Avoiding Corrosion at the Connector

Pushing Performance
Since 1945

PEOPLE. POWER. PARTNERSHIP.

Foreword

Connectors have become an indispensable element of modern industry. They speed up the assembly and disassembly of individual components, encourage modular designs, and thus significantly reduce costs over the entire service life. Based on these advantages, there is a widening range of applications that goes far beyond usage in industrial environments.

Connectors are increasingly being used under harsh environmental conditions. Thus, much tougher demands are placed on connection components than would be the case in a protected industrial environment.

The purpose of this white paper is to take a closer look at the use of connectors in more demanding environments, with a particular focus on the issue of corrosion. The possible types of corrosion and the resulting problems and requirements for connectors are also considered.

Finally, different strategies are discussed to minimise the risks of corrosion, thus ensuring corrosion protection that lasts for the entire service life of the connector.

Applications for industrial connectors

Connectors are now used in almost all areas of industry. They can be used both within protected indoor areas as well as in exposed outdoor areas. When it comes to resisting environmental influences, these two application types have different requirements. Whereas indoor environmental influences such as humidity, temperature and sunlight can be largely controlled, an outdoor connector is practically without protection against such influences.

To make matters worse, some prevailing outdoor conditions promote extensive corrosion. Such conditions are found in maritime and offshore applications. The corrosion risk is significantly increased by the high humidity and the increased salt content in the surrounding air.

Normative assessment of connectors and their corrosion behaviour

In order to describe and evaluate the corrosion behaviour of a connector, there are two different standards that are mainly used in practice to assess connectors:

- DIN EN ISO 12944-1 ff.

DIN EN ISO 12944 deals with the protection of steel structures using organic coatings that cure at room temperature.

- DIN 55633

DIN 55633 describes the corrosion protection of steel structures provided by powder coatings.

Both standards have their origin in the steel construction industry. They refer to steel structures whose components are made of alloy or low-alloy steel at least 3 mm thick, designed in accordance with a structural safety certificate and uncoated or hot-dip galvanised.

The standards also describe a corresponding test procedure, which is used to classify the respective components into different corrosion classes (C1 – C5). The condensation of water vapour according to ISO 6270-1 and the salt spray test according to ISO 9227 are the basis for the classification into the different classes.

HARTING Electric Stiftung & Co. KG
Wilhelm-Harting-Strasse 1, D-32339 Espelkamp, Germany
Phone: +49 5572 47-9736, Fax: +49 5772 47-909736
Christian.Bohne@HARTING.com

Here, the component is exposed to both a humid environment and an aggressive saline environment for a certain period of time and then tested for functionality. The length of the period determines the final classification into the corresponding corrosion protection class.

Corrosion Class	Examples of typical areas
C1	Heated, dry areas with very low pollutant exposure (60% rel. humidity)
C2	Dry, heated area with low pollution atmosphere
C3	Urban and industrial atmosphere with moderate SO_2 pollution, temperate climate
C4	Industrial atmosphere and coastal atmosphere with moderate salt load
C5	Industrial atmosphere with high humidity and aggressive atmosphere
C5H (high)	Costal- and offshore areas with high salt load

Figure 1: Corrosion protection classes according to ISO 12944-2

Applying standards in practice

The metallic connector housings from HARTING and many other suppliers are generally made of aluminium using a die-casting process. The housing surface is then painted using a powder coating process to increase resistance against external environmental influences.

In some cases, passivation or an additional surface coating is carried out before painting. This ensures better adhesion of the powder coating and thus even better corrosion resistance. These are referred to as multi-layered systems.

Looking at the corresponding components and their manufacturing processes, it becomes clear that a direct application of the above standards to connector housing is theoretically not permissible.

For lack of an alternative, most users nevertheless refer to these very standards to assess components.

For this reason, it is the manufacturers' task to harmonise the normative market requirements with their own products in a meaningful way that benefits the customer.

