

Basics for cylinders installed in corrosive environments

Anti-corrosion measures and protective treatments

The term "corrosive environments" for hydraulic systems refers to environmental conditions in which following situations can separately or simultaneously exist. They represent a potential cause of heavy corrosion for all components installed in the system.

- The surrounding atmosphere is so aggressive as to chemically attack the metal surfaces
- The operating fluid contains a high percentage of water to cause oxidation of the metal components in contact with the fluid itself

Corrosion is a natural process that converts metals into a chemically stable form such as oxide, hydroxide, or sulfide. It is the irreversible and progressive destruction of materials by chemical and/or electrochemical reaction with their environment.

It is the enemy of any metallic structure and component, being the very common cause of failure.

Atos has developed a complete line of stainless steel components specifically designed to withstand aggressive atmospheres, ensuring performance and reliability of systems operating with water-based fluids like those of oil-based hydraulics. (see tab. BW500)

1 AGGRESSIVE ATMOSPHERES

Hydraulic systems are often located in outdoor areas, exposed to rain and atmospheric agents, or in coastal and marine environments. Such critical installations can lead to severe corrosion of the external surfaces, with the consequent risk of breakdowns or in extreme cases structural collapses, which entail higher maintenance costs.

Coastal and marine environments are the worst corrosive conditions for metals because of the quantity of sodium chloride (salt) present in the water and then in the air. The marine atmosphere also includes installations where splashing and heavy sea spray are encountered. The equipment exposed to these splash zones are indeed subjected to the worst conditions of intermittent immersion with wet and dry cycling of the corrosive agent.

However, the above environments are not the only ones prone to accelerated corrosion.

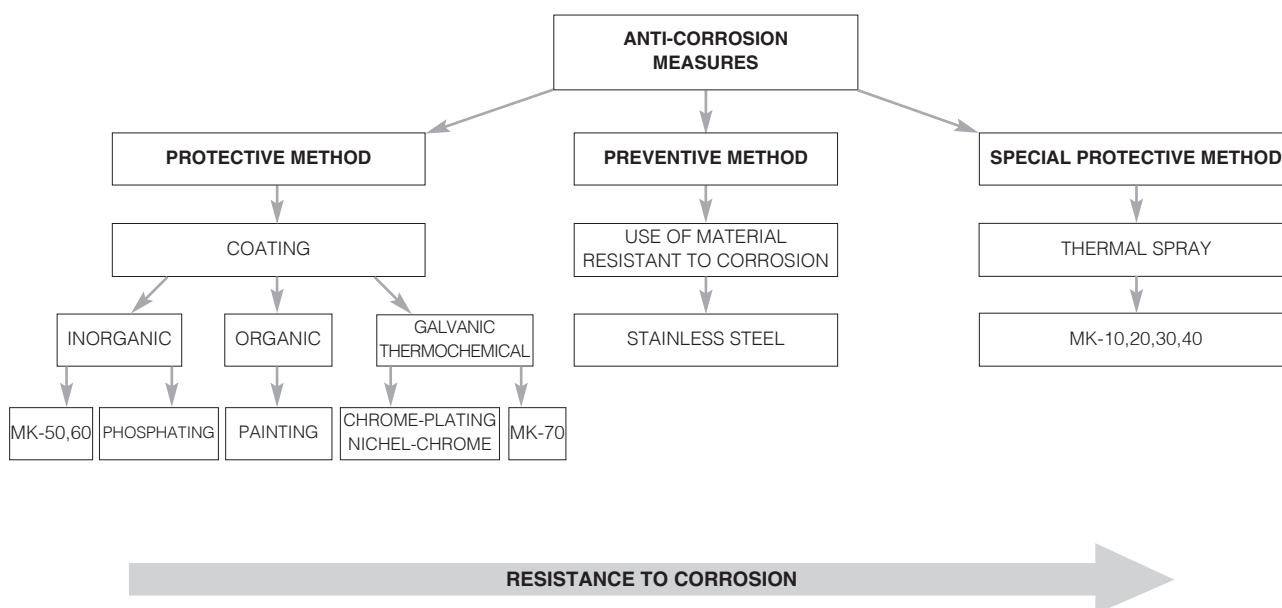
In highly industrial environments, contaminants in the air can contribute to corrosion. Emissions that come from factories, or power plants can potentially weaken the structure. Gases like sulfur and nitrogen oxide that are emitted into the atmosphere in industrial locations, return in forms of condensation, such as acidic dew or acid rain.

