

Wastewater Industry Solutions

Complete and Reliable Liquid Analysis



Visualize > Analyze > Optimize

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Analytical


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TRUSTED AROUND THE WORLD: THE MOST ADVANCED LIQUID ANALYSIS SOLUTIONS

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.

Visualize an online analytical solution for wastewater treatment that reduces labor with rugged instruments and sensors that provide data for increased regulation compliance and reduced maintenance costs.

Analyze your wastewater streams to meet local and national laws that safeguard water quality.

Optimize your multi-stage wastewater process to speed up the natural processes of water purification.

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

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

Wastewater is generated by homes, businesses, and industries and is treated in two major steps, primary and secondary treatment, with disposal of solids during both steps. Analytical measurements such as pH, ORP, and suspended solids are performed during the primary treatment stage in order to monitor the removal of solids from the wastewater.

Secondary treatment relies upon biological processes to further purify the wastewater, and maintaining proper dissolved oxygen (DO) levels is critical to this process. The RDO optical dissolved oxygen sensor is the perfect choice for maintaining the proper amount of oxygen required by microorganisms during biological processes.

Final treatment consists of chlorination and dechlorination and uses the Model 499ACL chlorine sensor. The final effluent is monitored for compliance and reporting purposes, and can include pH and chlorine measurements.

Solutions

pH Measurement

- Effluent pH monitoring

Chlorine Measurement

- Monitoring chlorine in final treatment

Dissolved Oxygen Measurement

- Monitoring and controlling oxygen in activated sludge process

Conductivity Measurement

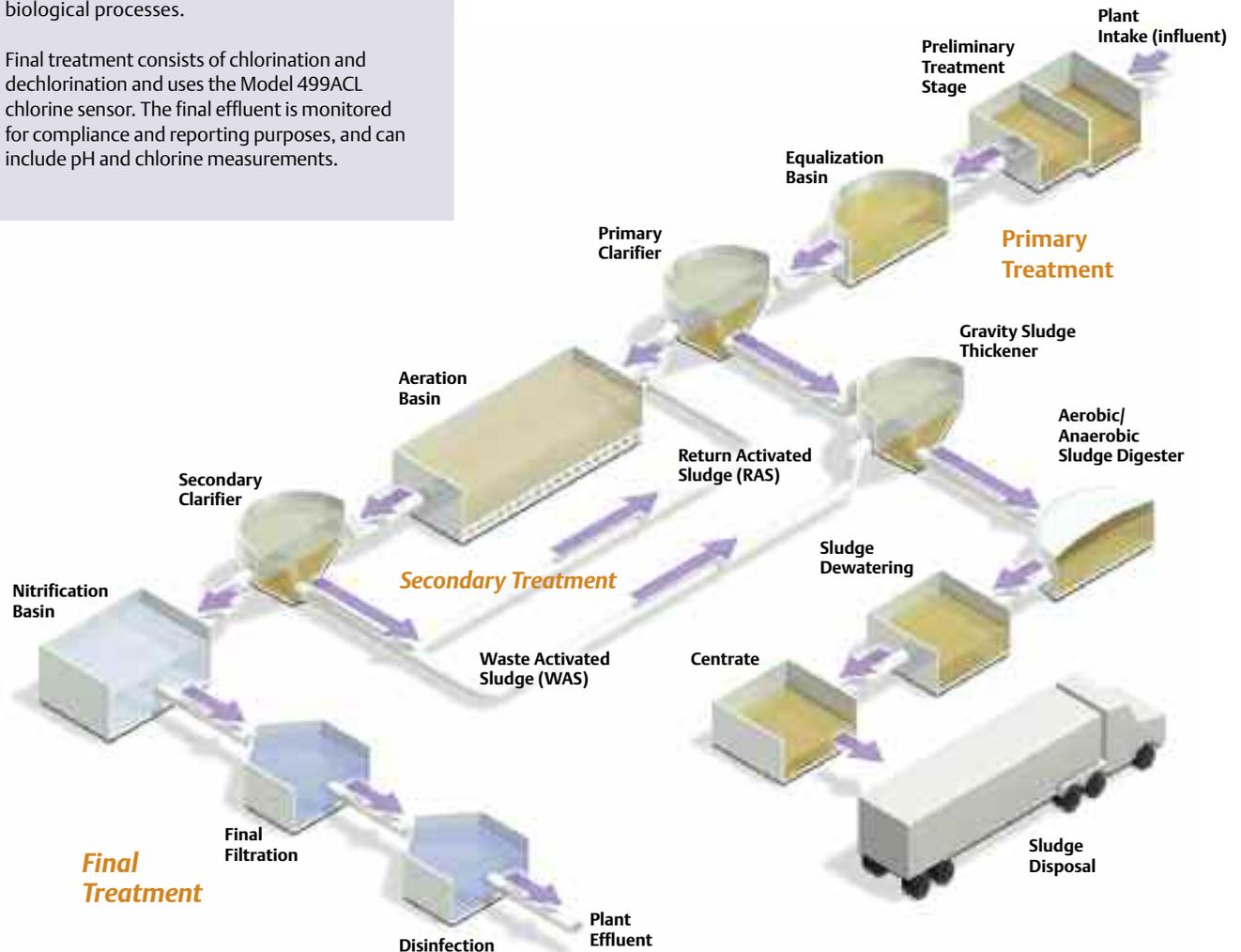
- Monitoring conductivity at influent and outfall



Model 1056 Analyzer



Model 3500 pH Sensor



PRIMARY TREATMENT

Mechanical or Physical Separation of Solids

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.

