Corrosion Mitigation

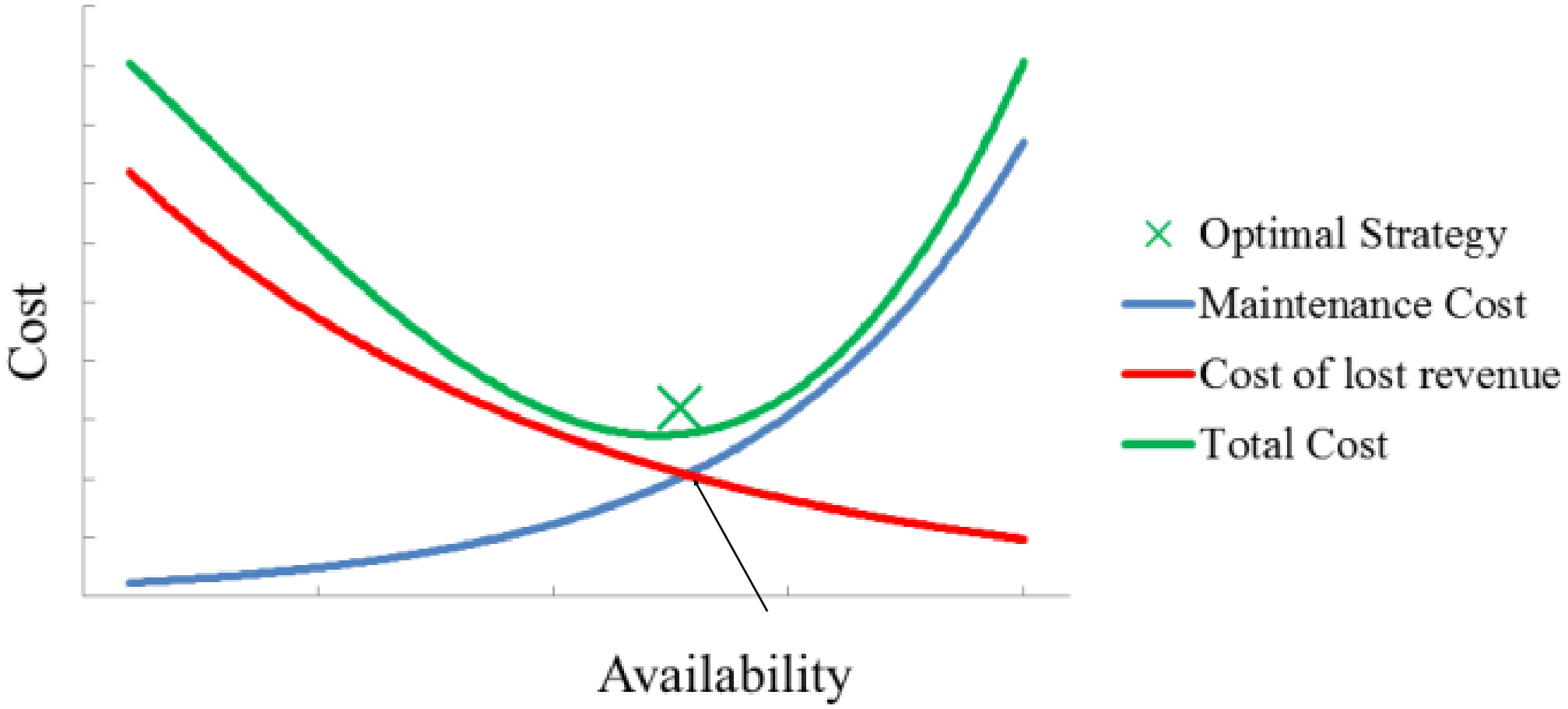
Corrosion Mitigation Learning Objectives:

- What is corrosion and its costs?
- Is corrosion and rusting the same thing?
- What does corrosion look like?
- What can be done to prevent corrosion?
- What does the future have to prevent corrosion?

