Wastewater Industry Solutions

Complete and Reliable Liquid Analysis

ROSEMOUNT® Analytical

EMERSON™ Process Management

We Start With One Idea in Mind: Make it Clean

Homes, industry, schools and businesses all generate sanitary wastewater, or sewage. Wastewater is +99% water and about 0.3% dissolved and suspended solid material.

Without treatment, wastewater would contaminate and overrun freshwater systems everywhere, leaving natural sources of drinking water polluted and unsafe. Because of this, local and national laws require specific treatments of wastewater to safeguard water quality. A wastewater treatment plant separates solids from liquids, and speeds up the natural processes of water purification. It is a multistage process that is critical to the clean-up of sewage before discharge or reuse.

To make it work, you can depend on the liquid analysis professionals at Emerson Process Management. We're ready to put our 60-plus years of experience to work for you by delivering the best in knowledge and systems, and by doing it quickly, thoroughly and cost-effectively, utilizing world-class Rosemount Analytical sensors and instrumentation.

**Wastewater Treatment:
A Multistage Process**

Years ago, sewage was treated by simply dumping it into waterways. The purification process was accomplished by microorganisms consuming sewage and turning it into carbon dioxide and other products. Dilution was on our side, but today, due to higher population and greater volume of both domestic and industrial wastewater, nature needs a helping hand. This is where wastewater treatment comes in.

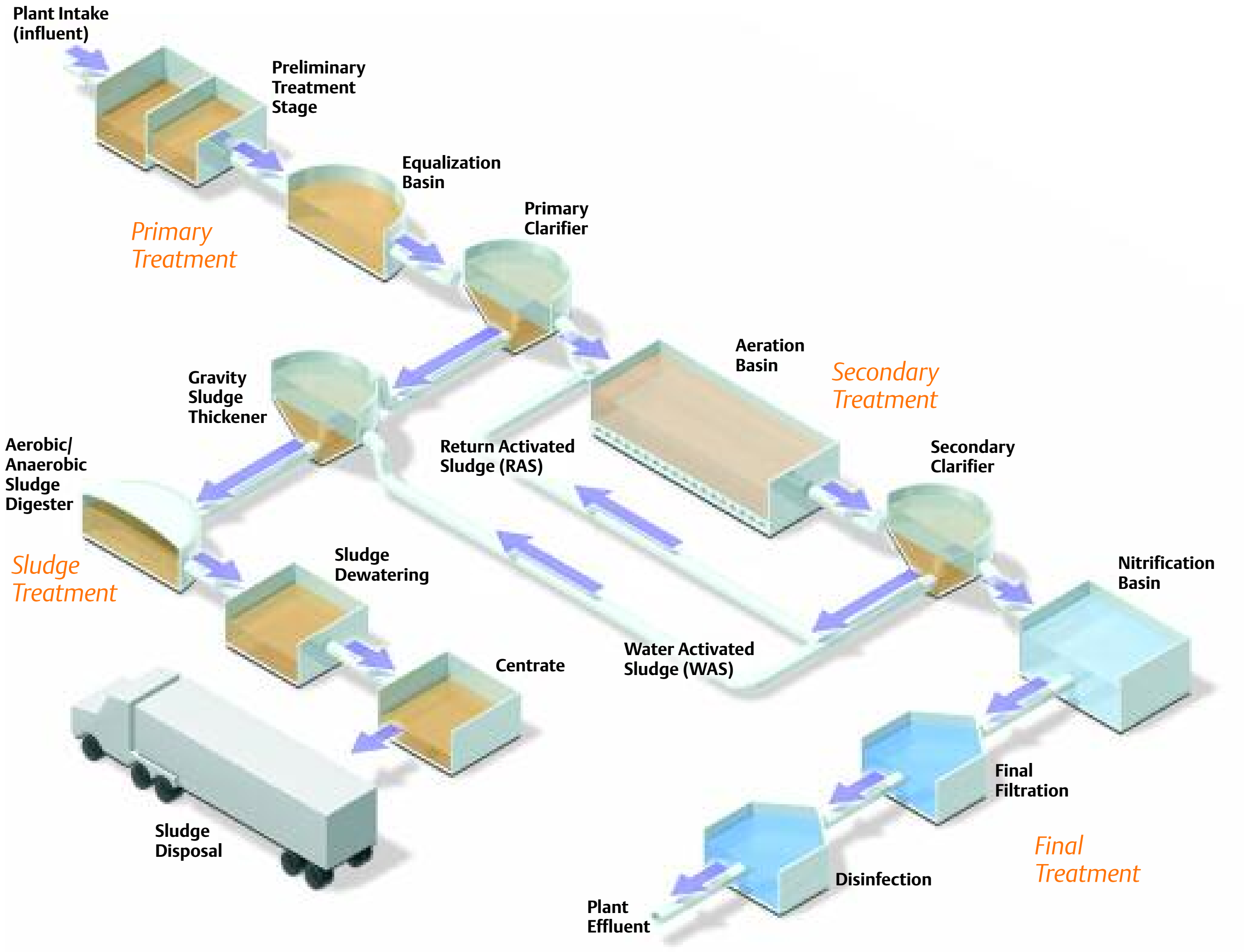
Typically, wastewater treatment includes four basic treatment stages: primary, secondary, sludge and final treatment. In the primary treatment stage, larger solids are removed from wastewater by screening and settling. Secondary treatment is a large biological process for further removal of the remaining suspended and dissolved solids. Sludge is generated during the first two stages and is treated to convert it into a stable organic solid. In the final treatment, wastewater is disinfected to kill any remaining harmful microorganisms prior to being released.

