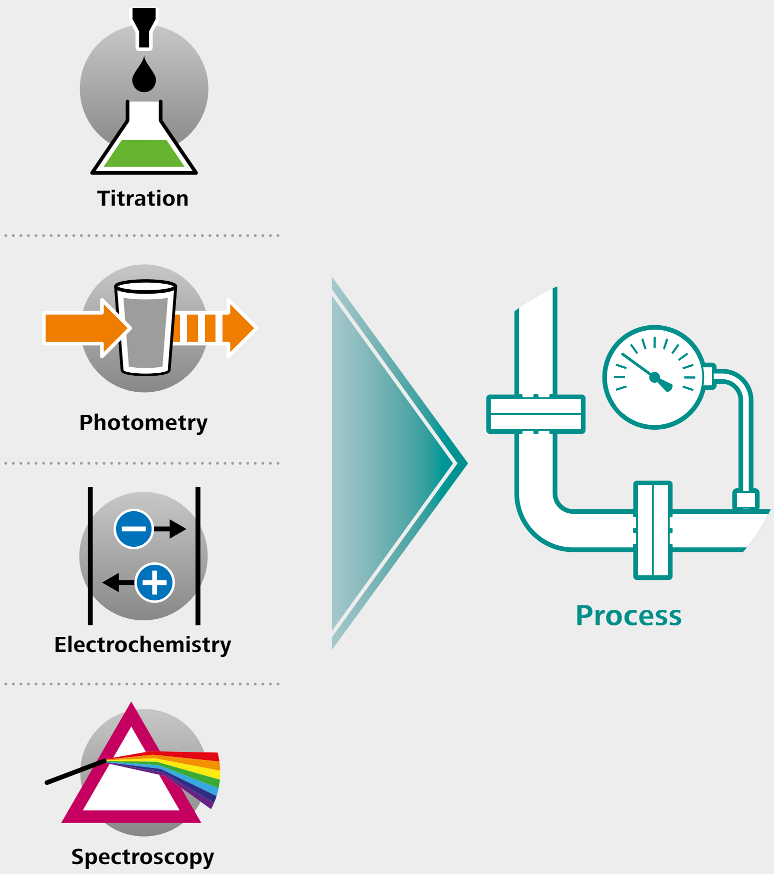
Metrohm Applikon
Applications for Process Analytics



Handbook 2019

Selections of sold applications to customers installed over the past 40+ years

Metrohm
Process Analytics

About this Handbook

This Metrohm Process Analytics Handbook for Sold Applications is meant to be a handy compendium to help guide you through our work at Metrohm Applikon over **40+ years** of process analysis control. Many major and critical analysis parameters in various industries are compiled here according to specific process areas, helping you to find the proper solution to any challenge. Metrohm knows your industry, and we are an active partner in your process control with our vast experience from thousands of installations around the globe.

Additionally, attention is called to our **Process Application Notes** (PANs) at the beginning of each industry chapter, below the introduction. PANs are a short overview about a specific process, problem (and its repercussions), and the Metrohm Process Analytics solution. These are freely downloadable from **www.metrohm.com**.

Process Solutions from Metrohm Process Analytics
Metrohm Process Analytics is the brand name representing the well-known Metrohm Applikon wet chemistry process analyzers as well as the Metrohm NIRSystems instruments for process analysis. Our process analyzers take the famous Metrohm laboratory solutions a step further, offering analytical systems for titration, spectroscopy, electrochemistry, ion chromatography, photometry, as well as ion selective measurements.

Fully automated, online customizable analyzers facilitate process monitoring across a wide array of applications. Drawing on our core competencies in titration, spectroscopy, and electrochemistry, we leverage our applications knowledge to create reliable solutions for process analysis that optimize efficiency, decrease chemical consumption and create a safer work environment.

We back our systems with a team of experienced support personnel to offer you the full value chain of process analytics:

- Process Control
- Process Optimization
- An increased yield
- Reduced operational cost

With our expertise and experience we do not just offer process analyzers, but an integrated solution to the end user. This helps optimizing process efficiency while reducing operation cost. Real time analysis as an integrated part of process control and automation will help you increase yields and improve production quality.

For your information, this document has been made **interactive** for easier usage on electronic devices.

New in 2019: 2060 MARGA

After the commercial launch in 2006, the **MARGA** (**M**onitor for **A**e**R**osols and **G**ases in **A**mbient air) has been used worldwide at >100 locations contributing data to many environmental monitoring programs and studies. At the end of 2018, the newest version of this family was launched: the **2060 MARGA**, suitable for either research or continuous air monitoring campaigns.

The 2060 MARGA from Metrohm Process Analytics offers sampling of gases and aerosols from the same air mass. These are separated from each other by selectively dissolving them in water. The resulting solutions are then analyzed via ion chromatography with conductivity detection. Separating gases from aerosols allows the detection of important precursor gases and the subsequent inorganic ionic species found in the aerosols.

Based on the all-new 2060 online analysis platform from Metrohm Process Analytics, the 2060 MARGA can operate for **up to 1 month unattended** at a remote site

For more information, visit:
www.metrohm.com/en/products/process-analyzers/applikon-marga/

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Chemical Industry: Chlor-Alkali Production

Production Processes
The chlor-alkali production process mainly relies upon the electrolysis of NaCl brine to produce caustic soda (sodium hydroxide, NaOH) and chlorine (Cl_2), which are then used in countless other industries.

Three main techniques are in use for the production of chlor-alkali from salt: the membrane technology which accounted for 59.2% of production in Europe in 2014, followed by the mercury process (24.7%) and the diaphragm process (13.7%). All new plants are based on the membrane technique, which does not include mercury and asbestos like the other processes. The shift towards membrane technology is in line with Euro Chlor's voluntary agreement to phase out the installed mercury capacity by 2020.

Brine Purity
In the membrane electrolysis production of chlor-alkali, the purity of the brine is very important. The presence of impurities such as calcium and magnesium can shorten the performance and lifetime of the membranes or can damage the electrodes. Partial membrane blockage from precipitation reactions will lead to high electrical operational costs and the high cost associated with replacing membranes.

Process Application Notes for the Chlor-Alkali Industry

- Chlor-alkali industry: Hardness in Brine.
  AN-PAN-1005
- Online Determination of Anions in 50% NaOH and 50% KOH by IC (ASTM E1787-16).
  AN-PAN-1046

Sold and Installed Applications

Brine Production:

- Alkalinity in Brine (Brine Production)
- Bromide [Br^-] in Brine (Brine production)
- Calcium [Ca^{2+}] in Brine (NaCl Production)
- Chloride [Cl^-] in Brine (Brine production)

Brine Purification:

- Caustic [OH^-] + Carbonate [CO_3^{2-}] in Brine (Pretreatment Raw Brine)
- Hydroxide [OH^-], Carbonate [CO_3^{2-}], + Calcium [Ca^{2+}] in Brine (Brine Purification)
- Hydroxide [OH^-], Carbonate [CO_3^{2-}], + Hypochlorite [ClO^-] in Brine
- Magnesium [Mg^{2+}] in Brine (Brine Purification)
- Sodium Hydroxide [NaOH] in Brine (Brine Pre-Treatment)
- Sodium Hydroxide [NaOH], Chlorine [Cl_2], + Carbonate [CO_3^{2-}] in Brine (Brine Purification)

Chlorine Production:

- Chloride [Cl^-] in 50% Sodium Hydroxide [NaOH] (Chlorine production)
- Chlorine [Cl_2], Hydroxide [OH^-], Carbonate [CO_3^{2-}], Chloride [Cl^-], + pH in Brine (Chlorine plant)
- Potassium iodate [KIO_3] in Brine (Chlorine production)

Ion Exchange Cell Membrane Electrolyzer:

- Calcium [Ca^{2+}] + Magnesium [Mg^{2+}] in Brine (Inlet Membrane Electrolyzer, Brine Treatment)
- Calcium [Ca^{2+}], Magnesium [Mg^{2+}], + Chloride [Cl^-] in Brine with % Hydrochloric Acid [HCl] (Inlet Membrane Electrolyzer)
- Calcium [Ca^{2+}], Magnesium [Mg^{2+}], Sodium Hydroxide [NaOH], + Sodium Carbonate [Na_2CO_3] in Brine (Inlet Resin Treatment)
- Chlorate [ClO_3^-] in Brine (Inlet Membrane Electrolyzer)
- Chlorine [Cl_2] in Brine (Outlet Membrane Electrolyzer)

Secondary Purification Resin Treatment:

- Hydroxide [OH^-] + Carbonate [CO_3^{2-}] in Brine (Brine Purification, Resin Treatment)

Waste Water:

- Chloride [Cl^-] in effluent waste to river (Effluent WWTP to river)
- Hypochlorite [ClO^-] + Sulfite [SO_3^-] (Mercury Cell Effluent)
- Sulfate [SO_4^{2-}], Chlorine [Cl_2], + pH in waste water (Effluent WWTP)

Other Applications for the Chlor-Alkali Industry:

- Ammonia [NH_3], Total Alkalinity, Carbonate [CO_3^{2-}], + Chloride [Cl^-] in Brine
- Carbonate [CO_3^{2-}] in Overcarbonated Brine

Chemical Industry: Soda Ash Production

Solvay Process

Soda ash (sodium carbonate, Na_2CO_3) is used as the precursor of many goods, in industries such as Pulp & Paper, glass, detergents, and chemical manufacturing. There are three major soda ash producers in the world: ANSAC of the United States, multiple producers in China, and Solvay S.A. (now INOVYN) of Belgium. The major production process for soda ash is the Solvay process, which uses brine and limestone (calcium carbonate) as precursors. In 2014, world soda ash production created 52 billion kilograms, which accounts for more than 7 kg per each human on earth that year. Out of this amount, about 72% has been created synthetically with the Solvay process, while the remaining 28% has been mined from natural sources. The Solvay process is responsible for most soda ash production outside of the US, which uses its own natural mineral deposits.

Process Application Notes for the Soda Ash Industry

- Analysis of Ammonia in the Preparation of Ammonia-Saturated Brine. **AN-PAN-1025**

Sold and Installed Applications

Soda Ash production:

- Calcium [Ca^{2+}] + Magnesium [Mg^{2+}] in Sodium bicarbonate [$NaHCO_3$] (Soda Ash production)
- Calcium Oxide [CaO] in soda lime (Soda Ash production)
- Carbon dioxide [CO_2] in soda (Soda Ash production)
- Carbonate [CO_3^{2-}] in the Gas Scrubber Carbonization Column (Soda Ash production)
- Hydroxide [OH^-] in soda (Soda Ash production)

Brine Preparation:

- Ammonia [NH_3] / Ammonium [NH_4^+] in brine (Preparation Ammonia Saturated Brine)
- Calcium [Ca^{2+}] + Magnesium [Mg^{2+}] in Brine (Soda Ash production)

Waste Water:

- Chloride [Cl^-] in effluent (WWTP)
- Ammonia [NH_3] / Ammonium [NH_4^+] in waste water (WWTP)

Other relevant PANs can be found in the Chlor-Alkali Industry section.

Chemical Industry: Polymer Production

Polymer and plastics in everyday life
Polymers and plastics are a mainstay of modern life due to their versatility and physical properties: they can be formed into nearly any shape, with different degrees of flexibility and other variable parameters. Polymers can also be made into fibers which are spun, woven, and made into synthetic fabrics with adjustable properties which can vary from flame resistance to bullet protection. Even rubber, such as the type used in automobile tires, is composed mainly of synthetic polymers.

Reaction monitoring and quality control
Polymer production is a demanding process in which high-purity raw materials undergo complex reactions and are turned into polymers, fibers, resins, rubbers, and gums. The polymerization reaction is the critical point in the production process, and poor-quality raw materials will inevitably yield poor-quality polymers. To make sure that the products meet the specifications, the materials and processes have to be monitored along the entire production chain. You therefore need methods that operate where the reaction takes place and that yield immediate results.

Final product
Polymers are the result of complex reactions and processes involving various raw materials and additives. The final product must therefore be thoroughly inspected to ensure that it meets the specifications. Our instruments and applications enable you to determine a variety of substances and parameters, including additives, copolymer levels, water content, halogens, and residual monomers or impurities.

Standards for quality control
The importance of polymer feedstock quality is reflected by the large number of standards relating to them. Metrohm instruments comply with numerous chemical standards, which can be found within the Polymer and plastics branch sites here:
www.metrohm.com/en/industries/

Process Application Notes for the Polymer Industry

- Inline monitoring of free isocyanate (%NCO) content in polyurethane.
  AN-PAN-1041

Sold and Installed Applications

PVC Production

Polyvinyl chloride (PVC) is a plastic polymer which is seen all over in everyday life – in pipes, bank cards, sports equipment, and even furniture. It is generally rigid, but can be made into more flexible forms with the addition of plasticizers such as phthalates. The precursor to PVC is the vinyl chloride monomer (VCM) which is reacted with itself to create the PVC polymer. VCM is created by another process, which begins by chlorinating ethylene. Manufacturing PVC is in fact the largest use of chlorine for industrial purposes. The process is followed by oxychlorination with hydrochloric acid, creating the intermediate – ethylene dichloride (EDC). EDC is then cracked by heating in a furnace, which splits the compound into vinyl chloride (VCM) and hydrochloric acid (which can be reused). The VCM must be cooled quickly (quenched) before it degrades further, requiring large quantities of water, which is also reused throughout the plant after cleaning. VCM is purified by distillation in large towers, then stored before making PVC.

The polymerization process happens inside of an autoclave in an emulsion or suspension with water. At this point, the process can be adjusted to produce different grades of PVC which are made into different products. Once the reaction in the autoclave is stopped, any unreacted VCM is stripped, purified and reused. A centrifuge removes excess water from the PVC slurry, which is then fed into a hot air dryer and a sieve to complete the process.

Applications for PVC:

- Acidity in Vinyl Chloride (VC/EDC/PVC Production)
- Calcium [Ca^{2+}] + Hydrochloric Acid [HCl] in PVC Production (Electrolysis)
- Free Chlorine [Cl_2] in Incineration Furnace Waste Treatment (PVC Production, WWTP)
- Free Chlorine [Cl_2] in PVC (PVC Production)
- Water [H_2O] content in 1,2-dichloroethane [$C_2H_4Cl_2$] (EDC/VCM production)

NIRS Applications for the Polymer Industry:

Near-Infrared Spectroscopy (NIRS) is a technique used to quickly and accurately determine many properties in process. No chemicals are needed and results are obtained very quickly. NIR spectroscopy can be used in many different areas within the polymer and plastic manufacturing process, for any polymer type (liquids or solids). Common applications include the determination of the acid value, amine value, hydroxyl number, moisture (typically higher than 100 ppm), adhesive content, antioxidant and UV inhibitor content, cure, melt index, HDPE/LDPE, melamine content, plastic identification, polymer analysis, end point determination, alcohol detection/analysis and residual solvent detection. NIRS analysis also allows for the determination of physical properties such as molecular weight, degree of branching, tacticity, melting point, particle size verification, density, and viscosity.

This list is intended as a starting point but is not comprehensive. Many determinations listed below could also be applied to other chemicals and products.