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



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

range is harmful to the microorganisms used to break down the wastewater, and a pH below 6.5 will damage concrete.

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 may exceed the plant capacity and excess untreated wastewater is discharged to nearby streams, rivers, and lakes. This discharge disturbs the biological systems, may contaminate 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

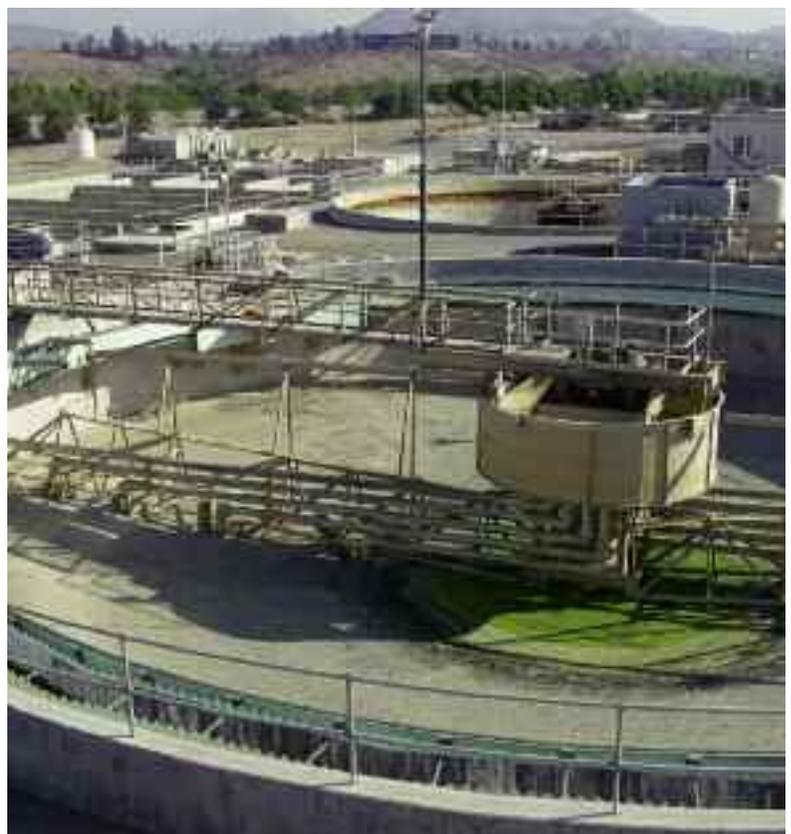
solids are still present after screening and grit removal. These small materials and particles are removed in sedimentation tanks, primary clarifiers, settling tanks, or settling basins by allowing the material to sink to the bottom. With the help of chemicals like ferric chloride and organic polymers, 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 TU^{PH}® Reference Technology such as Model 396P includes a large reference junction for minimal maintenance requirements.

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.



pH Sensor Model 396P requires minimal maintenance.



SECONDARY TREATMENT

Remove Remaining Organics

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, micro-organisms such as bacteria and protozoa gather on surfaces, multiply and consume most of the organic matter.



With a complete range of measurement inputs that can be configured in any combination, the Model 1056 is ideal for municipal plants with dual measurement requirements.

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.

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 nitrates, phosphates, sulfates and highly active bacteria. Stated simply, there are two main categories of microorganisms 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, the microorganisms need at least 0.1 to 0.3 mg/L DO. Most plants maintain about 2 mg/L of DO so the microorganisms contained inside the floc can also get oxygen. If the DO is less than 2 mg/L, the microorganisms in the center may die since the ones 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 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



The Model RDO optical dissolved oxygen sensor

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 microorganisms, 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 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 the RDO fluorescence quenching sensor and analyzer.

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 microorganisms coat the sensors, requiring constant cleaning and maintenance on a weekly and sometimes daily basis. With regular cleaning, the Model RDO sensor is less affected by fouling than membrane-covered polarographic sensors.



Sensor and Analyzer Model RDO for dissolved oxygen monitoring

The optical dissolved oxygen sensor is simple to install and has an accuracy reading of +/- 0.1 ppm between 0.0 and 8.0 ppm. The analyzer accepts a single or dual input. Calibration is simple and can be calibrated wither against a referee instrument or in water-saturated air. Air calibration is completely automatic. A manually entered correction for salinity is also available. Maintenance is fast and easy and consists primarily of replacing the sensing cap every year.

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.

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.

SLUDGE TREATMENT

Volume Reduction and Decomposition

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.

ADDITIONAL TREATMENT

Volume Reduction and Decomposition

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 coarse 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.

