Considerations for More Reliable Electrical Systems in Water and Wastewater Treatment Plants

White Paper

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Maintaining water and wastewater treatment plants is essential to meeting the critical need for clean water consumed by municipalities, process industries, and agriculture. Demand for treatment today is at an all-time high. In the United States alone, about 34 billion gallons of wastewater is processed each day. Much of this can be attributed to increasingly stringent, but environmentally necessary, government regulations that now require companies processing chemicals, pesticides, and other harmful materials to recover 95 to 99 percent of water from waste streams before releasing it back into the ecosystem. Other factors contributing to mounting demand are global population growth, urbanization, and the expansion of farming operations.

This situation, one that some experts are labeling a crisis, is complicated by the aging of water treatment plants (WTP) and wastewater treatment plants (WWTP). Most plants in the United States were designed with an average lifespan of 40 to 50 years, so the systems that were constructed in the 1970s, around the passing of the Clean Water Act in 1972, are reaching the end of their service lives and require massive overhauls. The Environmental Protection Agency (EPA) estimates that roughly $271 billion in wastewater infrastructure is needed in the next 25 years to maintain and improve the country's ailing water facilities. Climate change is also compounding the problem by disrupting hydrological cycles, making water more erratic, and increasing the severity of floods and droughts.

In this whitepaper we will address the market for water and wastewater treatment and provide an overview of standard WTP/WWTP processes and the significant challenges faced by electrical distribution systems in these harsh environments.

Emerson Single-Source Supplier

Emerson, through its Appleton™ brand, addresses the needs of WTP/WWTPs for highly reliable, energy-efficient electrical equipment with one of the world's largest, most diverse selections of corrosion-resistant lighting fixtures, control stations, fittings, plugs, motor starters, receptacles, and panelboards. Each is expressly engineered to meet the unique challenges posed by WTP/WWTPs, for both ordinary and hazardous locations. With Emerson, you have a single-source supplier for all the best-in-class electrical products you need, whether you are the facility manager, the designer of the electrical distribution system, or the distributor supplying the project.

Market Dynamics

Even after factoring in the negative economic effects of COVID-19, the global market for WTP/WWTP equipment was valued at $28.0 billion in 2020 and is projected to reach $41.8 billion by 2030. The overall market is gathering steam on account of rising investments by government. The recently passed Infrastructure Investment & Jobs Act (H.R. 3684), a nearly $1.2 trillion bill that includes $550 billion in new spending, allocates $55 billion to drinking water, wastewater, and storm water infrastructure funding. It is expected to stimulate the upgrading of the country's more than 16,400 WTP/WWTPs and 876,000 miles of municipal water piping.

Water Treatment vs. Wastewater Treatment

Prior to moving forward, we should review the different processes involved in water treatment versus wastewater treatment.

Basically, water treatment is the process of purifying fresh water drawn from a river or lake before it is distributed to a community, while wastewater treatment is the reclaiming of contaminated water after it is consumed and disposed of by the community. Since it is assumed that each drop of treated water is consumed by a person, water treatment centers have higher standards for pollution control. In contrast, treated wastewater is released into local waterways or used in irrigation, so the treatment standards are lower than those for drinking water facilities.

Water Treatment Processes

Five phases are required to achieve treated fresh water: coagulation/flocculation, sedimentation, disinfection, filtration, and post-disinfection.

Coagulation/Flocculation: During this first step, positively charged chemicals are added to the water to neutralize the negative charge of dirt and other dissolved particles. When this occurs, particles bind with the chemicals and form larger particles known as "floc".

Sedimentation: Next, the flocculated water flows to sedimentation. Due to its weight, floc settles to the bottom of the water supply, removing suspended solids denser than water and reducing the particulate load on the upstream filters. Sedimentation removes almost ninety percent of the solids in the water.

Disinfection: Chlorine is now added to the water to begin disinfection, a process designed to kill or inactivate most microorganisms in water, such as bacteria, viruses or intestinal parasites that cause waterborne diseases.

Filtration: In this step, the chlorinated settled water flows onto filters, passing through beds of coal, sand, or other granular substances to remove any remaining particulate impurities. Water collected from the bottom of the filters is considered "potable".

Post-Disinfection: Finally, chlorine is added a second time for post-disinfection, ensuring the water remains safe to drink even at the furthest reaches of a distribution system. Fluoride is also added at this phase for the strengthening of teeth and prevention of tooth decay.

