Sodium Monitoring On Power Plant

TECHNICAL NOTE

Introduction

Extensive on-line chemical monitoring of both the water/steam cycle and the water treatment plant on modern power stations, is now a very well established practice. This enables careful control of the water chemistry to achieve peak efficiency and minimise downtime due to excessive boiler corrosion or scaling.

Sodium is one of the most important parameters to be measured on boiler plant. Although conductivity measurement has been traditionally used to indicate total dissolved solids or chemical contamination, it lacks adequate sensitivity. Sodium is present in the critical dissolved compounds which include chlorine (Cl^-) and sulphate (SO_4^{2-}) which are found in surface water used for cooling and water treatment.

Unfortunately, on-line chloride monitors are unable to reach the low concentrations required, and on-line sulphate monitors are currently not available. These parameters can be detected indirectly using an on-line sodium monitor which is very sensitive and is an established measurement technique.

This Technical Note highlights typical sample points for on-line sodium monitors found on power stations and describes the information that the measurement provides.

What is sodium?

Sodium is the sixth most abundant element on earth. Although it is a metal, it is very reactive, and never found free in nature. Sodium occurs in large quantities in comparatively few compounds, the most common of which is sodium chloride. Typical levels of sodium in river water would be approximately 30mgkg^{-1}, and in sea water, approximately 12,000 mgkg^{-1}.

Nearly all sodium compounds are water soluble, and in the high purity waters (i.e. very dilute solutions) found in power generation plants, these compounds are dissociated into ions. In the case of sodium chloride (NaCl), into cations (positive sodium ions Na^+), and anions (negative chloride ions Cl^-).

Sample Points

The typical sample points for chemical monitoring are as shown in Figs. 1 to 3. Details of specific sample points, where on-line sodium monitoring is carried out, are as follows:

① - Cation Exchange Bed Outlet – Water treatment Plant

The function of the Cation Exchange Bed is to exchange cations (positively charged dissolved solids) in the water, with hydrogen ions (H^+) in the resin. Cations found in raw water include calcium (Ca^{2+}), magnesium (Mg^{2+}), ammonium (NH_4^+), potassium (K^+) and sodium (Na^+).

Ion exchange resins are more efficient at exchanging divalent ions (e.g. Ca^{2+}, Mg^{2+}) than monovalent ions (e.g. K^+, Na^+).

This process takes place until all the hydrogen ions on the resin are removed, known as bed 'exhaustion', when the level of cations will rise in the water from the bed outlet. This is known as 'breakthrough'. Since monovalent ions break through first, monitoring sodium will indicate exhaustion of the resin much earlier than measurements such as conductivity. At this point the bed is regenerated by passing acid through it, to reinstate the hydrogen ions on the resin.

