



Application Note AN-PAN-1013

Online analysis of boric acid in the cooling water of pressurized water reactors

Boric acid is used to absorb neutrons in the primary circuit of pressurized water reactors (PWR) of nuclear reactors, thus controlling the reactor's reactivity. Therefore, near-continuous monitoring of boric acid concentrations is crucial. Boric acid is typically monitored by manual laboratory analysis methods, but these are time-consuming and prone to human error. However, fast, reliable, online analysis is possible with the 2060 TI Process Analyzer. This Process Application Note discusses the online

analysis of boron in nuclear PWRs. The 2060 TI Process Analyzer's adaptive software, IMPACT, automatically switches between various burets, each with a different titrant strength depending on the boric acid concentration to maintain optimal accuracy across the entire measurement range. When integrated with the chemical and volume control system (CVCS), real-time monitoring enables early detection and mitigation of potential boric acid concentration issues, optimizing reactor control for safe and efficient operation.

INTRODUCTION

Approximately 9% of global electricity comes from nuclear energy sources [1]. Pressurized water reactors (PWRs) are one of the most common types of nuclear reactors for electricity generation purposes [1]. The safe and efficient operation of PWRs is critical to ensure a reliable energy supply while also protecting the environment.

In these PWRs, boric acid (B-10 isotope, ^{10}B) is added to the primary coolant to regulate the nuclear reaction. Boron effectively absorbs neutrons, preventing them from sustaining the fission process. By adjusting the concentration of boric acid in the coolant, operators can precisely control the reactor's power output.

Boron is carefully controlled within the primary and secondary circuit (Figure 1). While these circuits are

designed to be highly contained, potential risks such as accidents, leaks, or spills could lead to the release of contaminated water into the environment, ultimately impacting nearby water sources.

The boron concentration in the primary coolant varies from 0 to 2,000 mg/L or more, depending on the stage of the fuel cycle [2]. This is significantly higher than the maximum recommended level for drinking water, which is 2.4 mg/L according to the World Health Organization (WHO) [3], and 1 mg/L according to EU standards [4].

The CVCS is responsible for regulating boron concentrations in the reactor coolant. This system carefully adjusts the amount of boric acid added to the primary circuit to maintain optimal reactivity and ensure safe reactor operation.

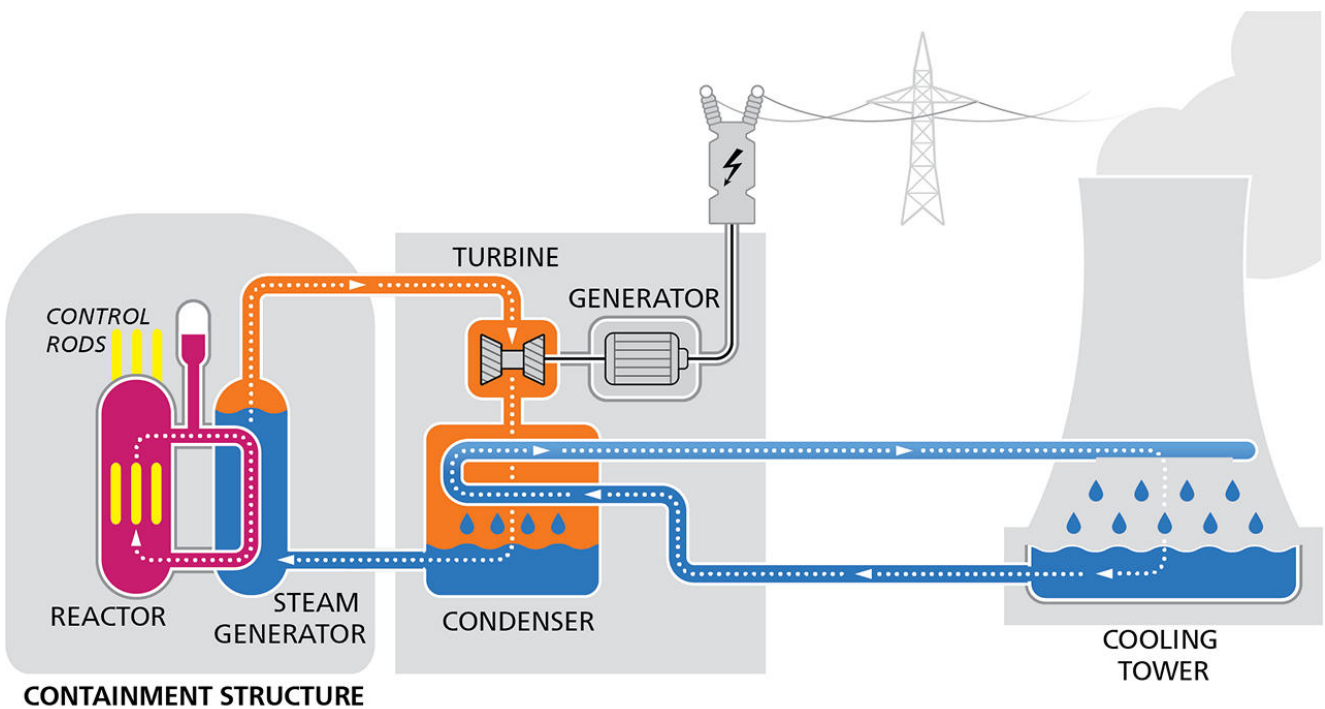


Figure 1. Illustration of the various water circuits in a nuclear reactor (left: primary circuit, center: secondary circuit, right: cooling circuit).