The various stages of wastewater treatment include physical, chemical and biological treatment processes. The chief liquid analytical measurements are:

> pH
> ORP
> suspended solids
> dissolved oxygen (DO)
> chlorination
> dechlorination

For these applications and more, count on Emerson. Our full line of Rosemount Analytical products for wastewater offer proven solutions. When you bring your problem to Emerson, consider it solved.

Wastewater Treatment Overview



Wastewater is generated by homes, businesses and industry, and is treated in four major stages: primary, secondary, sludge and final treatment. Disposal of solids is included in the first two stages.

Analytical measurements such as pH, ORP and suspended solids are made in the primary treatment stage to monitor the removal of solids from the wastewater.

Secondary treatment relies on the biological process to further purify wastewater, and maintaining the proper dissolved oxygen (DO) level is critical to this process.

The first two stages generate sludge from various settling basins. This sluge must be converted into a stable solid.

Final treatment consists of chlorination and dechlorination. The final effluent is monitored for compliance and reporting purposes, and can include pH and chlorine.

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Primary Treatment

The main activity of treatment occurring in the Primary Treatment stage consists of mechanical or physical separation of the solids from the liquid. At the plant inlet, wastewater can be loaded with biological activity producing nuisance odors and hazardous gases. To prevent odors and gases from escaping from open tanks and basins into the atmosphere, domed covers are often used to contain these air contaminants. In turn, these contaminants are removed via ducting connected to an odor scrubber using a combination of caustic and disinfectant chemicals. The addition of these chemicals are controlled using pH and ORP measurements.

Influent Treatment

In many wastewater plants, the influent pH and conductivity are measured. These measurements are used for monitoring purposes, and will alert the plant operator of a possible upset condition. A sudden change in influent conductivity, for example, may indicate an unusual discharge upstream from an industrial plant.

For monitoring influent, the Toroidal Conductivity Sensor Model 228 is ideal for coating applications and is not sensitive to flow rate or direction.

The toroidal conductivity sensor Model 228 is recommended, as it is not sensitive to flow rate or direction of flow, and is suitable for coating applications such as those found at the plant influent.

