



Anti-Corrosion - Technical Training

FERRO-PLAST SRL

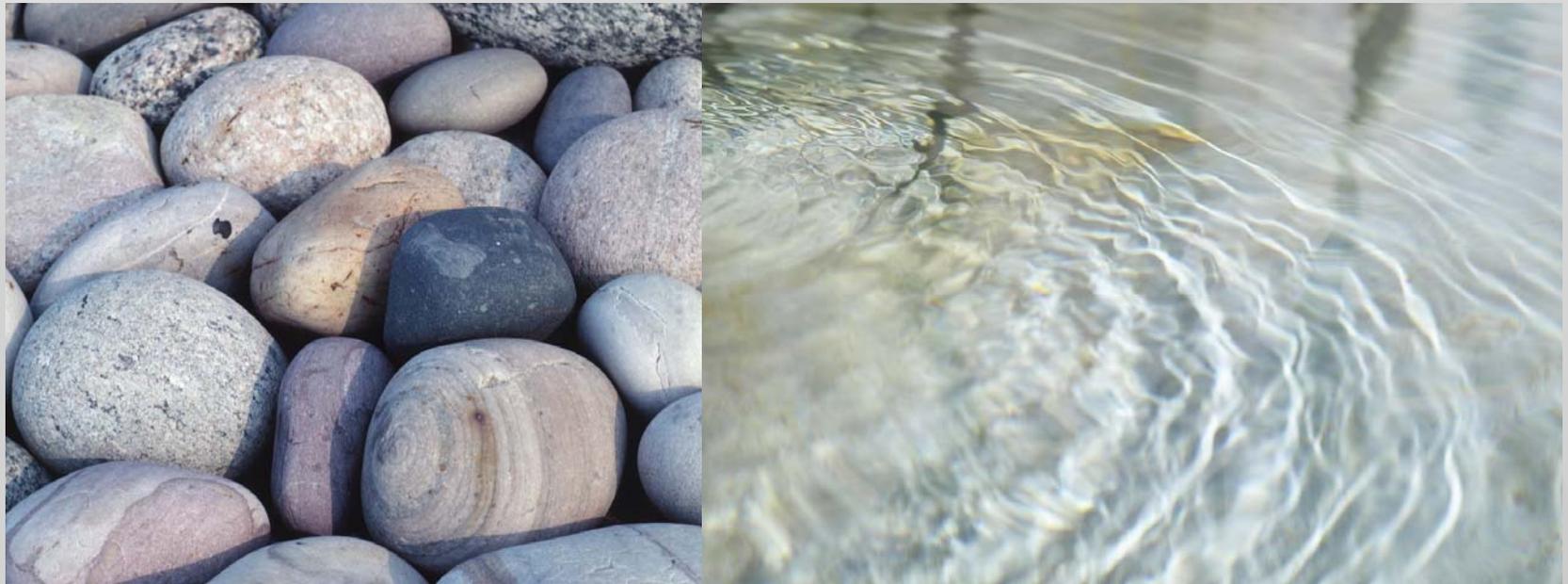
VIA GRANDI, 25 - 20090 VIMODRONE (MILAN) - ITALY

Tel. +39 02 27409415 - Fax +39 02 27409420

info@ferroplast.com - www.ferroplast.com

Overview

1. Corrosion process
2. Behavior of different materials in environment
3. Basic corrosion prevention methods
4. Inhibitors of corrosion
5. Influence of surface treatment on packaging using VCI technology
6. Requirements when using VCI
7. MetPro technical support



Corrosion facts

Corrosion affects almost everything. Corrosion forms at different rates. Corrosion cannot be stopped. It can only be slowed down.



