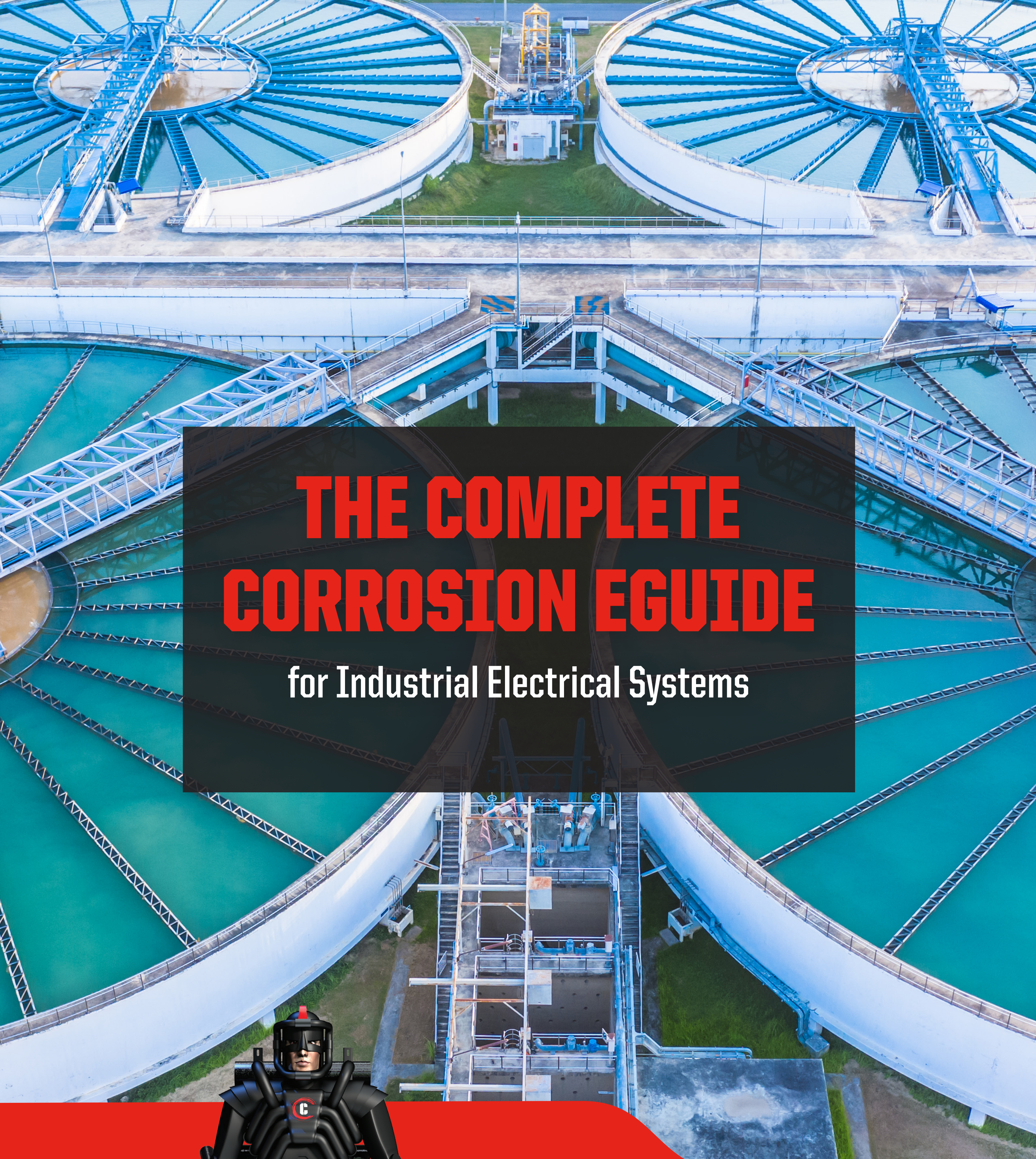


THE COMPLETE CORROSION EGUIDE

for Industrial Electrical Systems

CHAMPION FIBERGLASS®

In the ever-evolving industrial construction space, addressing corrosion in electrical systems is of paramount importance. Experienced electrical engineers and thought leaders in the industry have recognized that corrosion can lead to detrimental consequences such as equipment failure, safety hazards, increased maintenance costs and reduced system reliability.[1] In order to maintain optimal performance, it is important to properly ensure the integrity of electrical infrastructure.

