Corrosion Insurance:

Gel technology fights CUI on ammonia refrigeration piping

By Tony Garone, Marketing Director, Polyguard

It's every refrigeration engineer's nightmare.

In an ammonia refrigeration system, corrosion under insulation (CUI) can weaken the walls of steel and stainless pipes under cover of insulation. This sneak attack can go on for years, until the integrity of the pipe is undermined—ending in disaster if not caught in time by regular inspections.

Ultimately, a leak caused by corrosion on a pipe can lead to a cloud of toxic ammonia gas. If not dispersed quickly by air currents, it can severely damage the lungs, burn the skin, and cause blindness. It can be fatal if inhaled. If intense heat and pressure are present, the flammable gas could explode, possibly causing injury or death. Nearby areas may need to be evacuated. And beyond these safety and environmental concerns, the cost of shutting down a business for repairs to the pipes and insulation must also be considered.

Steel refrigeration pipes carrying ammonia are fitted with insulation to maintain the cold temperature of the product. Over the insulation, a waterproof vapor barrier protects from outside moisture, followed by a sheet-metal jacket. Over time, water may leak through the jacket, penetrating the vapor barrier and insulation to reach the surface of the pipe. And any water trapped beneath the jacket won't be able to escape.

In addition, because of the large temperature difference between the cold liquid in the pipes—usually around minus 40 degrees Fahrenheit—and the much warmer ambient air, condensation is highly likely. Even worse, ammonia refrigeration systems tend to cycle the temperatures, making condensation on the pipes even more likely.

A Recipe for Corrosion

Corrosion, or rust, is caused by a series of electro-chemical reactions between the iron atoms in the pipe and the hydrogen and oxygen ions in the water. The four ingredients needed for corrosion to occur in steel piping include:

- An anode—an area that sheds electrons
- A cathode—an area that attracts electrons
- An electrical path connecting the anode and cathode
- An electrolyte—a source of ions that can transport electric charge, such as water

The first three ingredients are already present in the steel, due to its material properties. Any water that reaches the surface of the pipe provides the last ingredient necessary to spark corrosion.

An Insurance Policy

In an ideal world, an engineer can design an ammonia refrigeration system with the proper amount of insulation, covered with a vapor barrier and/or jacket so that no further protection is necessary. But the odds of creating a 100 percent reliable moisture barrier that will last for years, especially in the construction industry, are not good. When water inevitably penetrates through leaks in the jacket to the insulation and down to the metal pipe surface, corrosion leading to a breach could eventually result.

For these reasons, savvy engineers look to a corrosion protection product as an insurance policy. Like any other insurance policy, you don't need it until you need it—but when you need it, it's already in place. As a result, more and more engineers are choosing to specify some type of corrosion protection product.

Corrosion Protection Methods

Historically, engineers have tackled the problem of CUI using a variety of techniques. One common method was wrapping bare pipes with a spiral fabric impregnated with petroleum jelly—known as a "grease tape." However, the inexpensive tape tends to break down quickly, leaving pipes vulnerable to moisture, while its added bulk increases the cost of insulation required for coverage.

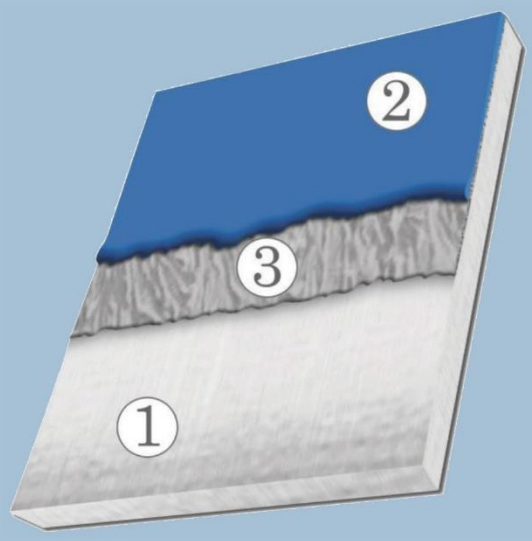
A more effective level of protection can be obtained using silicon or epoxy technologies, some of which can be pre-installed on new pipe.

Epoxy paint is a low-cost method for preventing CUI when calculated on a per-gallon basis. But when used in retrofit applications, the cost of installation is significantly higher. To apply epoxy on installed pipe with pre-existing corrosion, the refrigeration system must be shut down—with an associated cost due to loss of production. The pipe must be sandblasted to remove all evidence of corrosion down to bare metal. It then must be painted with two or three coats of epoxy, allowing the pipe to dry in between coats—adding days to the timeline. All these factors add up to a much higher system cost for the epoxy paint method of corrosion protection.

