# Inhaltsverzeichnis

# 4.1 Corrosion protection

**With a view to supplying reliable and durable products, Hilti is constantly active in the development of methods of corrosion protection suitable for use with screws and fastening systems.**

## Ambient conditions, categories of corrosion

Corrosion occurs under a variety of conditions. It may be caused or increased by the following

- microclimatic conditions
- the installation process and working with the items concerned
- contact with various materials



In order to select the most suitable type of corrosion protection for screws, the ambient conditions and the situation in which screws are to be used as well as the materials to be fastened must be taken into account.

In accordance with DIN EN ISO 12944-2, the ambient conditions can be divided into six categories:

| | **Examples:** |
|---|---|
| C1 = insignificant | heated buildings (schools, offices, etc.) |
| C2 = low | rural areas, unheated buildings (warehouses) |
| C3 = moderate | urban and industrial areas with moderate pollution |
| C4 = heavy | industrial and coastal areas with moderate salt pollution |
| C5i = very heavy (industry) | industrial areas with high rel. humidity and heavy pollution |
| C5m = very heavy (coastal) | coastal and offshore areas with high salt pollution |

While it is usually easy to differentiate between dry interiors (C1) and extreme conditions (C5), it is often difficult to differentiate between C2, C3 and C4.

For this reason, the screw selection aid provided in Section 3.5 is based on examples. These examples also take contact with the material to be fastened into account.

## Standards, approvals

When choosing the right material or corrosion protection for a fastener, the conditions under which it will be used, the applicable loads and the expected duration of use must be taken into account.
It is essential that the requirements laid out in the applicable regulations or codes, standards and approvals for the corresponding countries (e.g. ETA, DTU, etc.) are observed.

Below, as an example, is an extract from the ETA-10/0182 approval for the S-MD, S-MP and S-MS:

“The provisions made in this European technical approval are based on an assumed working life of the fastening screws of 25 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.”

## Duration of use and warranty

- Service life (or effective useful life) provides an indication of the duration for which the fastener can be expected to provide an intact connection between the components without impairment of its loadbearing characteristics or reduction of its loadbearing capacity. It is possible that signs of corrosion such as white rust or red rust may occur during the service life of the fastening but these only affect its appearance.
- Warranty period is a legal term that regulates the subject of liability for defective products.
- The service life possible without functional impairment and without increased risk of failure is usually significantly longer than the duration of the warranty period. Both, however, depend on whether the recommendations concerning the choice of material in relation to the conditions of use, including the surrounding atmosphere, have been observed.

# 4.2 Test procedures and evaluation of corrosion protection systems

Hilti operates a corrosion laboratory and several test stands where items are subjected to weathering under various climatic conditions. Regular laboratory tests ensure the consistently high quality of well-proven corrosion protection solutions. Descriptions of products often contain references to the laboratory tests carried out. The most important of these are described below.



**The salt spray test**

A standardized test for the evaluation of the corrosion protection offered by various coatings. The procedure followed by the tests is laid down in the ASTM B117 and DIN EN ISO 9227 standards. The items to be evaluated are placed in a test chamber in which they are sprayed constantly with a salt solution (usually sodium chloride). The duration of the test depends on the type and thickness of the coating on the item and the coating's corrosion resistance, and may vary between 6 hours and more than 1000 hours. Coatings with a high corrosion resistance require a longer test duration.

**Kesternich test and alternating humidity test**

„Kesternich test" is the name given to a corrosion resistance test in which specimens are exposed to sulfur dioxide in an atmosphere of condensing humidity. This test was developed in 1951 by Wilhelm Kesternich in order to simulate the damaging effect of acid rain and can be used for coatings as well as base materials. The test method is laid down in various standards (DIN EN ISO 6988, DIN 50018). The test specimens are placed in a test chamber where they are exposed to warm, humid air in conjunction with a defined quantity of sulfur dioxide. The test is conducted in 24-hour cycles. The alternating humidity test (ISO 6270) is carried out in a similar manner but without the addition of sulfur dioxide.

## Corrosion protection systems used by Hilti for screws.

Hilti currently offers three different corrosion protection solutions which are adapted according to how the products are to be used and the applicable ambient conditions:

**Galvanic zinc plated (electrogalvanized) carbon steel**

The thickness of the zinc layer is between 4 and 15 µm, depending on the type of screw. The steel is protected from corrosion by sacrificial corrosion of the zinc, which is a base metal (i.e. not a noble metal). The zinc layer dissolves during the course of this protective procedure. The period of time until the steel begins to rust is thus defined by the rate at which the zinc corrodes.