It is essential for project managers, electrical engineers, and contractors to understand the challenges posed by corrosion and its impact on the longevity and reliability of infrastructure. This guide provides an in-depth analysis of the types of corrosion affecting industrial electrical systems, the factors contributing to corrosion and the consequences of ignoring this critical issue. Continue reading for potential solutions offering a promising way forward for electrical infrastructure corrosion management.

WHERE CORROSION THRIVES – CHALLENGING ENVIRONMENTS AND CAUSTIC APPLICATIONS

Corrosion dynamics are unique to every environment. Industrial settings are especially susceptible to corrosion, and few environments are more caustic than wastewater treatment facilities where sodium hypochlorite (bleach), polymer wastewater sludge, liquid oxygen and waste-activated sludge can wreak havoc on electrical conduit systems. Chemical plants, refineries, food and beverage process plants and mining environments all pose similar threats from harsh chemicals used in the production process.

Marine and coastal environments, as well as bridge and transportation settings, can also introduce highly corrosive elements such as saline from the ocean and salt, fuels and oils from vehicles and road maintenance efforts.

Other exposed and buried conduit applications are subject to natural environmental factors such as temperature, humidity, precipitation and soil conditions that can affect the ability of metallic and nonmetallic electrical conduit and systems to properly protect the cabling within.

Let's dive deeper into corrosion causes, types and consequences.

FACTORS THAT CONTRIBUTE TO CORROSION

It is helpful for industry professionals to understand corrosion contributing factors in order to effectively mitigate its impact. These include:

Environmental Factors

A variety of environmental factors can influence the rate and severity of corrosion in electrical systems. These include temperature, humidity, and the presence of corrosive chemicals or pollutants.[2] For example, high humidity levels can promote the formation of an electrolyte on metal surfaces, while exposure to aggressive chemicals can accelerate the corrosion process.

Material Selection

The choice of materials used in the construction of electrical systems plays a significant role in their susceptibility to corrosion. Metals with differing electrochemical properties, when in contact, can increase the likelihood of galvanic corrosion.[3] Selecting materials that are inherently resistant to corrosion or using appropriate coatings and protection methods can help reduce the risk of corrosion-related issues

Design and Installation Errors

Mistakes in the design and installation of electrical systems can lead to increased susceptibility to corrosion. For instance, inadequate drainage, insufficient ventilation or the creation of crevices can promote the formation of corrosive environments.[4] Proper planning and execution of electrical system designs can help minimize the potential for corrosion-related problems.

Exposed conduit is subject to environmental factors such as temperature, humidity, precipitation and pollutants that cause corrosion.

UNDERSTANDING CORROSION TYPES AFFECTING INDUSTRIAL ELECTRICAL SYSTEMS

A comprehensive understanding of the various types of corrosion that can impact industrial electrical systems is crucial for industry professionals. This knowledge enables informed decisions when designing, installing and maintaining these systems.

Here are the types of corrosion that can occur in larger commercial or industrial projects:

Uniform Corrosion

This form of corrosion, also known as general corrosion, occurs uniformly over the entire surface of a metal. It is characterized by a consistent reduction in material thickness, which can ultimately lead to component failure.[5] Although predictable and relatively easy to control, uniform corrosion can pose a significant risk to the durability and longevity of electrical systems if not managed properly.

Galvanic Corrosion

Galvanic corrosion occurs when two dissimilar metals are in contact with each other and an electrolyte, such as water or moisture. The more reactive metal corrodes at an accelerated rate, while the less reactive metal remains relatively unaffected.[6] This type of corrosion is particularly problematic in industrial electrical systems, as it can lead to the rapid deterioration of critical components.

Pitting Corrosion

Pitting corrosion is a localized form of corrosion that results in small cavities or pits on the surface of a material. It can be particularly aggressive, as the pits can penetrate deep into the material, causing structural weakness and eventual failure.[7] This type of corrosion can be challenging to detect and manage, given its localized nature and the potential for rapid material degradation.

Crevice Corrosion

Crevice corrosion occurs in confined spaces, such as gaps, joints, or seams, where a stagnant microenvironment develops. This environment allows corrosive agents to concentrate, leading to an accelerated attack on the metal surface.[8] Crevice corrosion can cause considerable damage to electrical components, as it often goes unnoticed until a significant loss of material has occurred.

