

WHITE PAPER

ENVIRONMENTALLY SEALED CONNECTORS

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REIMAGINING CONNECTIVITY
TOGETHER

ENVIRONMENTALLY SEALED CONNECTORS

SEALED CONNECTORS ARE USED IN MANY APPLICATIONS WHERE LEAKAGE INTO OR OUT OF EQUIPMENT MUST BE AVOIDED.

Sealing is a very complex science in itself, as it involves many physical aspects including mechanical design, materials science, surface science and fluid behavior.

Three major application groups exist that require different sealing levels and different solutions: environmental sealing, hermetic sealing and high pressure sealing. This paper focuses on environmental sealing as encountered in many application areas, specifically as it relates to rain and dust.

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1. SEALING CATEGORIES AND SCOPE OF DOCUMENT

Three major application groups exist that require different sealing levels, and therefore call for different solutions.

Environmental sealing

In typical outdoor applications, one side of the connector might be exposed to rain, dust and other aggressive environments. The exposure is generally limited in time and pressure. Fischer Connectors' product range for these applications includes receptacles sealed in mated or unmated states; for example, styles DEU, DBEU, DBPU, etc., as well as plugs in association with sealed clamp sets. These products are designed to offer sealing up to IP68.

Hermetic sealing

Hermeticity is required for gas tightness. Examples would be vacuum applications or pressurized vessels. These applications require a high level of sealing to prevent gas leaks over longer periods of time. These product ranges, for example, Fischer Connectors' styles DEE, DBEE, DBPE, etc., are designed specifically for hermetic sealing and undergo a 100% leak test. Such connectors can be used also in other severe conditions like immersion for longer periods of time or exposure to strong water jets. They achieve an IP69K rating.

High pressure sealing

For applications requiring exposure for extended periods of time in liquids under high pressure (for example, deep-submarine applications), special designs can be proposed that combine hermetic sealing with high-strength mechanical design. Fischer Connectors' design center can assist customers with such special requests.

This document focuses only on environmental sealing as encountered in many application areas. For information on hermetic sealing, please refer to our white paper "Hermetically Sealed Connectors."

2. TYPICAL OPERATING CONDITIONS FOR SEALED CONNECTORS

When selecting the appropriate connector for your specific application, you need to consider all influences and conditions under which the connector will operate. The most frequent conditions encountered in environmental sealing are noted in the chart below:

| | |
|--|---|
| Substances to be blocked by sealing | Water (rain, soft) |
| | Water (sea) |
| | Dust |
| Temperature range | Normal -20°C to +60°C |
| | Military, extreme -50°C to +150°C ¹ |
| Pressure differential | Typ ≤0.2 bar ² |
| Type of exposure | Most common is splash, but jets or immersion are possible |
| Duration of exposure | Typ ≤1 day |

1) Although water or dust ingress may be less common at very low or very high temperatures, it is essential that the connector design allows correct operation in such extreme conditions. This, of course, also affects the design of your sealing elements.

2) In condition of regular maintenance

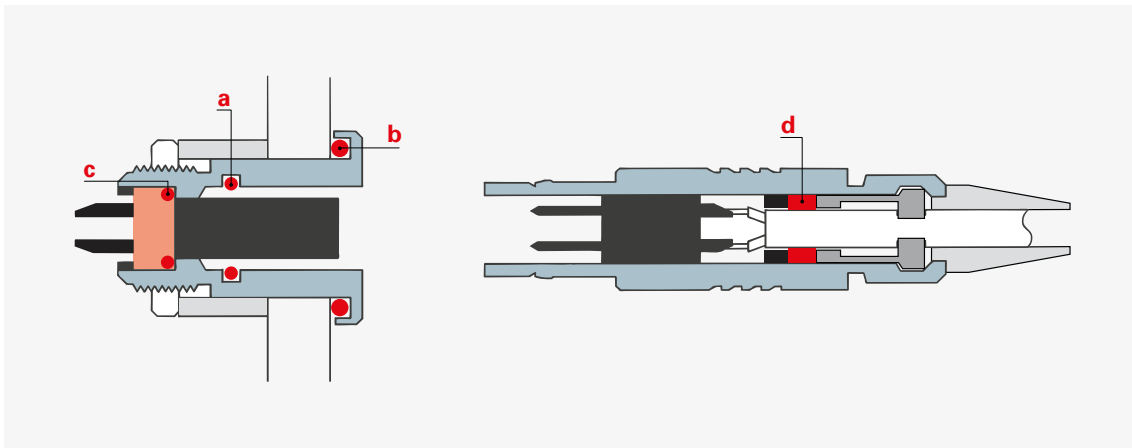
These conditions are typical, and offer a first filter for the selection of an appropriate connector range. Depending on risk analysis, a worst-case evaluation might be necessary in some critical cases.

