



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 ( $\text{NH}_3$ ). 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  $\text{NH}_3$  online in cooling water with a process analyzer can signal early problems in a plant before significant intermediation is necessary.

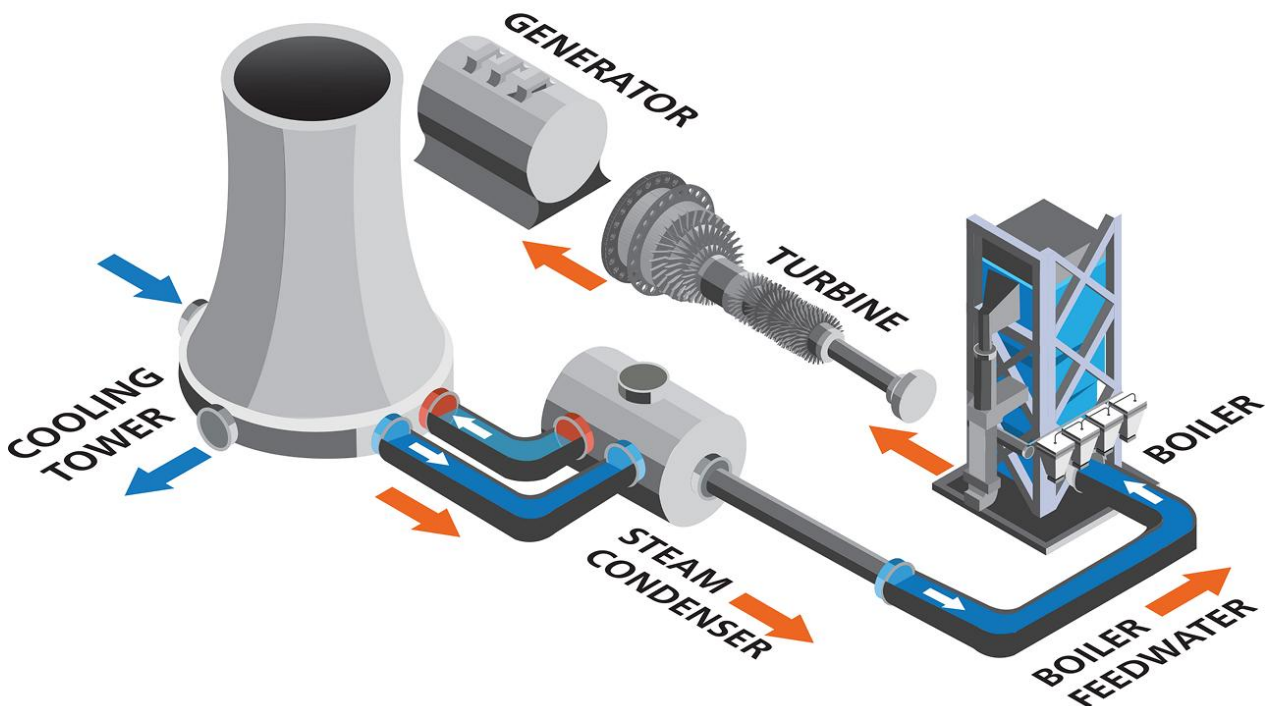
This Process Application Note presents a way to closely monitor the  $\text{NH}_3$  concentration in cooling water of power plants to ensure protection of expensive company assets (e.g. pipes, boiler, and more) and helps to safeguard plant operations.

## 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  $\text{NH}_3$ . Ammonia is also nutritional for microbes, which cause **biological fouling**. Ammonia stripping towers can be implemented on site to remove a significant percentage of  $\text{NH}_3$  via water-to-air stripping, otherwise water treatment is necessary. The cooling tower itself can strip the volatile  $\text{NH}_3$  at optimal pH levels. According to the Electric Power Research Institute (EPRI), in systems with copper alloys

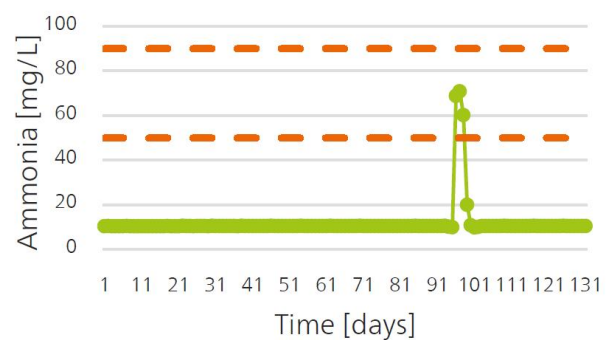
Corrosion of Cu and its alloys can be inhibited by adding **triazoles** to form sparingly soluble compounds on the surface of the metal. Routine system chlorination against biological fouling will reduce ammonia levels somewhat as chloramines are formed. Corrosion products and other impurities can be 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  $\text{NH}_3$  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.