Intergranular Corrosion

Intergranular corrosion is characterized by the selective attack of a metal's grain boundaries, which can lead to a loss of mechanical strength and eventual disintegration of the material.[9] This type of corrosion can be particularly detrimental to industrial electrical systems, as it can compromise the structural integrity of components without noticeable changes to the surface appearance.

Stress Corrosion Cracking

According to the Association of Materials Protection and Performance, stress corrosion cracking is "the cracking induced from the combined influence of tensile stress and a corrosive environment. The impact of stress corrosion cracking on a material usually falls between dry cracking and the fatigue threshold of that material." The required tensile stresses may be in the form of directly applied stresses or pressure or residual stresses.

High-Temperature Corrosion

Corrosionpedia describes high-temperature corrosion as a chemical attack from gases, solid or molten salts or molten metals, typically at temperatures above 750ºF (400°C). It is often found in the chemical, petrochemical, mineral and automobile industries.

Atmospheric Corrosion

This is the deterioration and destruction of a material and its vital properties due to electrochemical and other reactions of its surface with elements of the direct atmosphere. A key factor is the presence of moisture due to fog, dew, precipitation and relative humidity, explains Corrosionpedia. Any outdoor, exposed conduit in a variety of applications is subject to this type of corrosion.

Microbial Corrosion

Microbial corrosion is brought by the presence of microbes on a material. Applications where this type of corrosion is found include water and wastewater treatment facilities.

CONSEQUENCES OF CORROSION

The effects of corrosion in industrial electrical systems can be far-reaching and costly, so it is important to address the issue proactively.

1 Equipment Failure

Corrosion can lead to the weakening and eventual failure of electrical components, causing disruptions in system operations and potentially necessitating expensive repairs or replacements.[10]

2 Safety Hazards

The structural integrity of electrical components can be compromised by corrosion, creating potential safety hazards for personnel. In extreme cases, corrosion-related failures can lead to fires, explosions or electrocution.[11]

3 Increased Maintenance Costs

Addressing corrosion-related issues can result in significant maintenance costs, both in terms of labor and replacement parts. Preventing corrosion can help reduce these costs and extend the service life of electrical systems.[12]

4 Reduced System Reliability

The presence of corrosion in electrical systems can negatively impact their overall reliability, leading to downtime and reduced productivity. Ensuring the integrity of these systems is essential for maintaining efficient and dependable industrial operations.[13]

Buried conduit can be subject to stress corrosion cracking which can damage conduit systems.

CHOOSE CORROSION-RESISTANT ELECTRICAL CONDUIT TO PROTECT SYSTEMS

Standards for Electrical Conduit

When selecting electrical conduit for a project, it is important to consult the National Electric Code or the Canadian Electric Code. The National Electric Code (NEC®) establishes guidelines for material use by Class, Division and Group. It is important to check the NEC rating of conduit products by manufacturer, as their product standards may fall above or below the substrate guidelines provided by the NEC. Refer to NEC Article 501 (Gasses, Vapors, and Liquids), Article 502 (Dusts) and Article 503 (Fibers and Flyings) for more details.

Electrical Conduit Options

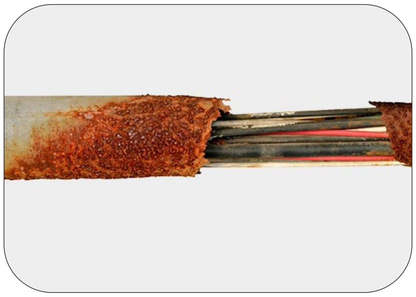
Left unchecked corrosion can cause millions of dollars of damage related to repairs and replacements, and in some cases, life-threatening conditions including explosions in refineries and gas transmission plants.

There are several conduit options available for use in industrial electrical systems, each with its own set of benefits and shortcomings. Proper material selection, matching conduit type to application requirements, is essential to ensure the optimal performance of electrical systems.

Common types of electrical conduit include:

Galvanized Rigid Conduit (GRC)

GRC is a heavy-duty conduit option made of steel and coated with a layer of zinc to provide corrosion protection. While GRC offers excellent mechanical strength, it is susceptible to corrosion in highly corrosive environments such as exposed applications, wastewater treatment, coastal environments or when the protective zinc layer is compromised.



Aluminum Conduit

Aluminum conduit is lightweight and easy to install, but it is also prone to galvanic corrosion, especially when in contact with dissimilar metals. Additionally, aluminum can corrode in the presence of certain chemicals, making it unsuitable for some industrial applications, such as chemical plants.