The ideal pH range of the influent is between 6 and 9. A pH outside this range is harmful to the microorganisms used to break down the wastewater, and a pH below 6.5 will damage concrete equipment.

The Oxidation and Reduction Potential (ORP) measurement will also give the plant operator an insight into the plant influent. Specifically, an increase in the strength of the biological loading at the plant influent will be indicated by a sharp decrease in the ORP readings. ORP is also gaining popularity as a trouble-shooting tool.

Preliminary Treatment

Large pieces of debris and other solids are removed by large screens, preventing upstream equipment damage and clogged pipes. These materials are a diverse assortment of paper, plastic, toys, vegetable matter, jewelry and sometimes even money. After screening, the sewage is passed through grit chambers for removal of heavy inorganic particles, and smaller solids such as stones, sand, coffee grounds, eggshells and cinder. This treatment stage is especially important in a combined plant where sewage and storm water are combined and washed into the sewer system.

A combined sewer system design carries both sanitary wastewater and storm water in the same pipe to the treatment plant. During periods of heavy rainfall or snow melt, the wastewater volume exceeds the plant capacity and excess untreated wastewater is discharged to nearby streams, rivers, and lakes. This discharge disturbs the biological systems, contaminates our drinking water sources, and creates threats to public health by coming in contact with untreated wastewater. The United States EPA estimates there are thousands of these incidents each year. Regulation, guidelines and measures have been established to prevent these conditions from occurring.

Odor problems develop in the sewer system due to decomposition, and odors are controlled by chlorine addition at the pumping stations at fairly high chlorine doses (10 mg/L) and are gradually reduced to determine the minimum amount required.

Decomposition at the plant influent can also produce odors and gases such as hydrogen sulfide, which are hazardous, explosive, and can cause corrosion and structural damage to plant equipment. Pre-chlorination with chlorine or hydrogen peroxide may be used in the preliminary treatment stage, but is not related to disinfection. It is used to temporarily prevent further wastewater decomposition, reduce odors, and protect plant equipment and personnel.

Analytical measurements in this hostile environment are ideally made using the Model 5081 Family Transmitter, which is both corrosion resistant (NEMA 4X) and suitable for

The Transmitter Model 5081 is ideal for harsh environments.

explosion proof and intrinsically safe environments (NEMA 7B).

Various polymers and chemicals, such as ferric chloride and ferrous chloride, can be added at the grit chamber to assist flocculation, sedimentation and precipitate phosphorus. The pH may also be adjusted to help the chemicals and polymers do a better job.