Wastewater Treatment

Unlike WTPs that typically have near identical system layouts, WWTPs are much larger, more expensive to operate, and do not follow similar facility designs, and in fact, differ widely. WWTPs tend to be unique depending to the diverse kinds of waste a community produces. For example, a WWTP that deals with high amounts of ammonia may install a stripping tower, while a wastewater facility with high organic loading may install an anaerobic digester for methane recapture. Furthermore, certain industries with very polluted wastewater are required by the EPA to apply their own form of treatment before sending the water to the community's WWTP.

In general, the process to treat wastewater is made up of three phases: primary, secondary, and tertiary.

Primary: After being screened for large items and aerated, wastewater is temporarily held in a settling tank where heavier solids sink to the bottom while lighter solids float to the surface. Mechanical scrapers are installed that continually drive collected sludge to a hopper while rakes are used to remove grease, oils, plastics, and soap floating on the surface. Researchers have developed chemical-free, eco-friendly processes to convert the sludge into a valuable source of fertilizer for food production.

Secondary: At this phase, the water is treated to degrade the biological content of the waste through aerobic biological processes. This is conducted either by biofiltration, aeration, or oxidation ponds.

Tertiary: In this step, pathogens are removed, which ensures that treated water, known as effluent, is safe to be discharged into a local river, lake, or the ocean.

WTP/WWTP Challenges to Electrical Equipment

WTP and WWTP facilities' environmental and operational conditions create an extremely hostile atmosphere for electrical equipment, causing deterioration and forcing early repair, frequent maintenance, and expensive replacements. Constant upkeep of equipment is required to slow this process to prevent premature failures.

Challenge 1: Corrosion

The greatest threat to metallic electrical products is corrosion. This is even more the case when the plant is located in a humid coastal area exposed to salt spray.

Corrosion comes in many forms. Filiform corrosion, for example, is induced by pinpoint penetration of moisture. Galvanic corrosion occurs when two different metals are electrically connected in the presence of an electrolyte like sodium chloride. Ferric chloride, chlorine, acids, and alkalis found in treatment centers will severely attack metal. Interaction of sewage components will also produce secondary chemicals having even more toxic and corrosive properties, leading to the faster destruction of metallic surfaces and concrete. Hydrogen Sulfide (H2S) or "sewer gas" is another threat to metallic components, causing so many corrosion problems for wastewater treatment facilities that it warranted an EPA report on the subject. Simple "fatigue" corrosion occurs in ductile metals, resulting in cracking or breaking. Bacteria in wastewater will attack metal components, leaving them vulnerable to corrosion by sulfuric acid.

Of course, the outdoor environment exposes metal components to corrosion as well. Electrical components and lighting fixtures mounted outdoors are put into jeopardy by rain, snow, UV rays, salt spray, and wide temperature fluctuations, in addition to aerosols from settling tanks and outdoor chlorination. This type of corrosion, known as atmospheric corrosion, accounts for more material failures, from both a tonnage and cost perspective, than any other.

The Cost of Corrosion

Corrosion costs WTP/WWTPs approximately $1.3 billion annually in damages, including replacing failed equipment, lost productivity, increased maintenance, and poor power quality. Worse yet, corrosion can mean downtime for a facility. Downtime triggers all the above costs, plus the expense of rebalancing the system for restart. It also adds to the potential for increased oversight by the Department of Environmental Quality (DEQ) along with expensive fines for violating clean water regulations if sewage must be sent into the nearest waterway.

How to Fight Corrosion

Since this isn't a perfect world, you can't eliminate corrosion, especially not in a WTP/WWTP. But you can limit its destruction. Here's how:

1. Use corrosion-resistant products. For corrosive and high-humidity environments, the first line of defense is material selection. Aluminum or stainless steel enclosures are generally accepted materials. In extreme conditions, fiberglass reinforced polyester enclosures may be necessary in lieu of metal construction.
2. Specify a protective finish. The best, most cost-effective way to combat corrosion is to choose a coating that effectively seals out water, chemicals, and other corrosive contaminants.
3. Control the environment. As much as possible, shelter electrical installations from the weather and corrosive

Emerson Corrosion Prevention

Emerson uses an epoxy powder coat finish on most Appleton brand aluminum products. Unlike liquid paint, powder coating uses an electrostatic process to apply a finish to metallic parts in a dry state. Once applied, it is heat-cured, creating a finish that is thicker, more even on all outer surfaces and edges, and more durable and corrosion-resistant than most paints. This makes epoxy powder coat one of the preferred protection choices for oil and gas, wastewater and other harsh, corrosive industrial applications.

