Corrosion

Fundamentals and practical guidance

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Failure to control corrosion can lead to;

* increased costs
* reduced safety
* negative environmental impact

25% of all corrosion problems could be prevented by easily using well-established techniques.

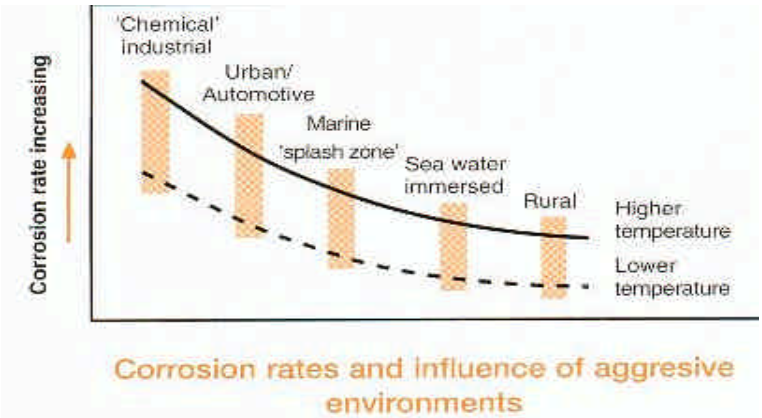
Corrosion results from the chemical interaction of a metal with its environment. Physical and chemical conditions influence both the rate and type of attack and the nature of the corrosion products.

Corrosion control begins during design. The following factors can influence corrosion

Environment – Chemical; Natural; Storage & Transit

How different types of atmosphere affect corrosion rates with two years exposure

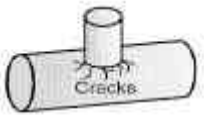
Metal	Industrial Air (microns/year)	Marine Air (microns/year)	Rural Air microns/year
Aluminium	0.81	0.71	0.025
Copper	1.19	1.32	0.58
Lead	0.43	1.41	0.48
Zinc	5.13	1.60	0.86
Mild steel	13.72	6.35	5.08
Weathering steel	2.54	3.81	1.27



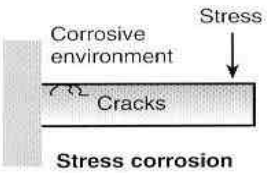
Corrosion rates and influence of aggresive environments

For many aqueous reactions a 30 deg. C temperature change results in a 10 fold change in corrosion rate, while a 20 deg. C change will approximately double the corrosion rate.

Stress - Residual stress from fabrication; Static; Variable and alternating stresses.



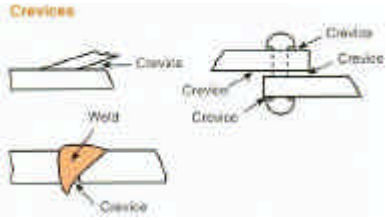
Cracks from residual stresses in poor fabrication (weld).

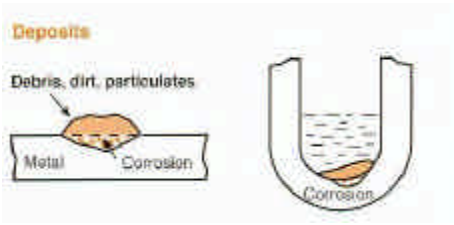


Stress corrosion

Shape – Joints and flanges; Crevices and deposits; Trapped and contained liquid.

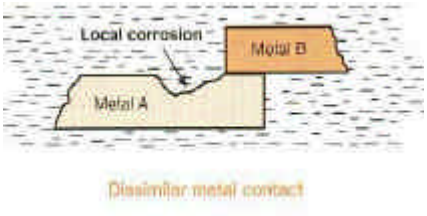
Poor welding and surface finishing can lead to crevices and stress raisers.





Compatibility – Metals with metals; Metals with other materials.

From the point of corrosion, metals may be incompatible with each other or other materials they contact. The relative areas of two different metals in electrical contact can affect their corrosion rates.



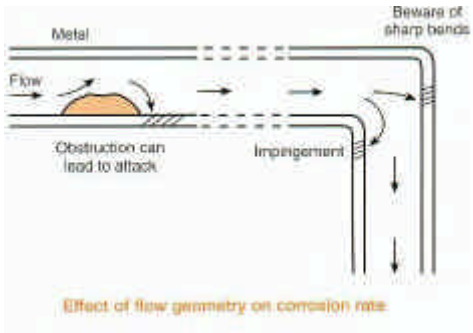
Dissimilar metal contact

This is particularly damaging if the more 'active' (anodic) metal has a smaller area.

Fabrication may create differences in metallurgical structure or alloy composition allowing local attack.

Changes in weld metal and base metal composition and structure result in galvanic corrosion or intergranular effects, such as weld decay in unstabilised stainless steel.

Movement – Flowing fluids; Entrained solids; Vibration and pulsing.



Effect of flow geometry on corrosion rate

The flow of fluids relative to a metal can increase the corrosion rate. Erosion corrosion may become significant at high rates of flow when the flow changes from laminar to turbulent.

Prevent localized corrosion by reducing the flow rate and avoiding turbulence.

Temperature – Oxidation; Scales and tarnishes; Heat transfer effects; Molten deposits; Condensation and dew points.

Higher temperatures generally increase corrosion rates.

Control – Surface cleaning and preparation; Coatings, Cathodic protection; Inhibitors; Inspection; Planned maintenance.

Corrosion rate is aggravated by surface contaminants such a mill scale, surface rust, dust, oil, grease and by defects such as scratches, machine marks, pits, dents, etc. Different surface preparations and cleaning procedures are required for different operating and different types of coating. The range of cleaning procedures include mechanical, chemical, steam and flame methods.

Inhibitors are substances added in small concentrations to closed systems, i.e. central heating, power boilers, sealed packaging to reduce the corrosion rate.

Cathodic and anodic protection is the control of metal potentials to reduce the corrosion rate. Suitable for immersed and underground conditions of plant and is achieved by either using sacrificial electrodes or using an impressed current.

Coating types and their lives

Protection duration needed	Requirement for coating type
Short term 1-5 years	Single pack materials such as alkyds, emulsions and acrylics are usually in this category
Medium term 5-10 years	Two-component materials such as zinc-rich primers, epoxies, polyurethanes, usually at lower thicknesses
Long term/high performance 10+ years	Two-component materials such as metal spray, epoxies, polyurethanes, glass flake and FRP

Painting or coating is the mainstay of corrosion prevention for materials not inherently corrosion resistant. This is a matter of economics. Paints and coatings are generally applied at low additional cost to the least expensive structural materials. Generally paints and coatings do not last as long as the operating lifetime of the material being protected.

The ability therefore to maintain the coating system is vital.

Acknowledgement is made to NPL and the National Corrosion Service for the use made of their material

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