Physical Characteristics (Thickness, Density, Viscosity):

- Monitoring Viscosity During a Phenolformaldehyde Resin Reaction (NIRS)
- Monitoring a Coating Material on Polystyrene Pellets (NIRS)

Monitoring Curing Rate:

- Monitoring Degree of Cure (Monomer Content) on Polymer Film (NIRS)
- Monitoring Cure Rate of an Adhesive (NIRS)
- Monitoring the Degree of Cure of Resin-Coated Fiberglass (NIRS)

Hydroxyl Number:
- Monitoring Hydroxyl Number and Acid Value in Various Polymer Products (NIRS)
- Monitoring the Hydroxyl Number in Powdered Resins (NIRS)
- Quantitatively Determining the Hydroxyl Number in Various Solid and Liquid Polyols (NIRS)
- Monitoring Hydroxyl Level of Polymer in an Ethanol/ Water Solution (NIRS)

Moisture/Water Content:
- Monitoring Moisture in Nylon (NIRS)
- Monitoring the Level of Water in Blends (NIRS)
- Determining the Relative Amounts of Water in an Acrylic Resin Throughout a Three Step Drying Process (NIRS)
- Monitoring the Concentration of a Polymer Intermediate and Moisture in a Feed Reactor (NIRS)
- Monitoring a Melamine Reaction and Determining Moisture in a Melamine Mix (NIRS)

Comparison / Distinguishing:
- Qualitative Comparison of Polystyrene Pellets (NIRS)
- Distinguishing Among Various PVC Samples (NIRS)

Monitoring Blend/Reaction Characteristics:
- Monitoring a Polyurethane Reaction (NIRS)
- Monitoring Blend Composition in Butadiene/Styrene/ Acrylonitrile Polymer Resins (NIRS)
- Monitoring Butadiene, Polycarbonate, and Butyl Acrylate in Polymer Pellets (NIRS)
- Monitoring the Levels of Vinyl-Acetate and Three Antioxidants in a LDPE-Based Polymer Pellet (NIRS)
- Monitoring Calcium Carbonate, Calcium Stearate, and Talc in Chlorinated Polyethylene (NIRS)

Additives:
- Monitoring the Level of an Additive in PVC Sidings (NIRS)
- Monitoring the Presence of an Additive in Polypropylene RCP Base Resin (NIRS)
- Quantifying an Additive in Polypropylene Pellets (NIRS)

Chemical Industry

The Chemical industry as a whole is responsible for creating and supplying the world with precursors and reagents for every possible use. Various grades of chemical quality are needed depending on their end use: pharmaceuticals need higher purity chemical reagents than metal leaching solutions in the mining industry, for example. It would be impractical to list every manufacturing process in this handbook, so for more information it is advisable to search for the most updated global market information online.

Process analyzers from Metrohm Applikon have been installed at numerous chemical plants worldwide for a variety of applications in many areas. The following are a selection of some of the more prominent chemical manufacturing processes to which we have sold many applications: the cumene process which produces acetone and phenol, caprolactam production for Nylon-6, the HPPO process which converts hydrogen peroxide to propylene oxide, and also the chemical fertilizer manufacturing process. Other sold and installed applications for various chemical industry processes can be found at the end of the chapter.

Standards for quality control

The importance of chemical products is reflected by the large number of standards relating to them. Metrohm instruments comply with numerous chemical and solvent standards, which can be found below:

www.metrohm.com/en/industries/chemical/chemical-industry-basic-chemicals/chemical-standards/

www.metrohm.com/en/industries/chemical/chemical-industry-solvents/chemical-solvent-standards/

Process Application Notes for the Chemical Industry

- HPPO process for Propylene oxide (PO): Analysis of peroxide.
  AN-PAN-1007
- Cumene process: Analysis of Sulfuric Acid in Acetone and Phenol.
  AN-PAN-1008
- Caprolactam Production: Determination of Permanganate Absorption Number.
  AN-PAN-1011

Sold and Installed Applications

Cumene process for Phenol & Acetone production

In this process, two products (acetone and phenol) are created from a cumene precursor (itself created by the reaction of benzene and propene). Both phenol and acetone are widely used in many industries – phenol mostly as a precursor to creating plastics and resins, and acetone mainly as a solvent and also the precursor to plexiglass (Poly(methyl methacrylate)). If the two products are allowed to react together, they form a third compound, bisphenol, which is used as a starting point in formation of polycarbonate plastics. Polycarbonate plastics are known to be lightweight and transparent, but also exhibit high impact strength and heat resistance. These plastics are used in many industries – from automotive and electronics to the food and beverage industries.

Bisphenol-A (BPA) is found in many hard plastics, such as water bottles, baby bottles, and even within the lining in food and beverage containers. This compound has often been in the news in recent years because it has been found to mimic the effects of estrogen in the endocrine system, and leaches out from the plastic despite having low solubility in water. The exposure to low concentrations are enough to disrupt the endocrine system, especially for children, and could lead to developmental disorders in later years.

Applications for Cumene Process:

- Caustic [NaOH] in Phenol (Phenol Production)
- Monitoring Parts per million (PPM) Levels of Moisture in Phenol (NIRS)
- Sulfuric Acid [H_2SO_4] in Phenol-Acetone/Phenol (Reactor – Acetone + Phenol production)
- Sulfuric Acid [H_2SO_4], Sodium Phenolate [C_6H_5NaO], + Sodium Hydroxide [NaOH] in process (Outlet Reactor)

Applications for Cumene Process Waste:

- Total Cyanide [TCN] in waste water (WWTP – Toluene/Cumene production)
- Phenol in waste water (WWTP)

Caprolactam industry

Caprolactam is the precursor chemical to create Nylon-6, which is ubiquitous in our lives. Nylon can be made into fabric, plastic machine parts, and even cookware (like spatulas) due to heat resistance up to its melting point of 256 °C. Multiple methods have been developed to synthesize caprolactam, though the majority is now created via a cyclohexanone precursor with bases and acids. Nearly all manufactured caprolactam is used for the synthesis of Nylon-6.

Applications for Polyamide/Caprolactam Production:

- Acid Number in Anolon (Cyclohexanone before Oxidation step)
- Alkalinity in cooling water (Chemicals, Cooling water for Refinery Facility)
- Ammonium [NH_4^+] + Nitrite [NO_2^-] in Caprolactam Production (Reactor)
- Ammonium Sulfite [$(NH_4)_2SO_3$] in Caprolactam Production (Reactor)
- Hydroxylamine [NH_2OH] in Caprolactam Production (Reactor)
- Kjeldahl-N + Acid Value in Caprolactam Production
- Permanganate Index in Caprolactam Production (Caprolactam Purification, End product)
- pH (Acidity) in Caprolactam Production (Reactor)

Applications for Caprolactam Process Waste:

- Ammonium [NH_4^+] in Outlet WWTP (Effluent)
- Sodium hydroxide [NaOH] in Outlet Reactor (Caprolactam Outlet Reactor)

HPPO Process – Propylene Oxide production

Propylene oxide is an important product for the chemical industries because of its wide range of applications that are predominantly used in the polyurethane and solvent industries. The total PO market is still growing and so is the need for a cost efficient and environmentally friendly production process. Today's industry leading technology process «HPPO» (Hydrogen Peroxide to Propylene Oxide) yields PO from propene and hydrogen peroxide using a titanium silicate catalyst, leaving water as a byproduct.

Hydrogen peroxide present in a methanol solvent is used as the sole oxidizing agent and is the critical feedstock and parameter to measure the complete conversion rate to PO. Therefore there is a high demand for accurate and robust online process monitoring throughout the entire reaction process. Measuring the H_2O_2 concentrations in the primary reaction tank plays a vital role to ensure high PO yields while reducing costs with low feedstock consumption.

Fertilizer manufacturing

Fertilizer is used to supply essential nutrients for proliferation of plant growth, leading to larger yields in the agricultural industry. Fertilizers can come from either natural (such as manure, bone meal, or compost) or synthetic sources. Primarily, synthetic fertilizers are made of nitrogen, phosphorus, and potassium compounds, though single-nutrient fertilizers are also available on the market. Synthetic fertilizers can be easily modified to better meet the nutritional needs of individual crops and soils. Deficiencies in these nutrients result in stunted growth, yellowed leaves, and an overall weak structure.

The synthesis of the nitrogen component begins with ammonia (NH_3) generally derived from the large-scale Haber process, which is then reacted with nitric acid (HNO_3) to create ammonium nitrate. Phosphorus can be derived from mineral sources with acid digestion, and can be made into either ammonium phosphate or triple superphosphate (TSP). The potassium component comes from potassium chloride, generally granulated in order for easier blending with the other compounds so that the fertilizer can be easily and properly distributed.

Applications for the HPPO Process:

- Hydrogen Peroxide [H_2O_2] + Hydroquinone [$C_6H_6O_2$] (Reactor, Hydrogen peroxide production)
- Hydrogen Peroxide [H_2O_2] in Anthraquinone [$C_{14}H_8O_2$] (Hydrogen peroxide production)
- Hydrogen Peroxide [H_2O_2] in Condensate (Hydrogen peroxide production)
- Monitoring Peroxide in a Reaction Stream (NIRS)

Applications for HPPO Process Waste:

- Hydrogen Peroxide [H_2O_2] in neutralized aqueous effluent (WWTP)
- Hydrogen Peroxide [H_2O_2] in waste water (Hydrogen peroxide production, WWTP)

Applications for Fertilizer Production:

- Phosphoric acid [H_3PO_4] in Diammonium phosphate [$(NH_4)_2HPO_4$] production
- Phosphorus pentoxide [P_2O_5] in Fertilizer Production
- Sulfate [SO_4^{2-}] in Fertilizer Production
- Sulfuric Acid [H_2SO_4] in Phosphoric Acid [H_3PO_4] for Fertilizer Production (H_3PO_4 Reactor)

Applications for Fertilizer Emission Control:

- Ammonia [NH_3] in Fertilizer Production (Emission Control)
- Ammonia [NH_3] + Nitrate [NO_3^-] in Fertilizer Production (Waste water recovery)
- Chloride [Cl^-] in Fertilizer Production (WWTP)
- Chloride [Cl^-] in Outlet Anion Exchange Column (Quality control, water after column with anion exchange resin)
- Fluoride [F^-] in Fertilizer Production (WWTP, Emission Control)
- Nitrate [NO_3^-] in Fertilizer Production (effluents treatment)
- Total Phosphate in Fertilizer Production (WWTP)
- Silica [Si] in Outlet Anion Exchange Column (Quality control, water after column with anion exchange resin)

Other Applications for the Chemical Industry:

- Ammonia [NH_3] in process (MDEA Production)
- Caustic [NaOH] in process
- Chlorine [Cl_2] in Titanium(II) oxide [TiO_2] (Titanium Oxide production)
- Hexavalent Chromium [Cr^{6+}] in waste water (Chromic Acids production)
- Hydrochloric acid [HCl] in process water (Herbicides, Acid Adjust Tank)
- Hypochlorite [ClO^-] + Thiosulfate [$S_2O_3^{2-}$] in process
- P&M Number in Demi water (Demi Water plant, Decarbonization)
- Sodium hydroxide [NaOH] in Caustic Scrubber
- Water determination in Carbon Tetrachloride [CCl_4] by Karl Fischer Titration

Waste Water:

- Ammonia [NH_3] in waste water (WWTP)
- Chemical Oxygen Demand [COD] in waste water (WWTP)
- Chloride [Cl^-] in waste water (Final Effluent discharge)
- Cyanide [CN^-] in influent WWTP (Chemicals, WWTP)
- Fluoride [F^-] in Recycled water (Fluorinated Polymers, WWTP)
- Free Chlorine [Cl_2] in condensing water (WWTP)
- Nitrate [$N\text{-}NO_3^-$] in waste water (WWTP)
- Phosphate [$P\text{-}PO_4^{3-}$] in waste water (WWTP)

NIRS Applications for the Chemical Industry:

This list is intended as a starting point but is not comprehensive. Many determinations listed below could also be applied to other chemicals and products.

Surfactants:

- Monitoring Surfactants in a Water/Isopropyl Alcohol Mixture (NIRS)
- Monitoring the Presence of a Surfactant in a Water Solvent (NIRS)

Moisture Analysis:

- Monitoring Low Level Moisture in Ethylenediamine (NIRS)
- Monitoring the Levels of Water and Fluorosulfonic Acid in a Mixed Hydrofluoric/Sulfuric Acid Stream (NIRS)
- Monitoring Water, Acetic Acid, Beta-Picoline and Dimethylacetamide in a Solvent Stream (NIRS)

Reaction Monitoring:

- Monitoring the Hydrolysis Reaction of Polyvinyl Alcohol (NIRS)
- Monitoring the Chemical Reaction of Nonene with Diphenylamine (NIRS)
- Monitoring Hydroquinol Production in a Reaction Stream (NIRS)
- Monitoring Bromine Number (Degree of Unsaturation) during the Hydrogenation of a Polyalphaolefin (NIRS)

Mixtures:

- Monitoring Methoxypropylamine and N,N Diethylaminoethanol in a Complex Mixture (NIRS)

Solvent purity and recovery:

- Monitoring Glycol Purity (NIRS)
- Monitoring the Levels of Toluene in an Organic Solvent (NIRS)

Petrochemical Industry

A demanding industry
Crude oil is a highly complex mixture of hydrocarbons and other compounds that through desalting, distillation and conversion is transformed into higher quality hydrocarbons. This refining is demanding and requires precise and reliable analysis.

Lubricant of the global economy
Nowadays crude oil, which consists of at least 500 different components, is processed by distillation and refining to produce liquefied gas, gasoline, diesel, heating fuel, and lubricants as well as a large variety of other products. As the «lubricant» of the global economy, crude oil is omnipresent. It covers approximately 40% of our energy demand and is used in the chemical industry for the production of plastics, textiles, dyes, cosmetics, fertilizers, detergents, building materials, and pharmaceuticals.

Explosion-proof systems for petrochemistry
In many cases, the IP66-NEMA4 housing of our Process Analyzers will be sufficient. In some cases in the petrochemical industry, however, explosion-proof systems are required. For those circumstances, the Metrohm Process Analytics 2045TI Ex proof Analyzer is available in a stainless-steel explosion-proof version for Zone I or Zone II according to the European explosive atmosphere directives (ATEX).