Emerson is also the only manufacturer in the electrical industry that uses a patented triple coat finish as standard on the majority of Appleton iron electrical products. First, zinc electroplate is applied onto the surface to create a formidable corrosion-resistant barrier. Next, the product is dipped in chromate. The chromate coating acts as paint does, protecting the zinc from white corrosion, making the product considerably more durable. It also destroys organic growth on the surface. Lastly, epoxy powder is applied to the product electrostatically. Drawn to the metal like a magnet, the powder covers evenly, reaching into the smallest crevices. The product is then heat-cured to ensure a strong bond. The result is a thick, uniform layer of protection that seals out the harshest corrosives, like those found in WTP/WWTPs including: sulfur oxides, nitrogen oxides, chlorine and chlorides, ammonia and ammonia salts, and hydrogen sulfide. The triple coat finish is extremely durable. And unlike conventional paint, it's flexible, so it stays intact when the underlying metal expands and contracts during temperature changes and stress fluctuations.

Emerson's epoxy powder coat finish and triple coat finish add value to Appleton brand electrical products through fewer callbacks and lower operational costs, while helping to safeguard the environment by virtually eliminating overspray particulates.

Independent salt fog performance testing by Intertek Laboratories (Arlington Park, IL) completed in 2019 demonstrated that Emerson's triple coat finish is far more effective at preventing corrosion than conventional paint finishes. For more information on the test and Emerson's triple coat finish, please visit www.appletonelec.com.

chemicals. Eliminate industrial contaminants from the air through ventilation and keep fuel-burning equipment in good repair to minimize emissions.

Challenge 2: Hazardous Locations

Decomposition of waste generates methane and hydrogen, both of which are flammable gases. Chemicals used for purification may also be potentially flammable, such as hydrogen peroxide and chlorine dioxide, even in relatively low concentrations. Electrical products installed where these chemicals are present — or may be present — must be rated for use in hazardous locations, per the National Electrical Code (NEC), and will require conduit seals and other special installation methods to reduce or eliminate the threat of fire and explosion. These ratings apply to new construction plus to additions or modifications of an existing treatment facility.

The NEC references NFPA 820 when classifying hazardous locations in wastewater treatment and collection facilities. The most common area classification in a WWTP is Class I, Division 1 or 2, Group D (Methane, Gasoline). Less common is Class II, Division 1 or 2, Group G (dried sludge). In certain cases, the application of proper ventilation and monitoring

Appleton Hazardous Location Products by Emerson

As noted earlier, there are specific areas within water and wastewater treatment plants where the presence of ignitable gases and chemicals require explosionproof electrical products per NEC 500(B). For over 100 years explosionproof Appleton brand lighting fixtures, control stations, fittings, plugs, receptacles, and motor starters have been engineered to contain the potential ignition source within the enclosure, preventing the escape of heat or flames into the surrounding atmosphere, thus providing Class I, hazardous location protection. When installed in a treatment center, NEC rated, explosionproof Appleton brand electrical products minimize the potential risk of explosion or fire. Each electrical product has been rigorously tested to adhere to the most stringent requirements whether your geography requires ATEX, ATEX/IECEx, NEC or CEC certification. Emerson also provides a full line of equally robust Appleton electrical products for ordinary location areas of the plant.

Moisture seeping into enclosures will result in corrosion of the internal components. Dirty water can also cause contamination by bacteria and organisms. Protection against water ingress requires NEMA rated, sealed and gasketed enclosures. Daily operations in a treatment plant require weatherproof NEMA enclosures in sludge treatment, odor control and out gassing, among other operations. The NEMA Standard for Enclosures for Electrical Equipment tests products for environment conditions found in water and wastewater treatment centers such as corrosion, rust, and icing. Our Appleton brand weatherproof products are designed to meet NEMA 3R (rain, sleet, ice), 4 (dust, rain, sleet, splashing water, hose directed water, ice) and 4X (dust, rain, sleet, splashing water, hose directed water, ice, corrosion) standards.

