Corrosion College

Properly specifying electrical products for highly corrosive environments will reduce overall long term cost and risk of failure.

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Product failure due to corrosion is estimated to cost $1 trillion annually. A key role of consulting and specifying engineers is to help ensure effective specification of products. This responsibility is especially critical when applications are in highly corrosive environments where product failure is not only extremely costly, but also raises the risk of catastrophe and human harm. There is reason to believe that many professionals, although aware of general facts specific to corrosion, do not maintain adequate knowledge of how and why diverse methodologies for corrosion prevention work well in some applications, but are ineffective in others.

The foundation for preventing corrosion damage is continuous education in the understanding of what causes and what prevents corrosion. In addition, an understanding of product life predictions as well as performance assessment methods are essential for knowing what products will truly survive in a corrosive environment. Lastly, knowing how to follow through with proper specification by using third party product testing results will result in tremendous long-term cost savings.

Short Course: Corrosion

As mentioned above at least a basic knowledge of corrosion is essential for prevention. It starts with a definition of corrosion; this one is from NACE (National Association of Corrosion Engineers):

"Corrosion is the deterioration of a substance, usually a metal, or its properties, because of an undesirable reaction with its environment."

Corrosion is a natural and inevitable process that once understood can be mitigated so that preventive measures and controlled outages can take place.

The next task is to determine the environmental conditions the electrical components will placed. Environmental conditions such as moisture, dust and temperature can affect the rate of corrosion.

Corrosion found on conduit placed underground at a gas station.

Moisture: The level of corrosion typically increases with moisture content. Common atmospheric sources of moisture are rain, dew and condensation.

Dust: Dust particles can cling to surfaces and retain moisture. Typical sources for dust include: soil/sand, smoke and soot particles or salts.

Temperature: Increasing the temperature of a corrosive environment will generally increase the rate of corrosion. For every 10 degrees Celsius rise in the temperature, the corrosions rate can double.

Common Types of Metal Corrosion

Knowledge of the common types of corrosion will aid in determining the best method of prevention. Below are the just few of the types of corrosion that can be found on projects consulting and specifying engineers face on the job.

1. General corrosion attack is the most common type of corrosion. It is typically caused by a chemical reaction that results in the deterioration of the entire exposed surface of a metal in a uniform manner. Ultimately, the metal deteriorates to the point of failure.
2. Galvanic corrosion exists between two dissimilar metals. If these metals are placed in contact (or otherwise electrically connected), this potential difference produces electron flow between them causing corrosion to occur.
3. Crevice corrosion is a localized corrosion that is associated with a stagnant solution located in material flaws, holes, gasket surfaces, lap joints, surface deposits, and crevices under bolt and rivet heads.
4. Pitting is a form of corrosion caused by a localized attack resulting in holes in the metal.
5. Erosion corrosion results when a protective layer of oxide on a metal surface is dissolved or removed by wind or water, exposing the underlying metal to further corrode and deteriorate.
6. Corrosion fatigue is the mechanical degradation of a material under the joint action of corrosion and cyclic loading or alternating stress.
7. High-temperature corrosion can be caused by compounds that are very corrosive towards metal alloys normally resistant to corrosion, such as stainless steel.

Once corrosion is discovered, it must be addressed. However, corrosion is unpredictable and the most effective way of controlling corrosion is by preventing it. A recent study by the Executive Branch and Government Accountability Office determined that the annual cost of corrosion could be decreased by as much as 40% (or $400 Billion) by preventing corrosion instead of treating it as it occurs.

Prevention of Corrosion

Education is the first step to preventing corrosion. Once becoming aware that corrosion is much more prevalent in your business, engineers can then take steps to selecting the best anti-corrosion products and apply them in the most effective ways. Once the mechanisms of corrosion in the environment are defined, the engineer must do their homework to select the correct material for the application.

Example of improper material selection for lighting component in a food manufacturing plant.

To begin, the material of choice must be given equal consideration as the design itself. Choosing the wrong material can result in frustrating or even dangerous situations. Defining the corrosive agents and determining the concentration can be a complex process. Usually several corrosive elements are present and interactions are not always well documented. Water is the most common corrosive element and is usually presents itself in one form or another such as humidity. Adjacent processing operations or other intermittent activities such as industrial cleaning and the general plant environment may expose the product to a variety of corrosive agents and temperatures. Each environment is unique and all possible corrosive agents should be identified for the intended application.

Aluminum, for example, should not be used in high-mineral acid environments. Stainless steels should also be avoided when there are halogens such as fluorine, chlorine, bromine and iodine. Should the decision be made to use one material over another without in-depth investigation, the user may be looking at a very short life span for their most vital electrical systems. Next, you must start to take into account some of the compliance issues and standards for the project.

Understand policies, regulations, standards, and management practices to increase corrosion savings through sound corrosion management.