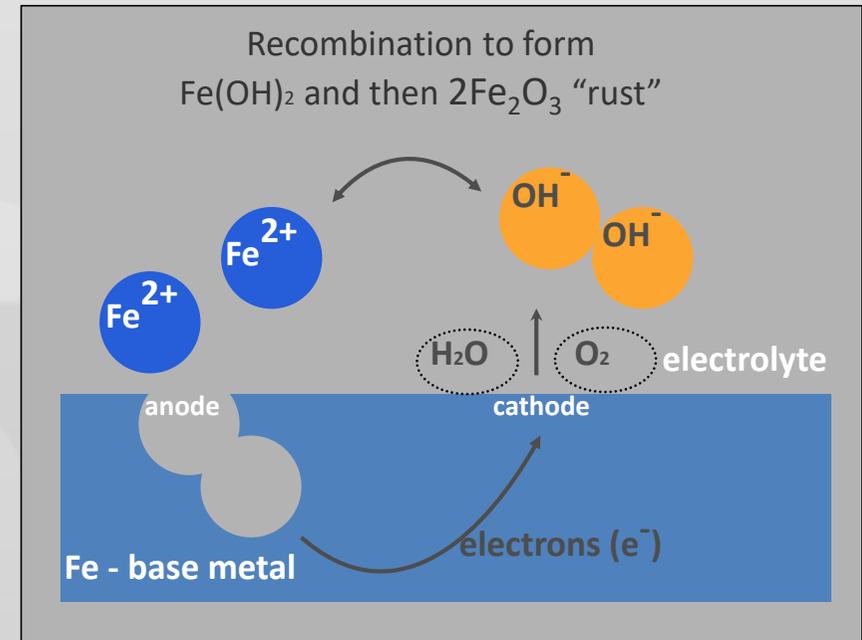
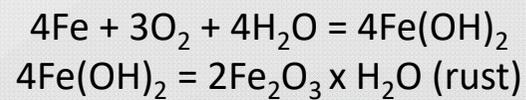
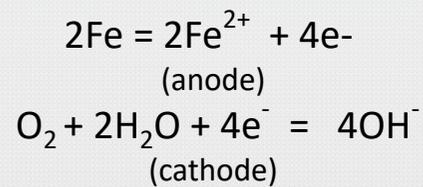
The natural and stable state of all metals is the ore state. That is the state all metals tend to return and we need to provide energy to get the metal from the ore state and keep it in the new form.

Regardless what we do, corrosion never stops and slowly consumes the mass of the metal depending on environmental conditions and type of metal we observe.



Corrosion process

Equation of Fe corrosion in normal environment:



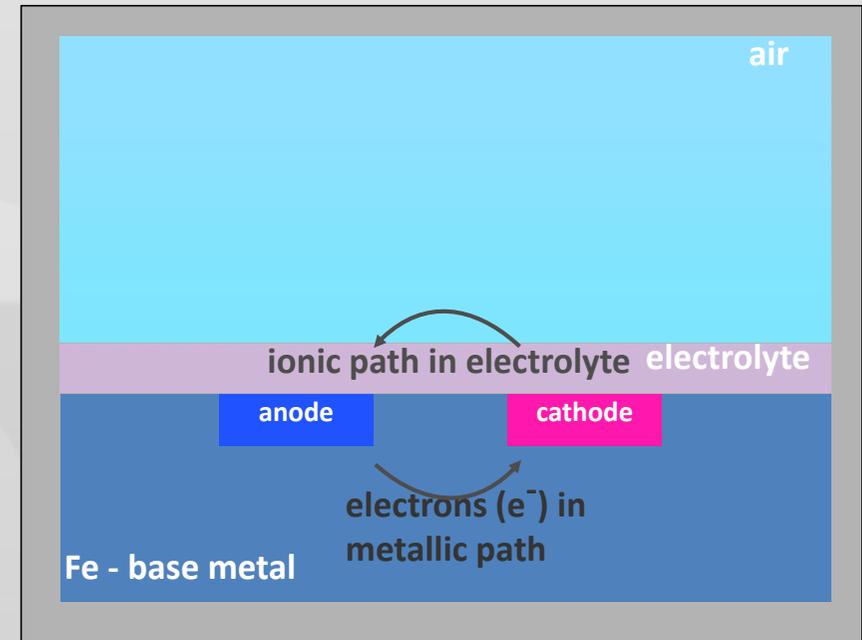
As seen on picture, corrosion process is chemical reaction depending on closed electrical circuit. On a single piece of metal surface we can always define 4 basic elements necessary for any corrosion process:

