Application Note AN-PAN-1038

火电厂冷却水的碱度(m 值)

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.

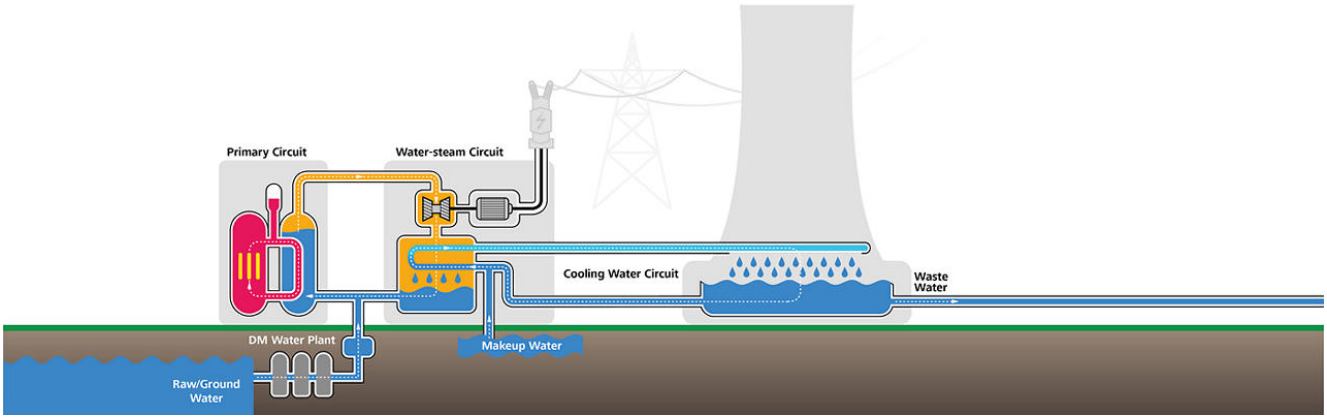

Figure 1. Schematic diagram of a thermal power plant. The cooling circuit (right) is an important attribute in two- and three-cycle power plants.

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

适用于电位滴定和离子选择性测量的 2035 Process Analyzer 过程分析仪,可使用专用电极和滴定剂进行分析。此外,该版本的 2035 Process Analyzer 过程分析仪还适用于使用万通高性能电极进行离子选择性分析。这一准确的标准溶液技术是处理复杂样品基质的靠谱方法。

此电位分析款型的分析仪可提供当前市场上所有测量技术的准确结果。滴定法作为常用的分析方法之一,具有远超过 1000 种应用可供使用,能分析数百种成份,从酸/碱元素直到电解池中金属浓度,可用于几乎任何行业。

滴定法是目前使用广泛的绝对化学方法之一。该技术简单易行,无需校准。

可用于此配置的部分滴定选项:

- 电位分析滴定
- 使用光纤技术的比色滴定
- 基于卡尔·费休滴定法测定水份

2060 Process Analyzer

2060 Process Analyzer 是一种在线湿化学分析仪,适用于无数应用。此过程分析仪提供了一个新的模块化概念,由一个称为«主机柜»的中心平台组成。

主机柜由两部分组成。上部包含触摸屏和工业计算机。下部含有柔性取样部,其中放有用于实际分析的硬件。如果主取样部容量不足以应对分析挑战,那么主机柜可以扩展为多达四个额外的取样部机柜,以确保有足够的空间来应对具挑战性的应用。附加机柜的配置方式使每个取样部机柜可以与具有集成(非接触式)液位检测的试剂柜组合使用,以增加分析仪的正常运行时间。

2060 Process Analyzer 提供不同的湿化学技术:滴定法、卡尔费舍尔滴定法、光度测定、直接测量和标准添加入法。

为满足所有项目要求(或满足您的所有需求),可提供样品预处理系统,以确保分析解决方案可靠。我们可以提供任何样品预处理系统,如冷却或加热、减压和脱气、过滤等。

2026 Titrolyzer

2026 Titrolyzer 通过高精度滴定管系统和高性能电极进行电位滴定。不同滴定类型,包括酸/碱、氧化还原和沉淀滴定。自寻式拐点技术可用于大多数应用。在一些内联传感器不奏效的情况下也可以使用分析仪测量 pH 值。

此外, 2026 Titrolyzer 可通过高精度滴定管和高性能离子选择性电极来执行动态标准加入法。该方法采用动态差分法将标准加入量与实际样品浓度相适应。此外还请注意 ISE 斜率值涉及到多个范围。这意味着 ISE 离子选择性电极可用于较低或较高的测量范围。伴随的温度测量消除了温度对分析结果的可能影响。

有几个市场与 2026 TITROLYZER 很是契合:如化工,石化,半导体,环境,采矿,钢铁/金属和饮用水。

选定的应用包括:

- 酸性或碱性溶液
- 氯化物
- 过氧化氢
- 硬度
- 氰化物
- 铜
- 氟化氢
- pH
- 等等