



Enviro-Shield - Three Levels of Environmental Protection

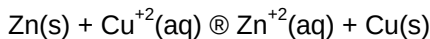
Introduction

For years, a major problem in the electronic industry has been the deterioration of electrical components from the natural elements such as rain, sleet, and snow. Other conditions such as salt from coastal areas or road salts cause accelerated corrosion on electrical components. Even sulfur dioxide produced from the burning of coal has a major impact on electrical component life. Cooling fans are no exception to this rule.

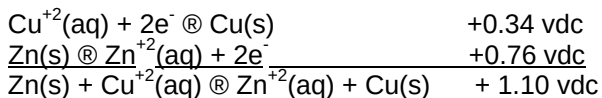
To combat the effects of harsh environmental conditions, several chemical coatings have been developed to form a protective barrier between the electrical components and the environments that they must operate in. These coatings range from a 1 mil thick conformal coating to fully encapsulated assemblies. This application note is written to identify the problems with corrosion and the methods available to combat them. To understand the effects of corrosion on electrical components, a brief explanation is written that describes the chemical reactions that occur and the conditions that they occur in. An example will discuss the process of corrosion that attacks electrical components such as copper wire. After understanding how corrosion occurs and the environments that accelerate this process, we will discuss several methods of protection.

Corrosion Explained

Corrosion is best understood as an oxidation – reduction reaction between 2 or more elements. Oxidation – reduction reactions, also known as redox reactions, occurs when one element loses an electron to another element. In the reaction between zinc (Zn) and copper (Cu), zinc is oxidized (gives up its electrons) and the copper is reduced (accepts electrons).

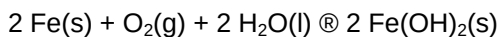


Because there is a transfer of electrons between the elements, a voltage potential is created between them. This voltage can be either positive or negative. A positive voltage would indicate a spontaneous reaction where a negative voltage would be a non-spontaneous reaction. This is demonstrated in the 2 half reactions of Zn(s) and $\text{Cu}^{+2}(\text{aq})$.

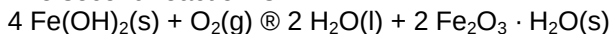


The redox reaction above occurs spontaneously because the reaction produces a positive 1.10 vdc potential. Other redox reactions occur spontaneously in nature such as the corrosion of iron. When iron (Fe) comes into contact with oxygen (O_2) and water (H_2O) a redox reaction occurs that oxidizes the iron into $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$, or more commonly known as "rust".

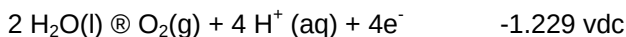
This reaction occurs spontaneously in 2 steps. The first reaction is:



The second reaction is:

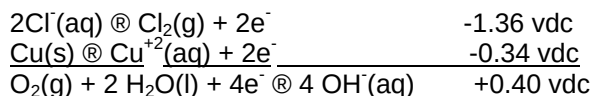


Non-spontaneous redox reactions also occur but require a voltage potential to drive the reaction. These non-spontaneous redox reactions are known as the process of electrolysis. Water can be broken into its elements through electrolysis. This reaction requires 1.229 vdc of potential.

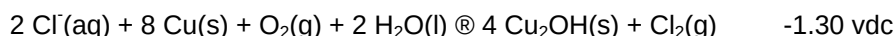


Corrosion on Electrical Components

As discussed previously, non-spontaneous redox reactions can occur if a voltage potential is applied between two or more elements. For electrical components, we will study the effects of salt water (NaCl (aq)) on copper wire. For this reaction, there are several chemical elements involved. Salt water is a solution of sodium ions (Na⁺) and chloride ions (Cl⁻) in water (H₂O). For simplicity, the sodium ions (Na⁺) will not be used in the calculation. The other elements involved are oxygen (O₂) and copper (Cu). For all of these chemical elements, they can be written as 3 half reactions.



When you add up all of the reactions, you get



This equation states that when copper is in the presence of chlorine, water, oxygen, and 1.30 vdc of electrical potential, the copper becomes oxidized into copperhydroxide. The solid copper wire is eaten away (reduced) and copperhydroxide is produced (oxidized). A reaction will also occur without the presence of chlorine; but chlorine, a small atom and an excellent oxidizer, greatly accelerates the corrosion process.

Solutions in Environmental Protection

Comair Rotron, the leader in innovative cooling ideas, has pioneered the way in environmentally protected fans. With the continuous advancements in conformal coating materials, Comair Rotron has researched various chemicals, materials, and processes that provide the greatest degree of protection to our customers. The results have produced our latest value-added product, "Enviro-Shield". The Enviro-Shield products are rated to 3 levels of protection; which are described later in this paper as Type 1, 2, & 3. Each material fully encompasses all electrical components, wires, circuit paths, motor windings, and stator assemblies; ensuring the optimum protection for any condition. These materials can be sprayed, dipped, or injected into the motor assemblies, creating a protective barrier between the delicate electrical components and the outside environments.

Comair Rotron's environmentally protected fans are designed and tested to withstand mild environmental conditions such as light water mists to the harshest environments including long term salt exposure. There are several standard specifications written with various degrees of protection and methods for testing to these standards. The most common standards are NEMA, IP, BELCOR, MIL, UL, and ASTM. These standards and the testing methods can be made available to you upon request.

