

**Abstracts****The Behaviour of Ammonia, Amines, Carbon Dioxide and Organic Anions during Condensation in an Air Cooled Condenser**

Geoff J. Bignold

Air cooled condensers are being used increasingly frequently in new plants, not only in arid locations where supplies of large quantities of cooling water are absent, but also in many places where restrictions are being imposed on the issue of licences for abstraction of water for cooling applications. It is economically important to achieve the lowest practicable steam temperature and pressure in order to maximise the efficiency of the steam turbine. Heat transfer from the condensing steam to air, with only a small temperature difference, requires an air cooled condenser (ACC) with very large areas of finned tubing, which is normally made of carbon steel. Even with very modest corrosion rates, the very large area of steel can contribute a significant amount of iron to the condensate, and this can be a major source of iron rich deposits accumulating in the boiler plant.

The corrosion processes occurring in a steel air cooled condenser will inevitably be influenced by the chemistry of the condensate, which changes as the condensation process proceeds.

In a circuit where alkalinity is provided by the presence of ammonia, the early stages of condensation in the ACC will have a relatively low ammonia concentration in the liquid phase and correspondingly low pH. Any organic anions such as acetate or formate found in the steam will suppress the pH further. Carbon dioxide will also have this effect. Thus it is the upstream ends of the ACC tubes that will be expected to contribute most to the iron level in condensate. As steam passes further along the condenser tubes, the pH in the condensate rises, so that any dissolved iron may become supersaturated and some particulate iron is produced.

If the steam contains an amine with a distribution coefficient that favours the water phase, then the water in the early stages of condensation may have an appreciably higher pH and the loss of iron from steel surfaces may be suppressed. However, the interactions are complex. Amine decomposition elsewhere in the circuit is likely to cause the concentrations of carbon dioxide and organic anions in the steam to rise, and these will be less volatile in the condenser and consequently more difficult to expel from the circuit. An initial approach to understanding these interactions is set out in this paper.

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**Southern Company's Approach to Cycle Chemistry**

S. Ronnie Pate, Sam J. McChesney, and Randy C. Turner

The Southern Company has long sought to develop water chemistry treatment philosophies and out-of-specification actions that ensure long-term operations and availability of the fossil-fueled steam units. This has been accomplished by utilizing the best known science from world class chemists, both academic and from original equipment manufacturers, and from organizations such as the Electric Power Research Institute (EPRI), as well as the personal experience of the chemistry practitioners. This paper explains the results sought and basic steps on how to achieve these ends. Some of the concepts covered include minimum qualifications for plant chemists, chemistry control philosophies, and annual peer reviews, including EPRI Benchmarking of each unit's chemistry program.

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**Water Chemistry Control of an Ultra-Supercritical Boiler – Avedøre Unit 2**

Jørgen P. Jensen, Katrine Nielsen, and Christian N. Ottesen

Avedøre Unit 2 is an ultra-supercritical boiler with an integrated steam cycle that includes a biomass boiler and two heat recovery steam generators. The unit is only equipped with a condensate polishing capacity of 14 % at full load. This results in chemical excursions during startup of the boiler, when salt deposits are washed off the turbine. Initiatives are being taken to eliminate a high content of impurities in the condensate and feedwater at startup.

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**Minimizing Levels of Volatile Organic Acids and Carbon Dioxide in Steam/Water Circuits**

Michael A. Sadler and Kevin J. Shields

Low concentrations of weak organic acids such as acetic and formic acids are commonly found in water sampled from the steam/water circuits of boilers and steam generators. The debate concerning their influence on corrosion in these circuits continues, but there is agreement that their presence is a nuisance and if reasonably possible levels of these impurities in steam/water should be minimized. The main origin of these volatile organic acids has been shown to be traces of more complex organic impurities present in makeup water. Improved techniques of deionization such as the use of reverse osmosis will significantly reduce the organic contaminant levels in makeup water. There is clear evidence that levels of weak organic acids can be effectively removed from the steam/water circuit by the use of condensate polishing operating in its conventional H-OH mode. Polishers operating in the economical ammonium form will in most cases also successfully control these impurities, but, in some circumstances, difficulties could arise, so care in monitoring their performance is recommended.

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**The Behaviour of Natural Organic Matter in Water Treatment and the Water/Steam Cycle: Deeper Insights**

Stefan A. Huber

The paper focuses on specific components of natural organic matter (NOM) whose molecular charge densities are too low to allow efficient removal by ion exchange. This fraction of NOM is mainly polysaccharidic in nature. It does not contribute much to conductivity in the makeup water, but in the water/steam cycle the reaction products are decomposed to organic acids (pathway: polysaccharides → monosaccharides → organic acids → carbon dioxide). In the past, non-ionic NOM was largely overlooked because it was not accessible to analytical techniques. Only recently has a new technique, called LC-OCD (liquid chromatography – organic carbon detection), allowed rapid identification and quantification. The paper describes in detail the behaviour of polysaccharides during pre-treatment, demineralization and in the water/steam cycle. Strategies on how to remove polysaccharides in the makeup water are also presented.

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**The Influence of Temperature on the Removal of Organics from Natural Waters by Ion Exchange – Laboratory and Pilot Plant Experiments**

Volker Ender, Björn Kettner, Thomas Schumann, and Sigrun Hajdamowicz

In laboratory and pilot plant experiments we investigated the influence of temperature on the removal of organics from natural waters by ion exchange resins and three types of scavenger resins. The temperature was varied during the loading phase as well as during the regeneration process (20 °C, 30 °C, and 40 °C in the laboratory experiments; 30 °C, 40 °C, and 50 °C in the pilot plant). The water quality was analysed using the liquid chromatography – organic carbon detection (LC-OCD) method.

The following main results were found:

- Neither the variation in the loading temperature nor the variation in the regeneration temperature could influence the removal of total organic carbon (TOC) before the breakthrough point. The reaction enthalpy of the removal of TOC from natural waters by ion exchange resins is therefore about zero.
- A higher loading temperature leads to a later TOC breakthrough point. Higher regeneration temperatures give better TOC regeneration rates.
- The most important potential for the improvement of the retention of organic matter by ion exchange resins is a better understanding of the relation between TOC ion exchange and the adsorption mechanisms regarding their individual fractions. This seems to be valid especially for the hydrophobics fraction.

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