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What's Eating You ?

Eric Munzner

Detecting and inhibiting the causes of HVACR coil corrosion

Copper coil corrosion appears to be on the rise—so much so that leading manufacturers of commercial and residential HVACR equipment have taken notice. They have even commissioned research studies from materials engineers in the hopes of identifying the root causes of the corrosion.

Literally, hundreds of thousands of pinhole leaks have occurred during the last decade. The majority of these corrosion leaks have been found in the fin pack area of evaporator and condenser coils, as well as at the tube sheets of the coils.

Although incidences nationwide are relatively uncommon in relation to the volume of equipment in operation, there's still a cause for concern. The issue is prevalent industry-wide, and a competitive study released by a group of leading manufacturers has shown identical corrosion failure leaks across all coil brands investigated. The progression of the corrosion has been found to be from the exterior of the copper tubing working its way inward. It slowly erodes the copper until penetration occurs, resulting in a refrigerant leak.

Placing the Blame

Initially, many service technicians believed the corrosive activity was due to acid levels within the refrigeration system causing corrosion from the inside outward. In a few cases, an acid eliminator was added to the refrigeration system, but the problem persisted.

Eventually, the studies determined that the source of the corrosion was a myriad of external, environmental contaminants and/or chemicals that were the overriding factors in the continual corrosion. For example, a rooftop unit in a coastal area could be corroded by ocean salt. An abundance of fertilizers, industrial plant processes, pollution and even acid rain also contribute to outdoor coil corrosion. Even bleaches, aerosol sprays, humidity, volatile organic compounds (VOC) and other prevalent factors found in every restaurant can contribute to indoor and evaporator coil corrosion.

Corrosion Mechanisms

A copper coil leak can have a litany of potential causes. They range from manufacturing or process-related defects to corrosion due to environmental conditions. There are a number of mechanisms that contribute to corrosion. This article will identify the most prevalent mechanisms discovered during recent studies.

These two corrosive processes could occur within weeks after installation, but typically, corrosion appears within a one- to four-year period, according to the aforementioned studies. Being able to distinguish between the different types of corrosion will help you identify and eliminate the source of the corrosive environment.

There are two main mechanisms of pitting corrosion of copper tubing:

• General pitting
• Formicary corrosion, or "ant" corrosion

Often visible to the naked eye, general pitting is corrosion caused by aggressive anion attack. An anion is an ion that contains more electrons than protons. Since electrons are negatively charged, an anion is a negatively charged ion that is in constant search of a cat-ion or cation. Conversely, cat-ions have fewer electrons than protons, causing them to be positively charged.

This brief physics study is imperative for the following: copper is an abundant source of cat-ions. The most common source of anions is chlorides. There is an abundance of chlorides in a restaurant environment, from bleaches to detergents, degreasers, dish soap, and even wall paper and carpeting. And, yes, even good old tap water contains chlorine, although such a small amount that it is not considered to be a major culprit in this corrosion mechanism.

Imagine the products used in housekeeping of restaurants in general, as well as the cleaners and water used by service technicians for cyclical preventative maintenance. You can pretty much guarantee there are some environmental variables that can contribute to accelerating the corrosion of HVACR coils in any given restaurant operation.

A Closer Look

Formicary or "ant's nest" corrosion develops at the surface of the copper tubing as multiple, tiny pinholes that are not visible to the naked eye, although some black or blue-grey deposits may develop. Microscopic inspection reveals a subsurface network of tunnels within the copper tubing wall that is larger than the pinholes on the outer surface and resembles an ant's nest.

This mechanism of corrosion is caused by VOCs or organic acids, such as acetic and formic acid. Acetic acid is found in a multitude of products, such as adhesives, paneling, particle boards, silicone caulking, cleaning solvents and insulation. Most importantly, acetic acid or its derivative, acetate, is produced naturally as food spoils and is the main ingredient in vinegar. It is also abundant in citrus-based food products. Typically, most incidents of formicary corrosion appear in refrigeration units that store salad products, such as dressings, toppings and fruits. Formic acid can also be found in disinfectants, latex paints, plywood and dozens of other materials.

A Recipe for Disaster

Given that these common products are found with ease in any restaurant environment, it is no surprise that coil corrosion is occurring at substantial rates within these facilities. This rise can also be associated with the trend in tighter building construction methods, which allows less outside air induction to dilute these volatile compound buildups.

These two forms of corrosion must have two essential ingredients to complete their destructive mission—oxygen and moisture. While oxygen is close to being unavoidable, limiting moisture levels might help stave off or at least inhibit accelerated corrosion of the copper tubing.

A less cited mechanism of corrosion is galvanic corrosion. Many facilities professionals are aware of this type of corrosion, but may not have been able to identify it. When two dissimilar metals, such as copper tubing and aluminum fins, are in contact with one another, a galvanic couple forms, which promotes the phenomenon of galvanic corrosion. The metal that corrodes and the metal that is protected depend on their relative positions in the series. Usually the aluminum fins corrode much faster than the copper because it is in greater abundance and due to its position in the series.

Moisture acts as the electrolyte in the reaction and, once again, plays a leading role in this form of corrosion. As mentioned earlier, outdoor coils located in coastal areas are affected by the salt-laden, moisture-rich air. In galvanic corrosion, the sea water exacerbates the issue because salty sea water is more conductive than fresh water.

Fighting Back

It may seem a daunting task to attempt to identify coil corrosion and then take steps to inhibit it. But not all hope is lost. The cyclical PM service that most facilities professionals have in place at their restaurants is a major step in staving off aggressive corrosion. Water is the most widely used cleaning agent for indoor and outdoor copper coil cleaning, but there are operating environments in which a chemical-based cleaner must be used to truly clean the coils. Numerous acid-based and alkaline-based cleaners rinsing to remove any and all residues of these cleaners is paramount as the cleaners themselves could initiate the corrosion process. The operating environment will be the overriding factor in determining the frequency and depth to which the coils should be cleaned.

What Manufacturers Are Doing

Manufacturers have taken great efforts to identify and help remedy the onslaught of corrosion. They have openly admitted that some processes associated in the manufacture of copper coils may also contribute to the early demise of their products.

Many have scrubbed their manufacturing processes, materials and environments to include oils and lubricants and eliminate corrosive agents in their manufacturing environment. They have also implemented quality control measures to prevent the use of poorly constructed copper, which is more susceptible to corrosion mechanisms.

Manufacturers have offered protective coatings for coils for quite some time. When properly applied and maintained, these coatings can make coils virtually corrosion-proof. Some industry members believe protective coatings limit heat transfer. This is really only a problem for existing coils in operation as a new coil can be oversized to offset the loss in heat transfer capabilities. These coatings are offered as a factory application for new coils and as a field applicable product for existing coils. Consult your manufacturer representatives and/or service partners when researching a coil coating option for your specific needs.

Awareness is the First Step

As stated earlier, the incidences of these corrosion mechanisms are still relatively low in relation to the voluminous inventory of equipment in operation nationwide. Manufacturers of commercial and residential HVACR equipment have heeded the call to address this issue and have made the information cited in this article readily available. They have also made adjustments to their processes and procedures in a concerted effort to reduce the incidences of corrosive activity at the manufacturing level.

Knowledge is the key in addressing a continual corrosion problem with both indoor and outdoor coils. As facilities professionals, we need to assess the variables that may contribute to the corrosive activity and do our best to inhibit or eliminate them. When preparing to address continual or premature corrosion problems, we must work to identify the type of corrosion that is taking place. Ultimately, coated coils may be the only option if it isn't possible to remove the source of the corrosion.

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