
HILTI
ATMOSPHERIC CORROSION OF FASTENINGS AND INSTALLATION SYSTEMS.
Hilti. Outperform. Outlast.
HILTI

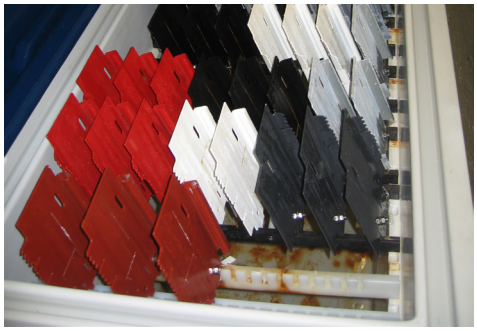
Lasting and reliable.
Fastening and installation systems for demanding environments.

It takes roughly one fifth of the world's annual steel production to replace parts damaged by corrosion. While this amounts to a considerable economic loss, a greater concern is the safety risks, where corrosion can lead to significant impairment to the functionality of the fastening systems of the structural elements.

Corrosion protection is the principle measure to mitigate these risks. Corrosion Protection is the principle measure to mitigate these risks. Active corrosion protection comprises the measures that directly influence the corrosion reaction, e.g. galvanic separation, resistant materials, or cathodic protection. Passive Corrosion Protection prevents or at least decelerates corrosion through the isolation of the metal material from the corrosive agent by the application of metallic or non-metallic protective layers of coating.

For fastening and installation systems, such as post-installed anchors, powder actuated fixings, screws or channel supports, the use of resistant material or a protective coating is considered to be the safest and most economical corrosion protection method.

This brochure presents a general guideline for selecting a suitable corrosion protection method for fastening systems in commonly accepted applications for given environmental conditions.



Tested protection

Hilti conducts comprehensive laboratory and field based tests to assess the corrosion resistance of its products. Thanks to the in-house research and close collaboration with renowned universities and laboratories, Hilti can offer the right solutions with the suitable corrosion protection for a wide variety of environmental conditions.

Corrosion is expected to occur when the material, the protection or the structural design of a metallic component do not match the requirements imposed by the surrounding environment.

To evaluate the risk of corrosion, it is essential to assess the interaction between environmental conditions, material properties, material combinations and design characteristics.

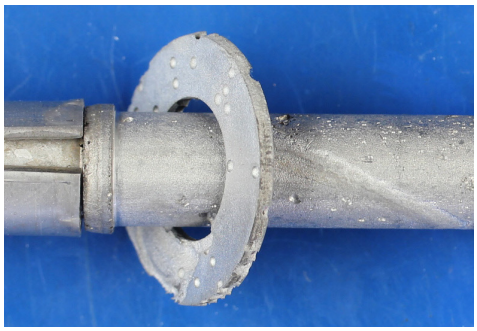
To understand this interaction, you would need to consider the following influencing factors to atmospheric corrosion:

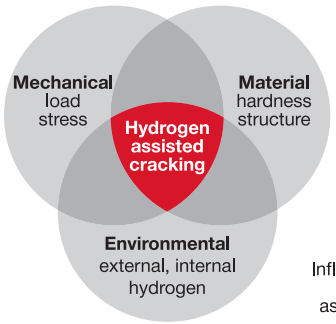
- **Humidity**: is a requirement for all atmospheric corrosion reactions
- **Temperature:** The higher the temperatures, the higher rate of corrosive attack
- **Salt:** Salt-laden air near the sea coast and the salt used for de-icing in winter accelerate corrosion
- **Industrial pollution:** the high content of sulphur dioxide accelerates corrosive reactions
- **Bimetallic corrosion:** is caused by the contact of dissimilar metals (where one metal is less noble than the other)

Special applications demand special attention to the corrosion protection of the metallic components. This could be for example the conditions prevailing in road tunnels, buildings with indoor swimming pools, or in chemical plants. For such specific applications, it is advisable to consult a specialist. Your local, qualified Hilti engineers will be pleased to provide you with technical support on your application.

“On real jobsites, corrosion resistance is one of the most underestimated aspects when it comes to fastening products. Knowing the basic facts can help the customer to find a suitable and sustainable solution.”

Alexander Tomandl,
Hilti Corporate Research and Technology





Influencing factors for hydrogen assisted cracking

Zinc-coated carbon steel

Zinc coated steel typically corrodes uniformly. Steel corrosion starts when the zinc protection is mostly consumed.

On duplex-coated products the zinc is further protected by an organic or inorganic coating.

Stainless steel

Stainless steel has the ability to form very thin but dense oxide layers to protect the surface against corrosion. However, in highly corrosive environments, stainless steel may suffer from pitting corrosion, which is a localised attack that significantly decreases the lifetime of stainless steel.