**Duplex-coated carbon steel**

A duplex coating system is a corrosion protection system consisting of galvanizing (see above) in combination with other coatings. The galvanizing and the additional coating work together as a protective system. The coating protects the zinc layer from the effects of the atmosphere and chemical influences, thereby reducing the rate of corrosion. This increases the life of the screw, making its use possible in corrosive atmospheres.

**A2 stainless steel**

A2 stainless steel is an austenitic, acid-resistant Cr-Ni steel with a low carbon content. Its high chromium content leads to formation of an oxide layer which provides a high level of corrosion protection. In situations where the oxide layer is destroyed  it usually reforms if oxygen and moisture are present.

## 4.3 Selecting the right corrosion protection for anchors, powder-actuated fasteners and screws

If a fastening is to be perfectly satisfactory and reliable for its entire service life, all surrounding conditions must be ascertained before a suitable fastener can be selected.

The following table provides a general guideline for commonly accepted applications for fastening elements with various corrosion protection in typical atmospheric environments and depending on the fastened material (see notes).



### Screws

| | Screws | S-MS Z<br>S-MD Z<br>S-MP Z | S-CD C<br>S-IT C | S-AD S<br>S-MS S<br>S-MD S<br>S-CD S | S-AD SS<br>S-MD SS<br>S-CD SS |
|---|---|---|---|---|---|
| | **Coating/material** | **C-Steel galvanic zinc plated** | **C-Steel duplex coated** | **Stainless steel A2** | **Stainless steel A4** |
| **Environmental conditions** | **Fastened part** | | | | |
| Dry indoor | Steel (zinc-coated, painted), aluminium, stainless steel | ■ | ■ | ■ | ■ |
| Indoor with temporary condensation | Steel (zinc-coated, painted), aluminium | – | ■ | ■ | ■ |
| | Stainless steel | | – | | |
| Outdoor with low pollution | Steel (zinc-coated, painted), aluminium | – | □ | ■ | ■ |
| | Stainless steel | | – | | |
| Outdoor with moderate concentration of pollutants (1-10km) | Steel (zinc-coated, painted), aluminium | – | □ | ■ | ■ |
| | Stainless steel | | – | | |
| Coastal areas (0-1km) | Steel (zinc-coated, painted), aluminium, stainless steel | – | – | – | ■ |
| Outdoor, areas with heavy industrial pollution | Steel (zinc-coated, painted), aluminium, stainless steel | – | – | – | ■ |
| Close proximity to roads | Steel (zinc-coated, painted), aluminium, stainless steel | – | – | – | ■ |
| Special applications | Steel (zinc-coated, painted), aluminium, stainless steel | – | – | – | – |

■ = expected lifetime of fasteners made from this material is typically satisfactory in the specified environment based on the typically expected lifetime of a building. The assumed service life in ETA approvals for screw fasteners is 25 years.

□ = a decrease in the expected lifetime of non-stainless fasteners in these atmospheres must be taken into account (≤ 25 years). Higher expected lifetime needs a specific assessment.

– = fasteners made from this material are not suitable in the specified environment. Exceptions need a specific assessment.

## 4.4 Environment categories

Applications can be classified into various environmental categories, by taking the following main factors into account:

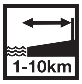
### Indoor applications

**Dry indoor environments**
(heated or air-conditioned areas) without condensation, e.g. office buildings, schools

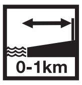
**Indoor environments with temporary condensation**
(unheated areas without pollutants), e.g. storage sheds

### Outdoor applications

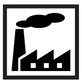
**Outdoor, rural or urban environment with low pollution**
Large distance (> 10 km) from the sea



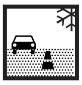

**Outdoor, rural or urban environment with moderate concentration of pollutants** and/or salt from sea water Distance from the sea 1-10 km




**Coastal areas**
Distance from the sea < 1 km



**Outdoor, areas with heavy industrial pollution**
Close to plants < 1km (e.g. petrochemical, coal industry)



**Close proximity to roadways** treated with de-icing salts,
Distance from roadways < 10 m

### Special applications

**Special applications**
Areas with special corrosive conditions, e.g. road tunnels with de-icing salt, indoor swimming pools, special applications in the chemical industry (exceptions possible)