Industrial dust particles can be contaminated with harmful metal oxides, chlorides, sulfates, sulfuric acid, carbon, and carbon compounds. These particles when combined with oxygen, water, or high humidity environments can be highly corrosive.

2 CORROSION PREVENTION MEASURES

There are several methods to protect the components from corrosion. Among these we can mention **protective** methods and **preventive** methods.

They represent two different approaches, normally selected depending on working conditions of the components and the level of aggressiveness of the environment in which they will operate.



2.1 Protective, preventive and special protective methods

They are based on protective coatings applied on the surface of carbon steel materials. They offer a good surface protection to aggressive atmospheres but no protection of internal parts in case of water-based fluids. The protection is affected by potential scratches on the surface.

In the following we evidence:

PROTECTIVE METHODS:

- **PHOSPHATIZING** offers a medium resistance to corrosive environments; it is not indicated for strong aggressive environments like salty atmospheres. It is a good basic treatment for subsequent painting.
- **CHROME PLATING** is a galvanic process that deposits a layer of chromium onto a metal through electrolysis, improving its hardness and corrosion resistance.
- **NICKEL-CHROME** is a multi-layer coating system where one or more layers of nickel are covered by a thin layer of chrome. It is the gold standard treatment when seeking the best balance between a bright aesthetic and resistance to atmospheric agents
- **MK-70** is a thermochemical surface-hardening treatment consisting of nitrogen enrichment on the surface of a ferrous alloy (steel or cast iron) heated in an appropriate medium.
- **BLACK OXIDIZING** is a controlled oxidation treatment that colors the steel surface a deep black (or bluish), improving its aesthetic appearance and providing limited protection against corrosion.
- **PAINTING** is a widely adopted method to protect the surfaces from corrosion. For strong aggressive environments like marine, inorganic zinc paint and specific painting processes as per ISO 12944-5 are used.
- **MK-50** is a thin zinc and aluminum-based coating, ideal for threaded components where high dimensional precision and standard protection are required.
- **MK-60** is a high-thickness protective treatment for superior resistance to cyclic corrosion, suitable for components exposed to severe environmental stress.

PREVENTIVE METHODS:

- **STAINLESS STEEL** is a corrosion-resistant alloy that offers structural protection throughout the material, guaranteeing permanent resistance to oxidation without the use of supplementary surface treatments.

SPECIAL PROTECTIVE METHODS:

- **MK-10** is a high-density coating based on metal carbides, optimized to guarantee exceptional resistance to abrasive wear and erosion under severe operating conditions.
- **MK-20** is a high-performance multifunctional coating, formulated to offer a balanced protection between mechanical strength and chemical inertia in corrosive environments.
- **MK-30** is an advanced ceramic coating applied via thermal spray, designed to provide a high thermal barrier and excellent resistance to dielectric wear.
- **MK-40** is a technical coating with a controlled structure, optimized to improve sliding properties and corrosion resistance in

3 TYPES OF TREATMENTS AND RELATED APPLICATION SECTORS

The following table shows the type of surface treatment according to the application.

	Component	Treatment	Sector				
			Industrial		Marine and off-shore		
			Light duty	Heavy duty	Non-submerged	Splash zone	Submerged
Rod		Chrome plating	✓	✓			
		Nickel-chrome		✓	✓		
		MK-10		✓	✓	✓	
		MK-20			✓	✓	
		MK-30				✓	✓
		MK-40					✓
		MK-70		✓			
Rod bearing		Zinc phosphating	✓				
		Manganese phosphating	✓				
Trunnion mounting and carriage		MK-50		✓			
		MK-60		✓	✓		
		Black oxidizing	✓				

RESISTANCE TO CORROSION

- Light-duty industrial: refers to industries producing consumer goods.
- Heavy-duty industrial: refers to mechanical, metallurgical, and iron & steel industries.

4 SPECIFICATIONS TO VERIFY THE CORROSION RESISTANCE

ISO 9227 - the method recognized at European regulatory level, is the accelerated corrosion tests in a salt spray chamber according to UNI EN ISO 9227:2006 Corrosion tests in artificial atmospheres - Salt spray tests

This standard defines the requirements of the equipment and the procedure that must be used to perform the tests in neutral salt spray (NSS), salt-acetic fog (AASS) and cupro acetic salt spray (CASS), to evaluate the resistance to corrosion of metallic materials, with or without permanent or temporary anticorrosive protection.