Hydrogen assisted cracking

This is the process by which high-strength or hardened carbon steel under stress become brittle and suddenly fails. This type of steel failure results when hydrogen is induced to the steel material during production or by corrosion attack.

To maintain the service life of fasteners, e.g. to prevent hydrogen assisted cracking, the application conditions for each product given in Hilti’s published literature must be followed.

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

For fasteners to be perfectly satisfactory and reliable for their entire service life, all the influencing factors must be identified before a suitable fastener can be selected.

The following table provides a general guideline for the most common applications of fastening elements. The appropriate corrosion protection for each fastening material is shown based on the typical atmospheric environments (see notes).

Anchors, powder-actuated fasteners and screws	product examples							
	Anchors		HSA, HUS, HST, HIT-V	HUS-HF	HSA-F, HIT-V-F	HSA-R2	HUS-HR, HSA-R HST-R, HIT-V-R HIT-Z-R	HST-HCR
	Screws	S-DS01, S-DD01	S-MD Z, S-MP Z	S-CD C, S-IT C		S-MD S, S-CD S	S-MD SS, S-CD SS	
	Powder-actuated fasteners		X-ENP [1], X-U X-GHP, X-GN	X-FCM-M			X-BT, X-CR, X-FCM-R	On demand
	Coating/ material	Carbon steel without corrosion protection	Electro-galvanized	Duplex-coated carbon steel	HDG/ sherardized 45-50 µm	A2 AISI 304	A4 AISI 316	HCR, e.g. 1.4529

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	–	–	□ [2]	□ [2]	■ [2]	■	■
	Stainless steel			–	–			
Outdoor with moderate concentration of pollutants (1-10km)	Steel (zinc-coated, painted), aluminium	–	–	□ [2]	□ [2]	■ [2]	■	■
	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		**Consult experts**						■

■ = expected lifetime of anchors 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 powder-actuated and screw fasteners is 25 years, and for concrete anchors it is 50 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.

[1] Outdoor exposure for up to 6 months during construction is permissible for high-strength electro-galvanized siding and decking fasteners such as the X-ENP (see instructions for use for details).

[2] From a technical point of view, HDG/duplex coatings and A2/304 material are suitable for outdoor environments with certain lifetime and application restrictions. This is based on long-term experience with these materials as reflected e.g. in the corrosion rates for Zn given in the ISO 9224:2012 (corrosivity categories, C-classes), the selection table for stainless steel grades given in the national technical approval issued by the DIBt Z.30.3-6 (April 2009) or the ICC-ES evaluation reports for our KB-TZ anchors for North America (e.g. ESR-1917, May 2013). The use of those materials in outdoor environments however is currently not covered by the European Technical Approval (ETA) of anchors, where it is stated that anchors made of galvanized carbon steel or stainless steel grade A2 may only be used in structures subject to dry indoor conditions, based on an assumed working life of the anchor of 50 years.

Hilti anchor channel (HAC) is available in hot-dip galvanized according to E ISO 1460:2009-10. HBC special bolts are available in electro-galvanized, hot-dip galvanized and A4 versions. HAC may be used together with HBC in any material combination in dry indoor environments according to ETA-11/0006 (28th February 2012). When HBC are hot-dip galvanized, they may be also used in indoor environments with temporary condensation

Selecting the right corrosion protection for wood nails

Wood can be corrosive due to the organic acids it contains. Besides atmospheric conditions, corrosive attack by the wood itself must also be considered when selecting the type of corrosion protection for wood nails.

The following table provides a general guideline for common applications in which wood nails are used in typical atmospheric environments for wood-to-wood connections.

Wood nails Hilti GX-WF	**Service Classes** in accordance with EN 1995 (Eurocode 5)	Service class 1	Service class 2	Service class 3		
	Coating/ material	Carbon steel without corrosion protection	Electro-galvanized	HDG 45-50 µm	A2[1] AISI 304	A4 AISI 316
Environmental conditions		lifetime in years				
Dry indoor		20 to 50	up to 50	up to 100	■	■
Indoor with temporary condensation		–	10 to 50	60 to 100	■	■
Outdoor with low pollution		–	5 to 20	40 to 100	■	■
Outdoor with moderate concentration of pollutants (1-10km)		–	2 to 10	20 to 40	■	■
Coastal areas (0-1km)		–	less than 5	10 to 30	–	■
Outdoor, areas with heavy industrial pollution		–	less than 5	10 to 30	–	■
Close proximity to roads		–	–	–	–	■
Special applications		**Consult experts**				

The table above provides typically assumed service life estimations based on corrosion considerations. Other factors determining the service life of fasteners must be evaluated separately.

■ = expected lifetime of nails made from this material is typically satisfactory in the specified environment based on the typically expected lifetime of a building.