HARTING focuses here on the basic functions of a connector that must be fulfilled for the corresponding application areas:

- Tightness/seal
- EMC compatibility
- Safe transmission of power, signals and data

Possible types of corrosion on the connector

Technically, corrosion is the reaction of a Material with its environment that causes a measurable change in the material.
All corrosion involves a chemical reaction in which an electrolyte (usually water) is present. It manifests itself in a transformation of the metal into another more chemically stable compound (mainly oxygen compounds), which then usually detach from the original metal (as flaking rust).

Surface corrosion

Surface corrosion is the most common form of corrosion. Here, the attack occurs relatively evenly over the entire metal surface.



Figure 2: Surface corrosion on steel pipes

This form of corrosion rarely occurs with connectors because of their mostly painted surfaces. However, if the paint layer is damaged by external influences, moisture will penetrate the crack that has formed and then contact the aluminium surface. Corrosion then begins.

HARTING Electric Stiftung & Co. KG
Wilhelm-Harting-Strasse 1, D-32339 Espelkamp, Germany
Phone: +49 5572 47-9736, Fax: +49 5772 47-909736
Christian.Bohne@HARTING.com

As this corrosion progresses, it infiltrates the adjacent paint layer and peels it off – and the corrosion continues.



Figure 3: Surface corrosion on the unpainted mounting surface of a connector

Damage to the surface can be caused by external influences (impact, shock or assembly) or may be the result of thermal processes that cause the housing to expand and contract. Thus, the paint layer becomes cracked. An additional but often neglected reason for damage to the painted surface is the repeated mechanical stress placed on certain housing parts. This can "rub off" certain areas of the paint layer over a longer period of time. The aluminium surface is then exposed and corrosion can begin.

Contact corrosion

Contact corrosion (also bimetallic corrosion or galvanic corrosion) is corrosion caused by the electrochemical reaction of two different metallic materials. The requirements are a different position in the electro-chemical voltage series, different corrosion resistances of the materials, their direct contact and joint wetting by an aqueous corrosion medium (an electrolyte).

Thus, a galvanic corrosion element is formed, whereby the less noble (i.e. less corrosion-resistant) material is destroyed by electro-chemical degrading.



Figure 4: Contact corrosion on a bronze shut-off valve

Contact corrosion can also occur with aluminium under certain circumstances. Direct contact of the material with a more noble material and the corresponding corrosion medium is required for this.

By applying this expertise to connector housings, certain areas can be identified that are exposed to an increased risk of contact corrosion:

- **Cable entry**

When an aluminium housing is combined with a metal cable gland (e.g. made of stainless steel or brass)

- **Screw connections**

By combining an aluminium housing with a screw connection (steel or stainless steel screw)



Figure 5: Contact corrosion in the vicinity of the cable entry and the screw locking

HARTING Electric Stiftung & Co. KG
Wilhelm-Harting-Strasse 1, D-32339 Espelkamp, Germany
Phone: +49 5572 47-9736, Fax: +49 5772 47-909736
Christian.Bohne@HARTING.com

- **Lever lock**

By combining an aluminium housing with a steel lever lock.

By repeatedly opening and locking the connector housing, the painted coating on the locking pin is worn away over its lifetime, which exposes the aluminium surface.

If the exposed aluminium surface comes into contact with the steel lever lock, contact corrosion will start here under the influence of a corresponding corrosion medium.

Avoiding corrosion on the connector

The risk of corrosion on a connector over its entire service life can never be completely eliminated. Due to a connector's long service life in sometimes harsh environments and unpredictable external influences, manufacturers today do not try to completely eliminate the corrosion risk of a connector, but instead try to minimise this risk. Different methods are used for this.

- **Decoupling the corrosive materials**

To counteract contact corrosion between two different metals (e.g. steel screw/aluminium housing), the corresponding components can be separated from each other using so-called separator elements. The aim here is to electrically insulate the different metals, thus preventing contact corrosion.