PVC-Coated Steel Conduit

PVC-coated steel conduit offers a combination of mechanical strength and corrosion resistance, but its performance can be compromised if the PVC coating is damaged, exposing the underlying steel to corrosive agents. There are some rare environments wherein PVC-coated rigid steel conduit may be the most resistant to corrosion – including operations with exposure to large amounts of liquid ammonia, hydrofluoric acid or methyl ethyl ketone.

Fiberglass (RTRC) Conduit

Fiberglass conduit is nonmetallic and durable, making it acceptable for applications susceptible to corrosion from the environment. Additionally, it offers impressive resistance to many chemicals as well as mechanical strength.

ADVANTAGES OF FIBERGLASS CONDUIT IN ELIMINATING CORROSION

While corrosion is inevitable, it is also controllable. Fiberglass conduit is an innovative solution that addresses the corrosion-related shortcomings of traditional conduit materials.

Fiberglass conduit is engineered to offer the widest range of corrosion protection of any conduit material available on the market today. In manufacturing, it is created by tension-winding strands of fiberglass over a rotating mandrel. The strands are laid in a precise pattern and impregnated with epoxy resin as they are wound onto the mandrel. They are then cured under high temperatures, creating a conduit product with flexural strength that also resists chemicals and corrosion.

This process ensures that fiberglass conduit comprised of epoxy resin is much more corrosion resistant than PVC conduit and polyester and vinyl ester resins. It is immune to galvanic corrosion, as it is non-conductive, and it is also resistant to moisture and hundreds of chemicals. Plus it offers a wide temperature range of -60 to 250° F.

Fiberglass conduit's corrosion resistance contributes to these benefits in construction projects:

- Reduced maintenance costs
- Longer service life
- Lower replacement frequency
- Enhanced safety and reliability
- Reduced risk of electrical failures
- Improved protection for cables and wiring
- Reduced costs for time, material and labor over time
- Improved environmental safety for workers

FIBERGLASS CONDUIT CHEMICAL RESISTANCE

Fiberglass conduit has proven to be a reliable, cost-effective solution for managing corrosion in chemical processing plants, wastewater treatment facilities and power generation plants.

Champion Fiberglass conduit has been tested with strict protocols against hundreds of chemicals. The corrosion guideline tests were performed by immersing epoxy coupons for 30 days in each chemical at designated temperatures. A very severe test, it has been shown that Champion Duct® can often be used for chemicals listed as “Not Recommended” (NR) as real cases often are limited to fumes, vapors and occasional splashes at the temperatures indicated.

UP TO TEMPERATURE, °F	EPOXY CONDUIT	
CHEMICAL	120°	210°
Acetaldehyde	N	N
Acetaldehyde, aq. 40%	N	N
Acetic Acid, glacial	N	N
Acetic Acid, 20% (25)	R	C
Acetic Acid, 80%	N	N
Acetic Anhydride	N	N
Acetone, 10%	N	N
Adipic Acid	C	N
Alcohol, allyl	N	N
Alcohol, benzyl	N	N
Alcohol, butyl (n-butanol)	C	N
Alcohol, butyl (2-butanol)	N	N
Alcohol, ethyl	C	N
Alcohol, hexyl	R	C
Alcohol, isopropyl (2-propanol)	C	N
Alcohol, methyl	N	N
Alcohol, propy (1-propanol)	R	N
Allyl chloride	N	N
Alum	R	C
Ammonia, gas	C	N
Ammonia, liquid	N	N
Ammonia, aq. 20%	–	–
Ammonia salts, except fluoride	R	C
Ammonia fluoride, 25%	R	N
Amyl acetate	N	N
Amyl chloride	R	N
Aniline	N	N
Aniline hydrochloride	R	N
Antimony trichloride	–	–
Aqua regia	–	–
Arsenic Acid, 80%	C	N
Aryl-sulfonic acid	R	R
Barium salts	R	C
Beer	C	N
Beet sugar liquor	R	N
Benzaldehyde, 10%	–	–
Benzaldehyde, 10–100%	N	N
Benzene (benzoil)	C	N
Benzene sulfonic acid, 10%	R	R
Benzene sulfonic acid, 50%	C	N
Benzoic acid	R	R
Black liquor–paper	R	C
Bleach, 12.5% active chlorine	C	N
Bleach, 5.5% active chlorine	C	N
Borax	R	R
Boric acid	R	R
Brine	R	N
Bromic acid, <50%	N	N