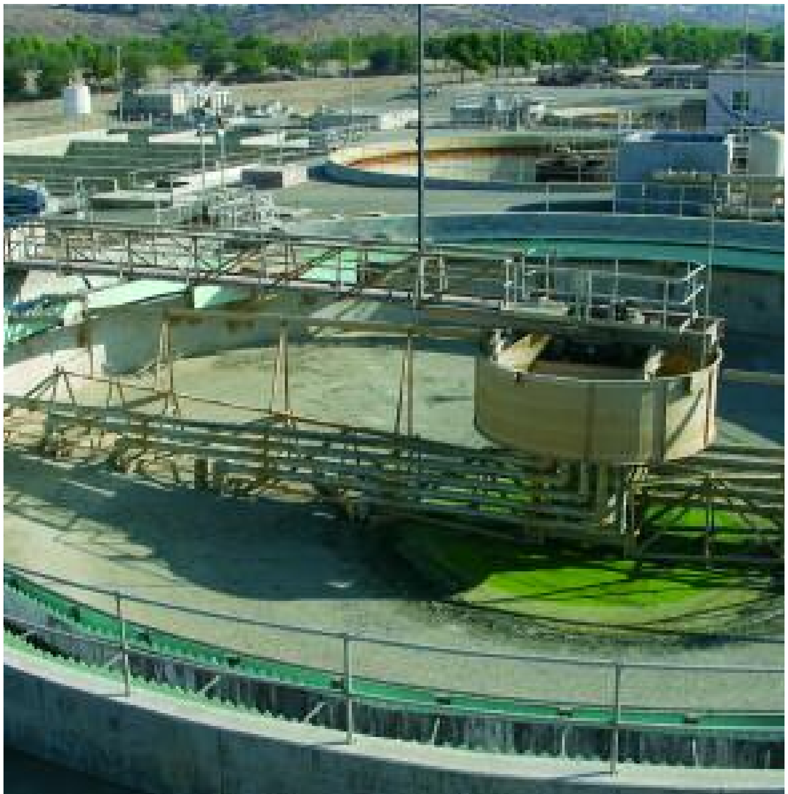
Primary Treatment

Organic and inorganic material, grease, oil and other suspended solids are still present after screening and grit removal. These small materials and particles are removed in sedimentation tanks, primary clarifiers, settling tanks, or settling basins by allowing the material to sink to the bottom. With the help of chemicals like ferric chloride and organic polymers, waste particles bond together in large enough mass to settle out. Lime may be added for pH control to aid flocculation.

Since lime will gradually coat the pH sensor surface, a sensor with TUpH Reference Technology such as Model 396P includes a large reference junction for minimal maintenance requirements.

pH Sensor Model 396P requires minimal maintenance.

At this point, approximately 60 to 80% of the total suspended solids in the water have been removed. These biosolids are commonly pumped from the sedimentation tanks into the sludge treatment stage, and may be used for fertilizer or landfill, or may be incinerated.



Secondary Treatment

Secondary treatment removes up to 85% of the remaining organic material through a biological process by cultivating and adding sewage microorganisms to the wastewater. This process is accomplished in a trickling filter or an aeration tank. A trickling filter uses a bed of stones or pieces of corrugated plastic media. As sewage is passed through these beds, microorganisms such as bacteria and protozoa gather on surfaces, multiply and consume most of the organic matter.

Some plants use aeration tanks and suspend microorganisms in wastewater. After leaving the primary treatment stage, sewage is pumped into aeration tanks. The sludge is loaded with microorganisms and mixed with air or pure oxygen. As air is forced into the aeration basins, it increases the activity of these microorganisms and helps keep the organic waste thoroughly mixed.

With 32 combinations, the Analyzer Model 1055 is ideal for municipal plants with dual measurement requirements.

Dissolved oxygen (DO) is added to the aeration basin to enhance the oxidation process by providing oxygen to aerobic microorganisms so they can successfully turn organic wastes into inorganic byproducts, specifically carbon dioxide, water and sludge, which may contain nitrated phosphates, sulfates and highly active bacteria. Stated simply, there are two main categories of microorganisms ("bugs") that digest waste—carbon eaters (carbonaceous) and ammonia eaters (nitrogenous)—and both of these groups need oxygen to reproduce and sustain life.

In order to metabolize food and reproduce, each bug must have at least 0.1 to 0.3 mg/L DO. Most plants maintain about 2 mg/L of DO so the bugs contained inside the floc can also get oxygen. If the DO is less than 2 mg/L, the bugs in the center may die since the bugs on the outside of the floc use up the DO first. If this happens, the floc breaks up.

Maintaining an environment conducive to keeping these microorganisms alive and most productive is a critical job for plant managers and operators. If the DO content is too low, the environment is not stable for these microorganisms (or bugs) and they will die due to anaerobic zones, the sludge will not be properly treated and plants will be forced to conduct an expensive and time-consuming biomass replacement process.

Because of this risk, many plants compensate by adding excessive amounts of DO to their process. However, when the DO levels become too high, energy is wasted, expensive aeration equipment undergoes unnecessary usage, and unwanted organisms (filamentous biology) are promoted.