**Important notes:**

The ultimate decision on the required corrosion protection must be made by the customer. Hilti accepts no responsibility regarding the suitability of a product for a specific application, even if informed of the application conditions.
The tables are based on an average service life for typical applications.
For metallic coatings, e.g. zinc layer systems, the end of lifetime is the point at which red rust is visible over a large fraction of the product and widespread structural deterioration can occur – the initial onset of rust may occur sooner.
National or international codes, standards or regulations, customer and/or industry specific guidelines must be independently considered and evaluated.
These guidelines apply to atmospheric corrosion only. Special types of corrosion, such as crevice corrosion or hydrogen assisted cracking must be independently evaluated.

## 4.5 Material and Corrosion resistance data for steel/metal screws



| Screw | Materials and coatings | Corrosion resistance |
|---|---|---|
| S-MS 01 Z 4,8 x 20 | Case hardened carbon steel according to DIN EN 10084 and ASTM A510-03 Grade 1022<br><br>Tensile strength $f_{u,k}$ = 1000 N/mm²<br>Shear strength $\tau_{u,k}$ = 600 N/mm²<br><br>≥ 8 µm galvanized as per ISO 4042 | ≥ 48 Std. Salt spray test w/o red rust on the screw head according to EN ISO 9227 |
| S-MD 01 Z 4,2 x L | | |
| S-MD 01 Z/LZ 4,8 x L | | |
| S-MD 01 Z 5,5 x L | | |
| S-MD 01 Z 6,3 x L | | |
| S-MD 03 Z 4,8 x L | | |
| S-MD 03 Z 5,5 x L | | |
| S-MD 03 Z 6,3 x L | | |
| S-MD 05 GZ 5,5 x L | | |
| S-MDU 21 Z 6,3 x 22 | | |
| S-MD 21 Z 5,5 x 25 | | |
| S-MD 23 Z 5,5 x 22 | | |
| S-MD 23 Z 6,3 x L | | |
| S-MD 25 GZ 5,5 x 40 | | |
| S-MS 41 Z 4,8 x 20 | | |
| S-MS 51 Z 4,8 x 20 | | |
| S-MD 51 Z 4,2 x L | | |
| S-MD 51 Z 4,8 x L | | |
| S-MD 51 Z 5,5 x L | | |
| S-MD 51 Z 6,3 x L | | |
| S-MD 53 Z 4,8 x L | | |
| S-MD 53 Z 5,5 x L | | |
| S-MD 53 Z 6,3 x L | | |
| S-MD 55 GZ 5,5 x L | | |
| S-MS 01 S 4,8 x 20 | Stainless steel (1.4301 / A2) – EN 10088<br><br>Tensile strength $f_{u,k}$ = 800 N/mm²<br>Tensile strength $\tau_{u,k}$ = 450 N/mm² | ≥ 20 cycles Kesternich test according to EN ISO 6988 |
| S-MD 01 S 4,8 x L | | |
| S-MD 01 LS 5,5 x L | | |
| S-MD 03 S 5,5 x L | | |
| S-MD 05 S 5,5 x L | | |
| S-MS 41 S 4,8 x L | | |
| S-MS 51 S 4,8 x L | | |
| S-MD 51 S 4,8 x L | | |
| S-MD 51 S 5,5 x L | | |
| S-MD 61 S 5,5 x L | | |
| S-MD 51 LS 5,5 x L | | |
| S-MD 61 LS 5,5 x L | | |
| S-MD 71 LS 5,5 x L | | |
| S-MD 43 S 5,5 x L | | |
| S-MD 53 S 5,5 x L | | |
| S-MD 63 S 5,5 x L | | |
| S-MD 73 S 5,5 x L | | |
| S-MD 53 S 6,3 x L | | |
| S-MD 63 S 6,3 x L | | |
| S-MD 73 S 6,3 x L | | |
| S-MD 55 S 5,5 x L | | |
| S-MD 65 S 5,5 x L | | |
| S-MD 75 S 5,5 x L | | |

