Application Note AN-PAN-1042

Online trace analysis of anions in the primary circuit of nuclear power plants

Water-steam circuits in fossil and nuclear power plants are inherently prone to corrosion, as metal components are constantly in contact with water. Measures to monitor or prevent corrosion are crucial in this context. In nuclear power plants, pressurized water reactors (PWR) are generally designed with a third water circuit in addition to the two found in conventional thermal power plants. In this so-called «primary circuit», the primary coolant water is pumped under high pressure to absorb heat generated by nuclear fission, further transferring this heat to the secondary circuit. The PWR ensures that radioactive materials remain contained and do not disperse to the secondary circuit and therefore potentially to the environment. This additional water circuit entails some specific requirements regarding chemical analysis and monitoring.

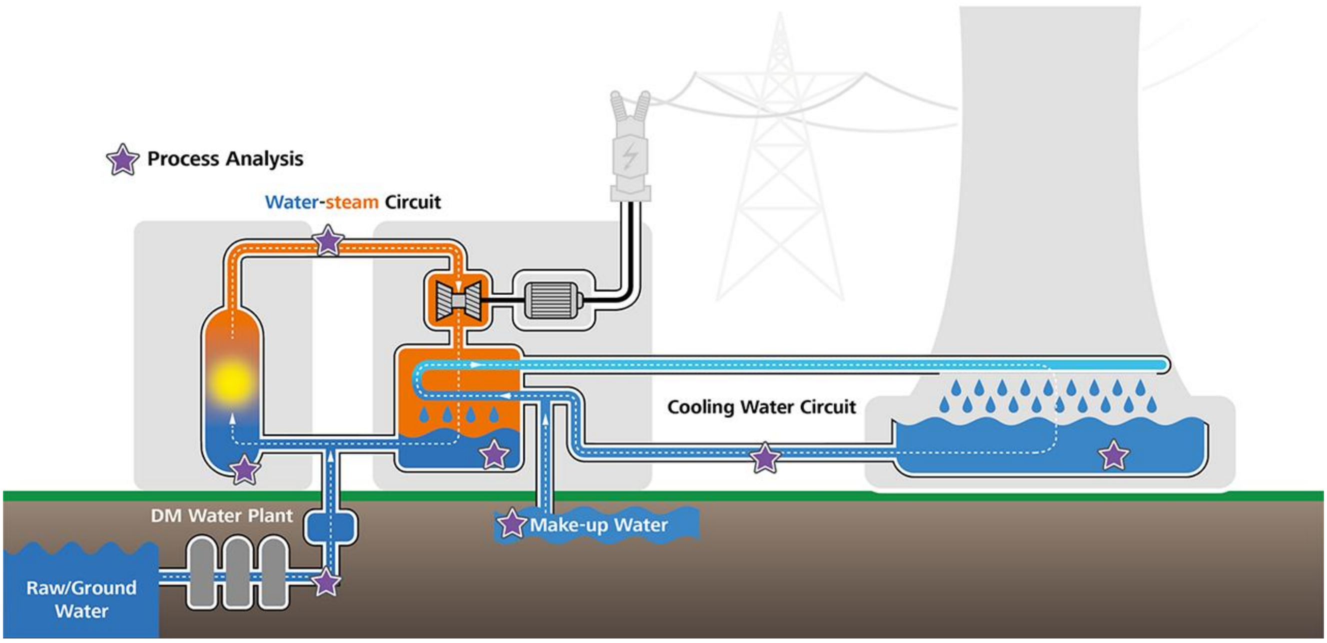

Figure 1. Diagram of a 3-water circuit nuclear power plant with stars noting areas where online process analysis can be integrated into the system.