To test a fan's ability to maintain such reliable protection, Comair uses a variety of testing apparatus. The most commonly refer to test is the salt fog test. This test demands that the fan be subjected to as many as 14 days of continuous exposure to salt fog environment. Types 2 and 3 materials have gone as high as 80+ days before encountering a failure. This says a lot considering 14 days is estimated as the equivalent to 10 years of normal operation. Other tests include direct water spraying on the fan, humidity, and dust.

Some discussion can be made over the type of bearing used. Comair has performed numerous tests and has found that the ball bearing system works exceptionally well. It is not recommended to use sleeve bearings in an environmentally protected fan. The ball bearings are double shielded which resists most contaminants from entering the bearing surfaces.

As a brief outline as to what type of protection is best suited for your needs, consider the following:

- **Type 1** protection is intended for environments that included exposure to water mists, sprays, dripping, dust, condensation, and moderate vibrations.
- **Type 2** protection is intended for harsher environments that include exposure to ocean salts in the form of fog or a mist. Type 2 protection also provides extra protection to the fan for excessive shock and vibration.

- **Type 3** protection is also intended for harsh salt fog environments but includes additional protection to the motor windings. Type 3 protection also provides extra protection to the fan for excessive shock and vibration.

Type 1 Environmental Protection

Type 1 environmental protection is a thin silicone coating that is applied to the complete motor assembly, including the motor windings, lamination stack, and the populated circuit board. The silicone material has a lower viscosity than most other materials; which allows the material to seep into and around all of the components and motor windings. The process for applying this material is typically by spraying 2 coats of the material to the motor assembly from several directions. This ensures good, uniform coverage of the material. Each motor assembly is thoroughly cleaned in a solvent bath to remove any oils or impurities before any protective material is applied. Cure time is within minutes, making this process quicker than the other more elaborate process. The material is also non-corrosive, fungus inert, and has a viable temperature range exceeding the range of the fans.

Type 1 environmental protection is designed to meet mildly harsh environmental conditions. These conditions include the occasional spray of water to the fan (wash-down requirements), exposure to fine dust particles, morning dew that may condense inside the fan, and other similar conditions. Type 1 protection will enhance the fans ability to resist moderate vibrations by acting as an adhesive to keep fragile electrical components such as resistors, diodes, and other small components. In general, this option is designed to meet standard specifications such as:

- NEMA 12, 12K
- IP 54, 55, 56

Details of these specifications and their relevant requirements are available upon request.

Type 2 Environmental Protection

Type 2 environmental protection is a thicker silicone coating that is also applied to the motor assembly. For this option, the motor winding and lamination stack is coated with the type 1 material. The motor winding and lamination stack has very tight tolerances between the rotating rotor and need only a thin coating. The populated circuit board is dipped into the thicker silicone material; which creates a thicker barrier, especially over sharp edges such as solder points. Each motor assembly is thoroughly cleaned in a solvent bath to remove any oils or impurities before any material is applied. **After the material has dried, the process is repeated to form a good thick coat. Cure time is about 30 minutes, per coat.** After the motor assembly has been cured from the second coating, the motor assembly can then be returned to the assembly line for final production. The material is also non-corrosive, fungus resistant, and has a viable temperature range exceeding the range of the fans. Because of the thick coat and the elastomer properties of silicone, this option also increase the fans ability to resist excessive vibration and shock.

Type 2 environmental protection is designed to meet the harsh environmental conditions. These conditions include the direct or indirect spray of water onto the fan, exposure to fine dust particles, morning dew that may condense inside the fan, long tem exposure to salt spray and salt fog. In general, this option is designed to meet standard specifications such as:

- NEMA 3, 3R, 3S, 4, 4X, 12, 12K
- IP 54, 55, 56
- BELCORE (GR-487)
- MIL 810E

Details of these specifications and their relevant requirements are available upon request.

Type 3 Environmental Protection

Type 3 environmental protection is a silicone material that is used to either pot the PC board into the venturi of the fan or completely encapsulate the motor assembly with the silicone material. For fans that are only potted, the

motor windings and lamination stack and coated with the Type 1 material. The motor winding and lamination stack has very tight tolerances between the rotating blade and need only a thin coating. For fans that are completely encapsulated, the motor assembly is placed into a mold; which has been cleaned, sprayed with a release agent, and heated in an oven. The material is then poured into the mold/motor assembly to a preset amount. After the material has been poured into the mold/motor assembly, the mold is vibrated to work out any air bubbles that may be trapped. The cure time between pouring the material and removing the encapsulated motor assembly from the mold is approximately 20 minutes. After the encapsulated motor assembly is removed, it is 100% inspected for conformity and returned to the assembly line for final production. The material is also non-corrosive, fungus-resistant, and has a viable temperature range exceeding the range of the fans. Because of the elastomer properties of silicone, this option also increases the fans ability to resist excessive vibration and shock.

Type 3 environmental protection is designed to meet the harshest environmental conditions. These conditions include the direct or indirect spray of water onto the fan, exposure to fine dust particles, morning dew that may condense inside the fan, long term exposure to salt spray and salt fog. In general, this option is designed to meet standard specifications such as:

- NEMA 3, 3R, 3S, 4, 4X, 12, 12K
- IP 54, 55, 56, 65, 66
- BELCORE (GR-487)
- MIL (810E)