Power costs associated with the operation of the aeration process generally run from 30 to 60 percent of the total electrical power used by a typical wastewater treatment facility. Today, however, plant managers can equip their aeration basins with on-line analysis systems that provide continuous DO measurement. Furthermore, an automated aeration system can maintain the correct amount of DO in the secondary treatment stage. And according to the USEPA, plant energy costs may be reduced by as much as 50 percent.

DO introduced in the aeration basins also provides the added benefit of mixing, thus bringing the bugs, oxygen, and nutrient together. Mixing also removes metabolic waste products. Too much mixing can break up the floc or form unstable floc particles. If there is inadequate mixing, proper

DO Membrane Sensor Model 499ADO helps maintain the correct dissolved oxygen levels.

Auto Air Blast Sensor Cleaning System Model DO-03/04 cleans sludge from the sensor without removing the sensor.

secondary treatment will not take place since there is a lack of contact between the bugs, their food and the oxygen source. Finally, the mixing or aeration keeps this floc suspended and prevents it from settling to the bottom.

In order to keep this waste treatment process functioning properly, the measurement of DO is a critical online measurement and can be accomplished using two different DO sensor technologies: membrane sensor Model 499ADO, and bare or open electrode Züllig DO sensor.

The aeration basins represent one of the toughest and most challenging environments for measurement sensors. The single celled bacteria consume proteins, carbohydrates, fats and many other compounds. During this process, their waste products form a thick slime layer outside their cell wall, making the cells stick together. This sticky substance covering the outside of the cell allows the bacteria to agglomerate into a floc.

Bio-slimes produced by the bugs coat the sensors with biofilms, requiring constant cleaning and maintenance on a weekly and sometimes daily basis. Fortunately, there are two kinds of on-line dissolved oxygen sensor systems that are suitable for this application.

The membrane sensors can be equipped with an auto air blast sensor cleaning system that blows a jet stream of air for a short period at set intervals. The programmable timer in the analyzer can control the cleaning frequency, and a small high-efficiency compressor, conveniently located near the sensor, provides the air supply. This kind of air blast system cleans the sensor and eliminates the need to remove it from the process for regular cleaning. As a result, membrane sensors used in combination with air blast cleaning systems can last up to three months or longer before any sensor cleaning maintenance is required.

In the open- or bare-electrode Züllig sensor design, a rotating diamond grindstone continuously polishes the electrode surfaces. This self-cleaning capability eliminates the time-consuming tasks of cleaning and replacing membranes and replenishing the electrolyte solution required in traditional membrane sensors.

In addition to DO, a proper pH range must be maintained in the aeration basin to support an active and healthy biological system. The ideal pH range is between 6.5 and 8.5, and a pH sensor Model 396P is recommended for this coating application.

Züllig Open Electrode Dissolved Oxygen System Model S12V continually polishes electrode surfaces.

Partially treated sewage from the secondary treatment process flows to a secondary clarifier, also called a settling tank, for removal of excess microorganisms. Some of the sludge collected at the bottom of this tank is wasted and is called Waste Activated Sludge (WAS). Most of the sludge however is recycled back to the aeration tank to consume more incoming organic material. The term Return Activated Sludge (RAS) is used because the sludge being returned from the settling tank to the aeration tanks contains microorganisms that have been depleted of food for some time, and are in an activated or hungry condition ready to biodegrade more waste.

This is a continuous flow process, and the measurement of suspended solids is critical to wastewater plant operations. These measurements tell the operator exactly how much sludge to return, and how much to waste. The results of a grab sample analysis in a laboratory usually take 2 to 24 hours, and accurate real-time adjustments are impossible since the process conditions have almost certainly changed due to the time lag.

Process changes in the condition of the influent flow or solids can occur during a rainstorm or an unplanned load change from an industrial discharge. A total suspended solids sensor such as the Züllig COSMOS®-25 sensor provides a continuous on-line measurement of total suspended solids.

Analyzer Model 54eA with programmable timer to control sensor cleaning frequencies.

Suspended Solids measurements can be made using the Züllig COSMOS®-25 sensor in open basins as well as in pipelines.