Anions corrode metals under high temperature and pressure; therefore, their concentrations must be monitored at all times. Since even traces can have devastating consequences, it is essential to use an analysis method that is appropriately sensitive. The analytical challenge in the primary circuit is detection of anions in the µg/L range alongside gram quantities of boric acid (H_3BO_3) and lithium hydroxide (LiOH). In addition to the standard anions – fluoride, chloride, nitrate, and sulfate – important organic degradation products such as glycolate, formate, and acetate can be present, indicating defective ion exchangers that are used to condition the boiler feed water. Phosphates are often added in order to prevent corrosion. Phosphates form corrosion-resistant protective films on metal surfaces, and cracks and defects are phosphatized in their presence. For this reason, it is often necessary to monitor the phosphate concentration as well.

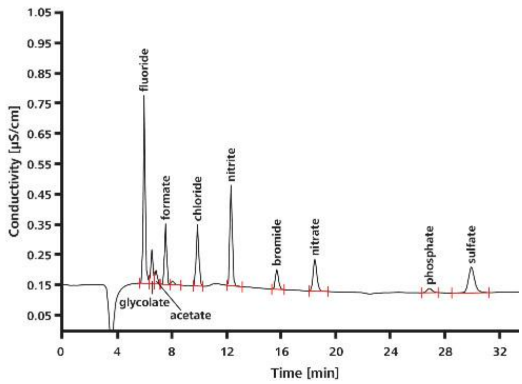

Figure 2. Water sample from the primary circuit of a pressurized water reactor containing 2 g/L H3BO3 and 3.3 mg/L LiOH spiked with 2 µg/L anions; preconcentration volume: 2000 µL

APPLICATION

Precise, reliable trace analysis requires the method to be automated as much as possible. Metrohm Process Analytics offers a complete solution for this task: the 2060 Ion Chromatograph (IC) Process Analyzer featuring combined Inline Preconcentration and Inline Matrix Elimination. With one injection, the 2060 IC is able to measure numerous ionic compounds in aqueous media from ng/L to % concentrations. The analysis system is fed directly and continuously with samples via a bypass in the process. Automatic calibration guarantees excellent detection limits, a high reproducibility, and excellent recovery rates.

The 2060 IC Process Analyzer provides alarms if preset warning or intervention concentration limits are reached, helping to save costs by preventing irreparable damage due to corrosion. The 2060 IC Process Analyzer can monitor both anions and cations, giving a comprehensive overview of the water circuit chemistry. The possibility to connect one analyzer to up to 20 sample streams means multiple areas within water-steam circuits in a power plant can be monitored by a single instrument. With a built-in eluent production module and optional PURELAB® flex 5/6 from ELGA® for pressureless ultrapure water, the 2060 IC Process Analyzer can be configured to run trace anion analyses autonomously for up to several weeks.

The analysis is carried out fully automatically using a combination of Inline Matrix Elimination (for the H_3BO_3) and Inline Neutralization (for the LiOH). Analyte detection is by conductivity.

Figure 3. The 2060 IC Process Analyzer is available with either one or two measurement channels, along with integrated liquid handling modules and several automated sample preparation options.

REMARKS

Analyzing these trace anions allows the parallel determination of chromate, which is a potential corrosion product.

BENEFITS FOR IC IN PROCESS

- **Inline eluent preparation** ensures consistently stable baselines
- **Safe working environment** and automated sampling
- Protect valuable **company assets** (e.g. pipes, PWR, and turbines, which are prone to corrosion)
- **High precision analyses** for a wide spectrum of analytes with multiple types of detectors

FURTHER READING

Related application notes

AN-S-306 - Trace anions including chromate in water-steam cycle of a boiling water reactor (BWR)

AN-Q-006 - Online analysis of trace anions in borated water of a pressurized water reactor (PWR)

Other related documents

8.000.6071EN Trace-level determination of anions in the primary circuit of a PWR-type nuclear power plant using ion chromatography after inline sample preparation

CONTACT

Metrohm Brasil
Rua Minerva, 161
05007-030 São Paulo
metrohm@metrohm.com.br