Anti-corrosion Reactive Gel Technology: How it works

Specially formulated anti-corrosion gels work in three ways:

1. **Barrier system – The gels have great adhesion characteristics and are hydrophobic to prevent moisture from reaching the metal surface.**
2. **Buffering system – Any moisture that penetrates the gel will be buffered to a high pH which protects the steel piping from corrosion.**
3. **Mineralization – The gel's patented composition reacts with the surface of the metal substrate to grow an integrated mineralized surface layer. This thin glasslike layer acts as a barrier between chlorides and the metal, which helps resist corrosion if moisture does reach the surface.**



When the ferrous (steel) surface (1) is covered with a layer of gel (2), the metal reacts with components in the gel to form a protective mineral layer (3) with a thickness of only 50-200 angstroms.

Gel Technology

Another corrosion protection method used by many food processing plants is gel pipe coating. These coatings have gained in popularity due to their high-quality performance and ease of application.

Gel coatings are typically not considered hazardous by the OSHA Hazard Communication Standard (29CFR 1910.1200). They can be glove applied by hand, using a gaged trowel to maintain the specified thickness. They can also be brushed or sprayed on. Gels remain sticky to the touch after application, and do not require a drying period before insulation is added to cover the pipe.

Pipe gel technologies come in two general categories—Reactive Gel (RG) and Pipe Coating Gel (PCG).

Though they are used on pipes in some cases, PCG coatings were originally designed for use as gear and chain grease type lubricants, rather than as a CUI coating. In contrast, RGs are anti-corrosion products primarily designed to be used in CUI applications.

Reactive gels are specially formulated and patented to react chemically with the steel pipe, creating a mineralization layer that becomes an integral part of the pipe's surface. This prevents undercutting, where moisture seeps under the coating and begins the corrosion process (see sidebar).

Evaluation Factors

The safety aspect of ammonia refrigeration is a critical topic in the food and beverage processing industry. Wherever ammonia piping gets used in any freezer or cooling operation, system integrity and worker safety are important considerations. As a result, engineers will need to closely evaluate certain factors when choosing a gel technology.

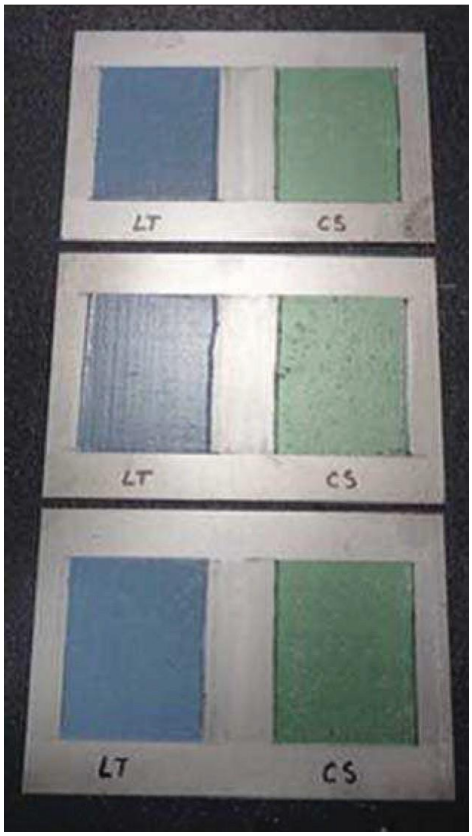


Fig. 1

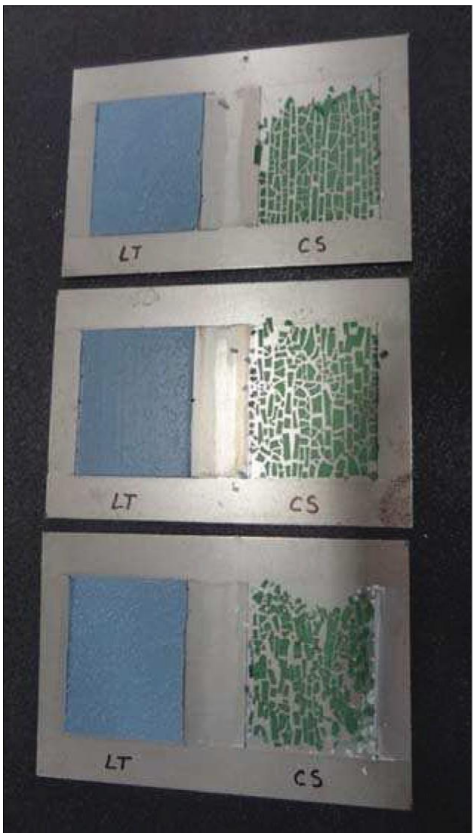


Fig. 2

RG and PCG products are made using different technologies and differ significantly in performance characteristics, as demonstrated in their performance histories, laboratory testing and field application trials.

Basic characteristics of a good CUI coating include:

- Thermal stability
- Water wash-off resistance
- Corrosion protection

An independent lab tested both types of products for thermal stability at 240°F. The products were applied within the manufacturer's specified thickness range of 25-27 mils to cold-rolled steel (CRS) panels (see Figs. 1 and 2). After 24 hours at 240°F the photos show the degradation of the PCG product, while the RG product showed little to no change in physical appearance.