Sludge Treatment

During the wastewater treatment process, sludge has been generated along the way from the settling basins or clarifiers, and secondary treatment. This sludge contains high concentrations of microorganisms, many of which are pathogenic, and will decay and produce odors. Sludge however can be used for a soil conditioner, agricultural fertilizer, or for landfill after it has been treated to remove the harmful contaminants.

Sludge treatment has two objectives: the removal of part or all the water to reduce the volume, and the decomposition of the organic solids into a stable organic solid. One common sludge treatment method is biological digestion and can be either aerobic or anaerobic. Both of these methods require analytical measurements including pH, DO, temperature and sludge blanket level. Aerobic digestion is similar to the activated sludge process. The anaerobic digestion process produces a methane gas, which has fuel value and can be burned to provide heat or even run electric generators in the plant.

Sludge received from the plant clarifiers can be processed in Gravity Thickeners prior to being pumped into the digesters. Sludge enters the thickener at 1.5% and is thickened to 8% to minimize pumping volume and is monitored using a suspended solids sensor, such as the Züllig COSMOS-25 sensor.

Suspended Solids Sensor COSMOS-25® with optional automatic self-cleaning mechanical wiper for submersion.

Final Treatment

In the final stage of wastewater treatment, disinfectants are added to kill disease-causing organisms and microorganisms used in the treatment process. Disinfection inactivates or destroys pathogenic organisms and prevents the spread of waterborne diseases to downstream users and the environment. A common disinfectant is chlorine gas, but some municipalities manufacture their own chlorine solution such as sodium hypochlorite. Chlorine dosages ranging from 5 to 20 mg/L are measured using a Model 499ACL sensor, and kill 99% of the harmful microorganisms in the final effluent.

In many areas, local or national agencies regulate the amount of chlorine allowed in the final plant effluent before being discharged into lakes, rivers, or the ocean. This requires dechlorination, which removes the free and combined chlorine residuals to reduce the toxicity after chlorination and before discharge. Limits are between 0.01 to 0.30 ppm of chlorine. Chlorine is closely regulated because even small amounts are harmful to aquatic organisms. Typically, plants are required to monitor their waste streams and report chlorine levels to a regulatory agency. Agencies can require either continuous or grab-sample testing.

Chlorine sensor Model 499ACL for continuous measurement in chlorination and dechlorination stages.

Chlorine is added to the effluent from the final clarifier as it enters the chlorine contact chamber. Excess chlorine is removed in a dechlorination stage by adding sulfur dioxide, sodium bisulfite, sodium sulfite, or sodium metabisulfite. The chlorine concentration is measured in both the chlorination and dechlorination stages using a Model 499ACL sensor.

ORP sensors are also being used in disinfection, but the ORP reading does not indicate the chemical concentration, but instead indicates the oxidizing activity of water. For chlorination, the ORP starting point is highly variable, the control point may vary considerably, and changes in background wastewater composition will affect the ORP readings. For chlorination the appropriate treatment point is determined using a laboratory method or portable colorimetric tests, and the corresponding ORP value is recorded. For dechlorination, the setpoint value depends on the results of off-line

ORP Sensor Model 396P can be used to establish the ORP starting point.

chlorine tests made at ORP levels around the desired point.

At one particular wastewater facility, three Model 396P ORP sensors are used to measure before the disinfection process to establish a background ORP level, a level after chlorine is added, and the level after the sulfur dioxide is added.

Alternates to disinfection with chlorine are gaining popularity, such

The Clarity II On-Line Turbidimeter is used to monitor and report the turbidity of the filter. effluent.

as ultraviolet light (UV). The effectiveness of UV radiation depends on the radiation intensity, the exposure time, the configuration and the characteristics of the wastewater. High turbidity and total suspended solids (TSS) in the wastewater can render UV disinfection ineffective. These suspended solids absorb the UV radiation and shield the embedded bacteria. Turbidity can be measured using a Clarity II On-Line Turbidimeter, and continuous TSS measurement is accomplished using a Züllig Model COSMOS-25 sensor.