3. CONNECTOR SEALING

The most rugged connectors will have barriers in multiple places, protecting against dirt and water from various angles and intensities.

3.1 Sealing Techniques for Environmental Protection

Fischer Connectors' products designed for rugged conditions, unlike standard commercial or consumer-grade connectors, have clearly independent sealing functions designed to control the connector's performance for every requirement. Several advanced sealing functions can be found on quality environmentally sealed products:



a. Interface Seal

By definition, this seal protects the connector interface, i.e. the junction between two connectors. It prevents ingress of water or harmful particles into the connection area where male and female contacts mate. This seal's function is to ensure long-term product reliability, especially if the connector is frequently mated and unmated.

Because the interface seal works dynamically when mating, and can be exposed to the environment, you should select the quality of the seal according to operating temperature, environment and fluids. A range of standard solutions is available; material selection is detailed below. Most standard, sealed Fischer Connectors products come with an interface seal.

b. Panel Seal

This sealing element joins the connector housing with the panel or equipment housing. The seal works in a static way; in most applications its exposure to the environment is very limited due to recessed O-ring position. Most standard, sealed Fischer Connectors products come with a panel seal.

c. Sealing of Block

Normally an open connector should be protected against environmental influences when disconnected by using an adequate protective cap. However, in some cases the connector must remain sealed even without protective accessories. In this case, the inner contact block of the receptacle must also be sealed to prevent dust or water ingress into the equipment.

High-quality sealing compounds are used for factory sealing of the block. Although this is a standard process on environmentally sealed products, it is not compatible with designs in which contacts are put into place by the customer (crimp contacts). In such cases, the use of protective caps is mandatory.

d. Cable Seal

This grommet-type seal is designed to protect your connection solution by preventing ingress of liquids into the connector along the cable. Cable material and quality strongly affect reliability of this seal; careful selection is essential to properly match the diameter of the seal to the diameter of the cable. Separate, environmentally sealed clamp sets are available for all common Fischer Connectors plugs.

3.2 Sealing Materials

It is important to understand the quality of the sealing materials your manufacturer selects. Fischer Connectors' materials selection is based on solutions that have proven high reliability in many difficult operating conditions. Standard sealing materials are:

Viton® is a fluoropolymer often designated FKM. Its low permeation and excellent broad chemical resistance are interesting for many applications. Fischer Connectors uses Viton® as first choice for most receptacle seals.

EPDM (ethylene propylene rubber) is another elastomer characterized by a wide range of applications. Commonly used as weather seals on vehicles, it combines good water resistance with low glass temperature. EPDM is the preferred choice for interface O-rings in connectors designed to be mated and unmated at low temperatures.

Fischer Connectors also offers a wide range of custom solutions for applications where special sealing requirements are essential.

4. CONNECTOR INSTALLATION

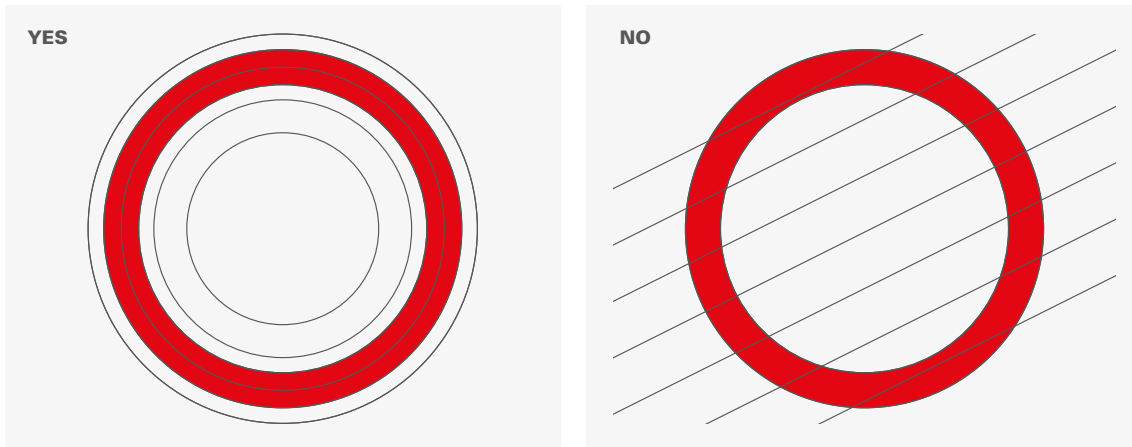
Installation of cable and panel-mounted connectors require distinct approaches for sealing.