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 Model RDO can provide a reliable DO measurement.

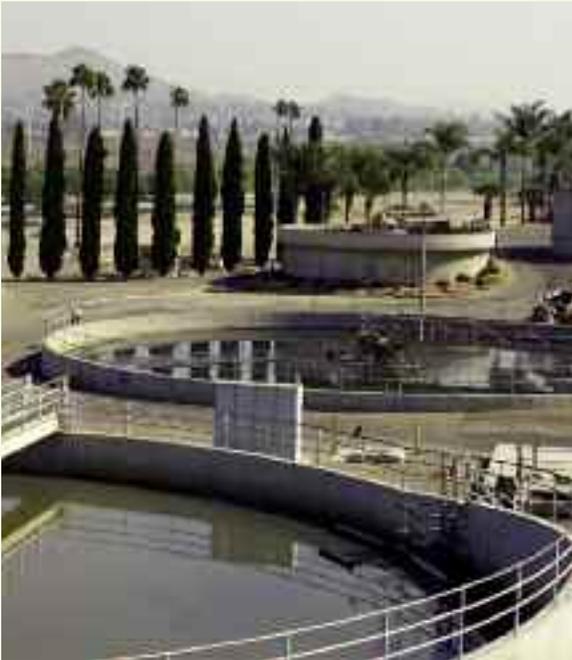
Denitrification reduces nitrates to nitrogen gas in the absence of oxygen. This reaction is also dependent on temperature, pH and occurs in the absence of oxygen.



PERpH-X® pH sensor has improved durability and increased reference electrode stability

Disinfection

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 down-stream users and the environment. A common disinfectant is chlorine gas, but some municipalities use their own chlorine solution such as sodium hypochlorite.



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

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 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 TCL Total Chlorine System.

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



Model TCL, System for Total Chlorine Measurement

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 chlorine tests made at ORP levels around the desired point.

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

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



pH sensor Model 399 for general purpose pH measurements.



Features	6081 Series	1056 Series	1057 Series	56 Series	5081 Series	SoluComp Xmt Series
Power Requirement	Lithium power module	115 - 230 VAC or 24 VDC	115 - 230 VAC or 24 VDC	115 - 230 VAC or 24 VDC	24 VDC	24 VDC
Number of 4-20 mA Outputs	Wireless	Two	Four	four	One	One
Number of Sensor Inputs	One	Two	Three	Two	One	One
Available Measurements	pH and contacting conductivity	pH/ORP/ISE, Conductivity, Resistivity, % Concentration, Dissolved Oxygen, Ozone, Flow, Turbidity, Chlorine (Total, Free, Monochloramine, pH Independent Free Chlorine)	pH/ORP/ISE, Contacting Conductivity	pH/ORP, resistivity/conductivity/TDS, % concentration, ratio conductivity, total and free chlorine, dissolved O ₂ , dissolved ozone, turbidity, pulse flow, temperature and raw 4-20mA input	Select one: pH, ORP, Conductivity, Resistivity, Dissolved Oxygen, Ozone, Chlorine, Gaseous Oxygen	Select one: pH, ORP, Conductivity, Resistivity, Dissolved Oxygen, Ozone, Chlorine
SMART pH	Yes	Yes	Yes	Yes	No	No
HART Compatible	Yes	Yes	No	Yes	Yes	Yes
FOUNDATION fieldbus Compatible	No	No	No	No	Yes	Yes
Wireless THUM Adaptor compatible	NA	Yes	No	Yes	Yes	Yes
Multi-lingual Menus	Yes	Yes	Yes	Yes	No	Yes
Relays	NA	4	4	4	NA	NA
PID Control	No	Timer control only	Timer control only	Yes	Yes/FF	Yes/FF
Advanced Diagnostics Capability	Yes	Complete	Complete	Yes	Complete	Complete
Area Classifications	Class 1, Div. 1 (future option)	Class 1, Div 2	Class 1, Div 2	TBD	Class 1, Div. 1 & Div. 2, Explosion proof	Class 1, Div. 1 & Div. 2
Available Approvals	CE, CSA	FM, CSA, CE, UL	CE, UL, CSA	TBD	CE, FM, CSA, ATEX	CE, FM, CSA, ATEX

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 sixteenth consecutive year.



With a fixed amount of fresh water available for consumption and our

worldwide increased demand for access to safe water, continuous monitoring and measuring of the water treatment process and water quality becomes one of the most important elements to prevent water-related diseases caused by pathogens.

Producing a source of safe and reliable drinking water and the removal of harmful microorganisms are the primary goals of every drinking water treatment plant. Thousands were killed each year due to cholera, typhoid fever, dysentery and hepatitis before cities began treating drinking water with chlorine. Today, chlorine, ozone and

UV are being used in primary disinfection at the pre-treatment stage and secondary disinfection in the final stage to inhibit or prevent regrowth of pathogens in the water distribution system.

Accurate on-line process instrumentation, such as pH, conductivity, chlorine, dissolved ozone, turbidity, and particle counters, plays a critical role in achieving the plant objective and meeting regulatory compliance at the local and federal 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.



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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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