The salt spray test it is not directly representative of the corrosion protection in real atmospheres, due to the high concentration of chloride and the absence of dry periods. However, this is a practical test, mainly used for the qualification of protection processes. It is a comparative method useful to verify the corrosion resistance of a certain material in comparison with others.

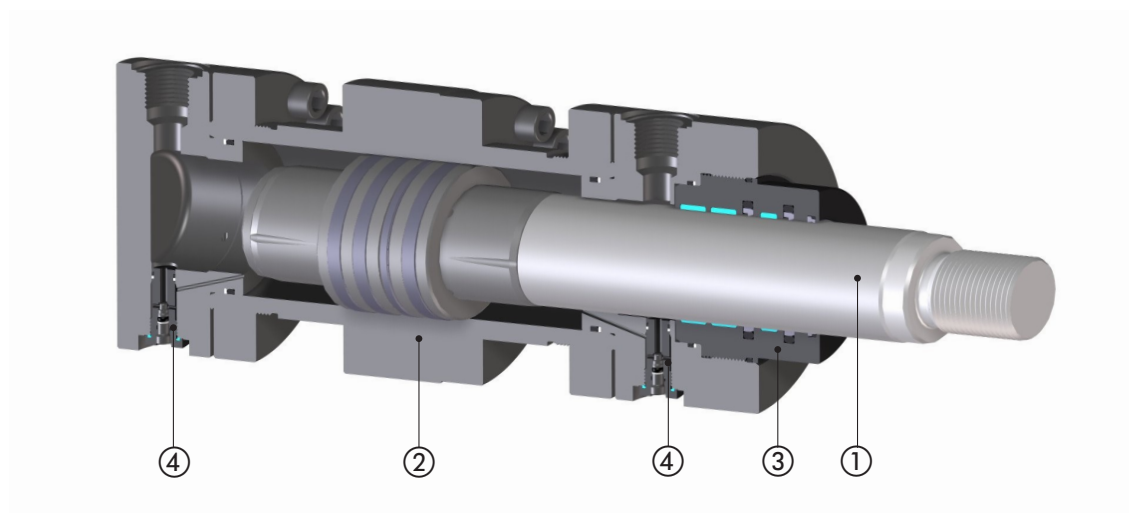
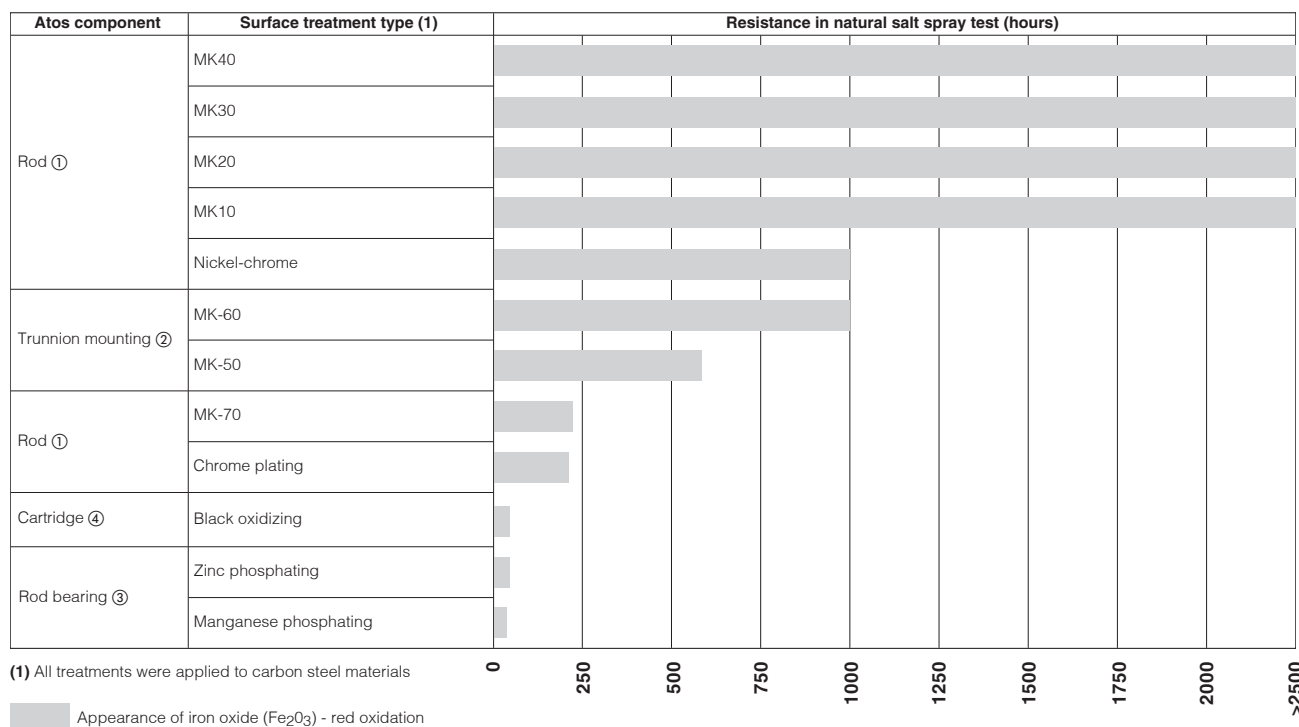
4.1 Resistance in NSS of carbon steel components with inorganic coatings