1. Anode
2. Cathode
3. Metallic path for electron transportation
4. Electrolyte for ionic transportation

Corrosion process

Any partial interruption of this closed circuit will cause the passivation effect and will slow down the corrosion. Investigation of individual elements will show us, that:

1. **Anodes** and **Cathodes** - are always present. They are defined by differences in level of electric charge which can be caused by shape, amount of impurities, carbon, noble metal atoms etc. In case of alloy grains of different metals can act this way. The surface of those can be changed however and its ratio is actively used in e.g. galvanic coating.
2. **Metallic path** for electron transportation - is always present. As we are talking about one piece of metal, there is no way to eliminate this element.
3. **Electrolyte** for ionic transportation - is the only element we can affect. Due to this either separation of electrolyte from surface (e.g. oils) or limitation of humidity (e.g. desiccants) were used for a long time. We can also influence the ionic quantity, pH and speed of chemical processes with more sophisticated methods.

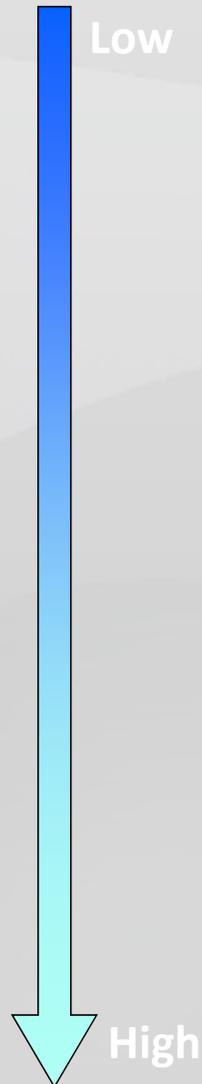


Note: Corrosion as all chemical processes is very temperature dependent.

Moreover due to normal nature of the electrolyte as water solution with temperatures below freezing point corrosion slows down to unnoticeable level.

Activity of metals in environment

Gold (AU) Platinum (PT) Silver
 (AG) Copper
 (CU) Cadmium (CD) Iron
 (FE) Zinc (ZN) Aluminum
 (AL) Magnesium
 (MG) Sodium
 (NA) Lithium (LI)



Note: This table shows the order of electrical potentials of raw metals. For oxides of this metals in specific environment the order of those named would be different. It is e.g. well known, that oxide of aluminium is more stable in normal air conditions than the oxide of iron etc.

Basic rust prevention methods for short time storage and transportation

Prevention method for short time storage or transportation has to be effective for certain time period and has to have no influence on the use of product after the storage or transportation finishes. This denies paints, galvanic protection etc. as they are irreversible (or with huge difficulties).

1) **oils and waxes** - the old fashioned method, easy to use but difficult to remove before another product placement. Nowadays moreover quite complicated due to waste disposal after cleaning.

2) **desiccants** - very good rust prevention method when used correctly with either aluminium heat sealed bag or very dense polymer based material. Its disadvantage is absolute humidity it can absorb as well as sensitivity to leaks. Any damage to barrier film will destroy the protection of whole unit, that is why it is strongly required to pack all units to wooden boxes. Amount of desiccant has to be calculated according to time, location etc. of transportation.

3) **VCI - volatile corrosion inhibitors** - are chemical compounds which in several ways change the corrosion environment in closed space. Those components are released from base material which is normally LDPE film, paper or foam. They are very clean, environmental friendly and safe but they require specific conditions.

