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.

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.

INTRODUCTION

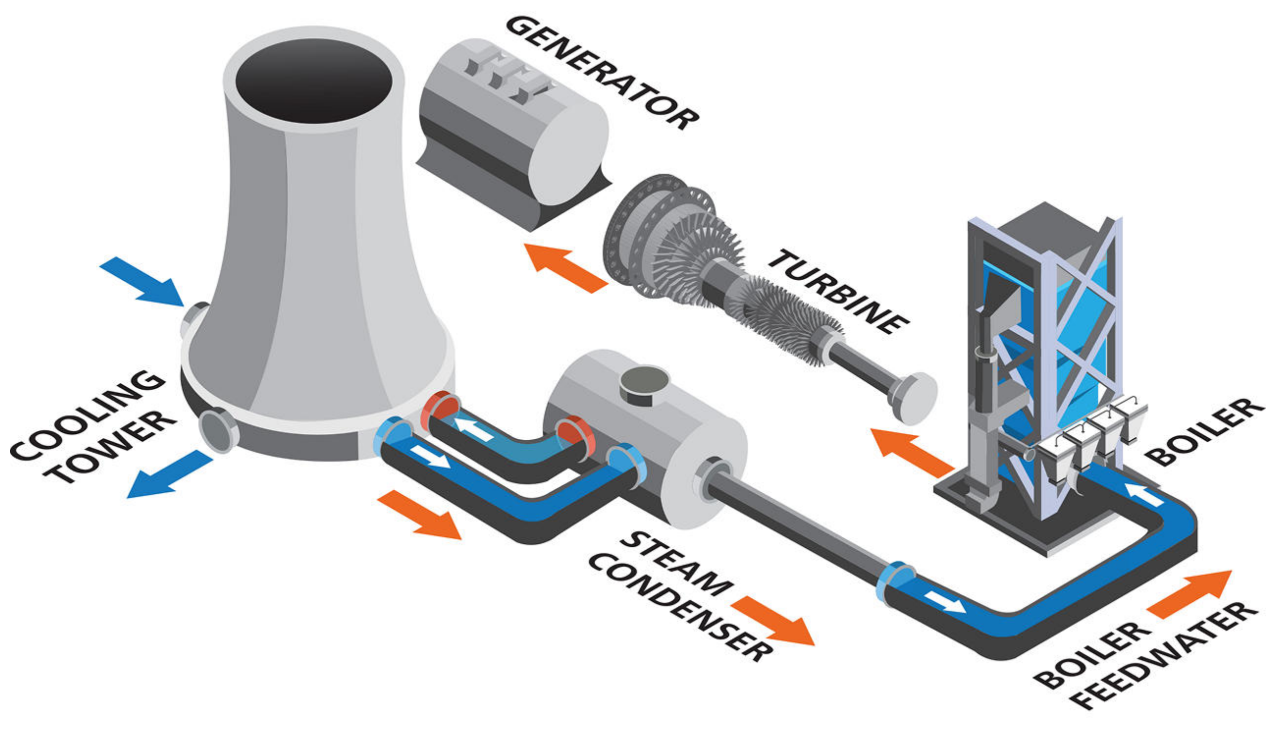

Figure 1. Example schematic of a wet recirculating cooling water system for a thermal power plant.

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.

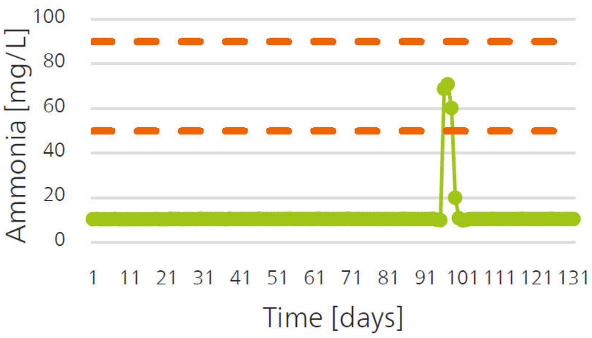

Figure 2. Trend chart of ammonia (NH3) showing a spike in concentration over a period of 130 days, which could lead to possible corrosion. The dashed lines are control measure guides, which can be changed depending on your process requirements.

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

The 2026 Titrolyzer performs potentiometric titrations by means of a high precision burette system and high performance electrodes. Different titration types include acid/base, redox and precipitation titrations. A self-finding inflection point technique can be applied for most applications. It is also possible to use the analyzer to measure pH in situations where inline sensors would otherwise fail.

Additionally, the 2026 Titrolyzer can perform the dynamic standard addition method by means of the high precision burette and high performance Ion Selective Electrodes (ISE). This method adapts the standard addition volume to the actual sample concentration by means of a dynamic differential approach. Moreover it takes into account ISE slope values over several ranges. This means that ISEs can be used to their ultimate low or high measuring ranges. An accompanying temperature measurement eliminates possible temperature effects on the analysis results.

Several markets are a perfect fit for the 2026 Titrolyzer such as chemical, petrochemical, semiconductor, environmental, mining, steel/metal, and potable water.

Selected applications include:

- Acidic or alkaline solutions
- Chloride
- Hydrogen peroxide
- Hardness
- Cyanide
- Copper
- Hydrogen fluoride
- pH
- and more

2060 Process Analyzer

The 2060 Process Analyzer is an online wet chemistry analyzer that is suitable for countless applications. This process analyzer offers a new modularity concept consisting of a central platform, which is called a «basic cabinet».

The basic cabinet consists of two parts. The upper part contains a touch screen and an industrial PC. The lower part contains the flexible wet part where the hardware for the actual analysis is housed. If the basic wet part capacity is not sufficient enough to solve an analytical challenge, then the basic cabinet can be expanded to up to four additional wet part cabinets to ensure enough space to solve even the most challenging applications. The additional cabinets can be configured in such a way that each wet part cabinet can be combined with a reagent cabinet with integrated (non-contact) level detection to increase analyzer uptime.

The 2060 process analyzer offers different wet chem techniques: titration, Karl Fischer titration, photometry, direct measurement and standard additions methods.

To meet all project requirements (or to meet all your needs) sample preconditioning systems can be provided to guarantee a robust analytical solution. We can provide any sample preconditioning system, such as cooling or heating, pressure reduction and degassing, filtration, and many more.