Standards for quality control
The importance of petroleum products is reflected by the large number of standards relating to them. Metrohm instruments comply with numerous petrochemical standards, which can be found within the three Petrochemical branch sites here:
www.metrohm.com/en/industries/

Process Application Notes for the Petrochemical Industry

- Sour Water Stripper (SWS): Analysis of hydrogen sulfide and ammonia in Sour Water. **AN-PAN-1001**
- Desalting Crude Oil – Analysis of Salt in Crude Oil. **AN-PAN-1014**
- Mercaptans and Hydrogen Sulfide Derived from Crude Oil According to ASTM D3227 and UOP163. **AN-PAN-1026**
- Inhibiting Polymerization: Monitoring the Concentration of TBC in Styrene According to ASTM D4590. **AN-PAN-1027**
- ASTM D8045: Online measurement of the acid number (AN) in oils with thermometric titration. **AN-PAN-1037**
- Inline monitoring of water content in naphtha fractions by NIRS. **AN-PAN-1047**

Sold and Installed Applications

Biodiesel Production:

- Acid number + Potassium in biodiesel
- Acidity + moisture in biodiesel

Kerosene Production:

- Mercaptans + Total Acidity in Kerosene (Kerosene purification process)
- Sodium chloride [NaCl] in Crude Oil (Salt in crude)
- Water determination in Kerosene and Diesel (Production and Purification Processes)

Other Downstream Processes:

- Free and Total Acid determination in Refinery Processes (Water Carbonate Removal)
- Ammonia [NH_3] / Ammonium [NH_4^+] in Petrochemical water treatments (Acid water treatment, Sour Stripper water, Circulation water, Waste water, etc.)
- Carbonate [CO_3^{2-}] in water recovery process
- Chlorine [Cl_2] in water treatment processes (Cooling water)
- Fluoride [F^-] in cooling water (Alkylation Unit)
- Hypochlorite [ClO^-] in Cooling water system
- Moisture in gasoline
- P&M value in water (Water Carbonate Removal)

Waste Water:

- Ammonia [NH_3] / Ammonium [NH_4^+] in waste water
- Ammonia [NH_3] + Sulfide [S^{2-}] in inlet of WWTP (Waste Water Treatment, Sour water)
- Ammonium [NH_4^+] + Hydrogen sulfide [H_2S] (WWTP)
- Barium [Ba^{2+}] in waste water (WWTP)
- Calcium [Ca^{2+}] in reactor WWTP (reactor WWTP)
- Chemical Oxygen Demand [COD] in refinery waste water (WWTP)
- Chloride [Cl^-] in refinery waste water (WWTP)
- Nitrite [NO_2^-] in waste water (WWTP)
- Total Nitrogen [TN] in water control
- Phenol [C_6H_5OH] in refinery waste water (WWTP)
- Phosphate [PO_4^{3-}] / Total Phosphate [TP] in waste water (water control, WWTP)
- Sulfate [SO_4^{2-}] in waste water (Seawater treatment, WWTP)
- Sulfide [S^{2-}] in refinery waste water (Stripped water, WWTP)
- Sulfite [SO_3^-] in waste water (WWTP)

Other Applications for the Petrochemical Industry:

- 4-tertiary-butylcatechol [TBC] in Styrene (Styrene Inlet Storage Tank)
- Acetic Acid [CH_3COOH] in Petrochemical Processes
- Acid number in synthetic light oil (Synthol reactor)

- Amine strength (Amine Production)
- Bromide [Br^-] Index + Bromine number in Petrochemical Processes (LAP Production, Naphtha Cracker)
- Carbonyl number in oxo-alcohols
- Caustic [NaOH] in Diethylene Glycol [DEG] (Ethylene Glycol production, MEG Scrubber)
- Caustic [NaOH] in fuels (Refinery process)
- Total Caustic [OH^-] + Free Caustic [OH^-] in Ethylene Scrubber
- Chloride [Cl^-], Iron [Fe^{2+}], + pH in Distillate stream (Overhead Condensing System of Crude Distillation Unit)
- Cobalt [Co^{2+}] in Petrochemical Hydrotreating Processes (Petrochemical production, Desulfurization process)
- Hydrogen peroxide [H_2O_2] in Dispensed/Recovery Liquid (Methanol/Propylene/H_2O/Propylene-Oxide mixture)
- Iron [Fe^{2+}], Chloride [Cl^-], + pH in Distillate stream (CDU Crude Distillation Unit)
- Methoxyethanol in aircraft fuel
- Saponification value in various petrochemical products (Petrochemical process)
- Water [H_2O] + Formic Acid [HCOOH] in Methanol (Water Removal Process)

NIRS Applications for the Petrochemical Industry:
NIR Spectroscopy can monitor many processes in the Petrochemical sector. Gasoline parameters measured with NIR cover research octane (RON, ASTM D2699), motor octane (MON, ASTM D2700), and road octane number (RdON), and volume percentage or even mole percent of individual components (paraffins, isoparaffins, aromatics, naphthenes, and olefins; PIANO). Common diesel parameters measured with NIR include specific gravity, viscosity, flash point, cold filter plugging point (CFPP), pour point, and cloud point. Also possible to monitor with NIRS: crude oil distillation, gasoline blending, diesel blending, and biofuels blending (ethanol in gasoline, biodiesel).

This list is intended as a starting point but is not comprehensive. Many determinations listed below could also be applied to other chemicals and products.

- Monitoring the Alkylation Process (NIRS)
- Monitoring a Gasoline Blend (NIRS)
- Monitoring the Level of Rolling Oil in a Rolling Oil Emulsion (NIRS)
- Monitoring a Mixture of Pentane, Pentane, and Pentyne (NIRS)
- Monitoring the Pour Point of Lube Oils (NIRS)
- Monitoring Saponification Value in Various Oil Products (NIRS)
- Monitoring Surfactants in Oil (NIRS)

Semiconductor / Electronics Industry

Semiconductors in everyday use

Semiconductors are the fundamental components of modern electronic goods. With the advent of the digital age and now the current «Internet of Things», smaller, faster, and more powerful processors are in constant demand for many goods and services. The semiconductor industry is largely responsible for improving many aspects of society as many services have been digitized and interlinked (e.g. Big Data, smart grids). Without sufficient processing power, a service can be rendered obsolete as new technologies are introduced daily. Security, health care, energy efficiency, and many other sectors benefit greatly from improvements within the semiconductor industry.

Record sales in 2014, slowdown in 2015

According to the Semiconductor Industry Association, 2014 was a record year, with worldwide sales totaling US $ 335.8 billion, increasing by 9.9 percent from 2013. In 2015, global sales were strong through June, but fell for the rest of the year. This resulted in a net increase of 1.1% from 2014, totaling US $ 337.3 billion. World Semiconductor Trade Statistics projects a modest 0.3% increase in market growth for 2016, and up to 3.1% in 2017.

Process Application Notes for the Semiconductor / Electronics Industry

- Electroless Nickel Plating; Semiconductor, PCB industry Analysis of Nickel ion & Hypophosphite content. **AN-PAN-1012**
- Monitoring Tetramethylammonium Hydroxide (TMAH) in Developer. **AN-PAN-1028**

Sold and Installed Applications

Aluminum Foil Etching:

- Free and Total Acid in Etching bath (Aluminum Foil for Electrolytic Capacitors, PCB)
- Free and Total Acid + Ortho-Phosphate [P-PO_4] in Etching bath (Aluminum Foil for Electrolytic Capacitors, PCB)
- Chloride [Cl^-] in Etching bath (Aluminum Foil Etching Bath)
- Phosphoric acid [H_3PO_4] in Etching bath (Aluminum Foil for Electrolytic Capacitors, PCB)

Glass Etching:

- Hydrofluoric acid [HF], Nitric acid [HNO_3], + Sulfuric acid [H_2SO_4] in etching baths (LCD Display, Glass etching)
- Nitric acid [HNO_3], Sulfurous Acid [H_2SO_3], + Hydrofluoric Acid [HF] in etching (LCD screen, Glass etching)
- Oxalic acid [$H_2C_2O_4$] in etching process (LCD manufacturing)
- Sulfuric acid [H_2SO_4] + Hydrogen Fluoride [HF] in process (Glass etching)

Solar Etching:

- Hydrogen fluoride [HF], Hexafluorosilicic acid [H_2SiF_6], Nitric Acid [HNO_3], + Acetic Acid [CH_3COOH] (Wafer texturing of solar panels)
- Hydrofluoric Acid [HF] + Nitric acid [HNO_3] Etching baths (Solar Cells, Etching Baths, Mixed acid etchant)
- Isopropyl alcohol [C_3H_8O] + Sodium hydroxide [NaOH] in etching baths (Wafer Texturing, Etching bath)
- Nitric acid [HNO_3], Hydrogen fluoride [HF], + Hexafluorosilicic acid [H_2SiF_6] / Hydrochloric acid [HCl] + Hydrogen fluoride [HF] / Potassium hydroxide [KOH] + Sodium hydroxide [NaOH] (Solar Panels, Etching Texturing)
- Potassium hydroxide [KOH], Isopropanol, + Hexafluorosilicic acid [H_2SiF_6] / Hydrochloric acid [HCl] + Hydrogen fluoride [HF] / Hydrogen peroxide [H_2O_2] (Solar Panels, Etching Texturing)

Wafer Etching:

- Acid (Total) - (Phosphoric acid [H_3PO_4], Nitric acid [HNO_3] and Citric acid) in etching process (LCD Manufacture)
- Total Acid in etching baths (Touch Panel, Etching bath)
- Acidity in etching baths (Copper bath)
- Acidity + Nitrite [NO_2^-] in etching baths (PCB, Etching bath)
- Chloride [Cl^-] in 50 to 80% Sulfuric Acid [H_2SO_4] (Waste H_2SO_4 recycling system)
- Copper [Cu^{2+}], Sulfuric acid [H_2SO_4], + Chloride [Cl^-] in etching bath (Micro-Chips, Etching bath)
- Copper [Cu^{2+}], Sulfuric acid [H_2SO_4], + Sodium peroxosulfate [NaPS] in Etching Cleaner (BOC (Board On Chip))
- Hydrochloric acid [HCl], Aluminum Chloride [$AlCl_3$], + Boric acid [$B(OH)_3$] in process (Transistor & Resistors, Etching bath)
- Hydrofluoric Acid [HF] + Hydrochloric acid [HCl] (binary acid etchant)
- Hydrogen peroxide [H_2O_2] + Hydrochloric acid [HCl] in etching bath (Surface treatment, etching bath)
- Hydrogen Peroxide [H_2O_2] + Sulfuric Acid [H_2SO_4] in Etchant (Touch Screen Panels, Monitoring Etchant, Etching Clean Bath)
- Iron [Fe^{2+}], Nickel [Ni^{2+}], + Copper [Cu^{2+}] in Etching Bath (Monitoring Etching Bath, SC1, SC2)
- Methanesulfonic acid [MSA] + Hydrofluoric acid [HF] in MSA/HF storage tanks (Wafers, Etching baths)
- Monitoring Etching Baths (NIRS)
- Monoethanolamine [MEA] + water [H_2O] in Alkaline Photoetch (Flexible Electronic Circuitry)
- Nickel [Ni] + Hypophosphite [$H_2PO_2^-$] in etching baths (Etching baths)
- Nitric acid [HNO_3] in etching bath (Etching)
- Sulfuric acid [H_2SO_4], Hydrofluoric acid [HF], + Hydrogen peroxide [H_2O_2] in etching baths (Wafers, Etching baths)

- Sulfuric acid [H_2SO_4], Phosphoric acid [H_3PO_4], Hydrogen Peroxide [H_2O_2], + Titanium in Etching bath (Copper Etchant, Mixing)
- Tin [Sn^{2+}] + Copper [Cu^{2+}] in etching bath (Integrated Circuits (PCB), Sn/Cu Plating bath)
- Tin [Sn^{2+}] + Free Acid in Tin Plating baths (Etching baths, Electronic components)

Photolithography:

- Tetramethylammonium hydroxide [TMAH] in Developer (LCD Screen, Photoresist, Developer Recycling System)
- Monitoring Tetramethylammonium Hydroxide [TMAH] in Water (NIRS)

Plating Baths:

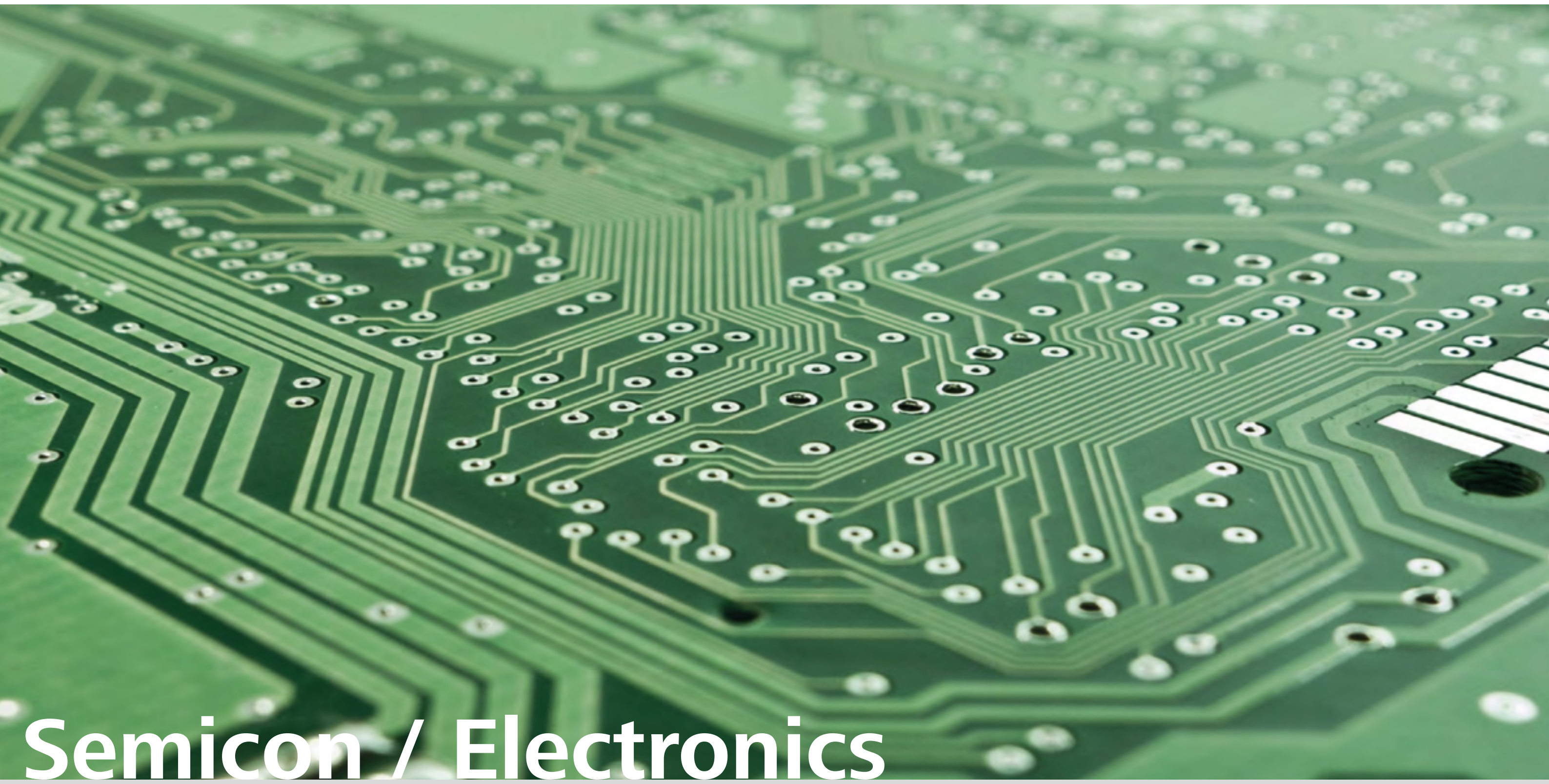
- Copper [Cu^{2+}] in plating (Electroless Copper Plating, Flexible PCB)
- Copper [Cu^{2+}] in Zinc Electrolyte (Zinc electrolysis)
- Copper [Cu^{2+}], Sodium hydroxide [NaOH], + Formaldehyde [CH_2O] in electroless Copper (BOC (Board On Chip))
- Dimethylamine borane [DMAB], Boric acid [$B(OH)_3$], Cobalt(II) sulfate [$CoSO_4$], + pH in Cobalt plating bath (Chip manufacturing, plating baths)
- EDTA in Cu Bath (PCB production)
- Glycolic Acid + pH in Cu-Electro plating bath (Chip manufacturing, plating baths)
- Formaldehyde [CH_2O], Sodium hydroxide [NaOH], + Dimethylamine borane [DMAB] in Cu plating solution (PCB, Copper Plating)
- Leveller in acid-Cu bath (Micro-Chips, Copper Plating at Pilot Plant)
- Nickel [Ni^{2+}] + Hypophosphite [$H_2PO_2^-$] in Nickel Plating Bath (Electroless Wafer Bumping, Nickel Plating Bath)
- Nickel [Ni^{2+}] + Phosphoric acid [H_3PO_4] (Nickel bath)
- Tin [Sn^{2+}] + Free Acid in Tin Plating baths (Etching baths, Electronic components)
- Tin [Sn^{2+}] + Copper [Cu^{2+}] in etching bath (Integrated Circuits (PCB), Sn/Cu Plating bath)