The 2060 TI Process Analyzer (Figure 2) offers a significant advantage over traditional laboratory testing methods in the nuclear sector. Its advanced

titration technique enables continuous, real-time monitoring of boron concentrations in the PWR without the need for manual laboratory testing.

Furthermore, the analyzer's self-calibration feature ensures consistent accuracy without requiring frequent manual adjustments.

By seamlessly integrating with nuclear power plant control systems, the **2060 TI Process Analyzer** enables

APPLICATION

Online monitoring of boric acid in cooling water is possible by means of potentiometric titration. The intelligent IMPACT software utilized by the 2060 TI Process Analyzer can automatically adapt to varying

automated reactivity adjustments based on measured boron concentrations. This automation enhances operational efficiency and helps maintain optimal reactor performance.

boric acid levels and switch titrant buret concentrations to ensure the highest accuracy is achieved throughout the full measuring range.

Table 1. Typical boric acid concentrations found in pressurized water reactors.

Parameters	[mg/L]
Boron	0–2000

REMARKS

Other process applications related to the water circuits of energy producers include silica, sodium, nickel, zinc, calcium, magnesium, and chloride. Reliable measurements of these critical parameters are possible with the 2060 TI Process Analyzer from Metrohm Process Analytics (**Figure 2**).



Figure 2. The 2060 TI Process Analyzer is suitable to monitor several critical parameters in nuclear pressurized water reactors.

CONCLUSION

The ability to monitor boric acid concentrations within the range of 0–2000 mg/L is particularly valuable in PWRs, where precise control of this parameter is

essential for safe and efficient operation. The 2060 TI Process Analyzer's versatility and accuracy make it a valuable tool for nuclear power plant operators.

REFERENCES

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2. Mesquita, A. Z.; Reis, I. C.; de Almeida, V. F.; et al. Boron-10 Effect on the Reactivity of the IPR-R1 Triga Research Reactor. *Annals of Nuclear Energy* **2019**, *132*, 64–69.
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3. Boron, a key challenge for reverse osmosis systems, successfully treated with LG Chem TFN membranes GWI. <https://www.globalwaterintel.com/articles/boron-a-key-challenge-for-reverse-osmosis-systems-successfully-treated-with-lg-chem-tfn-membranes-lg-chem> (accessed 2024-08-19).
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RELATED APPLICATION NOTES

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[AN-PAN-1032 Monitoring corrosion in power plants with online process analysis](#)

[AN-PAN-1038 Power generation: analysis of the m-number \(alkalinity\) in cooling water](#)

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[AN-PAN-1042 Online trace analysis of anions in the](#)

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[AN-PAN-1045 Online monitoring of copper corrosion inhibitors in cooling water](#)

[AN-PAN-1056 Online monitoring of sodium in industrial power plants](#)

BENEFITS FOR ONLINE PROCESS ANALYSIS

- Safer working environment for employees (nuclear reactor).
- Fully automated diagnostics – automatic alarms for when samples are out of specification parameters.
- Guarantee compliance with environmental standards.
- High accuracy for lower detection limits of boron.



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CONFIGURATION



2060 Process Analyzer

El 2060 Process Analyzer es un instrumento de análisis de química húmeda online que sirve para innumerables aplicaciones. Este instrumento de análisis de procesos ofrece un nuevo concepto de modularidad que consiste en una plataforma central, denominada "armario básico".

El armario básico consta de dos secciones. La sección superior contiene una pantalla táctil y un ordenador industrial. La sección inferior contiene la parte húmeda flexible donde se aloja el hardware para el análisis propiamente dicho. Si la capacidad básica de la parte húmeda no es suficiente para resolver un desafío analítico, entonces el armario básico puede ampliarse a hasta cuatro armarios más de parte húmeda para asegurar el espacio suficiente para resolver incluso las aplicaciones más difíciles. Los armarios adicionales pueden configurarse de tal manera que cada armario de parte húmeda puede combinarse con un armario de reactivos con detección de nivel integrada (sin contacto) para aumentar el tiempo de funcionamiento del instrumento de análisis.

El 2060 Process Analyzer ofrece diferentes técnicas de química húmeda: titulación, titulación Karl Fischer, fotometría, medida directa y métodos de adición de patrón.

Para cumplir con todos los requisitos del proyecto (o para satisfacer todas sus necesidades) se pueden proporcionar sistemas de acondicionamiento de muestras para garantizar una solución analítica robusta. Suministramos prácticamente cualquier sistema de acondicionamiento de muestras, como sistemas de refrigeración o calentamiento, reducción de presión y desgasificación, filtración, etc.