UP TO TEMPERATURE, °F	EPOXY CONDUIT	
CHEMICAL	120°	210°
Bromine, liquid	N	N
Bromine, gas, 25%	N	N
Bromine, aq.	N	N
Butane	R	R
Butanterol (erythriol)	–	–
Butanediol	–	–
Butyl Acetate	N	N
Butyl phenol	N	N
Butyric acid <50%	R	R
Calcium salts, aq.	R	R
Calcium hypochlorite	C	N
Calcium hydroxide, 100%	R	R
Cane sugar liquors	R	N
Carbon disulfide	N	N
Carbon dioxide	C	C
Carbon dioxide, aq.	C	C
Carbon monoxide	R	C
Carbon tetrachloride	R	N
Casein	R	R
Castor oil	R	N
Caustic potash (KOH)	C	N
Caustic soda (NaOH)	C	N
Chlorine, gas, dry	R	C
Chlorine, gas, wet	N	N
Chlorine, liquid	N	N
Chlorine, water	C	N
Chlorocetic acid	R	N
Chlorobenzene	N	N
Chloroform	N	N
Chlorosulfonic acid, 10%	N	N
Chromic acid, 10%	N	N
Chromic acid, 30%	N	N
Chromic acid, 40%	N	N
Chromic acid, 50%	N	N
Citric acid	R	R
Coconut oil	R	N
Copper salts, aq.	R	R
Corn oil	R	C
Corn syrup	R	R
Cottonseed oil	R	R
Cresylic acid, 50%	N	N
Crude oil	R	R
Cyclohexane	R	N
Cyclohexanol	R	N
Cyclohexanone	–	–
Diesel fuels	R	N
Diethyl amine	N	N
Dioctyl phthalate	R	C

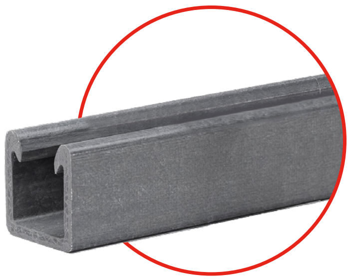
UP TO TEMPERATURE, °F	EPOXY CONDUIT	
CHEMICAL	120°	210°
Dioxane – 1,4	–	–
Dimethylamine	N	N
Dimethyl formamide	N	N
Detergents, aq.	R	R
Disbutylphthalate	R	N
Dibutyl sebacate	R	N
Dichlorobenzene	N	N
Dichlorethylene	N	N
Ether (diethyl)	N	N
Ethyl halides	N	N
Ethylene halides	N	N
Ethylene glycol	R	R
Ethylene oxide	N	N
Fatty acids	C	R
Ferric salts	R	R
Fluorine, gas, dry	N	N
Fluorine. gas, wet	N	N
Fluoroboric acid, 25%	R	R
Fluoroboric acid, 10%	C	N
Formaldehyde	C	N
Formic acid	C	N
Freon, F11, F12, 113, 114	N	N
Freon, F21, F22	N	N
Fruit Juices and pulps	N	N
Fuel oil	R	C
Furfural	N	N
Gas, natural, methane	R	N
Gasoline	N	N
Gelatin	R	N
Glycerine (glycerol)	R	R
Glycols	R	C
Glycolic acid	C	N
Green Liquor–paper	R	N
Heptane	R	R
Hexane	R	N
Hydrobromic acid, 25%	C	N
Hydrobromic acid	C	N
Hydrofluoric acid, 10%	R	N
Hydrofluoric acid, 60%	N	N
Hydrofluoric acid, 100%	N	N
Hydrocyanic acid	–	–
Hydrogen peroxide, 50%	N	N
Hydrogen peroxide, 90%	N	N
Hydrogen sulfide, dry	R	R
Hydrazine	N	N
Hypochlorous acid, 10%	N	N
Jet fuels, JP 4 and JP5	R	N
Kerosene	R	N

R = Generally resistant N = Generally not resistant C = Less resistant than "R" but still suitable for some conditions