Final effluent monitoring plays an important role in wastewater treatment plants and is required for compliance monitoring for reporting to regulatory agencies, protection of wetlands, and it provides an indication of overall plant performance. Continuous online measurements of plant effluent can also include pH, total suspended solids, ORP, and conductivity.

pH sensor Model 399 for general purpose pH measurements.

Tertiary Treatment

Since the early 1970's, an optional stage that falls between secondary and final treatment – known as tertiary treatment – has come into use in some areas. With a limited amount of usable fresh water, combined with the contamination of water sources, there is sometimes a need to reuse wastewater as a feed source to drinking water plants. This reuse, commonly called "Toilet to Tap", requires proper treatment and continuous monitoring and removal of various chemical components.

The increased need to reuse water for industrial and domestic use and to protect the receiving water have required additional treatment steps and advanced tertiary wastewater treatment. Advanced waste treatment techniques include phosphorus and nitrogen removal, physical and chemical separation such as filtration, carbon adsorption and reverse osmosis. As waste effluents are purified to higher degrees by such treatment, the effluent water can be used for industrial, agricultural, or recreational purposes, or even drinking water supplies. It can also be pumped back into the ground to prevent salt water intrusion.

Often, treatment consists of passing the wastewater through a filter medium. This method removes almost all bacteria, reduces turbidity and color, and removes odors and most other solid particles from the treated water. Often a combination of filter media is used to provide a course to fine filtration as water passes through the filter. As filtration proceeds, the headloss through the filter increases until it reaches an unacceptable level or until solids breakthrough occurs and the effluent becomes unacceptable.

Measurement of turbidity using the Clarity II On-Line Turbidimeter is an important indicator of filter breakthrough. At this point, the filter is backwashed.

Advanced treatment of sewage may also include a two step process of nitrification and denitrification for removal of nitrogen. The majority of nitrogen is in the form of ammonia and can be toxic to aquatic life. It is not removed, but converted by microorganisms feeding on ammonia to nitrite and nitrates. Regardless of the method chosen, sufficient oxygen must be available for nitrification to occur.

pH sensor Model 389 features triple reference junction for poisoning applications.

Nitrification systems are also sensitive to pH variations; the optimum pH is approximately 7.8 to 9.0. Continuous online measurement of pH and DO is critical for nitrification. DO levels must be greater than 2 mg/L to prevent denitrification. The DO membrane sensor Model 499ADO with the air blast cleaning option or the bare electrode Züllig DO sensor can provide a reliable DO measurement.

Denitrification reduces nitrates to nitrogen gas in the absence of oxygen. This reaction is also dependent on temperature, pH and occurs in the absence of oxygen.

Rosemount Analytical Instrumentation

The optimum solution for the process relies most heavily on selecting the right sensor to match the process needs. In most cases the instrument is simple to select and depends on the power, control, and communication requirements, in addition to other desired features, such as HART®, FOUNDATION fieldbus®, preventative diagnostics, and more. Choose the one that meets your needs.

Features	SoluComp II, 1055 Series	54e Series	5081 Series	SoluComp Xmt Series
Power Requirement	115 - 230 VAC or 24 VDC*	115 - 230 VAC or 24 VDC	24 VDC	24 VDC
Number of Sensor Inputs	Two	One	One	One
Number of 4-20 mA Outputs	Two	Two	One	One
Available Measurements	Select any two: pH, ORP, Conductivity, Resistivity, Dissolved Oxygen, Ozone, Chlorine, Flow, Turbidity	Select one: pH, ORP, Conductivity, Resistivity, Dissolved Oxygen, Ozone, Chlorine	Select one: pH, ORP, Conductivity, Resistivity, Dissolved Oxygen, Ozone, Chlorine	Select one: pH, ORP, Conductivity, Resistivity, Dissolved Oxygen, Ozone, Chlorine
HART Compatible	No	Yes	Yes	Yes
FOUNDATION Fieldbus Compatible	No	No	Yes	Yes
Multi-lingual	Yes	Yes	No	No
Relays	3	4	0	0
PID Control	No	Yes	Yes/Ff	Yes/Ff
Advanced Diagnostics Capability	Some	Complete	Complete	Complete
Area Classifications	Class I, Div. II	Class I, Div. II	Class I, Div. I and Div. II, Explosion proof	Class I, Div. I and Div. II
Available Approvals	FM, CSA, CE, UL*	FM, CSA, CE	FM, CSA, CE, ATEX	FM, CSA, CE, ATEX