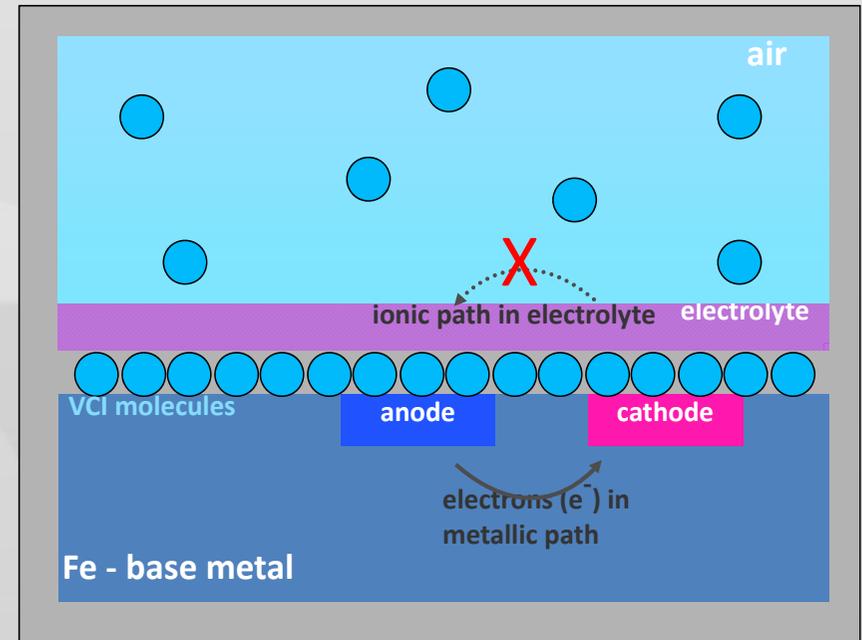


VCI (Volatile corrosion inhibitors)

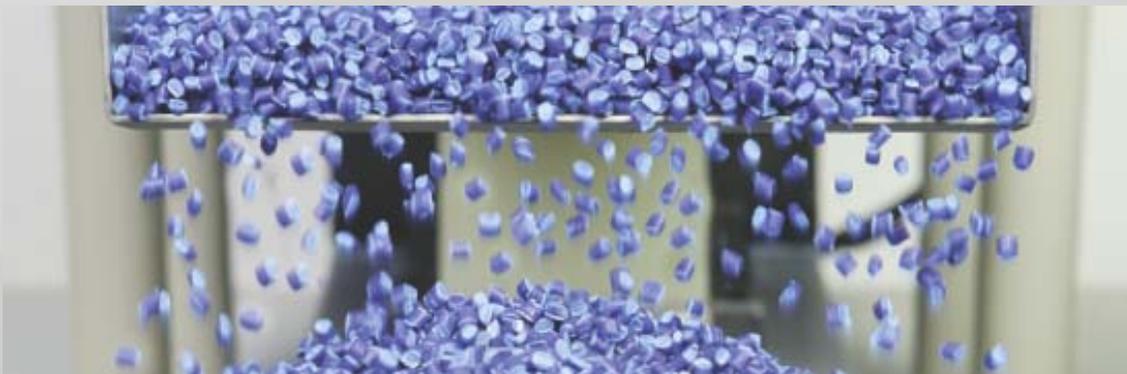
VCI molecules are released from the base material, which is normally also packaging material. They fill enclosed air space of packaging unit with its vapors and deposit on the surface of the material where they sit bonded with very weak OH^- bond.

Those molecules deposited on the surface create very thin (monomolecular) layer creating chemical barrier with specific influence (e.g. on pH, conductivity of electrolyte etc.)

Once the packaging is opened and the partial vapor pressure of VCI in air decreases, those VCI molecules bonded are free to move again and they are quickly released into open space. This is also the reason why metals protected with VCI are protected only when packaging is closed. Once taken out, those metals should be used as from the line.

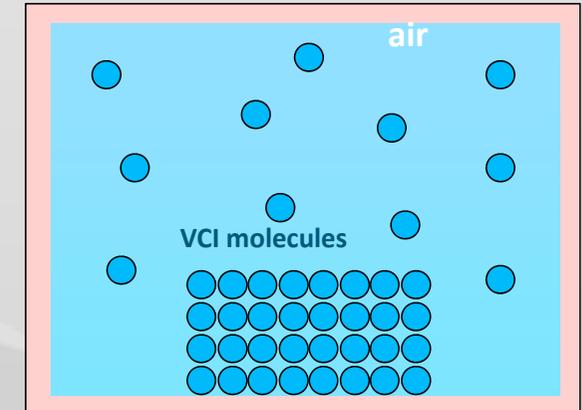
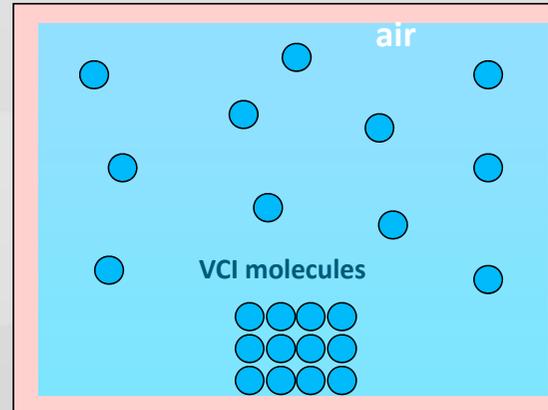


