. A high concentration of oxygen and low pH during the startup period enhance corrosion of the economizer and other components, generating additional corrosion products. The corrosion products later deposit, mostly in the boiler. Where the oxygen is mechanically or chemically scavenged,

the reduced pH can lead to flow-accelerated corrosion of carbon steel, particularly in the high flow velocity and wet steam areas.^{5,6}

Aerated Makeup Addition During Operation

Periodic addition of makeup into the condenser hotwell or a deaerator results in variations of oxygen concentration, pH, and conductivity, which also can influence system corrosion. Figure 1 gives an example of the effects of aerated makeup on oxygen concentration in the condensate. The makeup water temperature also influences the oxygen concentration.⁸

Exhaustion of Condensate Polishers

Adding aerated makeup during startups and operation causes fast exhaustion of condensate polishers by carbonates, and elution of the already exchanged impurities. This is especially a problem in steam cycles with high makeup requirements, such as in cogeneration cycles.

Contamination with Dirt

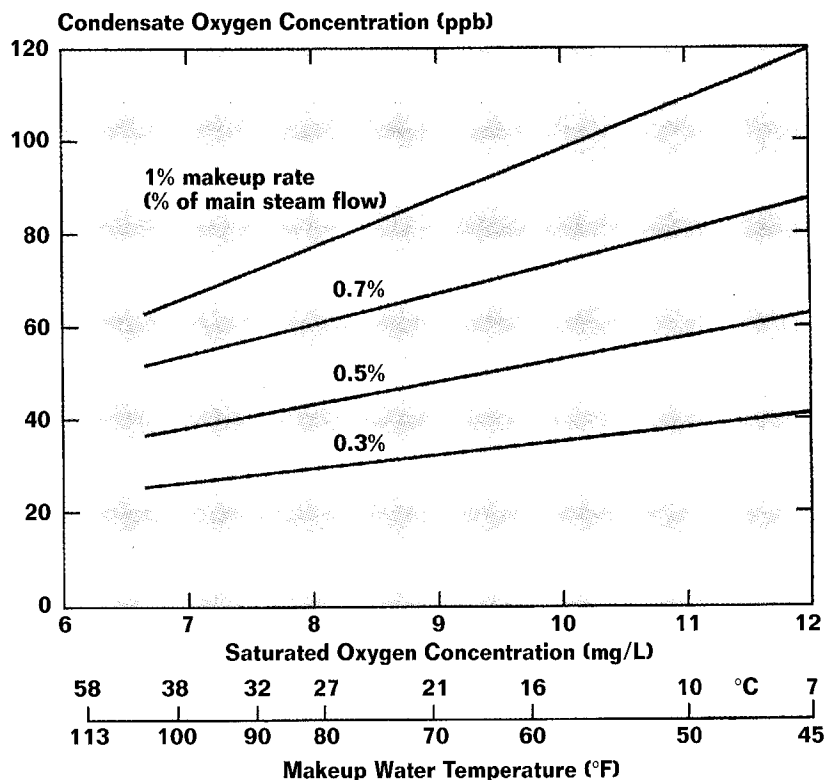
In the storage tanks, if the air vent is not equipped with a filter, dust and organic material from the environment can be sucked into the tank during water withdrawal. This may result in contamination of water by silica (SiO₂), alumina (Al₂O₃), and other inorganic and organic impurities. It also may result in organic growth in the tank.

Nitrogen-Sparging and Blanketing System

The above problems can be eliminated by protecting the stored water from exposure to air, which can be accomplished by nitrogen sparging and blanketing of storage tanks.

Figure 2 is a schematic diagram of a nitrogen system design: tank with the nitrogen bottom sparger (A), inlet pipe sparger (B), tank pressure control and vent (C), nitrogen supply and controls

FIGURE 1



Effect of air-saturated makeup on condensate oxygen level.⁹

(D), an overflow pipe (E), and an oxygen or conductivity analyzer (F). The sparging is through sintered SS sparging elements. The nitrogen pressure to the spargers is controlled by two pressure regulators: one for the bottom sparger and one for the inlet pipe sparger. The length of the sparging time is based on oxygen concentration at the bottom of the tank or conductivity (mostly elevated because of CO₂).