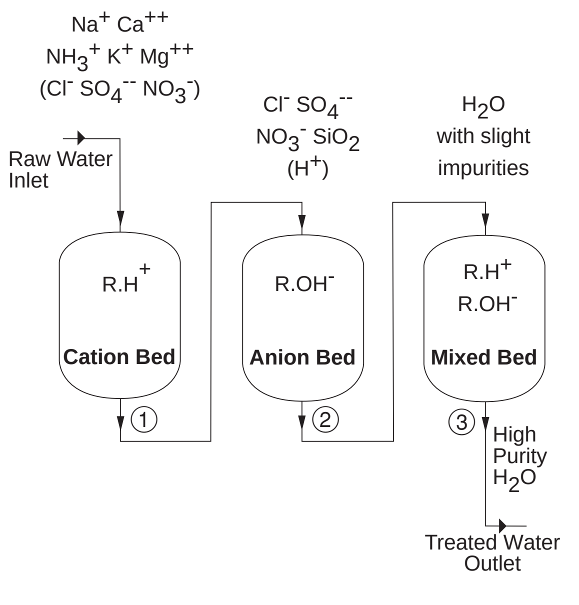

Fig. 1 Complete Demineralisation Process

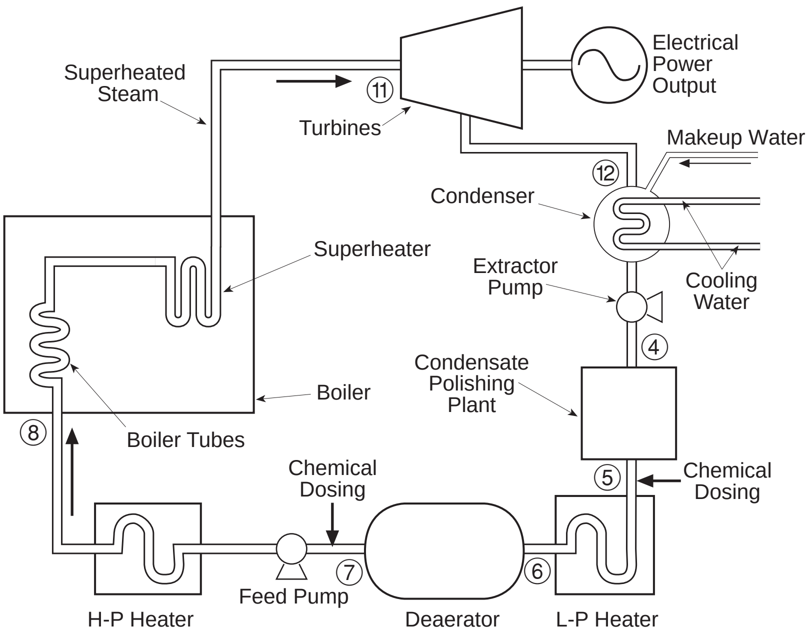

Fig. 2 Typical Generating Station Steam/Water Cycle for a Once-through Boiler

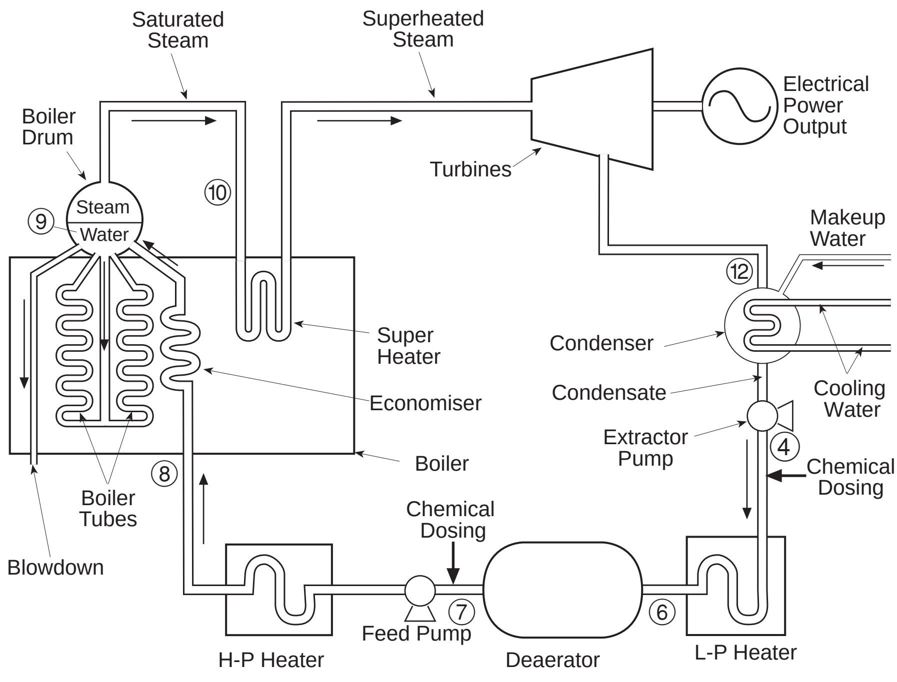

Fig. 3 Typical Generating Station Steam/Water Cycle for a Drum Boiler

③ – Mixed Bed Outlet – Water

The Mixed Bed contains a mixture of both cation and anion exchange resins to reduce the dissolved solids concentration further, and so produce the required treated water quality, which is then used as 'make-up' in the water/steam cycle.

Here, sodium monitors are again used to monitor the final water quality, and detect exhaustion of the cation exchange resin.

④ – Extraction Pump Discharge

The condenser is operated under high vacuum and is therefore susceptible to the ingress of cooling water into the condensate, due to leaks. The main concern is the ingress of chloride and sulphate, which are mainly in the form of sodium chloride and sodium sulphate. The on-line measurement of sodium, after the extraction pump, gives an indication of condenser leaks, with the added advantage of between 10 to 100 times the sensitivity of on-line chloride measurement techniques.

⑤ – Polishing Plant Outlet

The polishing plant is used mainly on Once Through type boilers to reduce chemical contamination, which is far more critical on this type of boiler. Because a polishing plant is similar to a water treatment plant, sodium monitors can be used again to detect resin exhaustion and monitor water quality.

On some power stations the polishing plant is incorporated into the main water treatment plant.

⑩ and ⑪ – Steam

Chemical contamination concentrates quickly in the drum on high pressure boilers, and may be carried over in the steam delivered to the turbine. Once again, sodium monitoring provides a good indication of the overall steam purity level required to minimise corrosion and avoid deposition of sodium salts on the superheater and turbines. Where this takes place in the boiler, it is known as 'hide-out'.

Comparisons of sodium readings taken from the saturated steam before the superheater and the condensate, allows greater evaluation of the changes taking place in the system e.g. deposition of sodium salts or condenser leaks.

The same measurement can be carried out on Once Through boilers, but because there are no separate superheaters, the sample is taken from the superheated steam before the turbine.