Application Note AN-PAN-1038

Power generation: analysis of the m-number (alkalinity) in cooling water

One way to maximize heat transfer efficiency and reduce costs in a power plant is by controlling the water chemistry in the cooling circuit. This cooling water is kept alkaline to maintain the protective oxide layer on the metal piping throughout the water circuit. However, alkalinity above the recommended range increases the probability of scale formation (deposition), so it is buffered with carbonate (CO_3^{2-}) and bicarbonate ions (HCO_3^-). Titration of the cooling water to pH 4.5 gives the so-called «m-alkalinity» (methyl orange alkalinity), a measure of total alkalinity. Below this pH, there is no more alkalinity present, only free acid (H^+), carbonic acid (H_2CO_3), and CO_2.

This Process Application Note details the online

analysis of alkalinity in cooling water. This method offers results in less than 30 minutes, meaning faster response times for out of specification readings. In combination with the power plant's Distributed Control System (DCS), online monitoring of this parameter using a process analyzer ensures that corrosion can be controlled before it affects the power plant efficiency, ultimately decreasing downtime and lowering maintenance costs.

INTRODUCTION

One way to maximize heat transfer efficiency and reduce costs in a power plant is by controlling the water chemistry in the cooling circuit (**Figure 1**). Cooling water is used to condense the exhaust steam from the turbine to water, which is then sent back to the water-steam circuit as feed water. The heat of condensation (energy) from the steam is transferred to this cooling water as it flows through kilometers of (titanium) piping in the condenser. The water chemistry depends on the type of power plant, cooling circuit design, and construction materials. Every cooling circuit has a unique design and its own analytical requirements.

The cooling water temperature is reduced either by once-through cooling, in which the water is taken from the environment and returned at a slightly higher temperature, or in a circuit in a cooling tower. Water requirements for once-through cooling circuits are much more demanding because of the large volumes needed for continuous cooling. Oxygen (among other impurities) is also prevalent in the water taken from rivers and lakes, leading to corrosion in the pipelines if not removed adequately. Continuous circulation of the cooling water increases the concentration of contaminants in the circuit but uses much less water.

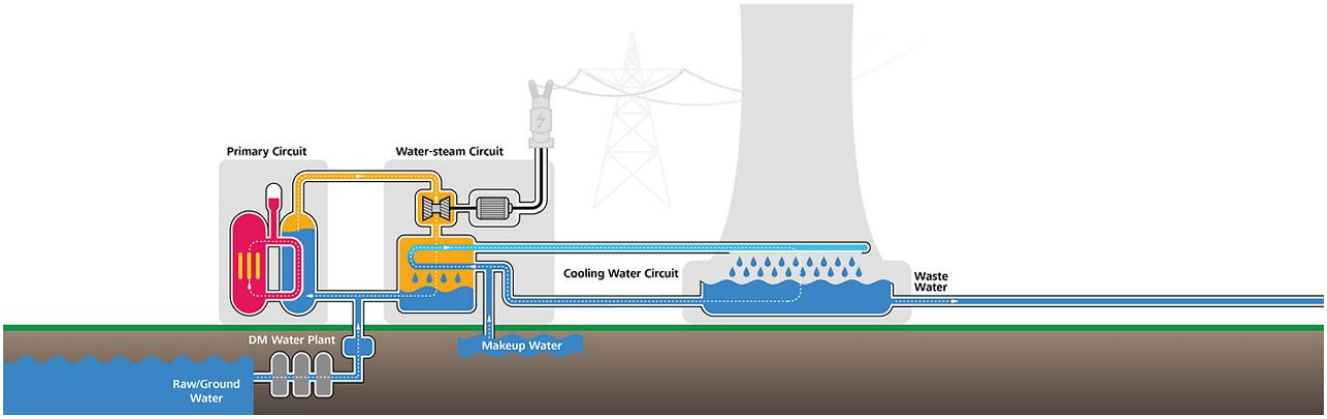

Figure 1. Schematic diagram of a thermal power plant. The cooling circuit (right) is an important attribute in two- and three-cycle power plants.

Cooling water is kept alkaline to maintain the protective oxide layer on the metal piping throughout the water circuit. Acidic water will dissolve the protective oxide layer and the metal surface. However, alkalinity above the recommended range increases the probability of scale formation (deposition). The water is therefore buffered against further pH changes with carbonate (CO_3^{2-}) and bicarbonate ions (HCO_3^-) (Reaction 1).

Traditionally, the water can be analyzed by laboratory titration. However, this methodology does not provide timely results and requires human intervention to implement the laboratory analysis results to the process. Online process analysis allows constant monitoring of water quality without long waiting times in the laboratory, giving more accurate and representative results directly to the control room.

