



Application Note AN-PAN-1042

核电站单次回路中阴离子的在线痕量分析

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.

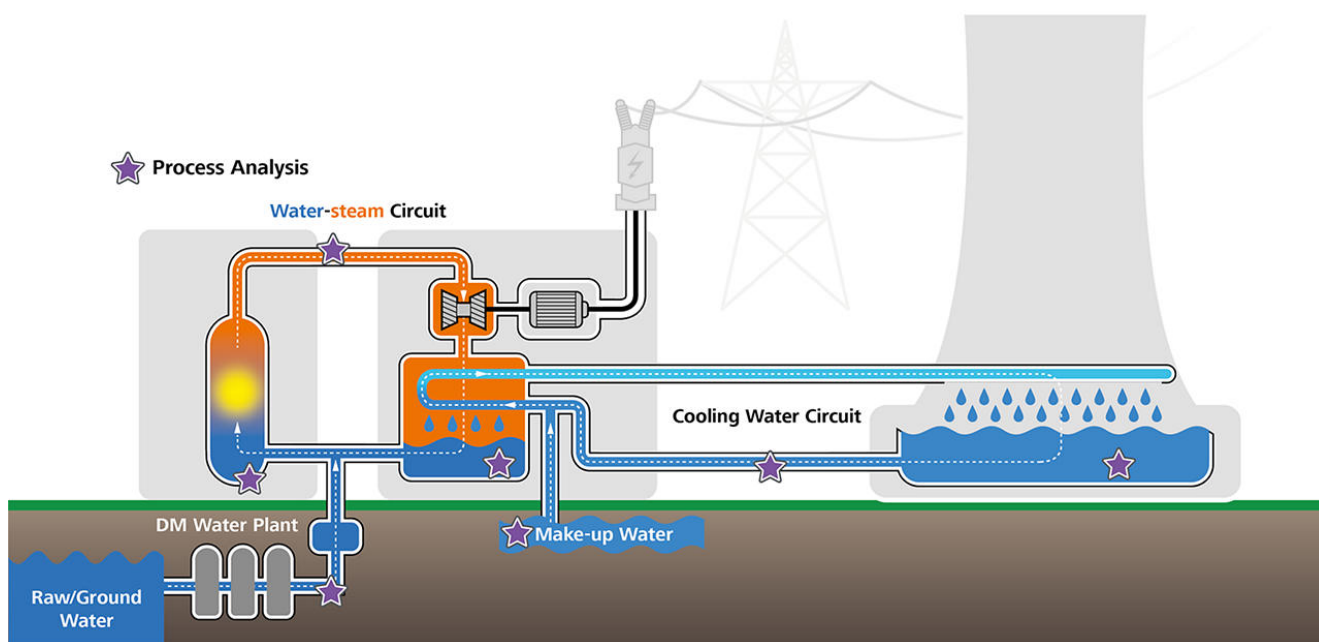


Figure 1. Diagram of a 3-water circuit nuclear power plant with stars noting areas where online process analysis can be integrated into the system.

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 $\mu\text{g/L}$ 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.

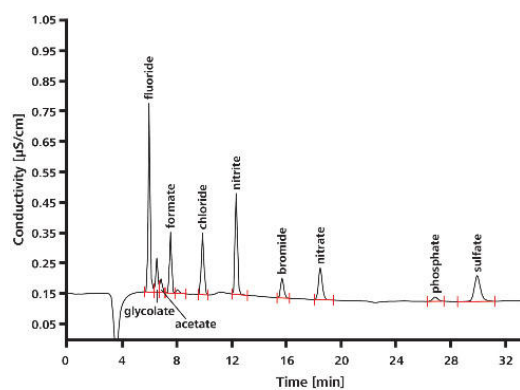


Figure 2. Water sample from the primary circuit of a pressurized water reactor containing 2 g/L H_3BO_3 and 3.3 mg/L LiOH spiked with 2 $\mu\text{g/L}$ anions; preconcentration volume: 2000 μL

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.

REMARKS

Analyzing these trace anions allows the parallel determination of **chromate**, which is a potential

corrosion product.



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.

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 boric acid solution 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](#)

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CONFIGURATION



2060 IC Process Analyzer

Metrohm Process Analytics 的 2060 Ion Chromatograph (IC) Process Analyzer 基于模块化 2060 平台概念。这种模块化的体系结构可将机柜分开在工厂周围的不同位置,并可连接多达 20 个样本流,从而可在工厂内部的多个区域进行省时的顺序分析。

此分析仪在硬件、软件和应用定制方面没有限制。从连续淋洗液生成模块、用于样品预滴定的取样部模块以及多个 IC 检测池,2060 IC Process Analyzer 具有任何工业应用需要的所有选项。

2060 软件是一种 "多合一" 软件解决方案,可控制分析仪执行常规分析,并有不同的操作方法、时间表和趋势图。此外,由于过程通信协议多种多样(例如 Modbus 或 Discrete I/O),可对 2060 软件进行编程,以向过程发送自动反馈和警报,并必要时采取行动(例如,重新测量样品或开始清洁周期)。所有这些功能可确保每周 7 天全天候对工业过程进行全自动诊断。