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| Screw | Materials and coatings | Corrosion resistance |
|---|---|---|
| S-MD 01 PS 4,8 x L | Stainless steel (1.4567 / A2L) – EN 10088<br><br>Tensile strength $f_{u,k}$ = 650 N/mm² Shear strength $\tau_{u,k}$ = 400 N/mm² | ≥ 20 cycles Kesternich test according to EN ISO 6988 |
| S-MD 01 PS 5,5 x L | | |
| S-MD 03 PS 5,5 x L | | |
| S-MD 05 PS 5,5 x L | | |
| S-MD 31 PS 4,8 x L | | |
| S-MD 31 PS 5,5 x L | | |
| S-MD 33 PS 5,5 x L | | |
| S-MD 35 PS 5,5 x L | | |
| S-CDW 51 C 6,5 x L | Carbonitride hardened Duplex Coated<br><br>Tensile strength $f_{u,k}$ = 1000 N/mm² Shear strength $\tau_{u,k}$ = 600 N/mm² | ≥ 1000 h Salt spray test w/o red rust on the screw head according to EN ISO 9227<br><br>≥ 15 cycles Kesternich test according to EN ISO 6988 |
| S-CDW 61 C 6,5 x L | | |
| S-CD 53 C 5,5 x L | | |
| S-CD 63 C 5,5 x L | | |
| S-CD 73 C 5,5 x L | | |
| S-CD 55 C 5,5 x L | | |
| S-CD 65 C 5,5 x L | | |
| S-CD 75 C 5,5 x L | | |
| S-CDW 51 S 6,5 x L | Stainless steel (1.4301 / A2) – EN 10088<br><br>Tensile strength $f_{u,k}$ = 800 N/mm² Shear strength $\tau_{u,k}$ = 450 N/mm² | ≥ 20 cycles Kesternich test according to EN ISO 6988 |
| S-CDW 61 S 6,5 x L | | |
| S-CDW 71 S 6,5 x L | | |
| S-CD 53 S 5,5 x L | | |
| S-CD 63 S 5,5 x L | | |
| S-CD 73 S 5,5 x L | | |
| S-CD 55 S 5,5 x L | | |
| S-CD 65 S 5,5 x L | | |
| S-CD 75 S 5,5 x L | | |
| S-MP 53 Z 6,5 x L | Case hardened carbon steel according to DIN EN 10084 and ASTM A510-03 Grade 1022<br><br>Tensile strength $f_{u,k}$ = 1000 N/mm² Shear strength $\tau_{u,k}$ = 600 N/mm² | ≥ 48 h Salt spray test w/o red rust on the screw head according to EN ISO 9227 |
| S-MP 52 Z 6,3 x L | | |
| S-MP 63 S 6,5 x L | Stainless Steel (1.4301) – EN 10269<br><br>Tensile strength $f_{u,k}$ = 800 N/mm² Shear strength $\tau_{u,k}$ = 450 N/mm² | ≥ 20 cycles Kesternich test according to EN ISO 6988 |
| S-MP 63 S 6,5 x L | | |
| S-MP 63 S 6,5 x L | | |
| S-MP 52 S 6,3 x L | | |
| S-MP 62 S 6,3 x L | | |
| S-MP 72 S 6,3 x L | | |
| S-MP 54 S 6,3 x L | | |
| S-MP 64 S 6,3 x L | | |
| S-MP 74 S 6,3 x L | | |
| S-WD 11 C 3,8 x L | Case hardened carbon steel according to DIN EN 10084 and ASTM A510-03<br><br>Tensile strength $f_{u,k}$ = 1000 N/mm² Shear strength $\tau_{u,k}$ = 600 N/mm² Duplex Coated | ≥ 48 h Salt spray test w/o red rust on the screw head according to EN ISO 9227 |
| S-WD 11 C 4,2 x L | | |
| S-WD 13 C 4,8 x L | | |
| S-WD 13 C 5,5 x L | | |
| S-WD 13 C 6,3x L | | |
| S-WD 15 C 5.5 x L | | |
| S-IT 01C 4,8 x L | C-Stahl, case hardend, Duplex Coated | ≥ 15 cycles Kesternich test according to EN ISO 6988 |
| S-IT 01C 6,3 x L | | |
| S-IDP 4,8 C / 40 x L | | |
| S-IDP 4,8 C / 8040 x L | | |
| S-IDP 4,8 C / 50 x L | | |
| S-IDP 6,7 C / 40 x L | | |
| S-IDP 6,7 C / 8040 x L | | |