Waste Water:

- Ammonia [NH_3] in waste water (WWTP)
- Ammonia [NH_3], Fluoride [F^-], + pH in Hydrofluoric Acid Waste (HFW) (WWTP)
- Boron [B] in waste water (Glass Thinning in LCD Industry, WWTP)
- Cadmium [Cd] in waste water (Solar Panels, WWTP)
- Calcium [Ca^{2+}] in waste water (WWTP)
- Chemical Oxygen Demand [COD] in waste water (Chip (Wafer), Solar Panels, WWTP)
- Chloride [Cl^-] in waste water (WWTP)
- Hexavalent Chromium [Cr^{6+}] in waste water (PCB Industrial, Electroplating Products, WWTP)
- Copper [Cu^{2+}] in waste water (PCB Industrial, CCW, Chip (Wafer), WWTP)
- Copper(I) [Cu^+] and Copper(II) [Cu^{2+}] in waste water (PCB Industrial, WWTP)
- Copper [Cu^{2+}] + Cobalt [Co^{2+}] in waste water (Chip (Wafer), Heavy Metals Waste Treatment, WWTP)
- Copper [Cu^{2+}] + Hydrogen Peroxide [H_2O_2] in slurry Copper waste treatment (Chip (Wafer), waste water treatment)
- Copper [Cu^{2+}], Iron [Fe^{3+}], + Nickel [Ni^{2+}] in waste water (WWTP)
- Cyanide [CN^-] in waste water (Electroplating Products, WWTP)
- Fluoride [F^-] in waste water (Chip (Wafer), Semiconductor, Solar Cells, WWTP)
- Hydrogen peroxide [H_2O_2] in waste water (WWTP)
- Nickel [Ni^{2+}] in waste water (WWTP)
- Nitrite [NO_2^-] in waste water (Solar Panels, Detox Waste Water, WWTP)
- Phenol [C_6H_5OH] in waste water (Semiconductor, WWTP)
- Ortho-Phosphate [PO_4^{3-}] in waste water (WWTP, Outlet LED production)
- Sulfate [SO_4^{2-}] in waste water (Final Effluent monitoring, WWTP)
- Tin [Sn^{2+}], Lead [Pb], + Copper [Cu^{2+}] in waste water (WWTP)

Other Applications for the Semiconductor/ Electronics Industry:

- Ammonia [NH_3] in cooling water (Microchips production)
- Ammonium [NH_4^+] in Chemical Dilution system (Semiconductor parts)
- Ammonium Hydroxide [NH_4OH] (Chemical distribution, Blending system)
- Ammonium Hydroxide [NH_4OH] + Hydrogen Peroxide [H_2O_2] in SC1 Clean
- Benzotriazole (BTA) [$C_6H_4N_3H$] as Copper Corrosion Inhibitor in flexible circuitry
- Copper [Cu^{2+}] + Hydrogen Peroxide [H_2O_2] in SCW (Slurry Copper Waste) (Ion exchange Treatment, Chip wafer)
- Copper [Cu^{2+}], Zinc [Zn^{2+}], Nickel [Ni^{2+}], Free and Total Acid (Zinc, Acid baths)
- Hydrochloric acid [HCl] in recovery systems (TMAH Recovery System, Wafers)
- Hydrochloric acid [HCl] + Germanium [Ge] (Germanium purifying)
- Hydrochloric acid [HCl] + Hydrogen Peroxide [H_2O_2] in SC2 Clean
- Hydrofluoric acid [HF] in process water (Chemical preparation, Dilution system, Blending)
- Hydrogen Peroxide [H_2O_2] in CMP Slurry (Wafer polishing, Chemical Mechanical planarization)
- Hydrogen Peroxide [H_2O_2] + Ammonia [NH_3] in reclaim water (Reclaim water)
- Hydrogen peroxide [H_2O_2], pH, Temperature, + Conductivity (CMP Slurry chemical blending)
- Phosphoric acid [H_3PO_4], Hydrogen peroxide [H_2O_2], + Copper [Cu^{2+}] (semiconductors)
- Silica [Si^{4+}] in make-up water (Solar Cells, Make-up water)
- Sodium [Na^+] in Make-up Water (Solar Cells, Make-up water)
- Sodium hydroxide [NaOH] in cleaner for Electroless Copper Wet Bench



Mining Industry

Ever-increasing demands

Mining produces both common and rare elements which are then refined and used in all kinds of other industries, from creating jewelry to the manufacture of electronics. The global mining industry is undergoing massive expansion to meet the increasing demand for minerals and metals. This expansion is taking place in an environment where costs of capital, labor, raw materials and other inputs are all rising, demanding that operations must be run at optimum efficiency.

Extraction and refining

In order to extract some materials, a process known as «leaching» is performed by introducing a leaching solution (such as hydrochloric acid, sulfuric acid, or nitric acid) into bore holes and fracture lines in the ground. The solution is pumped out after a certain amount of time and allowed to flow through ion exchange resins to concentrate the material (such as uranium). In some situations, rather than pumping the carrier solution down into the ore, the ore is ground up and allowed to mix with the solution, such as in gold cyanidation where cyanide is used to leach gold. The cyanide lowers the amount of oxygen in the water considerably which can affect the rate of leaching, but this waste water has severe consequences for the environment and must first be treated with oxidants to decrease its toxicity.

Electrowinning can be used instead of ion exchange resins to recover materials, in fact – this is the only process to refine aluminum from ore. In this case, the semi-saturated leaching solution is electrolyzed and the material (such as copper or gold) is electroplated on a large scale. Some metals need subsequent reduction to be refined, while others can deposit at the bottom of the plating tank and form anodic sludge, which also requires further treatment before the refined material can be used.

Quality control with chemical analysis

Accurate and reliable chemical analysis plays a crucial role in meeting these challenges. It is required to keep mining and refining operations running at peak efficiency, as well as ensuring that raw materials and products are of the specified quality. Moreover, waste streams and remediation processes require chemical analysis to ensure that environmental impact is minimal. For the mining industry, continuous control of the production process, the quality of the product, and the composition of any waste streams is of utmost importance.

Process Application Notes for the Mining Industry

- Hydrometallurgical Process: Analysis of Free, Total & WAD Cyanide in gold leach slurry & wastewater. **AN-PAN-1002**
- Zinc production: Analysis of Zinc, Sulfuric acid and Iron. **AN-PAN-1006**
- Analysis of Bayer Aluminate Liquors Using Thermometric Titration. **AN-PAN-1034**

Sold and Installed Applications

Copper Mining & Purification:

- Chloride [Cl^-] in Copper Electrolyte solution (Copper refinery, Electrolyte tanks)
- Copper [Cu^{2+}] in refining processes (Copper electro refining, Nickel purification, Refinery Deep Electrolyte Decopperization, Smelter, Metal recovery)
- Copper [Cu^{2+}] + Iron [Fe^{3+}] (Copper mining)
- Metals (Cadmium [Cd] / Cobalt [Co] / Copper [Cu] / Germanium [Ge] / Antimony [Sb]) (Metal Purification, Recovery)
- Sulfuric acid [H_2SO_4], Copper [Cu^{2+}], Iron [Fe^{2+}], Iron [Fe^{3+}], + BT (Copper refinery)

Electrowinning Processes:

- Acid, Chloride [Cl^-], Iron [Fe^{2+}], + Rx in Copper electrowinning process (Electrolysis)
- Chloride [Cl^-] in Copper Electrolyte solution (Copper refinery, Electrolyte tanks)
- Copper [Cu^{2+}] from copper electrowinning (Copper electro refining)
- Copper [Cu^{2+}], Sulfuric Acid [H_2SO_4], + Chloride [Cl^-] in Electrolyte (Metallurgy company, Refinery Deep Electrolyte Decopperization)
- Free Acid (Nitric Acid) [HNO_3] in process (Uranium Processing, Uranium Extraction (Yellow Cake Process))
- Sulfur Dioxide [SO_2] in Electrolyte solution (Manganese, SO_2 Absorption into Feed Electrowinning)
- Sulfuric acid [H_2SO_4] (Zinc purification, Copper Electrowinning, Copper Electro Refining)

Gold Mining & Purification:

- Cyanide, Free [CN^-] in gold mining (Gold winning, WWTP)
- Cyanide, total [TCN] (Gold mining, Detoxination Plant (CIP/CIL Plant))
- Cyanide, Weak Acid Dissociable [CN-WAD] (Gold mine, WWTP, Gold winning, Electroplating)

Leaching Processes:

- Ammonia [NH_3] + Carbon Dioxide [CO_2] (Nickel, Leaching S/X Circuit)
- Metals (Total) + pH (Leach plant)
- Silica [SiO_2] in Ammonium sulfate [$(NH_4)_2SO_4$] in Manganese processing (Leaching, Thickening, and Purification)
- Sulfuric acid [H_2SO_4], pH, Redox, + Chloride [Cl^-] (Copper mining, Leaching)
- Zinc [Zn^{2+}] + Sulfuric Acid [H_2SO_4] in process (Zinc production, zinc leaching)

Nickel Mining & Purification:

- Aluminum [Al^{3+}] (Nickel Purification)
- Ammonia [NH_3] in process (Nickel, Solvent Extraction, WWTP)
- Ammonia [NH_3] + Carbon Dioxide [CO_2] (Nickel, Leaching S/X Circuit)
- Copper [Cu^{2+}] in Nickel(II) sulfate [$NiSO_4$] refining process (Deep removal copper process)
- Nickel [Ni^{2+}] from purification processes (Nickel Purification)
- Sulfide [S^{2-}] gas in flue gas in acid smelter in Nickel mine (Nickel)
- Zinc [Zn^{2+}] (Nickel Purification)

Platinum Refineries:

- Acid, pH, Redox, + Caustic [NaOH] in multiple sample streams (Platinum refineries)
- Molar Ratio [Ni/NH_3] (Platinum refineries)

Zinc Mining & Purification:

- Acid + Iron [Fe^{2+}] in Zinc Mining
- Acidity in zinc production processes (Zinc Purification)
- Cadmium [Cd] in Zinc sulfate [$ZnSO_4$] (Zinc Purification, WWTP)
- Cobalt [Co^{2+}] in Zinc Electrolyte (Zinc electrolysis)
- Cobalt [Co^{2+}] in Zinc-plant liquid purification (Zinc plant)
- Copper [Cu^{2+}] + Iron [Fe^{3+}] (Copper mining)
- Hydrogen Sulfide [H_2S] in Process (Zinc production)
- Hydrogen sulfide [H_2S] in zinc purification processes (Zinc purification)
- Iron [Fe^{2+}] (Zinc purification)
- Iron [Fe] + Sulfuric Acid [H_2SO_4] in Electrolysis (Zinc production, Electrolysis)
- Sulfuric Acid [H_2SO_4] in Electrolysis (Zinc production, Electrolysis)
- Zinc [Zn^{2+}] + Manganese [Mn^{2+}] in Electrolysis (Zinc production, Electrolysis)
- Zinc [Zn^{2+}], Manganese [Mn^{2+}], + Sulfuric Acid [H_2SO_4] in Electrolysis (Zinc production, Electrolysis)
- Zinc [Zn^{2+}] + Sulfuric Acid [H_2SO_4] in process (Zinc production, zinc leaching)

Waste Water:

- Ammonia [NH_3] in process (Nickel, Solvent Extraction, WWTP)
- Cadmium [Cd] in Zinc sulfate [$ZnSO_4$] (Zinc Purification, WWTP)
- Calcium [Ca^{2+}] in waste water (Zinc Copper mining, WWTP)
- Hexavalent Chromium [Cr^{6+}] in Waste Water Treatment Plant (Nickel, PN Feed)
- Cyanide, Free [CN^-] in waste water (WWTP)
- Cyanide, total [TCN] in Process Waste (Polymetallic mining, Cyanide Destruction Plant)
- Cyanide, Weak Acid Dissociable [CN-WAD] in waste water (WWTP)
- Fluoride [F^-] in waste water (Waste water treatment)
- Hydrochloric acid [HCl] in Waste Water Treatment Plant (Nickel, PN Feed)
- Manganese [Mn^{2+}] in Waste Water Treatment Plant (Nickel, PN Feed)
- Metals (Total) in effluent (Waste water treatment)
- Phosphate [PO_4^{3-}] in waste water (Grit Chamber, precipitation of particles, WWTP)
- Silica [SiO_2] in waste water (Metallurgy company, WWTP)
- Sulfate [SO_4^{2-}] in waste water
- Sulfide [S^{2-}] in waste water (Zinc & Lead Production, WWTP)

Other Applications for the Mining Industry:

- Acid and Chloride [Cl^-] in copper electrolyte solution
- Acidity (Total + Free), Zinc [Zn], Iron [Fe], + Chloride [Cl^-] in process (Acid Recovery Plant)
- Chromic acid [H_2CrO_4] (Chrome production)
- Dinitrogen trioxide [N_2O_3] in H_2SO_4 (Reactor, Sulfuric Acid by absorption of SO_2)
- Hypochlorite [OCl^-] in a scrubber system for exhaust gas (mining)
- Metals (Total) and Acid in spent electrolyte (Autoclave Spent Electrolyte)
- Monitoring Moisture Content in Concentrated Iron Ore Samples (NIRS)
- Sodium Hydrosulfide [NaHS] in copper production (Molybdenum selection)

Steel / Metal Industry

An industry with nerves of steel

The Metals industry, and steel in particular, is responsible for creating the infrastructure that our modern world depends on. Steel is essentially a form of iron, combined with a small amount of carbon (typically less than 1%), which is refined for strength and formability. In 2014, according to the World Steel Association, 51.2% of global steel production went toward construction projects, such as houses and skyscrapers. China is the largest steel producer in the world, followed by Japan, India, the US, and Russia. In 2015, world crude steel production slowed, with a change of -2.8% compared to 2014.

Bessemer Process

The industrial production of steel is performed via the Bessemer process, patented in the 1850's. Iron from iron ore, coal converted to coke (pure carbon) at 1100 °C, and limestone are blended, sintered (a process also used in lead and copper production), and poured into a blast furnace. The iron is released and combined with carbon by the coking process and injection of hot air (around 1250 °C) into the furnace, eventually forming liquid «pig iron» and lighter slag as a byproduct. The iron is collected and lime powder added to reduce the sulfur content in order to preserve ductility in the final product.