4.1 Panel-Mounted Connectors

Correct panel sealing can be achieved only if the contact surface for seal "b" (panel seal) is correctly prepared. Special care must be taken depending on manufacturing techniques. The following aspects are most commonly encountered in seal designs:

- The surface flatness shall be designed in such a way that sealing can be achieved without excessive torque required to mount the connector. Typical recommended flatness is <0.05mm, usually not problematic for modern machining techniques. However, plastic moldings may be more critical and must be carefully designed.

- Machining grooves shall be circular and not perpendicular to the O-ring seal.



If, however, circular machining is not possible, reasonable sealing performance can be obtained if surface roughness is $<Ra\ 0.8\ \mu m$.

- Edges and burrs of panel cut-out shall be carefully cleaned.

4.2 Cable-Mounted Connectors

Several factors impact the long-term behavior and reliability of the plug seal. When selecting cable, the following aspects are particularly important:

- Cable sheath material. The grommet-type seal acts through compression by tightening the connector backnut. Soft cable materials may relax over time, resulting in a potential loss of sealing efficiency and/or loosening of the backnut. Trials are always recommended to determine the right grommet size.
- Cable diameter and shape. Some cable qualities show poor cross-sectional circularity; this can also have negative impact on short and long-term sealing reliability. Sometimes selection of a smaller seal size can help to overcome this problem.

If you specify an adequate match of cable and seal, IP ratings up to IP68 or even IP69K for limited periods of time can be achieved.

For the highest reliability of long-term sealing in demanding applications, we recommend overmolding the plug back-end. This offers a strong hermetic link between cable and connector even in applications subjected to intense mechanical load. Fischer Connectors can offer customer-specific solutions for overmolding.

5. SEALING STANDARDS

The protection level offered by a typical envelope (IP rating) is described in IEC 60529. When connectors will be used in harsh operating environments, check the manufacturer's IP rating for sealing to dust and water at various depths and operating time frames. Make sure you understand the end use environment for your connectors, and then compare that scenario with the details behind the manufacturer's IP rating. Most of the IP designations have specific conditions, but the IP68 rating can be defined by each manufacturer differently. When looking for a connector with an IP68 sealing rating, inquire exactly how the manufacturer's IP68 rating is measured. A system being submerged at 2 meters for 24 hours has a different impact on the connector than at 120 meters for 24 hours, but both situations can be defined as an IP68 rating.

Environmental tests performed during design and qualification of Fischer Connectors' environmentally sealed products are standardized to IP68 at a depth of 2 m and duration of 24 hours.

IP69K is an additional sealing level defined to protect an envelope from intense water jets for short duration (typically for high-pressure cleaning). IP69K is a definition from German DIN 40050-9.

ADDITIONAL RESOURCES

Learn more about IP ratings

IEC Home Page www.iec.ch

IEC Web Store (buy IEC standards online) <https://webstore.iec.ch>

LIMITATIONS

The recommendations provided in this present White Paper are given only with the intention of assisting with the choice of a connector with respect to its particular application. It remains always the responsibility of the equipment manufacturer, and not the connector supplier, to determine the appropriate technical standards, as well as the necessary safety factors for a given application.



ABOUT FISCHER CONNECTORS

Fischer Connectors has been designing, manufacturing and distributing high-performance connectors and cable assembly solutions for more than 60 years. Known for their reliability, precision and resistance to demanding and harsh environments, Fischer Connectors' products are commonly used in fields requiring faultless quality, such as medical equipment, industrial instrumentation, measuring and testing devices, broadcast, telecommunication and military forces worldwide.

Primary design and manufacturing facilities are located in Saint-Prex, Switzerland, with subsidiaries and distributors located worldwide.



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