Listed below are some of the most relevant polices, regulations and standards for the electrical industry and a link for you to find more information if you need more details for your particular project.

About UL

UL Mark is one of the most recognized symbols of safety in the world. UL is an architect of U.S. and Canada safety systems. UL tests more than 19,000 types of products, and 21 billion UL Marks appear in the marketplace each year.
http://www.ul.com

ASTM International

ASTM International is one of the largest voluntary standards development organizations in the world-a trusted source for technical standards for materials, products, systems, and services.
http://www.astm.org

NEMA: National Electrical Manufacturers Association

It is NEMA's belief that standards play a vital part in the design, production, and distribution of products destined for both national and international commerce.
http://www.nema.org

NECA: National Electrical Contractors Association

The NECA Codes and Standards Committee are involved with development, administration, and enforcement of installation codes, safety standards, product standards, and other related industry regulations. This includes, but is not limited to, the National Electrical Code (NEC®), National Electrical Installation Standards (NEIS™), National Electrical Safety Code (NESC), Various NFPA Standards, UL Safety Standards, and OSHA Regulations.
http://www.necanet.org/

Advance life prediction and performance assessment methods: Independent Testing

Many products meet some or all of these standards however these do not guarantee that the product will perform as promised. There is a new need for the importance of independent product performance verification as distinguished from verification of product safety compliance.

So how do you differentiate between similar certified products?

Start by using empirical data to compare product longevity and accurately assess factors related to the risk of product failure from companies like Intertek that provide Independent Testing results. In many cases, ASTM test methods are just that – a test method. Regulated standards like ETL put criteria around these test methods that will create the standard itself and determine a grade of pass or fail based on the results.

Intertek: Independent Testing

Intertek is the world's largest independent testing, inspection and certification organization. When a manufacturer enters a product into a verification program, they must provide an initial qualification sample to Intertek. The sample is then independently tested to the specifications of the appropriate standard. If the sample is found to meet the requirements, an Intertek field representative is sent to the manufacturer's location to independently select a final qualification sample for further independent testing. Once the second sample is found to meet performance requirements, the product may be marked by the manufacturer as "ETL Verified". The manufacturing facility is then subjected to quarterly audits to ensure ongoing compliance.
www.intertek.com

Case Study: Proof for Need of Independent Testing; Coated Conduit

For years all available brands of PVC-coated galvanized conduit met exactly the same UL 6 standards and carried an identical UL label relating to safety conformance. Yet, it was apparent in the marketplace that not all brands performed the same. With products like coated conduit, adhesion of the coating is crucial. If the coating bond is broken a void is created and moisture penetrates to the metal substrate and corrosion is actually accelerated. The lack of performance requirements for coated conduit has been recognized by many companies and is gaining recognition by users. This fact is confirmed by recent discussions with consulting, specifying and maintenance engineers at paper plants, waste water treatment facilities, etc.

The Basics: Testing for PVC coated conduit adhesion and corrosion protection

To confirm the performance of the PVC coating Intertek evaluated PVC-coated galvanized conduit brands solely for product performance and longevity as tested under conditions consistent with highly corrosive environments. Heat and humidity are recognized corrosion accelerators in corrosion engineering textbooks and published technical documents from organizations such as the National Association of Corrosion Engineers (NACE).

PVC coated conduit specimen where the coating adhesion has failed. This conduit sample was exposed for approximately two days in the Hot Water Immersion Test. Once the cuts are made, the PVC coating is easily removed by pulling the coating by hand and exposing the galvanized steel conduit.

PVC Coated Conduit Specimen with Acceptable Adhesion.

The test results provided a quantitative method to compare the relative performance of coated conduit systems in conditions typical of the corrosive application environments. The results of both tests confirm significant differentiation in adhesion performanceof PVC coated conduit available in the market and why only certain brands carry the ETL label.

Products verified by ETL are clearly labeled.

Summary

There is a need for consulting and specifying engineers to understand corrosion and how to improve specification of products to avoid the high cost, and sometimes disastrous, effects of product failure caused by corrosion. Hence, as evident from this article there is a pressing need to look for, appreciate, and accept specification-related third-party verification standards that reach beyond traditional or historic ways of qualifying products intended to help fight the high cost of corrosion damage. Solid empirical product data; that is to say, documentation of product performance which is independently validated by recognized, objective, third-party sources should be considered and used to control the cost of corrosion in order to produce long-term cost savings on projects. ♦

References:

1. http://www.nace.org/
2. http://en.wikipedia.org/wiki/Corrosion

Sources:

1. http://metals.about.com/od/metallurgy/a/Types-Of-Corrosion.htm
2. http://corrosion-doctors.org/Corrosion-History/Eight.htm
3. http://corrosion.ksc.nasa.gov/index.htm
4. http://www.nace.org/
5. http://www.corrosion.org/