UP TO TEMPERATURE, °F	EPOXY CONDUIT	
CHEMICAL	120°	210°
Lauric acid	R	R
Lauryl chloride	R	R
Lauryl sulfate	R	R
Lead salts	R	R
Linoleic acid	R	N
Linseed oil	R	R
Lithium salts	R	R
Lubricating oils	R	N
Machine oil	R	N
Magnesium salts	R	R
Maleic acid	R	R
Manganese sulfate	R	R
Mercuric salts	R	R
Mercury	R	R
Methane	R	R
Methyl acetate	N	N
Methyl bromide (gas)	N	N
Methyl cellosolve	–	–
Methyl chloride	N	N
Methyl chloroform	N	N
Methyl cyclohexanone	N	N
Methyl methacrylate	N	N
Methylene bromide	N	N
Methylene chloride	N	N
Methylene iodide	N	N
Milk	R	R
Mineral oil	R	R
Molasses	R	N
Monochlorozenzene	N	N
Monoethanolamine	N	N
Motor oil	R	R
Naphtha	R	N
Naphthalene	R	R
Nickel salts	R	R
Nitric acid, 0 to 20%	N	N
Nitric acid, 21 to 100%	N	N
Nitric acid, fuming	N	N
Nitrobenzene	N	N
Nitrous acid	R	N
Oleic acid	R	R
Oleum	N	N
Olive oil	R	R
Oxalic acid	R	R
Ozone, gas, 5%	C	N
Palmitic acid, 10%	R	R
Palmitic acid, 70%	R	R
Paraffin	R	R
Perchloric acid, 10%	R	C
Perchloric acid, 70%	R	C
Perchloroethylene	R	C
Petroleum, sour	R	R
Petroleum, refined	R	R
Phenol, 88%	N	N
Phenylcarbinol	N	N
Phenylhydrazine	N	N
Phosphoric acid	C	R
Phosphorous, yellow	N	N
Phosphorous, red	N	N
Phosphorous trichloride	N	N
Phthalic acid	R	R
Potassium salts, aq.	R	R
Potassium permanganate, 25%	C	C
Propane	R	R
Propylene dichloride	N	N
Propylene glycol	R	R
Propylene oxide	N	N
Pyridine	N	N
Rayon coagulating bath	R	N
Sea water	R	R
Salicylic acid	R	N
Sewage, residential	C	N
Silicic acid	R	R
Silicone oil	R	R
Silver salts	R	R
Soaps	R	R
Sodium hydroxide	N	N
Sodium salts, aq. Except	R	C
Sodium chlorite, 10%	R	N
Sodium chlorate	R	R
Sodium dichromate, acid	R	R
Stannic chloride	R	R
Stannous chloride	R	R
Stearic acid	R	R
Sulfite liquor	R	C
Sulfur	R	N
Sugars, aq.	R	R
Sulfur dioxide, dry	R	R
Sulfur dioxide, wet	C	C
Sulfur trioxide, gas, dry	R	R
Sulfur trioxide, gas, wet	N	N
Sulfuric acid, < 26%	R	N
Sulfuric acid, 26 to 80%	C	N
Sulfuric acid, 81 to 100%	N	N
Sulfuric acid, 10%	R	N
Tannic acid	R	R
Tartaric acid	R	R
Tetrachloroethane	C	N
Tetrahydrofuran	N	N
Thionyl chloride	N	N
Thread cutting oil	R	N
Terpineol	R	R
Toluene	C	N
Tributyl phosphate	R	N
Tricresyl phosphate	R	N
Trichloracetic acid	C	C
Trichloroethylene	N	N
Triethanolamine	R	N
Triethylamine	C	N
Turpentine	R	N
Urea, 50%	R	N
Urine	R	N
Vaseline	R	R
Vegetable oils	R	R
Vinegar	R	R
Vinyl acetate	N	N
Water, distilled	C	N
Water, fresh	R	N
Water, mine	R	N
Water, salt	R	N
Water, tap	R	N
Whiskey	R	N
Wines	R	C
Xylene	C	N
Zinc salts	R	R

R = Generally resistant N = Generally not resistant C = Less resistant than "R" but still suitable for some conditions

CHAMPION STRUT™: A CORROSION RESISTANT FRAMING SYSTEM FOR TOUGH ENVIRONMENTS



As a component of electrical conduit infrastructure, electrical conduit systems typically require a framing and support system. In corrosion-prone environments, Champion Strut™'s epoxy resin strength offers durable, corrosion-resistant support to stabilize heavy piping and conduit.

Champion Strut is made from pultruded polyester and vinyl ester fiberglass. Pultrusion results in straight, consistent parts of virtually any length. Parts are internally reinforced with permanently bonded continuous glass fibers, which provide great strength. Special UV additives along with a polyester surfacing veil are added to give the components increased UV and corrosion resistance. Additionally, Champion Strut is fire retardant for added protection.