The resistance to corrosion is expressed in hours of performance in neutral salt spray (NSS according to UNI ISO 9227), before white and red oxidization appears on 5% of the total surface of the sample under test.

The white oxidization is the first step of corrosion. It evidences that the protective effect of the zinc passivation is ended, and the salt is going to attack the zinc layer. In this situation the steel material remains integer because it is still protected by the zinc layer.

Once the zinc layer is finished, the corrosion attacks the steel material and then there will be the appearance of red oxidization (red rust), which is the second type of corrosion that must be verified in the salt spray test.

The salt spray resistance of the main Atos components is shown in the following table.



4.2 Corrosion categories for organic coating (painting)

ISO 9223 - this standard establishes a classification system for the corrosiveness of atmospheric environments.

It defines the corrosivity classes of atmospheric environments, based on the corrosion rate detected on standardized metallic samples in one year of exposure.

The corrosion rates are classified in 6 different categories C1, C2, C3, C4, C5, CX calculated on the annual corrosion loss of metals like zinc, copper and carbon steel [$\mu\text{m}/\text{year}$] and it makes possible a rough identification of the corrosivity class based on the knowledge of the local environment.

The standard specifies the key factors in atmospheric corrosion of metals and alloys. These are made up of the combined effect of temperature and humidity and sulfur dioxide pollution and salinity carried by the air.

Classification based on measurement of corrosion rate for Zinc - data are provided for the first year of exposure to the specific environment

Atos cycles (1)	Duration of protection (3) ISO 12944-1	Salt spray test ISO 9227	Corrosion category ISO 9223	Corrosiveness	Corrosion rate for Zinc layer (m/year)	Typical outdoor environment
A	-	-	C1	Very low	<0,1	Dry or cold zone, atmospheric environment with low pollution
STD B	-	-	C2	Low	0,1÷0,7	Temperate zone, atmospheric environment with low pollution (SO ₂ < 12 $\mu\text{g}/\text{m}^3$) Dry or cold zone, atmospheric environment with short
A A B	Short Medium Long	120 h 240 h 480 h	C3	Medium	0,7÷2,1	Temperate zone, atmospheric environment with medium pollution (SO ₂ : 12÷40 $\mu\text{g}/\text{m}^3$) or certain effect of chlorides, coastal areas
A B C	Short Medium Long	240 h 480 h 720 h	C4	High	2,1÷4,2	Temperate zone, atmospheric environment with high pollution (SO ₂ : 40÷80 $\mu\text{g}/\text{m}^3$) or substantial effect of chlorides, e.g. polluted urban areas, industrial areas, coastal areas without
C Int D (2),Ext E (2) Int D (2),Ext E (2)	Short Medium Long	480 h 720 h 1440 h	C5	Very high	4,2÷8,4	Temperate zone, atmospheric environment with very high pollution (SO ₂ : 80÷250 $\mu\text{g}/\text{m}^3$) and/or strong effect of chlorides, e.g. industrial areas, coastal and offshore areas with salt spray.
Contact technical office	Contact technical office	Contact technical office	CX	Extremely high	>8,4	Subtropical and tropical zone, very humid period, atmospheric environment with very intense pollution (SO ₂ above 250 $\mu\text{g}/\text{m}^3$)

(1) Atos cycles provide protection levels equivalent to ISO 9227. Contact our technical office in case of certificate request.

(2) Sandblasting is strictly required, Ext: Outdoor environment Int: Indoor environment

(3) Short = 2-5 years
Medium = 5-15 years
Long = >15 years