* Not available for Turbidity

Emerson Process Management: The Proven Source

Emerson Process Management is the proven supplier of Rosemount Analytical on-line electrochemical sensors and instrumentation with over 60 years experience in drinking water treatment, waste treatment and process control. In recognition of our dedication to customer service, product excellence, and quality, we have received the #1 Readers Choice Award from Control Magazine for the eleventh consecutive year.

With populations ever on the rise, wastewater treatment is more critical than ever before. Without treatment, wastewater would contaminate and overrun freshwater systems everywhere, leaving natural sources of drinking water polluted and unsafe. Because of this, local and national laws require specific treatments of wastewater to safeguard water quality. A wastewater treatment plant separates solids from liquid, and speeds up the natural processes by which water is purified. It is a multistage process that is critical to the clean-up of sewage before discharge or reuse.

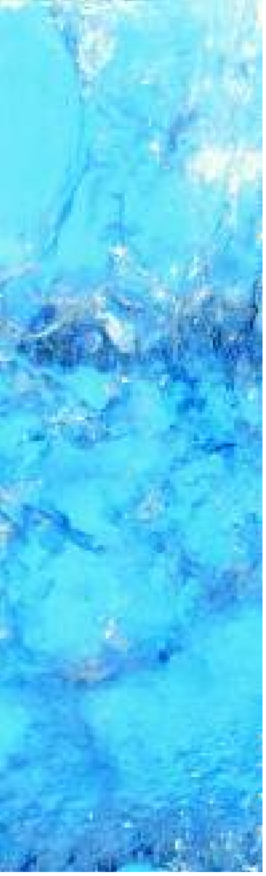
Accurate on-line process instrumentation measuring pH, conductivity, chlorine, dissolved oxygen, suspended solids and turbidity plays a critical role in achieving the plant objective and meeting regulatory compliance at the local and national level. Count on Emerson for the systems and solutions you need in an ever-changing, dynamic world. See us on the web at ***RAIhome.com.***

PlantWeb® Brings It All Together

Rosemount Analytical's instruments are part of Emerson Process Management's PlantWeb® field-based architecture: a scalable way to use open and interoperable devices and systems to build process solutions. The PlantWeb architecture consists of intelligent field devices, scalable platforms and standards, and integrated modular software, all working together to create, capture, use, and distribute information and process control data.

This architecture can reduce your capital and engineering costs, reduce operations and maintenance costs, increase process availability, reduce process variability, and streamline regulatory reporting.

To see what PlantWeb can do for *your* operation, call or visit us at ***PlantWeb.com/RunSafe***



Offices Worldwide

Emerson Process Management's field sales offices are your source for more information on the full line of Rosemount Analytical products. Field sales personnel will work closely with you to supply technical data and application information.

For more information on any of the products listed in this brochure and their applications, please contact your nearest Rosemount Analytical sales office. To request copies of our literature, call 800.854.8257 or visit our website.

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Emerson's Rosemount Analytical Liquid Division provides technologies and services for the analysis of liquid processes. For a wide range of applications, Emerson provides more than 60 years of expertise in high-precision analytical sensors, instrumentation and services. For information, call 800.854.8257.

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