Note: As the VCI is bonded to metal surface with very thin bond, it is necessary to have clean and dry surface before any VCI application. Also time to saturate the space is necessary depending on size of the packaging unit.



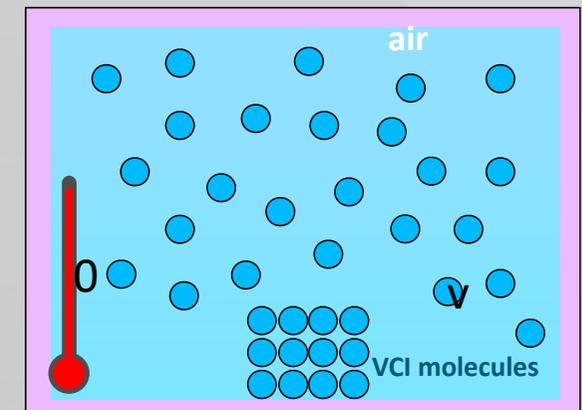
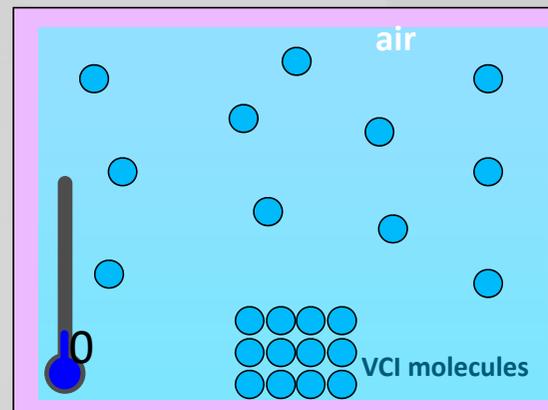
VCI temperature and concentration dependence

Quantity of VCI molecules in space can reach only certain level. Any spare molecules of VCI will therefore remain in base material until the level is not lower again e.g. due openings, holes, natural exchange of air through film etc. More VCI does not automatically mean more protection.



Note: In some cases more VCI in base material (film, foam etc.) can speed up the build up phase. Also the effectiveness of that film lasts longer, as there is more molecules to replenish the loss. That is why it may be recommended for thin films or packaging with technologically known holes etc.

In lower temperatures the corrosion rate is lower and also the absolute quantity of VCI molecules in enclosed space is smaller. With increasing temperature the partial vapor pressure increases so does the amount of VCI in space - this helps to protect faster in more difficult conditions.



VCI - conditions for packaging

Pack only clean and dry parts into enclosed space. VCI can be only effective, when they are able to reach the metal surface with no contamination from previous process (metalworking and cleaning fluids etc.)



More tight packaging means less VCI loss during the shipment. Holes can be fixed with tape with no influence on VCI effectivity.



Always use gloves when dealing with parts to be packed after final cleaning stage. Human sweat contains basic acids which can be very corrosive in certain conditions.

Temperatures of packed product, all packaging materials and environment should be the same. Large differences can cause condensation before the VCI saturates the internal space of packaging and create the protective layer on the surface.



Advantage of VCI packaging is its ability to pack group of products into one unit protected with e.g. single bag. Do not ever allow direct contact between organic materials (wood, cardboard, plywood etc.) and metal surface. Organic acids appearing when moisture ingress are of the most dangerous.