In the case of CUI, any water leaking into the system could cause the protective gel to wash off the pipe—known as water wash-off. PCG products will be much less resistant to water-wash off because they have a much lower specific gravity than RG and are less dense than water:

- Water = 1.00
- Typical Pipe Coating Gel = 0.85 – 0.95.
- Typical Reactive Gel = 0.98 – 1.08

Corrosion Testing

Corrosion engineers world-wide use the ASTM B-117 (Salt Spray) test to qualify anti-corrosion coatings and to directly compare product performance. Following these guidelines, an independent lab coated Cold Rolled Steel (CRS) panels with RG and PCG to a thickness of 25 – 27 mils with an 'X' scribe in the coating (Figs. 3 and 4). After 183 hours, the results can be seen in Figs. 5 and 6. The RG received a grade of 10-G and the PCG received a grade of 3-G per ASTM D610 (Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces).

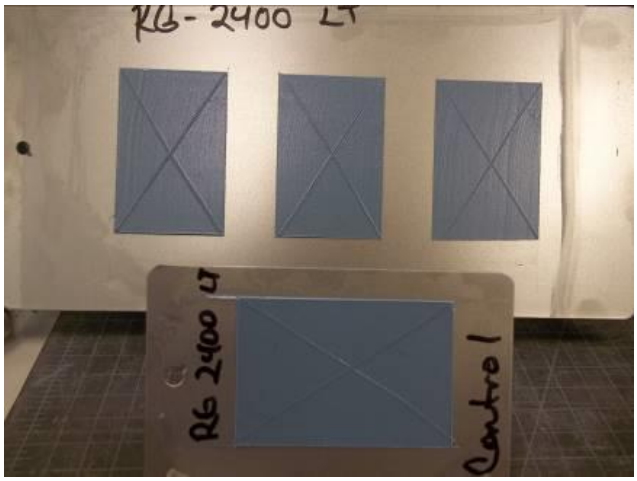


Fig 3. Reactive Gel before test

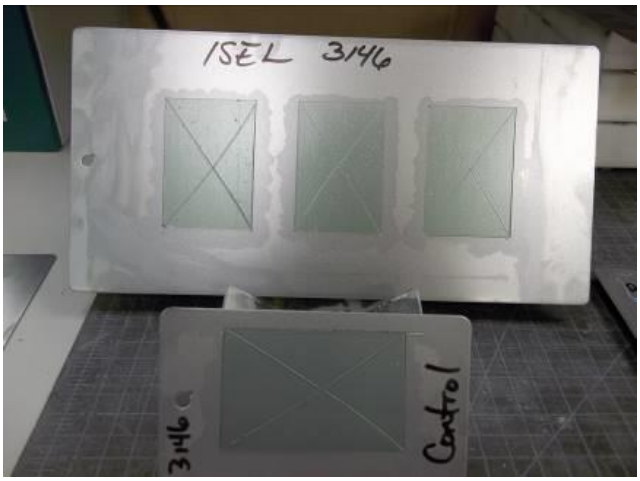


Fig 4. Pipe Coating Gel before test

Fig 5. RG (post cleaning) after 183 hours

Fig 6. PCG (post cleaning) after 183 hours

In actual field performance of gel products, a leading manufacturer of PCG reported exposing a pipe to the coastal elements of Florida for one month, with no corrosion forming. However, PCG products do not have a documented record of long-term success in mitigating corrosion, and specifically CUI.

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Reactive gel has been tested in a saltwater immersion test where pipes were coated, covered with fiberglass insulation, and submerged in 5% aerated saltwater for 2 years (see Figs. 7, 8, 9, and 10).

In addition, RG technology has 40 years of performance history in preventing corrosion in the auto industry and on U.S. Navy vessels in highly corrosive salt-air environments. RG products have almost 15 years' experience in mitigating CUI in the food & beverage Industry as well as the oil industry on the Alaskan North Slope.

Corrosion Under Insulation is a serious health, safety, and environmental concern. Especially in a challenging environment like Ammonia Refrigeration. Make sure you take the time to research the products you specify and don't hesitate to ask a manufacturer for more information. If a manufacturer makes a claim that a product is specifically formulated to protect against corrosion it should be able to provide various test data and case studies to support that statement. Both lab testing and historical field performance has shown that reactive gel technology outperforms other pipe gel coatings in protecting steel surfaces and preventing corrosion under insulation.

About Polyguard

Polyguard manufactures RG-2400, a gel product designed specifically for use on ammonia refrigeration piping to prevent CUI. Its relatively low level of surface preparation compares favorably with the installed cost of an epoxy paint, including the material and labor. In both laboratory and field tests, RG-2400 surpassed the efficacy of pipe coating gel (PCG) in preventing CUI for ammonia refrigeration piping systems.