Application Note AN-PAN-1040

Ammonia in cooling water of thermal power plants

Thermal power plants require enormous amounts of water, using high purity steam at high pressure to rotate turbines. A separate cooling water circuit is implemented, helping to form a vacuum when the steam condenses after the turbines. Maintaining this vacuum with optimal condensation parameters is critical for the power plant efficiency.

The copper condensers are susceptible to corrosion by ammonia (NH_3). Small cracks in the condenser combined with the large pressure differential between the steam circuit and the cooling water circuit will contaminate the high purity water in the boiler, causing major problems and necessitating a shutdown for plant maintenance. Monitoring NH_3 online in cooling water with a process analyzer can signal early problems in a plant before significant intermediation is necessary.

This Process Application Note presents a way to closely monitor the NH_3 concentration in cooling water of power plants to ensure protection of expensive company assets (e.g. pipes, boiler, and more) and helps to safeguard plant operations.

INTRODUCTION

Thermal power plants require enormous amounts of water to convert energy from generated heat to electricity, using high purity steam at high pressure to rotate turbines. The steam loses energy and condenses, forming a vacuum after the turbines, and the re-condensed vapor is sent back to the boiler for reuse. Maintaining this vacuum with optimal condensation parameters is critical for the power plant efficiency.

Cooling water is used in a separate water circuit to exchange heat from the condenser to the ambient surroundings. Water sources for cooling can range from seawater, lakes, and rivers, to re-treated municipal wastewater (MWW). The cooling water circuit, discussed in other Metrohm Process Application Notes (AN-PAN-1013, AN-PAN-1038), is classified as either once-through or recirculating (dry cooling is not discussed here). The growing number of environmental guidelines and thermal discharge limits has forced many plants to use closed recirculating cooling water circuits, reducing the cooling water needs by about 95% compared to once-through cooling systems. The heat from the condenser can dissipate in a number of manners, most commonly by an evaporative cooling tower (**Figure 1**). Only small amounts of makeup water are required to replace evaporative, drift, and blowdown losses in recirculating cooling water circuits. The cooling water chemistry is primarily maintained to inhibit scale formation and microbial growth (fouling) as well as control corrosion.

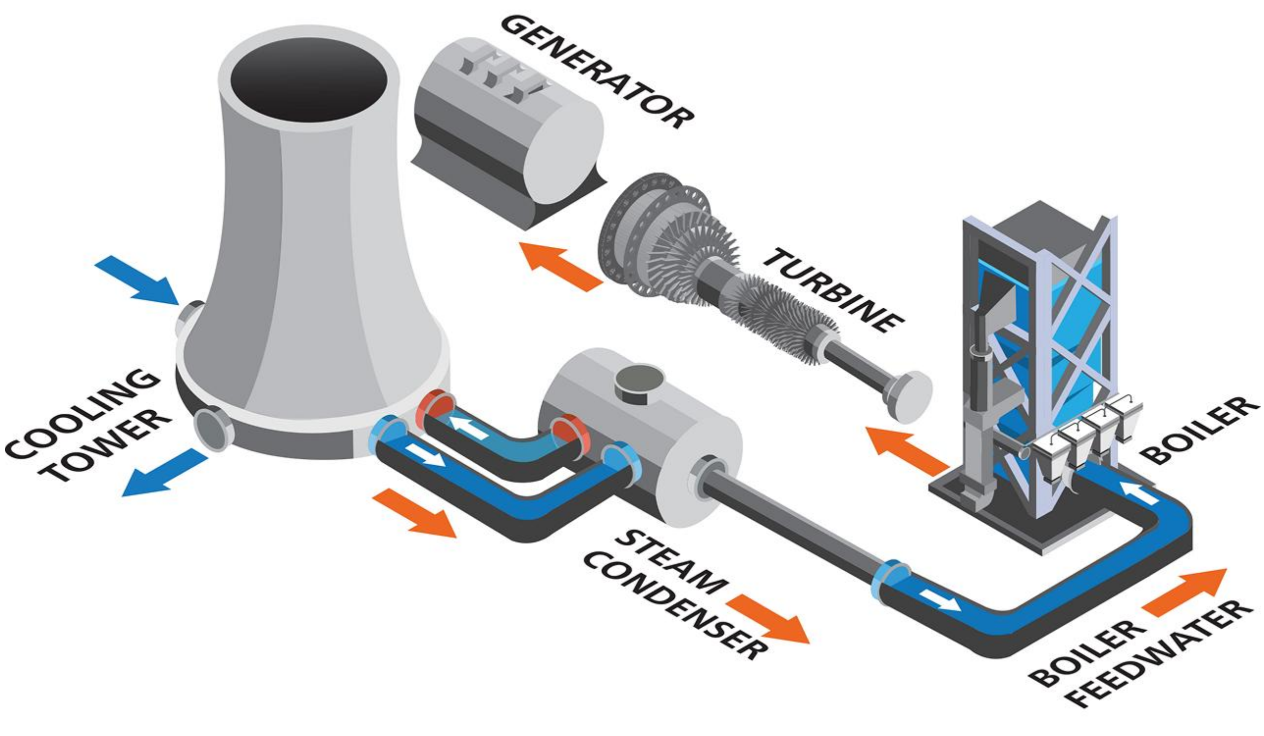

Figure 1. Example schematic of a wet recirculating cooling water system for a thermal power plant.