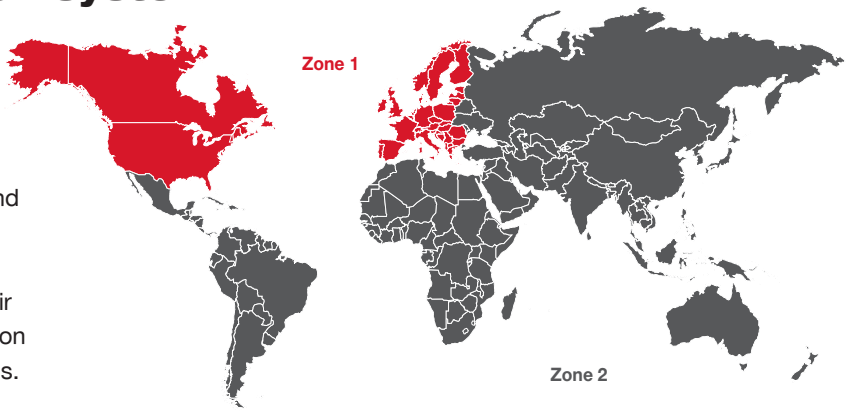
– = nails made from this material are not suitable for the environment or the typical lifetime of a building is not achieved.

[1] For nails made of A2 material, discoloration of nail heads can occur before the service life in the table above is reached. To avoid this, use A4 material.

Certain wood species including, but not limited to, oak, Douglas fir or western red cedar, require the use of stainless steel nails, independent of Service Class and environmental conditions.
The use of certain wood treatments including, but not limited to, fire retardants or preservatives can change the chemical composition of the wood and may require the use of stainless steel nails, independent of Service Class and environmental conditions.

Selecting the right installation system

The typical lifetime rating of the coatings depends on the corrosivity of the atmosphere which differs significantly throughout the world. For a practical approach, Hilti differentiates between two zones. Zone 1 is countries where air quality and climate data prove the absence of polluted and tropical environments. Today these countries are European Countries and North America. Zone 2 countries are those outside Zone 1, which either lack the availability of reliable air quality data or the data proves the presence of heavy pollution (especially in urban zones) and/or hot tropical climate regions.



The typical lifetime expectancy of Hilti installation systems is shown in the below table. For environmental conditions where the lifetime for Zone 1 and Zone 2 differ, the number of years for Zone 1 are show below those of Zone 2 between parentheses.

Installation systems 	**Channel system**	MM + MQ + MC system	MQ-F MC-OC system	MQ ASTM MC-OC-A system	MI HDG system	MQ system stainless A2/ AISI 304	MQ system stainless A4/ AISI 316
	Pipe fastening	Indoor pipe rings[1]	HDG pipe rings[2]		MI-UB, MI-PS	Stainless pipe rings[3]	
Environmental conditions		lifetime in years (zone 2)					
Dry indoor		70 to 100	up to 100	up to 100	up to 100	■	■
Indoor with temporary condensation		25 to 70	40 to 100	60 to 100	60 to 100	■	■
Outdoor with low pollution		2 to 10 (4 to 10)	15 to 60 (25 to 90)	25 to 100 (40 to 100)	25 to 100 (40 to 100)	■	■
1-10km Outdoor with moderate concentration of pollutants		–	10 to 40 (20 to 40)	20 to 50 (25 to 50)	20 to 50 (25 to 50)	■	■
0-1km Coastal areas		–	7 to 20 (10 to 20)	10 to 40 (15 to 40)	10 to 40 (15 to 40)	–	■
Outdoor, areas with heavy industrial pollution		–	5 to 20 (10 to 20)	10 to 40 (15 to 40)	10 to 40 (15 to 40)	–	■
Close proximity to roads		–	–	–	–	–	■
Special applications		**Consult experts**					

■ = expected lifetime of an installation system made from this material is typically satisfactory in the specified environment based on the typically expected lifetime of a building.

1) Indoor pipe rings: MP-H, MP-HI, MP-LH, MP-LHI, MPN, MP-MI, MP-MIS, MP-M, MP-MXI, MP-MX, MP-PI, SDC, MP-SP

2) HDG pipe rings: MP-MI-F, MP-M-F, MP-MXI-F, MP-MX-F

3) Stainless pipe rings: MP-SRN, MP-SRNI, MP-MR, MP-MRI, MP-MRXI

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.

The tables published in this brochure describe only a general guideline for commonly accepted applications in typical atmospheric environments.

Suitability for a specific application can be significantly affected by localised conditions, including but not limited to:

- Elevated temperatures and humidity
- High levels of airborne pollutants
- Direct contact with corrosive products, such as found in some types of chemically-treated wood, waste water, concrete additives, cleaning agents, etc.
- Direct contact to soil, stagnant water
- Electrical current
- Contact with dissimilar metals
- Confined areas, e.g. crevices
- Physical damage or wear
- Extreme corrosion due to combined effects of different influencing factors
- Enrichment of pollutants on the product

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