Figure 6: Principle of electrical insulation using the example of a flange connection

- **Sealing the contact connection**

Another way to avoid contact corrosion is to sufficiently seal the two contacted metals.

This prevents the penetration of an aqueous contact medium (electrolyte), so that contact corrosion (e.g. in the threading) is prevented.



Figure 7: Sealing ring for a stainless steel cable gland

- **Combining with non-corrosive materials**

Another way to avoid contact corrosion is to combine non-corrosive materials. The aim here is to eliminate the galvanic potential of the different components in order to prevent contact corrosion.



Figure 8: Connector with plastic cable gland

HARTING Electric Stiftung & Co. KG
Wilhelm-Harting-Strasse 1, D-32339 Espelkamp, Germany
Phone: +49 5572 47-9736, Fax: +49 5772 47-909736
Christian.Bohne@HARTING.com

Avoiding Corrosion at the Connector

Pushing Performance
Since 1945

PEOPLE. POWER. PARTNERSHIP.

- **Surface treatment**

By applying one or more layers of paint, the housing surface is optimally protected against corrosion. Several layers of paint (multi-layered paint) and a paint surface that is as homogeneous as possible result in significantly improved corrosion resistance.

Surface treatments before the actual painting process further improve the corrosion protection. Pre-treatment of the surface using additional coating processes (e.g. passivation) provides an improved adhesion primer. This delivers more corrosion protection before painting.

- **Avoiding corrosive materials**

If the application permits, the use of corrosive materials can be avoided completely. Non-metallic connector housings made of plastic can be used here.



Figure 9: Han-Eco® B plastic connector

Summary

Due to the various requirements for modern industrial connectors and their wide application range, one uniform approach to reducing or eliminating the risk of corrosion is not practical. Likewise, the different components of a connector and their mutual interaction in a corrosion-friendly atmosphere make a uniform assessment of the complete connection solution difficult.

Thus, it is the responsibility of the end customer to define the specific requirements for the connector (as precisely as possible) and to work out a solution together with the supplier that will be both technically effective and affordable.

The challenge here is to find the best possible combination of the individual strategies that prevent corrosion, while at the same time meeting the connector's specific technical requirements.

HARTING Electric Stiftung & Co. KG
Wilhelm-Harting-Strasse 1, D-32339 Espelkamp, Germany
Phone: +49 5572 47-9736, Fax: +49 5772 47-909736
Christian.Bohne@HARTING.com

Avoiding Corrosion at the Connector

Pushing Performance
Since 1945

PEOPLE. POWER. PARTNERSHIP.

Corrosion protection at HARTING

As the global market leader in heavy-duty industrial connectors, HARTING has a special responsibility as a supplier.

Thanks to our broad product portfolio, we enable our end customers to implement many different combinations when designing their individual connector solutions.

With a wide variety of materials, different coating processes and the continual corrosion resistance innovations in our components, we support our partners with the optimal design for their connector solutions.

For HARTING, the focus is always on a component design that is both technically effective and cost-efficient.

To meet the increasing demands on modern industrial connectors – especially for corrosion resistance – HARTING has an accredited laboratory. Here, we not only test the corrosion behaviour of our components in accordance with applicable standards, but also implement a continuous improvement process through product developments.



Figure 110: IPX9 test chamber

We also offer our customers the options for testing and assessing the corrosion behaviour of individually designed components, so that the best possible solution can be reached in joint cooperation.



Figure 10: Test specimens in the salt spray chamber

For HARTING, the focus of an assessment – and in accordance with the applicable standards – is that the correct functionality of the connector comes **before** the corresponding service life.

HARTING is, thus, a reliable partner for its customers throughout the entire development process – both during the design and during the expert assessment of the interface for resistance to corrosion.

HARTING Electric Stiftung & Co. KG
Wilhelm-Harting-Strasse 1, D-32339 Espelkamp, Germany
Phone: +49 5572 47-9736, Fax: +49 5772 47-909736
Christian.Bohne@HARTING.com