The ability for maintenance personal to safely install luminaires in hazardous locations is a priority. Because special equipment is often required to reach high ceilings or areas above tanks, look for products with innovative features that speed maintenance and ensure the integrity of the electrical product remains un-compromised. Appleton brand lighting fixtures offer several design features that provide the easiest installation with the most flexibility. Our explosionproof Code • Master™ LED Series offers a wireless mounting design which simplifies installation and minimizes the time workers spend in Division 1 locations. Our Mercmaster™ LED Series has an extra high hinged mounting hood design and allows many different mounting types with one standard luminaire body. Our Baymaster™ LED Series is available with a quickmount pendant system, allowing for faster and safer installations, while removing the need for a multi-person installation.

Hazardous Location Designations

Class I : Areas containing flammable gases, flammable liquid produced vapors or combustible liquid produced vapors
Division 1: Areas where hazards are present under normal operating conditions
Division 2: Areas where hazards are present under abnormally operating conditions
Group A: Acetylene
Group B: Have either a MESG value which is less than or equal to 0.45 millimeters, or a MIC ratio which is less than or equal to 0.40. Examples: hydrogen, butaiene, ethlene oxide, propylene oxide
Group C: Have either a MESG value which is greater than 0.45 millimeters and less than or equal to 0.75 millimeters, or a MIC ratio which is greater than 0.40 and less than or equal to 0.80. Examples: cyclopropane, ethylene, ethyl ether
Group D: Have either, a maximum MESG value which is greater than 0.75 millimeters, or a MIC ratio which is greater than 8.80. Examples: acetone, benzene, butane, hexane, natural gas, paint solvents, propane
Class II: Areas where combustible dust present
Division 1: Areas where hazards are present under normal operating conditions
Division 2: Areas where hazards are present under abnormally operating conditions
Group E: Atmospheres containing combustible metal dusts, or other combustible dusts whose particle size, abrasiveness, and conductivity present similar hazards in the use of electrical equipment. Examples: metal dusts: aluminum, magnesium, and their commercial alloys
Group F: Atmospheres containing combustible carbonaceous dusts that have more than 8 percent total entrapped volatiles or that have been sensitized by other materials so that they present an explosion hazard. Examples: carbon black, charcoal, coal, coke dusts
Group G: Atmospheres containing combustible dusts not included in Group E or F. Examples: plastic dusts, most chemical dusts, food dusts, and grain dusts
Class III: Areas where there is a presence of fibers or flyings in the air

may allow the electrical hazard classification to be made less stringent i.e., Class I, Division 2 can be reduced to "unclassified." Positive confirmation of continuous airflow with a flow monitor is needed when ventilation is used to reduce the area classification, with both a supply and exhaust fan being mandatory. Both types of fans are to be monitored by a Combustible Gas Detector (CGD) equipped with a backup power supply. Ventilation air can only be sourced from an unclassified area.

According to NFPA 820, examples of classified areas within a WWTP requiring explosionproof electrical equipment would be processes involved in Liquid Steam Treatment such as bar screens, grit removal, pre-aeration, primary settling and odor control. Areas where solids are being treated, specifically in the handling, thickening, storage and conveyance of sludge and the skimming of scum, are also classified. In addition, NFPA 820 lists collection system locations as being classified. These would be sanitary sewers (Division 1), combined sewers (Division 1), storm sewers (Division 2), and wastewater pump station wet wells (Division 1 or 2 depending on air changes).

Given the dangers involved, don't assume that the area classifications listed on a plan are always correct, or that the rated area doesn't extend well beyond a tank or structure. There is no room for error. When in doubt contact your AHJ (Authority Having Jurisdiction).

Challenge 3: Energy Efficiency

Faced with higher operational costs and tighter budgets, energy efficiency has become a top priority within the water and wastewater sector, with facility operators and governments ramping up efforts to reduce energy costs and improve environmental performance. 25 percent to 40 percent of a plant's total operating costs are made up of electrical usage[1]; lighting accounts for a considerable amount of that, therefore, it makes up a significant portion of a municipality's total energy bill.

Traditionally, water and wastewater facilities use three types of high intensity discharge (HID) lighting: high-pressure sodium (HPS), metal halide (MH) and mercury vapor (MV) lights. Laws were enacted in 2007 prohibiting manufacturers from producing and selling mercury vapor lamps and high wattage metal halide ballasts.