Nitrogen-Sparging and Blanketing Advantages

- Filling the boiler, deaerator, and feedwater system with deaerated water containing low concentrations of oxygen and CO₂ leads to minimization of iron and copper oxide scale and corrosion, faster startups (less iron and copper holds), and lower frequency of boiler chemical cleaning.

- Using deaerated makeup reduces exhaustion of condensate polishers by carbonates.

- There is no need for auxiliary steam for deaerators during startups, resulting in saved energy.

- Use of oxygen scavengers is reduced, leading to less environmental impact, reduced organic breakdown products (organic acids and CO₂), and lower costs.

- Storage tank contamination by dust, organic growth, and the resultant need for cleaning are eliminated.

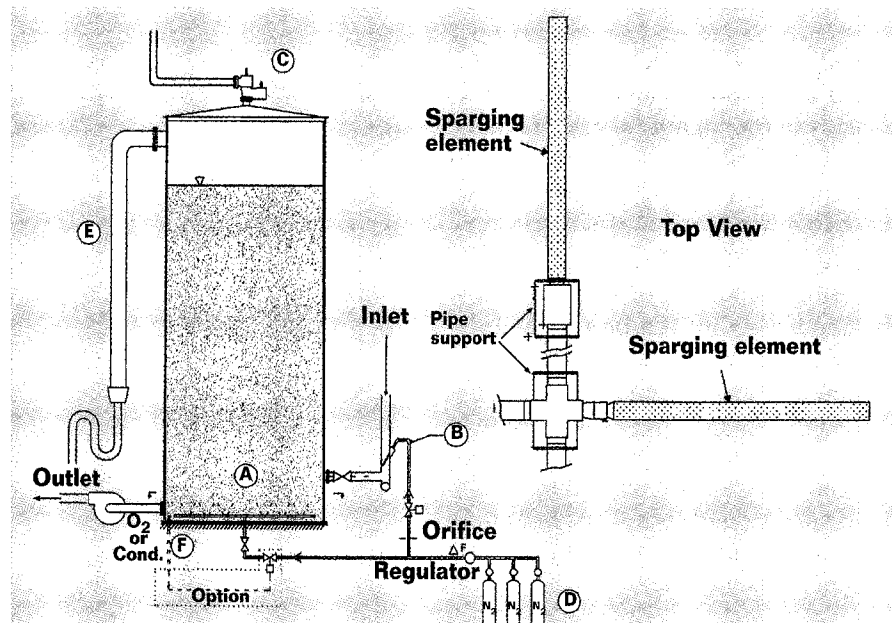
- Online deaeration of the incoming water results in low nitrogen consumption.

Anticipated Performance

A nitrogen-sparging and blanketing system will maintain oxygen concentration in water storage tanks at <300 ppb and conductivity at <1 μS/cm. These parameters are maintained during pumping in, pumping out, and water storage without pumping, even when the tank capacity is exceeded and a larger volume of water is re-

Chemical Treatment

FIGURE 2



A storage tank nitrogen system and sparging elements.

quired. As a result, generation and transport of corrosion products can be reduced by a factor of 2 to 5.

References

1. ASME Handbook on Water Technology for Thermal Power Systems (New York, NY: ASME, 1989).
2. O. Jonas, "Transport of Chemicals in Steam Cycles," CORROSION/85, paper no. 245 (Houston, TX: NACE, 1985).
3. Cycling, Startup, Shutdown, and Layup Fossil Plant Cycle Chemistry Guidelines for Operators and Chemists, TR-107754 (Palo Alto, CA: EPRI, 1988).
4. D.N. French, Metallurgical Failures in Fossil Fired Boilers, 2nd ed. (New York, NY: Wiley, 1993).
5. Flow-Accelerated Corrosion in Power Plants (Palo Alto, CA: EPRI, 1986).
6. O. Jonas, "Control Erosion/Corrosion of Steels in Wet Steam," Power, A. 102, March 1985.
7. O. Jonas, et al., "Copper Deposition and MW Loss Problem Solutions," 57th International Water Conference, Pittsburgh, October 1996.
8. Y.H. Lee, D.M. Sopocy, MP 24, 3 (1985).
9. Guide to the Design of Secondary Systems and Their Components to Minimize Oxygen-Induced Corrosion, NP-2294 (Palo Alto, CA: EPRI, March 1982).

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