When the refined iron is reheated prior to steelmaking, scrap steel is added to help control the temperature due to oxidation of impurities in the mixture. Pure oxygen is added in the blast furnace to the liquid pig iron, oxidizing the impurities into slag, and eventually the mixture reaches a final temperature of 1650 °C. Excess carbon is also removed via vacuum degassing.

Metal alloys can be created with other elements like titanium, manganese, or aluminum, which can be added to de-oxidize and improve the ductility of steel for example. Inert gases such as argon are bubbled through the hot mixture to stir and ensure homogeneity in composition and temperature, as well to float out remaining impurities into the slag above.

The liquid steel is then poured into casts and while still warm, rolled out into increasingly thinner sheets, which can then be further treated based on customer requests. Pickling baths with hydrochloric acid are used to remove the oxide layer which formed on the surface during the hot strip mill. The cold mill squeezes the sheets of steel even further, giving a smooth finish and increasing the steel's strength.

Hot vs. cold roll
Hot rolled steel is suitable for pipes, tubing, auto frames, rail cars, and construction and agricultural equipment. Cold rolled steel is better suited for exposed automotive body parts, appliance cabinets, office furniture, and electric motors. Cold rolled steel is harder, and sometimes must go through an additional heat treating process called annealing to restore its formability. Surfacing techniques such as galvanization are used to make metal corrosion- and heat-resistant. Metal surfacing information can be found in the following chapter.

Process Application Notes for the Steel / Metal Industry

- Steel Industry: Analysis of Acids and Iron in Pickling Baths.
  AN-PAN-1019

Sold and Installed Applications

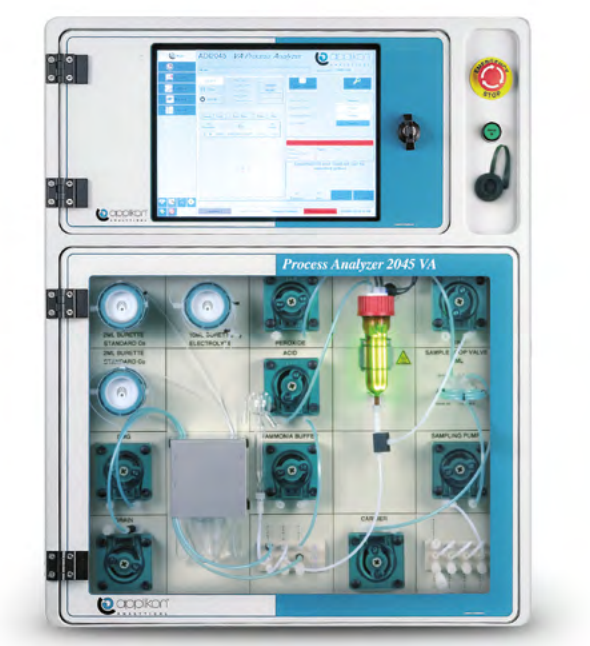
Pickling Process:
- Acid (Total), Hydrogen fluoride [HF], + Nitric acid [HNO_3] (Acid Pickling Stainless Steel)
- Hydrochloric acid [HCl] in Pickling solution (Pickling bath)
- Hydrochloric acid [HCl] + Iron [Fe] in Pickling solution (Pickling bath)
- Hydrogen Peroxide [H_2O_2] in Pickling solution (Stainless Steel, Pickling process)
- Iron [Fe^{3+}], Sulfuric Acid [H_2SO_4], + Hydrogen Fluoride [HF] in pickling bath (Pickling bath)

Waste Water:
- Ammonia [NH_3] in waste water (WWTP)
- Ammonia [NH_3], Nitrate [NO_3^-], + Nitrite [NO_2^-] in waste water (Steel, WWTP)
- Ammonia [NH_3], Phenol [C_6H_5OH], Cyanide [CN^-], + Thiocyanate [SCN^-] in effluent WWTP (Outlet WWTP Cokes plant)
- Chemical Oxygen Demand [COD] (BDS, WWTP)
- Chloride [Cl^-] in waste water (Effluent WWTP)
- Hexavalent Chromium [Cr^{6+}] in waste water (WWTP, Steel, Aluminum metal bashing)
- Cyanide, total [TCN] in waste water (WWTP)
- Fluoride [F^-] in industrial waste water (WWTP)
- Iron [Fe^{2+}] in waste water (Steel, WWTP)
- Total Iron [Fe^{2+} / Fe^{3+}] in waste water (Steel/Metal, WWTP)
- Manganese [Mn^{2+}] + Sulfate [SO_4^{2-}] in waste water (Manganese Based Metals, WWTP)
- Nickel [Ni^{2+}] in ground/waste water (WWTP)
- Nitrate [NO_3^-] in influent (Stainless Steel, WWTP)
- pH, Free-Ammonia [NH_3], + Total Ammonia [NH_3] in waste water (Steel, Waste De-Ammonization of Coke plant)
- Sodium sulfate [Na_2SO_4] in waste water (WWTP)
- Thiosulfate [$S_2O_3^{2-}$] in waste water (WWTP)
- Zinc [Zn^{2+}] in waste water (Metal treatment, WWTP)
- Zinc [Zn^{2+}] + Sulfuric acid [H_2SO_4] in waste water (WWTP)

Aluminum Milling:
- Aluminum [Al^{3+}] + Caustic [NaOH] (Aluminum)
- Fluoride [F^-] in 2.5% Sulfuric Acid [H_2SO_4] bath (Aluminum Annealing Line)
- Fluoride [F^-] + Free and Total Acid in etching bath (Aluminum plates, Aluminum Coating Baths)
- Sulfuric acid [H_2SO_4] + Aluminum [Al^{3+}] in Aluminum etching bath (Aluminum Cast Line, Al anodization)

Other Applications for the Steel / Metal Industry:

- Total Acid (TA), Free Acid (FA), + Iron [Fe^{2+}] in Manganese [Mn]/Phosphating Bath (Tubes for Crude transport)
- Ammonia [NH_3] in Cokes Gas (Steel, Coking Plant)
- Ammonia [NH_3] + Sulfide [S^{2-}] in Scrubber (Ammonia Recovery plant)
- Total + Free Ammonia [NH_3] in Stripper (Steel, Coking Plant, Waste water from Strippers)
- Calcium [Ca^{2+}] (Aluminum Smelter, Dosing unit)
- Chloride [Cl^-] in process water (Steel, cold mill 2)
- Chromate [CrO_4^{2-}] in process (Steel, Metal Finishing)
- Copper [Cu^{2+}] (Copper tubes)
- Copper [Cu^{2+}], Sulfuric Acid [H_2SO_4], + Chloride [Cl^-] in Copper Plating bath (Copper Foil Plating Bath)
- Copper [Cu^{2+}] + Tin [Sn^{4+}] in Etching baths (Steel wire for Tire, Etching process)
- Hydrochloric acid [HCl] + Aluminum [Al^{3+}] (House Cooking Equipment, Etching bath)
- Hydrochloric acid [HCl] + Iron [Fe] (Carbon Steel production)
- Hydrogen Sulfide [H_2S], Ammonia [NH_3], + pH in Acid Stripper (Steel, Outlet Acid Scrubber)
- Iron [Fe] + Chloride [Cl^-] (Steel, Cold mill 2)
- Silica [Si^{4+}] (Steel, Cold mill 2)
- Sodium [Na^+] in water (Steel, Demi Water plant)
- Sodium Hydroxide [NaOH], Sodium Cyanide [NaCN], Sodium Carbonate [Na_2CO_3], + Copper [Cu^{2+}] in Copper Plating Bath (Metal Wire Production)
- Sulfuric acid [H_2SO_4] in water (Zinc extraction, metal recovery, Process water treatment)
- Sulfuric acid [H_2SO_4] in Ammonium sulfate [$(NH_4)_2SO_4$] (Outlet reactor)
- Tin [Sn] + Sulfonic acid [$R\text{-}S(=O)_2\text{-}OH$] (Steel production)
- Zinc [Zn^{2+}], Nickel [Ni^{2+}], + Nitrate [NO_3^-] in zinc phosphating bath (Phosphate plating)
- Zinc [Zn^{2+}] + Sulfuric acid [H_2SO_4] in process (Steel, Leaching)



Galvanic / Metal Surface Industry

Corrosion

In the earth's crust, many metals are found in their oxidized, ore state. Iron for example, is found naturally in a multitude of oxide forms as magnetite (Fe_3O_4), hematite (Fe_2O_3), goethite (FeO(OH)), and more. As a refined metal, iron is especially vulnerable to corrosion, which is visible as red-brown colored rust. The iron is only trying to revert back to its oxide form. Considering the immense amount of time and energy funneled into mining, refining, and producing metals, protection against corrosion from the air, water, and other harsh environments is a top priority.

Nothing lasts forever

Despite the various types of surfacing techniques available, rusting and corrosion are inevitable over the lifetime of the refined metal. Wet, salty environments such as areas near the ocean, or cold climates where salt is used to de-ice roads, decrease the effectiveness of protective metal coatings due to the high electrical conductivity of saltwater. Corrosion rates are increased in these environments, which is why rusted automobiles are more prevalent in cold, northern climates compared to hot, dry climates where the protective layer on the body is more preserved. More information about our atline and online products and services for metal surface finishing analysis can be found here:

www.metrohm.com/en/industries/

Surfacing

Corrosion- and heat-resistant properties are highly valued in the metal industry. The thin plating of one metal on top of another can take advantage the oxidized coating that results, shielding the base layer from the environment. Immersion of steel sheets (or other metals or alloys) in baths of molten zinc for galvanization makes the surface rust resistant. Galvannealing combines the process of galvanizing (hot-dip) and then immediately annealing the steel inline, creating a matte finish which is resistant to corrosion and can be easily painted. This type of steel is used in many industries, including automotive, because of its lifetime and paintability. Aluminum coated steel is also used in the automotive industry and other industries for long-life parts which can withstand high heat. Electrogalvanizing (electrolytic plating) of cold rolled steel with zinc or a Zn/Ni mixture is another option to provide a non-reactive surface.

Passivation and Anodizing

Passivation is the state in which a metal surface is shielded from some environmental forces such as air and water, usually by an applied oxide coat made of a base material. This oxide coat strengthens and protects the metal surface, while inhibiting deeper corrosion. Passivation can occur naturally or result from applying a micro-coating on the metal's surface. Anodizing is an electrolytic passivation process which can increase the thickness of the oxide layer, increasing the resistance to corrosion. Anodized materials are able to be easily painted and glued due to the porous qualities of the surface. Both aluminum (including its alloys) and steel are common metal surfaces which use anodization and passivation for protection.

Galvanization

Galvanization, originally invented in India, is an anti-corrosive measure taken with iron and steel (and other metals) by applying a protective zinc coating. Protection against the elements occurs by forming a coat of rust-resistant zinc over the iron (or other metal) which does not allow oxidation to occur, and the zinc also acts as a sacrificial anode which still protects the underlying metal in the event of a scratch or gouge in the galvanized surface. Electrogalvanization (electrolytic plating) results in a thinner layer, which is beneficial for automotive manufacturers and other industries which apply additional rust-proof paint as protection. This is not limited to steel – aluminum, copper and many other types of metals and alloys can be galvanized as well.

Hot-dip galvanization

Hot-dip galvanization is the most common method of galvanization. This method utilizes a bath of molten zinc, in which the metal parts are dipped into, coating them with a thick protective layer. Constant exposure to a corrosive environment (such as salt water) will eventually corrode hot-dip galvanized steel, but stainless steel can be used instead in these situations. The Brooklyn Bridge, built in 1883, was the first bridge to use hot-dip galvanized steel wire for its suspension cables. At the time, it was 50% longer than any other bridge constructed, making it the longest in the world. The suspension cables were found to be in good condition after the bridge's rehabilitation more than 100 years later.

Thermal diffusion galvanization

Also known as dry galvanizing, this form diffuses a zinc alloy coating on iron or copper-based materials. Zinc powder and metal parts are sealed and tumbled in a rotating drum at about 300 °C, where the zinc evaporates and diffuses into the substrate. Thermal diffusion galvanization can provide better corrosion resistance than hot-dip galvanization in many cases, as well as emit less waste products.

Phosphatizing

The phosphatizing process produces a hard, electrically non-conducting surface coating that adheres tightly to the underlying metal. This layer protects the metal from corrosion and improves the adhesion of paints and organic finishes to be subsequently applied. Phosphatization consists of two parts: an etching reaction with phosphoric acid which increases the surface roughness, and a second reaction at the surface between the alkali phosphates and the previously generated metal ions. This coating is quite thin and offers only basic corrosion protection. The addition of metal cations such as Zn^{2+}, Mn^{2+}, and Ca^{2+} to the phosphatizing bath results in the formation of very resistant zinc phosphates with a coating thickness between 7 and 15 times thicker, perfectly suited for outdoor use.

This is not an exhaustive list of metal surface treatments.

Process Application Notes for the Galvanic / Metal Surface Industry

- Galvanic Industry – Metal Surface Treatment Aluminium etching/anodizing for analysis of Acids, Bases and Aluminium. **AN-PAN-1018**
- Steel Industry: Analysis of Acids and Iron in Pickling Baths. **AN-PAN-1019**

Sold and Installed Applications

Waste Water:

- Hexavalent Chromium [Cr^{6+}] in waste effluent (Effluent monitoring, WWTP)
- Total Chromium [Cr^{6+} / Cr^{3+}] in final waste effluent (Mechanical Components for Aviation Industry, WWTP)
- Copper [Cu^{+} / Cu^{2+}] in final waste effluent (Mechanical Components for Aviation Industry, WWTP)
- Free Cyanide [CN^{-}] in final effluent (WWTP)
- Total Cyanide [TCN] in effluent (plating company, WWTP)
- Digester Unit for final waste effluent (Mechanical Components for Aviation Industry, WWTP)
- Nickel [Ni^{2+}] in waste water (Chrome / Nickel Plating, Mechanical Components for Aviation Industry, WWTP)
- Sulfate [SO_4^{2-}] in waste water (WWTP)
- Zinc [Zn^{2+}] in waste water (Steel, WWTP)

Other Applications for the Galvanic / Metal Surface Industry:

- Acids, Sodium Hydroxide [NaOH], + Aluminum [Al^{3+}] (Etching bath)
- Boric Acid [$B(OH)_3$], Aluminum [Al^{3+}], + Nitric Acid [HNO_3] in plating bath (Plating bath control)
- Copper [Cu^{2+}] in Electrolysis Bath (Copper alloys, Electrolysis Bath)
- Hydrofluoric acid [HF], Nitric Acid [HNO_3], + Titanium [Ti] in Plating baths (Titanium, Plating Bath Quality Control)
- Nickel [Ni] + Copper [Cu] (Inkjet Printer Heads, Plating line)
- Nickel Sulfate [$NiSO_4$] + Cobalt Sulfate [$CoSO_4$] in etching baths (Cathode materials for Lithium-Ion secondary battery, Etching baths)
- Potassium hydroxide [KOH] in scrubber (Carbon Dioxide Scrubber)
- Sodium Hydroxide [NaOH] in etching baths (Cathode materials for Lithium-Ion secondary battery, Etching baths)
- Sodium Hydroxide [NaOH] + Ammonia [NH_3] in etching baths (Cathode materials for Lithium-Ion secondary battery, Etching baths)
- Sodium hydroxide [NaOH] + Calcium [Ca^{2+}] in process (Sodium Monochromate)
- Sulfuric acid [H_2SO_4] + Hydrogen Peroxide [H_2O_2] in etching bath (Etching bath)
- Tin [Sn] + Acid (Tin plating)
- Zinc [Zn^{2+}] in galvanic bath (Surface finish)

Galvanic / Metal

Pulp and Paper Industry

Paper or plastic?
The Pulp and Paper industry is one of the largest industries in the world, taking in more than 40% of all industrial wood traded globally. This industry is responsible for creating products such as paper-based packaging, matte and glossy paper, tissues, toilet paper, and so on. A major benefit for the use of paper products is that they can generally be recycled. Though recycling paper materials is a feasible option most of the time, paper fibers lose quality over successive cycles, and so new pulp (a paper precursor) will always be in need.