Emerson Energy Efficiency

With models for every area of the facility, indoors and outdoors, Emerson's broad portfolio of Appleton brand LED luminaries is proven to significantly reduce energy consumption and maintenance costs, translating into bottom-line savings for WTP/WWTPs. Appleton LED luminaries are available for both ordinary and hazardous locations. Each provides optimized visibility and visual comfort to help promote a safe work environment and increase productivity.

Appleton LEDs by Emerson last three times longer and consume up to 70 percent less electricity than even the most efficient fluorescent or HID lamp. Given these savings it is no surprise that the payback period for switching to LEDs is short, in some cases, six months or less. In addition to energy savings, because LEDs they last longer — up to 60,000 hours — they require fewer labor hours for re-lamping and fixtures repair, thereby significantly decreasing labor costs and reducing the need to maintain expensive inventories of replacement components.

Lighting accounts for nearly 5 percent of global CO_2 emissions. LED lighting achieves energy savings of 50-70 percent+ compared to the old technologies.[2]

Retrofitting existing HID lighting with energy efficient LEDs, combined with photocells, occupancy sensors, and dimming capabilities, can reduce lighting's energy draw up to 70 percent. Along the way, it can also decrease CO_2 emissions by 65 percent. As a bonus, LEDs offer "instant on" capability, even in extremely cold temperatures, eliminating the prolonged warm-up time associated with HIDs. Installing LEDs may also qualify the plant for a rebate incentive from its local energy provider.

In Conclusion

Water and wastewater treatment is a dynamic, global industry with an increasing demand for electrical products designed for long-term, continuous operation. When specifying an electrical product manufacturer, choose a brand that offers state-of-the-art engineering and meticulous specifications to ensure your electrical products will keep plants running without time-consuming maintenance, even in the most challenging and heavily loaded industrial and municipal applications.

Emerson Closing Thoughts

Emerson recognizes that every stakeholder in the industry has a tremendous responsibility to the local community with regard to water safety, availability, and quality management. We strive to help them meet those commitments, while addressing sustainability goals in the drive to conserve resources and reduce pollution.

Emerson has led the way in striking this balance, reinforcing its legacy as an industry-recognized source for Appleton brand LED lighting, control stations, fittings, plugs, motor starters, receptacles, and panelboards. Our Appleton electrical products largely operate behind the scenes, but as the world's demand for clean water continues to spiral, this equipment becomes more integral to the health and wellbeing of people around the world.

① *Energy Efficiency in Water and Wastewater Facilities | Local Government Climate and Energy Strategy Series, U.S. Environmental Protection Agency, 2013, page 1, https://www.epa.gov/sites/default/files/2015-08/documents/wastewater-guide.pdf*
② *The Climate Group. 2022 https://www.theclimategroup.org/led*

United States (Headquarters)
Appleton Grp LLC
9377 W. Higgins Road
Rosemont, IL 60018
United States
T +1 800 621 1506

Australia Sales Office
Bayswater, Victoria
T +61 3 9721 0387

Korea Sales Office
Seoul
T +82 2 3483 1555

China Sales Office
Shanghai
T +86 21 3338 7000

Chile Sales Office
Las Condes
T +56 2928 4819

Canada
EGS Electrical Group Canada Ltd.
99 Union Street
Elmira ON, N3B 3L7
Canada
T +1 888 765 2226

India Sales Office
Chennai
T +91 44 3919 7300

Jebel Ali- Dubai Office
Emerson, Building A
Appleton Group
Jebel Ali Free Zone- South
T +971 4 811 81 00

Middle East Sales Office
Dammam, Saudi Arabia
T +966 13 510 3702

Europe
ATX SAS
Espace Industriel Nord
35, rue André Durouchez,
CS 98017
80084 Amiens Cedex 2, France
T +33 3 2254 1390

Latin America
EGS Comercializadora Mexico
S de RL de CV
Calle 10 N°145 Piso 3
Col. San Pedro de los Pinos
Del. Álvaro Obregon
Ciudad de México. 01180
T +52 55 5809 5049

Asia Pacific
EGS Private Ltd.
Block 4008, Ang Mo Kio Ave 10,
#04-16 TechPlace 1,
Singapore 569625
T +65 6556 1100