VCI - fingerprints

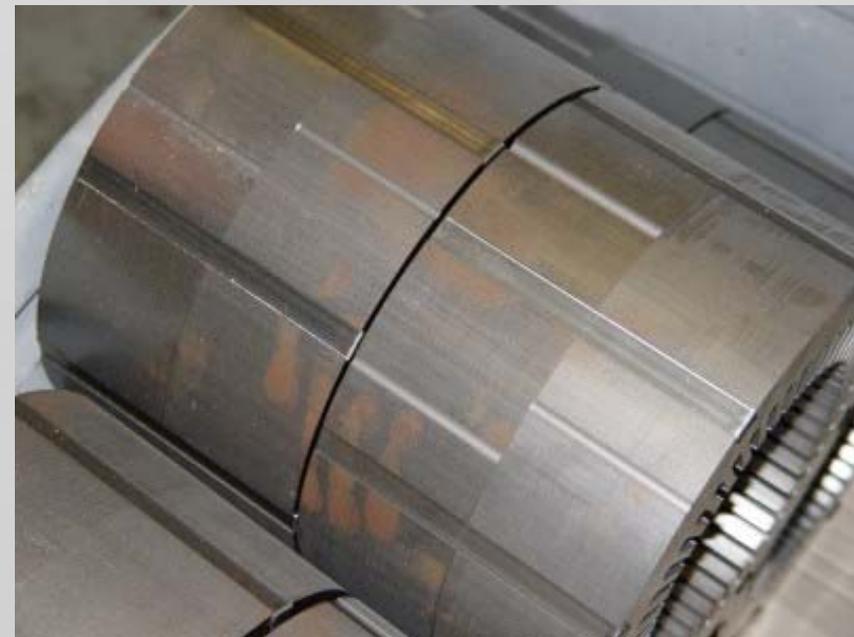
Always use gloves when dealing with parts to be packed after final cleaning stage. Human sweat contains basic acids which can be very corrosive in certain conditions.



Fingerprints are very common problem, which is created long before packed into VCI and appears after unpacking few weeks or months later. It also shows very poor quality of the packaging department of manufacturer. Still, it is very common problem as it affects all types of rust preventive packaging, not VCI ones only.



Fingerprints on galvanized steel when steel coil was pushed by bare hands (top) and rotor parts of electric engine (right).



VCI - conditions for packaging

Advantage of VCI packaging is its ability to pack group of products into one unit protected with e.g. single bag. Do not ever allow direct contact between organic materials (wood, cardboard, plywood etc.) and metal surface. Organic acids appearing when moisture ingress are of the most dangerous.



Aluminium parts packed in large cardboard box and interleaved with cardboard. While layers were covered with inert LDPE film, pieces of cardboard separating pieces to protect against mechanical harm were not.

Simple carboxylic acids are created when moisture has an ingress into organic compounds. Over time repeating drying creates very concentrated acids. Aluminium on this picture was more dissolved than corroded only.

The radius of that action is clearly visible.



VCI - conditions for packaging

Temperatures of packed product, all packaging materials and environment should be the same. Large differences can cause condensation before the VCI saturates the internal space of packaging and create the protective layer on the surface.



Water appearing after the steel coil was packed in LDPE film 3 hours after packaging.

Heavy coils, even those made by cold milling, have very big heat accumulated inside of the core. However the temperature is only several degrees above the environment and material used for packing, its cooling time can be measured in days. In this case it is very important the type of packaging - either with almost no air inside (very tight), minimizing the quantity of humidity packed, or with long time to cool down.



MetPro Global Solution

Pre-sales support

- liquids and surface treatment
- choice of proper VCI packaging material
- lab tests in climatic chambers
- trial packaging
- evaluation of trial data
- preparing of packaging manuals

Continuous touch with customer

- fast quotation and production
- quality assurance
- deliveries on time
- solutions for unexpected situations
- immediate response when advise needed

Innovation to actual needs

- continuous look-up for more efficient products
- helping to find out more environment friendly solutions
- simplifying of the packaging unit
- help in case of product or material change



MetPro Ongoing Technical Support

Every batch of MB produced is tested in our in-house lab in Ireland as well as samples of each film production run using German Standard TL8135-0043