Kraft Process
The breakdown process from solid wood to sheet of paper involves quite a number of preparative steps. The main process which converts wood into pulp is named the Kraft process, which utilizes white liquor (a mixture of sodium hydroxide and sodium sulfide) to break down the lignin and cellulose linkages. Trees are pulverized into wood chips, which are then steamed to force out air pockets. The wood chips are saturated with a mixture of chemicals (liquors) and cooked in pressurized digesters. The high pH, pressure, and temperature allow lignin and hemicellulose to break down, and the resulting pulp is then sieved, washed, and sometimes bleached. The chemical liquors are processed and recovered for further use, where possible, considering their adverse environmental effects.

Process Application Notes for the Pulp and Paper Industry

- ABC Titration: Analysis of Alkali, Carbonate, hydroxide and sulfide in Pulping Liquors. **AN-PAN-1004**

Sold and Installed Applications

Bleaching Process:
- Caustic [NaOH] in Hypochlorite [ClO^-] (Bleach production)
- Residual Peroxide [H_2O_2] in bleaching solution (Bleaching Mechanical Produced Pulp, Bleaching process)

Waste Water:
- Chemical Oxygen Demand [COD] in waste water (WWTP)
- Chemical Oxygen Demand [COD], pH, + Conductivity in waste water (WWTP)
- P&M Number + Hardness [Ca^{2+} / Mg^{2+}] in waste water (WWTP)
- Ortho Phosphate [PO_4^{3-}] + Total Phosphate (TP) in waste water (WWTP)

Other Applications for the Pulp and Paper Industry:
- Dissolved Carbon Dioxide [CO_2] in Treated/Recycled Water (Water purification)
- Caustic [OH^-], Carbonate [CO_3^{2-}], Hydrogen Sulfide [HS^-], + Sulfate [SO_4^{2-}] in Black, Green & White Liquor (recovery process)
- Silica [Si^{4+}] (Pulp Process)
- Sodium Bisulfite [$NaHSO_3$] in paper production (Paper production)
- Sulfite [SO_3^{2-}] in process (Tannin production, Reactor)

NIRS Applications for the Pulp and Paper Industry:
The Pulp and Paper industry has used NIR analysis for many years providing qualitative and quantitative information about incoming timber materials and lignin content. Discriminant NIR analysis can be used to determine species: hardwoods from softwoods, and sapwoods from heartwoods. Common paper and pulp attributes measured with NIR include: kappa number, lignin content, kraft pulp yield, tall oil, moisture, resin, brightness, wood species, hardwood/softwood ratio, coatings, and component analysis (clay, titanium dioxide, fillers, ash, etc.).

This list is intended as a starting point but is not comprehensive.

Kappa Number:
- Determining Kappa Number in Blended Wood Pulp Samples (NIRS)
- Determining Kappa Number in Pulp in Blowline Samples (NIRS)
- Monitoring Kappa Numbers in Pulp-Cotton Linters Mixtures (NIRS)

Moisture Content:
- Monitoring Moisture in Paper Coating Mixtures (NIRS)
- Determining Moisture in Paper and Lacquer Weight on Backed Paper (NIRS)

Resin Levels:
- Monitoring Wax and Phenolic Resin Content in Wood Fiber (NIRS)
- Monitoring Percent Resin and Percent Volatiles in Paper Material (NIRS)

Energy / Power Industry

Increasing energy consumption
Humans are set apart from other organisms in many ways, among them is the drive and knowledge to create and harness excess energy. We have the capacity now to develop power plants which convert kinetic (wind, water) and thermal energy (nuclear energy, chemical energy) into electrical power which improves our lives immensely. However, energy supply has become a major issue of modern times. It is well-known that the burning of unclean fuel sources such as fossil fuels for energy is now putting our climate in danger. The rapid increase in the Earth's population, which is growing by about 80 million every year, has led to rising energy consumption. Calculations by the International Energy Agency (IEA) predict that the global energy demand will increase by about 65% by 2035. A major fraction of the required energy will continue to be provided by fossil fuel-fired and nuclear power plants, despite climate talks.

Process water: Water circuits in thermal power plants
Thermal power plants use the heat generated by combustion or nuclear fission to produce steam, which is fed into a turbine driving a generator that converts the mechanical energy into electrical energy. Downstream of the turbine, the steam is converted to water in a condenser. This water is held in a feed tank from where it is pumped back into the steam boiler. Cooling water flows through the condenser in a separate circuit and removes the heat of condensation released by the steam via a heat exchanger. Nuclear power plants with pressurized water reactors have an additional water circuit known as the primary circuit.

An optimized water chemistry is essential
The water chemistry depends on the type of power plant, the cooling circuit design, and the construction materials. Every cooling circuit has a unique design and its own analytical requirements. A well-devised water chemistry ensures safe and efficient power plant opera-

tion. Nearly 50% of the unplanned downtimes in power plants are caused by contaminants or problems with the chemistry of the water-steam circuit, with corrosion being the primary factor.

High-purity steam is essential if the steam turbine is to operate efficiently and trouble-free. Cooling water is used to condense the exhaust steam from the turbine to water, which can then be returned and used as feed water. Continuous circulation of the cooling water increases the concentration of contaminants. This necessitates water analyses to monitor and control corrosion, and deposition processes taking place in the cooling water circuit. However, the purity requirements of cooling water are much lower compared to those of the boiler feed water.

Corrosion of metals in power plants is a commonly occurring phenomenon due to the continuous contact of the metal with a corrosive environment. The very high temperatures in the steam generator lead to corrosion and deposits that severely reduce the efficiency of the power plant. This can be combated with an optimized feed water chemistry. On the one hand, the water must be ultrapure and on the other, the addition of conditioning agents (phosphates, oxygen scavengers) must be continuously monitored.

Turbine and lubricating oils

Turbine and lubricating oils are exposed to extreme conditions in power plants. New power plant technologies and improvement of the efficiencies of gas and steam turbines present ever greater requirements regarding lubricant performance. Key parameters to be determined are the acid and base numbers as well as the water content using Karl Fischer titration. Numerous international standards define the requirements and test procedures for in-service maintenance of the turbines.

Metrohm instruments comply with numerous standards related to the energy and power industry, which can be found within the Energy and Power Plant branch sites here:
www.metrohm.com/en/industries/

Process Application Notes for the Energy / Power Industry

- Carbon Capture Plants, Power Generation Industry: Measurement of the «rich» and «lean» Amine Concentration and the amount of CO_2 captured (CO_2 Loading). **AN-PAN-1003**
- Nuclear Power Plants: Analysis of Boric Acid in cooling water PWRs. **AN-PAN-1013**
- Flue-gas desulfurization; incineration process – Analysis of calcium and sulfate. **AN-PAN-1015**
- Power Plant: Analysis of Silica in boiler feed water. **AN-PAN-1016**
- Monitoring Flow Accelerated Corrosion & Metal Transportation in Power Plants: Online Ultratrace Measurements of Fe and Cu. **AN-PAN-1032**
- Power Generation: Analysis of the M-Number (Alkalinity) in cooling water. **AN-PAN-1038**
- Ammonia in cooling water of thermal power plants. **AN-PAN-1040**
- Online trace analysis of anions in the primary circuit of nuclear power plants. **AN-PAN-1042**
- Online trace analysis of cations in the primary circuit of nuclear power plants. **AN-PAN-1043**

- Online trace analysis of amines in the alkaline water-steam circuit of power plants. **AN-PAN-1044**
- Online monitoring of copper corrosion inhibitors in cooling water. **AN-PAN-1045**

Sold and Installed Applications

Boiler Feed:

- Ammonia [NH_3] in boiler feed water (Boiler Feed)
- Iron [Fe^{2+} / Fe^{3+}] in boiler feed water (Boiler Feed)
- pH + Alkalinity in Boiler feed water (Boiler feed water, Neutralization process)
- Phosphate [PO_4^{3-}] (total and ortho) in water (Boiler feed water, Feed to softeners)
- Silica [Si^{4+}] in Boiler Feed Water (Boiler Feed)
- Sodium [Na^+] in Boiler Feed Water (Boiler Feed)

Cooling Water:

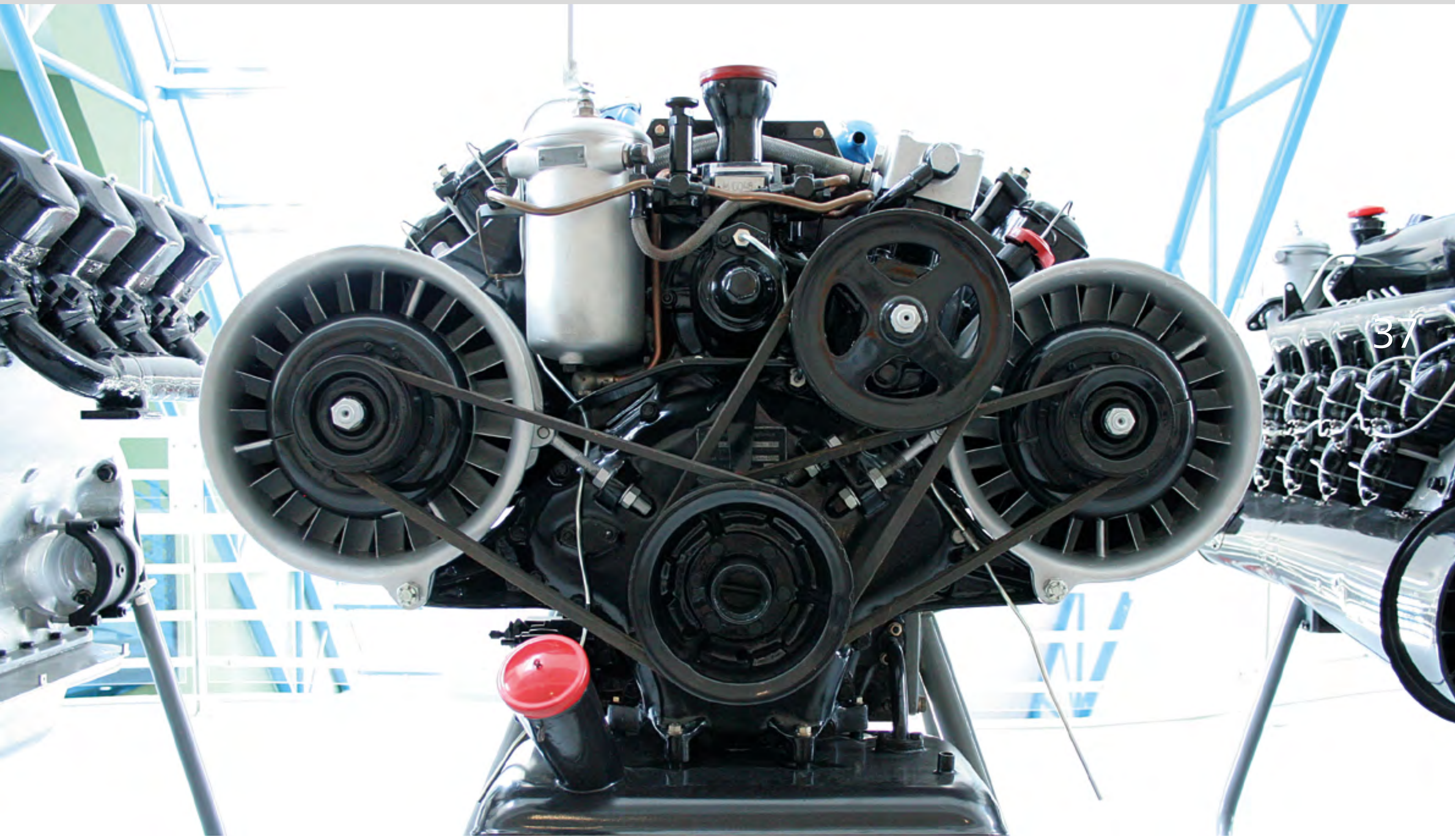
- Ammonia [NH_3] in cooling water (Nuclear Power Plant, Cooling of Reactor)
- Boric acid [$B(OH)_3$] in heavy water / cooling water of Nuclear Power Plants (Cooling water circuit)
- Heavy Metals [Ni + Fe + Zn + Cu] in Cooling Water (Coal Plant – Electricity, Cooling water circuit)
- P&M number in cooling water (Preparation cooling water)
- Potassium [K^+] + Ammonium [NH_4^+] in primary circuit cooling water (Nuclear Power Plant, Primary Circuit Water)
- Sulfide [S^{2-}] in cooling water (Nuclear Power Plant, Cooling Water)
- TAC, pH, + Total Hardness [Ca] in cooling water (riverwater) (Inlet Cooling Water)

Waste Water:

- Ammonia [NH_3] in waste water treatment (WWTP)
- Total-Ammonia [NH_3], Free-Ammonia [NH_3], + pH in waste water (Coking plant, De-Ammonization of waste water)
- Chlorine [Cl_2] in cooling water discharge (Cooling Water discharge, WWTP)
- Chemical Oxygen Demand [COD] in waste water (WWTP)
- Hexavalent Chromium [Cr^{6+}] in surface water (Heavy Metals monitoring)
- Copper [Cu^+ / Cu^{2+}] in outlet waste water (WWTP)
- Sulfite [SO_3^{2-}] in waste water (WWTP)
- Volatile Fatty Acids (Anaerobic WWTP)

Other Applications for the Energy / Power Industry:

- Aluminum [Al^{3+}] (Feed to softeners)
- Ammonia [NH_3] in scrubber ash (Stack Scrubber control for Ash content)
- Calcium [Ca^{2+}] + Sulfate [SO_4^{2-}] in process (Incinerator plant)
- Carbon Dioxide [CO_2] Loading in Organic Absorber Liquid (Carbon Dioxide Capture System)
- Chloride [Cl^-] in condensate return (Energy production)
- Free acidity in Uranyl Nitrate (fuel rod production)
- Hardness [Ca^{2+} / Mg^{2+}] in demi water plant
- Hypochlorite [NaOCl] in make-up water (Disinfection Treatment Monitoring)
- Iron [Fe^{2+} / Fe^{3+}] in process water (Coal-fired Power Plant, Process Water)
- Silica [SiO_2] in demi water (Boiler feed)
- Determination of Uranium prior to discharge to WWTP (Effluent from Ion Exchange Column)



Automotive and Aerospace Industry

Transportation: Driving societal growth

Trading and mixing of ideas between different locales and cultures would be so much more difficult without automobiles and airplanes. Transportation and mobility are vital to modern society. Our earliest ancestors walked endlessly as nomads until we formed agricultural societies – taming the land and animals alike. We learned to make animals work for us, which lessened our burdens and freed up more time for other pursuits. Sailing ruled as a form of transport for centuries, both for trading and emigration purposes. Eventually, the Industrial Revolution came in the middle of the 19^{th} century, and machines, production lines, and factories became more and more prevalent in our lives. The automotive industry was born, and soon after came aerospace. Eventually, we even travelled outside of our own planetary boundaries.