## 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 ( $\text{NH}_3$ -ISE) is used in this application for quick, simple, and accurate online analysis of  $\text{NH}_3$  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  $\text{NH}_3$  concentration in the sample is determined using the dynamic standard addition method.

**Typical range** 0–100 mg/L  $\text{NH}_3$

an upper limit of **2 mg/L  $\text{NH}_3$**  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.



**Figure 2.** Trend chart of ammonia ( $\text{NH}_3$ ) 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.



**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<sub>2</sub> 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

Der 2026 Titrolyzer verwendet zur Durchführung potentiometrischer Titrations ein hochpräzises Bürettensystem und Hochleistungselektroden. Zu den verschiedenen Titrationsarten gehören Säure/Basen-, Redox- und Fällungstitrationsarten. Bei den meisten Anwendungen kann eine automatische Wendepunkttitration eingesetzt werden. Das Analysengerät kann zudem verwendet werden, um in Situationen den pH-Wert zu messen, in denen Inline-Sensoren ansonsten versagen würden.

Darüber hinaus kann der 2026 Titrolyzer unter Anwendung der dynamischen Standardadditionsmethode Messungen mittels einer hochpräzisen Bürette und leistungsfähiger ionenselektiver Elektroden (ISE) ausführen. Bei diesem Verfahren wird das Standardadditionsvolumen mittels dynamischer Potentialänderung an die jeweilige Probenkonzentration angepasst. Zudem werden mehrere Steigungswerte der ionenselektiven Elektrode berücksichtigt. Dies bedeutet, dass die ISE bis in ihren untersten oder obersten Messbereich genutzt werden können. Durch die gleichzeitige Temperaturmessung können mögliche Auswirkungen der Temperatur auf die Analysenergebnisse ausgeschlossen werden.

Der 2026 Titrolyzer ist für verschiedene Märkte perfekt geeignet, unter anderem für die Bereiche Chemie, Petrochemie, Halbleiter, Umwelt, Bergbau, Stahl/Metall und Trinkwasser.

Ausgewählte Anwendungen sind:

- Saure und alkalische Lösungen
- Chlorid
- Wasserstoffperoxid
- Härte
- Cyanid
- Kupfer
- Fluorwasserstoff
- pH
- Und viele mehr ...



## 2060 Process Analyzer

Der 2060 Process Analyzer ist ein Online-Analysengerät für die Nass-Chemie, das sich für zahlreiche Anwendungen eignet. Dieser Prozessanalysator bietet ein neues Baukastensystem, das eine zentrale Plattform hat, den sogenannten „Basisschrank“.

Der Basisschrank besteht aus zwei Teilen. Der obere Teil enthält einen Touchscreen sowie einen Industrie-PC. Im unteren Teil befindet sich der flexible Nassteil, in dem die Hardware für die eigentliche Analyse untergebracht ist. Wenn die Kapazität des Nassteils aus der Grundausstattung nicht ausreicht, um eine analytische Herausforderung zu bewältigen, kann der Basisschrank auf bis zu vier weitere Nassteilschränke erweitert werden. So lässt sich sicherstellen, dass selbst für die anspruchsvollsten Anwendungen genügend Platz vorhanden ist. Die zusätzlichen Schränke lassen sich so konfigurieren, dass jeder Nassteilschrank zwecks Erhöhung der Betriebszeit des Analysengeräts mit einem Reagenzienschrank, der über eine integrierte (kontaktlose) Füllstandserfassung verfügt, kombiniert werden kann.

Der 2060 Process Analyzer bietet verschiedene nasschemische Methoden: Titration, Karl-Fischer-Titration, Photometrie, Direktmessung und Standardadditionsverfahren.

Zur Erfüllung aller Projektanforderungen (oder all Ihrer Bedürfnisse) sind auch Probenaufbereitungssysteme erhältlich, die eine stabile Analyselösung garantieren. Wir können jedes Probenaufbereitungssystem liefern, unter anderem zum Kühlen oder Heizen, Druckmindern oder Entgasen, Filtrieren und für vieles mehr.