Optimal water chemistry begins with an online analyzer such as the 2026 Titrolyzer from Metrohm Process Analytics. Save time and increase efficiency without manually sampling process points. Online analysis helps protect against corrosion and fouling in the cooling water circuit, allowing more uptime and reducing maintenance costs. Titration to pH 4.5 indicated by a pH electrode gives the so-called «m-alkalinity» (methyl orange alkalinity), also a measure of total alkalinity. Below a pH of approximately 4.3 there is no more alkalinity present, only free acid (H^+), carbonic acid (H_2CO_3), and CO_2. Therefore:

$$m - alkalinity = [HCO_3^-] + [CO_3^{2-}] + [OH^-]$$

Reaction 1. Overall reaction of m-alkalinity.

APPLICATION

Titration is performed with 0.1 mol/L hydrochloric acid (HCl) to pH 4.5. The endpoint is detected automatically by recording the change of pH/mV signal in relation with the dosed amount of titrant. A suitable pH electrode is used for accurate indication of this pH/mV change. In addition to the 2026 Titrolyzer, the 2035 Potentiometric, and 2060 TI Process Analyzers (Figures 2 and 3) can also monitor alkalinity online, guaranteeing high process efficiency and low operating and energy costs.

Figure 2. 2035 Process Analyzer – Potentiometric.

Figure 3. 2060 TI Process Analyzer from Metrohm Process Analytics.

Table 1. Thermal power plant measurement parameters * Other concentrations below the stated range can be measured by changing the concentration of the reagents.

Parameters	Range
m-alkalinity	0–110 mmol/L *
$CaCO_3$	0–1000 mg/L *

CONCLUSION

Metrohm Process Analytics offers a wide range of online process analyzers to monitor power plants around the clock. From single parameter analyzers (e.g., 2026 Titrolyzer) to multiparameter analyzers (e.g., 2035 Process Analyzer – Potentiometric and the 2060 TI Process Analyzer)—all of these solutions can measure alkalinity, helping to safeguard plant operation and optimize process cooling efficiency.

RELATED APPLICATION NOTES

AN-PAN-1003 Amine ("rich" and "lean") and free & total CO_2

BENEFITS FOR TITRATION IN PROCESS

- **Increased longevity** of valuable company assets
- Monitor **multiple sample streams** (up to 10) for more savings per measurement point and results
- **Safer working environment** and automated sampling
- **Fully automated diagnostics** – automatic alarms for when samples are out of specified parameters

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CONFIGURATION

2035 Process Analyzer Potentiometric

用于位滴定和子性量的 2035 Process Analyzer 程分析,可使用用和滴定行分析。此外,版本的 2035 Process Analyzer 程分析用于使用万通高性能行子性分析。一精的准溶液技是理品基的理想方法。

此位分析款型的分析可提供当前市上所有量技的最精果。滴定法作最常用的分析方法之一,具有超 1000 用可供使用,能分析数百成,从酸/元素直到解池中金属度,可用于几乎任何行。

滴定法是目前使用最广泛的化学方法之一。技易行,无需校准。

可用于此配置的部分滴定:

- 位分析滴定
- 使用光技的比色滴定
- 基于·休滴定法定水

2060 Process Analyzer

2060 Process Analyzer 是一在湿化学分析,用于无数用。此程分析提供了一个新的模化概念,由一个称«主机»的中心平台成。

主机由部分成。上部包含触摸屏和工算机。下部含有柔性取部,其中放有用于分析的硬件。如果主取部容量不足以分析挑,那主机可以展多四个外的取部机,以保有足的空来最具挑性的用。附加机的配置方式使每个取部机可以与具有集成(非接触式)液位的合使用,以增加分析的正常行。

2060 Process Analyzer 提供不同的湿化学技:滴定法、舍滴定法、光度定、直接量和准添加入法。

足所有目要求(或足的所有需求),可提供品理系,以保分析解决方案可靠。我可以提供任何品理系,如冷却或加、和脱气、等。

2026 Titrolyzer

2026 Titrolyzer 通高精度滴定管系和高性能行位滴定。不同滴定型,包括酸/、化原和淀滴定。自式拐点技可用于大多数用。在一些内感器不奏效的情况下也可以使用分析量 pH 。

此外, 2026 Titrolyzer 可通高精度滴定管和高性能子性来行准加入法。方法采用差分法将准加入量与品度相。此外注意 ISE 斜率涉及到多个范。意味着 ISE 子性可用于低或高的量范。伴随的温度量消除了温度分析果的可能影。

有几个市与 2026 TITROLYZER 完美契合:如化工,石化,半体,境,采,/金属和用水。

定的用包括:

- 酸性或性溶液
- 化物
- 化
- 硬度
- 化物
-
- 化
- pH
- 等等