Automotive Industry

In Europe alone, about 75% of all goods (which account for 90% of the value of all goods in Europe) are transported over land by commercial vehicles. The Automotive industry is estimated to account for 4-6% of the European GDP by offering 12.1 million direct and indirect jobs. The EU is responsible for producing a major portion of the world's automobiles, and as such, invests significant amounts of time and capital (€ 41.5 billion annually) into research and development in this industry. In 2014, the EU produced 25% of the world's passenger cars and 23% of motor vehicles overall. Production from the Americas in 2014 stood at about 23%, while Asia led the way with 50% of all passenger car production. In 2015, the EU output for passenger car increased by 6.2% compared to 2014, with a total of about 15.9 million cars manufactured. The market is expected to increase modestly in 2016 according to the European Automobile Manufacturers' Association (ACEA).

Aerospace Industry

The Aerospace industry in the EU is the world leader in the production of civil aircraft. Overall, the industry provided more than 573,000 jobs in the European Union in 2014, and generated €199.4 billion in turnover, which was a 1% increase from the previous year. The division of turnover revenue within the EU aerospace industry is balanced almost equally between military (48.7%) and civil (51.3%) sectors. Research, development, and innovation in this sector are highly valued, and this is reflected in both the quality and volume of aerospace products which are exported worldwide.

A detailed description of the many metal surfacing techniques available for this industry can be found in previous sections.

Sold and Installed Applications

Electroplating Surface Treatment:

- Boric Acid [$B(OH)_3$] in Nickel [$NiCl_2$] Electroplating Bath (Aerospace Engines, Nickel Electroplating Surface Treatment)
- Chromium [Cr^{3+}] in Chromic Acid [$H_2Cr_2O_4$] Electroplating Bath (Aerospace Engines, Chromium Electroplating Surface Treatment)

Etching Baths:

- Caustic [NaOH] in Electrolytic Clean, Nitric Acid [HNO_3], Hydrofluoric Acid [HF] + Neutralizer in Etching Baths (Blade production, Nickel Turbine Etching Baths)
- Caustic [NaOH], Nitric acid [HNO_3], + Ammonium Bifluoride [NH_4HF_2] in Etching Baths (Blade production, Titanium Fan Blade Etching Baths)
- Sulfuric acid [H_2SO_4], Phosphoric Acid [H_3PO_4], Total Iron [Fe^{2+} / Fe^{3+}], + Hydrochloric Acid [HCl] (Turbine Blade Production, Electrolytic Etching Baths)

Zinc-Phosphatizing:

- Acid [Free and total], Fluoride [F^-], Zinc [Zn^{2+}], + Accelerator (Zn-Phosphatizing Bath)
- Acid [Free and total], Nitrite [NO_2^-], + Zinc [Zn^{2+}] (Zn-Phosphatizing Bath)
- Fluoride [F^-] in Surface Treatment Bath (Cars, Zinc-Phosphatizing Bath)
- Sulfuric acid [H_2SO_4] + Zinc [Zn^{2+}] (Phosphatizing bath)

Waste Water:

- Aluminum [Al^{3+}], Copper [Cu], + Chromium [Cr^{3+} /Cr^{6+}] in Effluent (Airfighters production, Effluent WWTP)
- Fluoride [F^-] in waste water (WWTP)
- Iron, Total [Fe^{2+} / Fe^{3+}] + Zinc [Zn^{2+}] in Effluent (Airfighters production, WWTP)

Other Applications for the Automotive and Aerospace Industry:

- Caustic [NaOH] in Surface Treatment Bath (Car, Surface treatment)
- Hydrofluoric acid [HF] (Car screen (glass))
- Sodium Hydroxide [NaOH] in Scrubber (Scrubber, Automotive parts for car & aviation industry)

Textile Industry

Origins of textiles and clothing

Humans have been creating textiles and clothing for about 8,000 years, intended as protection from the harsher elements. Fabric can be used for many different purposes – to decorate, to clothe, and to protect. Durability, texture, weight, and even the source are important characteristics. There is a dizzying array of clothing made from textiles available in nearly every size, color, and shape created from both natural and synthetic fibers.

Natural vs. Synthetic Sources

There are many ways to create fabric, but certain characteristics may be desired over others. Sports enthusiasts, and mountaineers in particular, know that the breathability of certain fabrics can help or hinder during exertion. Sweating is a natural way of losing heat through the evaporation of water from our skin. Natural fibers, such as cotton, will soak up the water, holding it against the skin, offering no respite from overheating. In cold climates, this wet layer against the skin can lead to hypothermia and worse, which is why it is advised to wear fabrics made from synthetics because they keep the skin dry and allow the water to evaporate easier.

Creation of synthetic textiles begins with a polymerization process in which the resulting liquid is forced through tiny holes (called spinnerets, similar to those of spiders) and forms small threads. These tiny threads are then dyed and woven into fabric. There are many types of synthetic fibers, such as nylon, polyester, acetate, spandex, acrylic, and rayon (viscose). Kevlar, Twaron, and other para-aramid fibers which are man-made are strong enough to withstand bullets. The properties (such as elasticity) of these synthetic materials can be modified much easier than for natural fibers. In 2016, we now have many items which are even created from graphene (carbon fiber), one of the strongest, lightest materials known.

Process Application Notes for the Textile Industry

- Viscose / Rayon production: Analysis of Sulfuric Acid and Zinc Sulfate. **AN-PAN-1010**
- Online Analysis of Indigo, Hydrosulfite, and Other Parameters in Textile Dye Baths. **AN-PAN-1035**

Sold and Installed Applications

Acrylic Fiber Production:
- Cyanide [CN^-] in waste water (WWTP)
- Sulfite [SO_3^-] in influentv WWTP (WWTP)

Cellulose Fiber Production:
- Chemical Oxygen Demand [COD] in waste water (Fiber production, Discharge waste water)

Spin Bath Process:
- Sulfuric acid [H_2SO_4] in Spin Bath (Fiber Production, Cellulose Fibers, Spin bath)
- Sulfuric acid [H_2SO_4], Zinc sulfate [$ZnSO_4$], + Sodium sulfate [Na_2SO_4] in Spin Bath (Fiber Production, Spin bath)

Other Applications for the Textile Industry:
- Hydroxide [OH^-] + Carbonate [CO_3^{2-}] in cleaning solution (Textile cleaning)
- Indigo [$C_{16}H_{10}N_2O_2$] + Hydrosulfite [$S_2O_4^{2-}$] (Textile Production, Indigo dye bath)
- Determining moisture and oil content in wool samples (NIRS)
- Sodium Hypochlorite [NaOCl] in bleaching solution (Fiber Production, Bleaching)
- Sulfuric acid [H_2SO_4] + Formaldehyde [CH_2O] in acid bath (Fiber cloths, Acid bath)

NIRS Applications for the Textile Industry:
NIR has been long used in the textile industry to differentiate fiber types for carpet recycling. Blend analysis of different polymer fibers can be analyzed with NIR. Real-time analysis of the application of polyvinyl alcohol (PVA or PVOH) sizing to warp yarn has been done with NIR online process analyzers. Common fibers identified with NIR include: cotton/linen, merchandized cotton, acrylic, modified acrylic, acetate, triacetate, Nomex®, Kevlar® (K-29, K49, and K129), nylon-6, nylon-6,6, silk, polyester, cationic and disperse dyeable polyester, polypropylene, PVA and PVC.

This list is intended as a starting point but is not comprehensive.

Fiber Blends:
- Monitoring Fiber Blends for Blend Ratios, Moisture and Finish (NIRS)
- Distinguishing Between Nylon, Polyester, and Polypropylene Threads (NIRS)

Finishing:
- Quantitative Determination of Bond and Finish on Nylon Thread (NIRS)
- Measuring Finish on Crimped and Uncrimped Fibers, and Total Solids in Bath Liquor (NIRS)
- Monitoring Oil Finish on Nylon Fibers (NIRS)
- Monitoring Resin Content in a Textile Finishing Bath (NIRS)

Fire Resistance:
- Monitoring the Amount of PBI During the Batch Production of Fire Retardant Fabric (NIRS)

Heatset Monitoring:
- Qualitative Monitoring of Heatset Temperature of Nylon (NIRS)

Pharmaceutical / Biochemical Sector

Determination of active ingredients, excipients, and impurities
Pharmaceutical analysis provides information on the identity, purity, content and stability of starting materials, excipients, and active pharmaceutical ingredients (API). A distinction is made between analysis of the pure active pharmaceutical ingredients used to cure, soothe, prevent, or identify illnesses and diseases (active ingredient analysis) and analysis of drug products (drug product analysis). Drug products come in various forms (ointments, tinctures, pills, lotions, suppositories, infusions, drops, etc.) and consist of the pharmaceutically active substance and at least one pharmaceutical excipient. Impurities are mainly introduced during the synthesis of the active ingredient, and are usually monitored according to both the directives of the ICH (International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use) and the pharmacopoeias.

Pharmacopoeias and drug safety
According to the World Health Organization (WHO), specifications and test methods for commonly used active ingredients and excipients are outlined in detail in monographs contained in the national pharmacopoeias of more than 38 countries. These include the United States Pharmacopeia (USP), the European Pharmacopoeia (Ph.Eur.), derived from a harmonization of the regulations of a number of individual states, and the Japanese Pharmacopoeia (JP), to name just a few examples. The pharmacopoeias are official compendia containing statutory requirements pertaining to identity, content, quality, purity, packaging, storage, and labeling of APIs and other products used for therapeutic purposes. They are essential for anyone seeking to produce, test, or market medicinal products.

Metrohm instruments comply with numerous pharmacopoeia standards, which can be found within the Pharmaceutical branch sites here:
www.metrohm.com/en/industries/

Process Application Notes for the Pharmaceutical Industry

- Inline moisture analysis in a pilot scale granulation process by NIRS. **AN-PAN-1048**
- Inline moisture analysis in fluid bed dryers by NIRS. **AN-PAN-1050**

Sold and Installed Applications

Waste Water:
- Ammonia [NH_3] in waste water (WWTP)
- Chemical Oxygen Demand [COD] in waste water influent WWTP)
- Chloride [Cl^-] in Outlet WWTP (WWTP, Hospitals)
- Nitrite [NO_2^-] in BioReactor (Inlet BioReactor, WWTP)
- Phosphate [P-PO_4] in Final Effluent (Pharmaceutical, WWTP)

Other Applications for the Pharmaceutical / Biochemical Sector:
- Ammonia [NH_3] in Fermenter Cultures (Control of Ammonia in Fermenter Cultures)
- Calcium [Ca^{2+}] in Bioreactor (Reactor)
- Sodium hydroxide [NaOH] + Sodium Carbonate [Na_2CO_3] in Scrubber (Biopolymer, Scrubber)
- Salt [NaCl] + pH in perfusion solutions (Perfusion solutions, Filling bags)

NIRS Applications for the Pharmaceutical Industry:

Specifications and test methods for the commonly used active ingredients and excipients are monographed in detail in national pharmacopeias in more than 38 states according to the World Health Organization (WHO). NIRS has emerged as a powerful tool for the analysis of pharmaceuticals. The manufacture of pharmaceutical products from raw material identification to the measurement of content uniformity of dosage forms can be assisted by the implementation of NIR methods. The FDA and European Union health guidelines have increased the workload and rigor associated with receiving inspection, blending, and content assay. With the advent of 100% container testing for receiving inspection of raw materials in Europe and Canada, NIR technology can reduce the time and skill level required to meet the increased challenge of compliance. Common pharmaceutical applications using NIR include: receiving inspection of excipients and active pharmaceutical ingredients (API), blend uniformity, granulation, drying and coating, and particle size verification analysis. Additionally, NIR is an invaluable tool for the detection of counterfeit drug products and the determination of water and residual solvent content.

With the PAT (process analytical technology) initiative, the FDA aims to bring about an increase in efficiency in pharmaceutical production, including a trend away from final checks towards real-time process analysis and control. The future is **quality by design**, compared to today's techniques of quality by testing. The initiative requires rapid analytical techniques that allow comprehensive online and inline monitoring of the manufacturing process. To this end, NIRS is the most powerful analytical tool that is currently dominating all PAT projects.

NIRS is described in the European (Ph.Eur.) and Japanese (JP) Pharmacopoeia as well as in the United States Pharmacopeia (USP). The Vision® software used by Metrohm Process Analytics NIR Analyzers is available in two versions: for general use but also in a pharmaceutical version which complies with FDA standards – fully validated and 21 CFR Part 11 compliant. The Vision® software for chemical/pharmaceutical NIR data analysis is available as a single- or multi-user version.

This list is intended as a starting point but is not comprehensive.

Active Ingredients (API) / Content Uniformity:
- Erythromycin A in Fermentation Broth (NIRS)
- Naproxen in Tablets (NIRS)

API – Antacids:
- Calcium Carbonate [$CaCO_3$] in Antacid Powders and Tablets (NIRS)
- Magnesium Hydroxide [$Mg(OH)_2$] in Antacid Powders (NIRS)
- Polydimethylsiloxane in Antacid Liquids (NIRS)

API – Cough Syrup:
- Acetaminophen in Cough Syrup (NIRS)
- Dextromethorphan in Cough Syrup (NIRS)
- Doxylamine Succinate in Cough Syrup (NIRS)
- Pseudoephedrine in Cough Syrup (NIRS)

API – Foot Powder:
- Aluminum Chlorohydrate in Foot Powder (NIRS)
- Salicylic Acid in Foot Powder (NIRS)

API – Transdermal Patches:
- Methylphenidate in Transdermal Patches (NIRS)
- Nicotine in Transdermal Patches (NIRS)
- Nitroglycerine in Transdermal Patches (NIRS)

Drying:
- Moisture in Bleomycin Sulfate (NIRS)
- Moisture in Lyophilized Products (NIRS)
- Moisture in Aspirin Granulations and Tablets (NIRS)
- Monitoring granulation and drying in fluid bed dryers (NIRS)

Food and Beverage Industry

You are what you eat...
Beyond their nutritive value, foods and beverages are consumed for their taste or flavor. Increasingly, they are also a source for maintaining health and enhancing our well-being via high-quality nutrition. At the same time, with an ever-increasing number of processed foods, food quality and safety aspects are becoming more important. All the more because foods are highly complex materials – prone to degradation and contamination – that contain myriads of compounds.

Analytical chemistry ensures that consumers obtain safe and sanitary food in compliance with regulatory requirements. Nutrient information, food traceability, and protection against fraud are further challenges. From the process point of view, analytical chemistry supports the manufacturer to improve yields and optimize quality by offering robust, efficient, and sensitive instrumentation.

Process control in food production
It is a long way before a raw material becomes a finished product in the food industry. Numerous production steps, such as pulverization, filtration, fermentation as well as heating, cooking, pasteurization, sterilization or distillation, are involved in the preparation of a product and to make it storable. In addition to the statutory final inspection and testing, control of the different production steps also has an important role, which is to maximize throughput and yield of a product. Valuable time is lost if the product cannot be further processed or packaged while samples from the various production steps are being tested in the laboratory. It is thus a great advantage if these analyses can be performed directly at the process site while production goes on uninterrupted.