Champion Strut has been used as a hanger and support for piping and conduit in highly corrosive applications including steel mills, rendering facilities, utilities, refineries, petrochemical plants, pulp and paper, desalination facilities, water reclamation facilities, theme parks, aquariums, pools and underground vaults. It can be used as horizontal and vertical piping support in these projects.

Availability & Fast Delivery

Accurate, in-stock product counts for Champion Strut are now live on our website. Counts for strut fittings, clamps and more can be found as well.

We also offer same or next-day shipping to get Champion Strut to customers fast.

STRONG, DURABLE FIBERGLASS CONDUIT, ELBOWS AND STRUT STAND UP TO TOUGH CHEMICAL PLANT ENVIRONMENTS

CHAMPION FIBERGLASS®

Challenge

A large chemical company in Texas that produces the plastic resins for PVC was struggling with corrosion. Polyvinyl chloride (or PVC) is a type of plastic commonly used for chemical spray bottles, pipes, clothing, bags, upholstery, tubing, flooring and pool toys. It's nearly 57% chlorine and requires less petroleum than other plastics. The highly corrosive chlorine used as a base material is hard on manufacturing plant systems, including production equipment and electrical.

To protect electrical infrastructure, the company had installed PVC-coated steel conduit. But that selection required replacement every five years. The caustic environment was taking its toll on electrical conduit and the price paid was repeated re-install production disruption in addition to high product and installation costs.

Solution

PVC-coated steel is a common conduit solution in volatile applications that require a strong, durable and corrosion resistant conduit to protect electrical systems. It's got strength from steel plus a coating that protects against corrosion, ideally.

Yet many contractors and project managers are unaware that there's another alternative out there. Fiberglass conduit, elbows and strut supports are nonmetallic, yet strong and durable. They are corrosion resistant to many chemicals and in most cases eclipse the protection provided by PVC-coated steel. Their longevity is far superior. On top of that, they are less costly than PVC-coated steel conduit and support systems.

While fiberglass conduit, elbows and strut have the strength to withstand caustic chemical plant environments, they are also lightweight for smooth portability in the field. Also, quick connections make installation fast, and both the conduit and strut are easy to cut in the field, making installation seamless.

Results

Installation progressed swiftly, saving time, money and production disruption on the re-install. Additionally, material costs were lower, as PVC-coated steel conduit and supports are substantially heavier and much more expensive than fiberglass conduit, elbows and strut. The Champion Fiberglass conduit and strut systems are outlasting the PVC-coated conduit and support counterpart, saving substantial production time and money as no replacements due to corrosion are required.

For this chemical plant, the replacement of deteriorated PVC-coated steel conduit started small. After the contractors and project managers became familiar with installation and saw the corrosion-resistance of fiberglass conduit, elbows and strut, they continued to use Champion Fiberglass.

QUICK FACTS

PROJECT NAME
Large Plastics Manufacturer

APPLICATION
Chemical Plant

CHAMPION FIBERGLASS PRODUCT(S)
Champion Duct®
Champion Elbows
Champion Strut™

BENEFITS

- Extreme corrosion resistance for a caustic environment
- Light weight and easy connections for smooth installation
- Cost savings due to lower materials and installation cost
- Product longevity that eliminated regular PVC -coated steel re-installs

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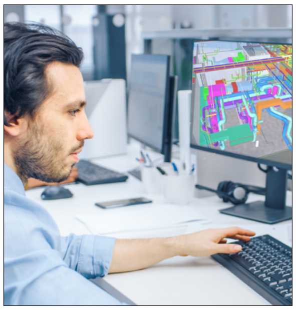

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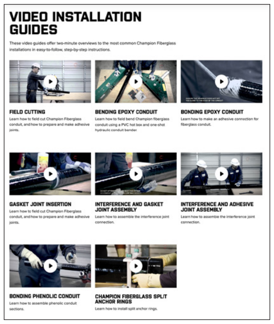

VIDEO INSTALLATION GUIDE

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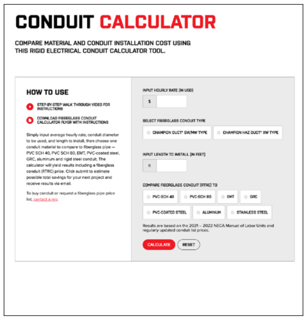

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