Copper (Cu) alloys are now used almost exclusively in condensers of the water-steam circuit. The drawback is the susceptibility of copper and its alloys to **corrosion** by NH_3. Ammonia is also nutritional for microbes, which cause **biological fouling**. Ammonia stripping towers can be implemented on site to remove a significant percentage of NH_3 via water-to-air stripping, otherwise water treatment is necessary. The cooling tower itself can strip the volatile NH_3 at optimal pH levels. According to the Electric Power Research Institute (EPRI), in systems with copper alloys an upper limit of **2 mg/L NH_3** must be adhered to in order to prevent severe corrosion. The result is increased Cu concentration in effluents or other discharges, which is of environmental concern. Corrosion can also cause leaks and catastrophic failure in the piping. Small leaks and cracks combined with the large pressure differential between the steam circuit and the cooling water circuit will contaminate the high purity water in the boiler, causing major problems and necessitating a shutdown for plant maintenance.

Corrosion of Cu and its alloys can be inhibited by adding **triazoles** to form sparingly soluble compounds on the surface of the metal. Routine system chlorination against biological fouling will reduce ammonia levels somewhat as chloramines are formed. Corrosion products and other impurities can be removed by chemical cleaning. However, it is clear that ammonia is detrimental to the cooling water circuit and must be treated or otherwise removed before Cu corrosion can occur. **Metrohm Process Analytics** offers multiple online process analyzers which can measure NH_3 in cooling water of power plants, alerting the Chemical Distribution System (CDS) to add more corrosion inhibitors, chlorine, or other treatment chemicals to the circuit before extreme damage can occur.

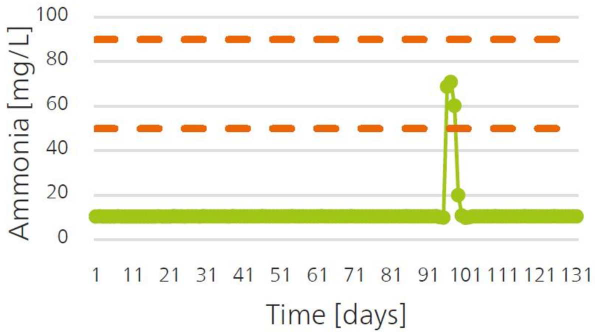

Figure 2. Trend chart of ammonia (NH3) showing a spike in concentration over a period of 130 days, which could lead to possible corrosion. The dashed lines are control measure guides, which can be changed depending on your process requirements.

APPLICATION

Online monitoring of the ammonia content is possible with either the **2060 Process Analyzer** or with the **2026 Titrolyzer** from Metrohm Process Analytics (**Figure 3**). An ammonia ion-selective electrode (NH_3-ISE) is used in this application for quick, simple, and accurate online analysis of NH_3 concentrations in cooling water. After sampling, a Total Ionic Strength Adjustment Buffer (TISAB) solution is added to adjust the pH to 11 or higher, and the NH_3 concentration in the sample is determined using the dynamic standard addition method.

Typical range 0–100 mg/L NH_3

Figure 3. Some of the Metrohm Process Analytics analyzers capable of determining the ammonia concentration online. Left: 2060 Process Analyzer, right: 2026 Titrolyzer.

REMARKS

Lower concentrations of ammonia can be analyzed online with **colorimetric or ion chromatographic methods**, also available from Metrohm Process Analytics. Other online applications are available for the energy and power industry such as: silica in boiler feed water, calcium and sulfate in the flue-gas desulfurization process, boric acid in cooling water Pressurized Water Reactors (PWRs), ultratrace measurements of iron (Fe) and Cu, rich/lean amine concentration and CO_2 captured in Carbon Capture Plants, and many more.

FURTHER READING

Monitoring corrosion in power plants: online ultratrace analysis of Fe and Cu
2026 Ammonia Analyzer
Power generation: Analysis of the m value (Alkalinity) in cooling water
Online monitoring of sodium in industrial power plants

BENEFITS FOR TITRATION IN PROCESS

- **Safe working environment** and automated sampling
- **Protect valuable company assets** (e.g. pipes, PWR, and turbines, which are prone to corrosion)
- **Save money** by reducing downtime: analyzer sends alarms for out-of-specification values which inform the operator sooner

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CONFIGURATION

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

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。