Metrohm instruments comply with numerous standards related to the food and beverage industry (including the FDA regulation Title 21 CFR Part 11) which can be found within the Food and Beverage branch sites here:
www.metrohm.com/en/industries/

Process Application Notes for the Food and Beverage Industry

- Monitoring Peracetic Acid (PAA) in a Beverage Bottling Facility. **AN-PAN-1029**
- Effectively Monitoring Hydrogen Peroxide as a Delousing Agent in Salmon Farms. **AN-PAN-1031**
- Alkalinity & hardness in process and make-up water for the production of beer. **AN-PAN-1036**
- Online determination of bromate and other disinfection byproducts in drinking & bottled water with IC. **AN-PAN-1049**

Sold and Installed Applications

Beverages:

- Alkalinity in process and make-up water (Beverages, Water treatment, Make-up water)
- Free + Total Alkalinity of brewing water
- Calcium [Ca^{2+}] in water (Beer, Water control)
- Hardness [Ca^{2+} / Mg^{2+}] in carbonated beverages (Beverages (Soda), Water Purification System)
- Total Iron [Fe^{2+} / Fe^{3+}] in ground water (Beverages, Groundwater inlet, Water control)
- Lactic Acid in Raw Milk
- Manganese [Mn^{2+}] in water (drinking water, inlet raw water, Potable water purification, Dairy products)
- Peracetic Acid (PAA) [CH_3CO_3H] in beverage industry filling systems (Aseptic Bottling Line)
- Polyacrylamide (PAM) solution (Bottling plant)
- Sulfide [S^{2-}] (Beverage production)

Potato Products:

- Calcium [Ca^{2+}] in blanching water (Potato chips processing)
- Chloride [Cl^-] in potato chips production (Potato chips, Potato production)
- Glucose in process (Potato Chips, French fries, Water flume)
- Total Phosphorus [P] (Potato processing)
- Sodium dihydrogen pyrophosphate [$Na_2H_2P_2O_7$] in deep-frozen potato products (blanching process)

Waste Water:

- Ammonium [NH_4^+] in Inlet WWTP (Soya production, WWTP)
- Chemical Oxygen Demand [COD] (WWTP)
- Fluoride [F^-] in waste water (WWTP)
- Nitrite [$N\text{-}NO_2^-$] in Inlet WWTP (Soy production, WWTP)
- Phosphate [PO_4^{3-}] in waste water (Food, Milk, Inlet WWTP, Outlet WWTP)

Other Applications for the Food and Beverage Industry:

- Ammonia [NH_3] in food casings (Food casings)
- Calcium [Ca^{2+}] in process (Pectin solution, Calcium removal)
- Chlorine [Cl_2] in disinfection (Disinfection, Clean in Place)
- Chlorine [Cl_2] in Hypochlorite [ClO^-] (Starch products, Hypochlorite production)
- Citric/Malic Acid in Pickling Solution (Dried fruit, Pickling solution)
- FFA (Free Fatty Acids) and soap in edible oils
- Fluoride [F^-] in toothpaste (Toothpaste, Dental rinsing)
- Hydrogen peroxide [H_2O_2] in seawater (Salmon treatment)
- Hypochlorite [OCl^-] in bleach
- Iodide [I^-] (salt production)
- Salt [NaCl] and vinegar [CH_3COOH] in mayonnaise production
- Sodium [Na^+] in Pickling Solution (Dried fruit, Pickling solution)
- Sodium hydroxide [NaOH] (Cellulose housing for food)
- Sulfuric acid [H_2SO_4] (Cellulose housing for food)
- Sulfuric acid [H_2SO_4], Ammonium Sulfate [$(NH_4)_2SO_4$], + total Sulfate [SO_4^{2-}] (Casings for sausage)
- Sulfuric acid [H_2SO_4] + Ammonium Sulfate [$(NH_4)_2SO_4$] in process (Casings for sausage)
- Total Chlorine for disinfection processes (Dosing disinfection of boiling water, Meat products)

Industrial Waste Water

Harmful substances in water

Water is the source and basis of all life. It is essential for metabolism and is our most important foodstuff. As a solvent and transporting agent it carries not only the vital minerals and nutrients, but also, increasingly, harmful pollutants, which bioaccumulate in aquatic or terrestrial organisms. There are roughly 1700 substances, mainly of anthropogenic origin, that can today be detected in water. As a source of food and energy, during use in irrigation, as a solvent, cleaning agent, or coolant, and also as a means of transportation and discharge system for effluents, water becomes contaminated with fertilizers, pesticides, drugs, hormones, heavy-metal compounds, body care and synthetic products.

Because of the associated health risks, the World Health Organization (WHO) has issued guideline values for about 200 substances found in water. These guideline values, together with the hydrogeological conditions of the various countries, form the basis for the setting of country-specific limits. That is why water is the subject of a host of laws, regulations, and standards in most countries.

Metrohm instruments comply with numerous water analysis standards, which can be found here:
www.metrohm.com/en/industries/environmental/environment-water/table_water_standards/

Process Application Notes for the Waste Water Industry

- Waste Water Treatment Plants: Nitrogen Removal – Simultaneous analysis of Ammonia, Nitrate, and Nitrite. **AN-PAN-1009**
- Detecting Chromate (Cr(VI)) in Waste Water Streams. **AN-PAN-1030**
- Ortho- and total phosphate phosphorus analysis online according to DIN EN ISO 6878:2004-09 (formerly DIN 38405-D11). **AN-PAN-1039**

Sold and Installed Applications

- Alkalinity in Effluent WWTP (Waste water treatment (Nitrification), Effluent WWTP)
- Ammonia [NH_3] in effluent WWTP (Municipal WWTP)
- Ammonia [NH_3] + Sulfide [S^{2-}] in waste water treatment (Municipal Wastewater Treatment, WWTP)
- Ammonium [NH_4^+] in waste water effluent (Municipal WWTP)
- Calcium [Ca^{2+}] in waste water (Waste water Treatment)
- Chemical Oxygen Demand [COD] in waste water (WWTP)
- Chemical Oxygen Demand [COD] + Ammonia [N-NH_4] in municipal wastewater (Outlet WWTP)
- Hexavalent Chromium [Cr^{6+}] in waste water (Waste water Treatment, Municipal + Industrial)
- Copper [Cu^+ / Cu^{2+}] in waste water (Outlet WWTP)
- Free Cyanide [CN^-] in Influent + Effluent WWTP (WWTP, Outlet WWTP)
- Fluoride [F^-] in waste water (Effluent WWTP)
- Heavy metals [Cu, Zn, Cd, Pb] in waste water treatment (WWTP)
- Hydrogen Peroxide [H_2O_2] + Peracetic acid [CH_3COOH] in waste (Oxidative Substances, WWTP)
- Total Iron [Fe^{2+} / Fe^{3+}] in water treatment process (Water treatment, WWTP)
- Manganese [Mn^{2+}] in waste water effluent (Municipal WWTP)
- Nickel [Ni^{2+}] in waste water (Steel wire for Tire, Effluent WWTP)
- Nitrate [NO_3^-], Nitrite [NO_2^-], + Ortho-Phosphate [P-PO_4^{3-}] in waste water (Municipal WWTP, Outlet WWTP)
- Nitrite [NO_2^-] in water treatment (Biological reactor)
- Nitrite [NO_2^-], Nitrate [NO_3^-], + Ammonium [NH_4^+] in waste water (WWTP)
- Phenol [C_6H_5OH] in waste water (WWTP)
- Ortho-Phosphate [P-PO_4^{3-}] in outlet and effluent WWTP (Municipal WWTP, Effluent WWTP)
- Ortho-Phosphate [P-PO_4^{3-}] + Total-Phosphate [TP] in effluent WWTP (Municipal WWTP, Effluent WWTP)
- Phosphate [PO_4^{3-}], Total Phosphate [TP], + Chemical Oxygen Demand [COD] in Surface water (Municipal WWTP, Total Phosphate [TP] in Effluent WWTP (Outlet WWTP)
- Sodium [Na^+] in waste water (Waste water)
- Volatile Fatty Acids in biomatrix (anaerobic WWT) (Water treatment, WWTP)
- Zinc [Zn], Lead [Pb], Cadmium [Cd], + Copper [Cu] in WWTP (Waste Incineration, WWTP)
- Zinc [Zn^{2+}] in waste water (Steel wire for Tire, Effluent WWTP)

This is not an exhaustive list. Each industry also has some examples of specific waste water treatment.

Environmental Sector

The importance of environmental analysis

The rapid growth in the world population has led to sharp increases in the consumption of energy and resources and in the production of consumer goods and chemicals. It is estimated that there are a total of 17 million chemical compounds on the market, including as many as 100,000 that are produced on a large industrial scale. Substances introduced into the environment are distributed among the environmental compartments water (hydrosphere), soil (pedosphere), rock (lithosphere), and air (atmosphere), as well as among the organisms living on them (biosphere).

Water

As its physical state changes, water passes through all spheres. It is the most frequently analyzed environmental compartment and is also the easiest, because – unlike air or soil – it already exists in the liquid phase. If drinking water samples are to be analyzed, sample preparation is usually not necessary; however, it is usually unavoidable in the case of wastewater samples.

Air

The atmosphere is an important thermal buffer against space, and protects the earth from cosmic radiation. It is the place where clouds are formed and water is present there in all its physical states. Thus it is a heterogeneous mixture of finely dispersed, solid or liquid particles in a gas (air). Its constituents are characterized by extreme mobility, enter our bodies easily through breathing, and influence the climate and weather. Filter methods, and aerosol and gas collectors bring the constituents of air into the aqueous phase, which is preferable for chemical analysis.

We can only protect the environment and its inhabitants if we know the type and quantity of these contaminants. This requires internationally accepted standards, in which limits and test methods are defined. Metrohm instruments comply with numerous environmental standards, which can be found within the three Environmental branch sites here:
www.metrohm.com/en/industries/

Sold and Installed Applications

Potable (Drinking) Water:

- Aluminum [Al^{3+}] in drinking water (Potable water)
- Ammonia [NH_3] in drinking water (Drinking water monitoring)
- Ammonia [NH_3] in tap water (outlet waste water, WWTP)
- Boron for water in desalination plants (Water treatment process)
- Chloride [Cl^-] in outlet Carbon Filter (Drinking water, Outlet Carbon Filter)
- Free Cyanide [CN^-] in drinking water (Drinking water monitoring)
- Fluoride [F^-] in drinking water (Drinking water monitoring)
- Iron(II) [Fe^{2+}] + Iron(III) [Fe^{3+}] in drinking water (Drinking water treatment)
- Langelier Saturation Index (Hardness) in drinking water (Potable water)
- Manganese [Mn^{2+}] in outlet drinking water (Outlet to Storage, Potable water)
- Nitrite [NO_2^-] in drinking water (Drink water quality self-monitoring)
- Phenol [C_6H_5OH] in drinking water (Drinking water monitoring)

River and Surface Waters:

- Ammonia [NH_3] + Nitrate [NO_3^-] in river water (River Water Monitoring)
- Ammonium [NH_4^+] in river water (River Water Monitoring)
- Boron in Surface Water (Surface Water Monitoring)
- Cadmium [Cd], Lead [Pb], Copper [Cu], + Zinc [Zn] in river and surface waters (River Water Monitoring, Surface Water Monitoring)
- Chloride [Cl^-] in surface water (Surface Water Monitoring)
- Hexavalent Chromium [Cr^{6+}] in surface and river waters (River Water Monitoring, Surface Water Monitoring)
- Copper [Cu^+ / Cu^{2+}] in surface water (Surface Water Monitoring)
- Free Cyanide [CN^-] in river and surface waters (River Water Monitoring, Surface Water Monitoring)
- Manganese [Mn^{2+}] in surface water (Surface Water Monitoring)
- Nickel [Ni^{2+}] in surface water (Surface Water Monitoring)
- Nitrate [NO_3^-] in river water (River Water Monitoring)
- Phenol [C_6H_5OH] in river and surface waters (River Water Inlet, WWTP, Surface Water Monitoring)
- Ortho-Phosphate [PO_4^{3-}] in river water (River Control, River Water Monitoring)
- Phosphate [PO_4^{3-}], Total Phosphate (TP), + Chemical Oxygen Demand [COD] in surface water (Surface Water Monitoring)
- Sulfate [SO_4^{2-}] in surface water (Environmental control of river water, River Water Monitoring)
- Zinc [Zn^{2+}] in surface water (Surface Water Monitoring)

Air Pollution:

- Applications involving air quality are generally performed with PILS or **MARGA** Analyzers.

Overview of Process Analyzers from Metrohm Process Analytics

Whatever your project requirements and budget, Metrohm Applikon has the right analyzer and monitoring solution for you. From our low cost, single method, compact process analyzers (202X) to our multi-stream, multipurpose ADI 2045 range we provide you with an innovative and customizable analyzer to cover all your process monitoring needs. We also offer environmental solutions such as the **2060 MARGA** (**M**onitor for **A**e**R**osols and **G**ases in **A**mbient air) for research or continuous air monitoring campaigns, and near-infrared spectroscopy (NIRS) analyzers for inline analysis of several parameters.

Wet chemical systems

Single method Process Analyzers

Features	2016 Titrolyzer	2016 pH Analyzer	2029 Process Photometer
Number of sample streams	1–2	1–2	1–2
Ion Selective Electrodes	✓	✓	×
Colorimetry	×	×	✓
Titration	✓	✓	×
Karl Fischer Titration	×	×	×
Infrared Detection	×	×	×
Modular Configuration	✓	✓	✓
Ex-proof Zone 1 or 2	×	×	×

Wet chemical systems

Customizable, multi-stream Process Analyzers

Features	2035	ADI 2045PL	ADI 2045TI	ADI 2045TI Ex	ADI 2045VA	Process IC ONE/TWO
Number of sample streams	1–10	1–10	1–10	1–10	1–10	1–20
Ion Selective Electrodes	✓	✓	✓	✓	×	×
Colorimetry	✓	✓	✓	✓	×	×
Titration	✓	✓	✓	✓	×	×
Karl Fischer Titration	✓	✓	✓	✓	×	×
Voltammetric Analysis	×	×	×	×	✓	×
Ion Chromatography	×	×	×	×	×	✓
Modular Configuration	✓	✓	✓	✓	✓	✓
Ex-proof Zone 1 or 2	×	×	×	✓	×	×

Reagent-free systems

NIRS – Near Infrared Spectroscopy Process Analyzers

Features	NIRS XDS Process	NIRS Pro
Number of sample streams	1–9	1
Reagent-free	✓	✓
Wavelength range	800–2200 nm	1100–1650 nm
Transmittance Mode	✓	×
Transflectance Mode	✓	✓
Reflectance Mode	✓	✓
Immersion Mode	✓	✓
Direct Light/Non Contact option	✓	✓
Single fiber option	✓	×
Microbundle option	✓	✓
Dedicated Sample Interfaces*	✓	✓
Long-distance measurement	✓	×
Ingress Protection	IP65/Nema 4X	IP69K
Ex-proof Zone 1 or 2	✓	×
Acquisition Time	20–30 seconds	< 1 second

* Collection probes, probes with purging options, angled fibers, and other customizable solutions are available. Preconditioning systems and shelters can also be custom-built by Metrohm.

www.metrohm.com

Subject to change
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