What is……

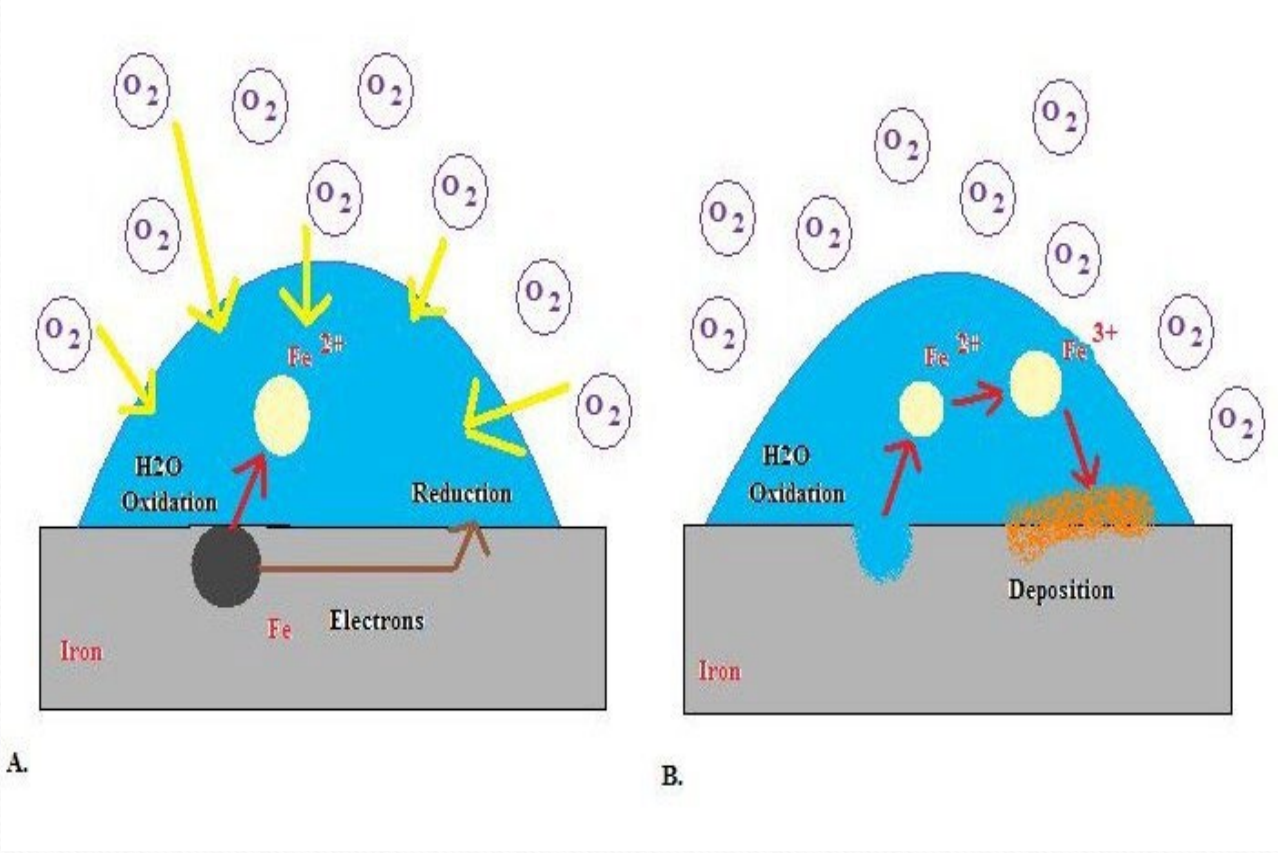
The Lesson of the Washer……

Cost of Ownership?



What Happens?

Corrosion happens through a series of reduction-oxidation reactions, similar to those of a battery. The metal being corroded acts as the anode; the metal is oxidized, forming metal ions and free electrons. The free electrons reduce the oxygen, often times forming hydroxide, and providing a complimentary cathodic reaction. The dissolution of the metal at the anode has two possible outcomes; the metal ions can go into solution, becoming hydrated, or the metal ions can form a solid compound that collects on the surface. In the former case, further oxidation of the metal ions can occur and an open pit can form. In the latter case, a protective barrier may be formed and the collection of solid metal ions will inhibit further corrosion.



Nobel Metals

The noble metals are a subset of the metals, but the membership in the group is not well-defined.

The strictest definition of a noble metal is metal with a filled electron d-band. According to this definition, gold, silver, and copper are noble metals.

Another definition of a noble metal is one which resists oxidation and corrosion. This excludes copper, but adds in other platinum group metals, such as rhodium, palladium, ruthenium, osmium, and iridium.

The opposite of a noble metal is a base metal.

Noble metals are valued for use in jewelry, coinage, electronics, medicine, and chemistry as catalysts.

ruthenium , rhodium , palladium , silver , osmium,

iridium , platinum , gold

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Types of Corrosion

- Uniform Corrosion
- Pitting Corrosion
- Crevice Corrosion
- Intergranular Corrosion
- Stress Corrosion Cracking
- Galvanic Corrosion
- Filiform Corrosion

General Corrosion

Even attack across entire surface

Most common type of corrosion

Relatively benign

Easily spotted

Pitting Corrosion

Most destructive type

Hard to predict, detect and characterize.

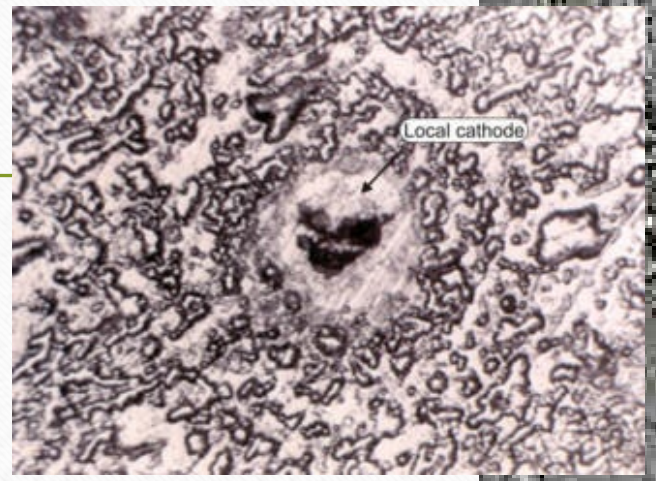
Attacks an anodic or cathodic point

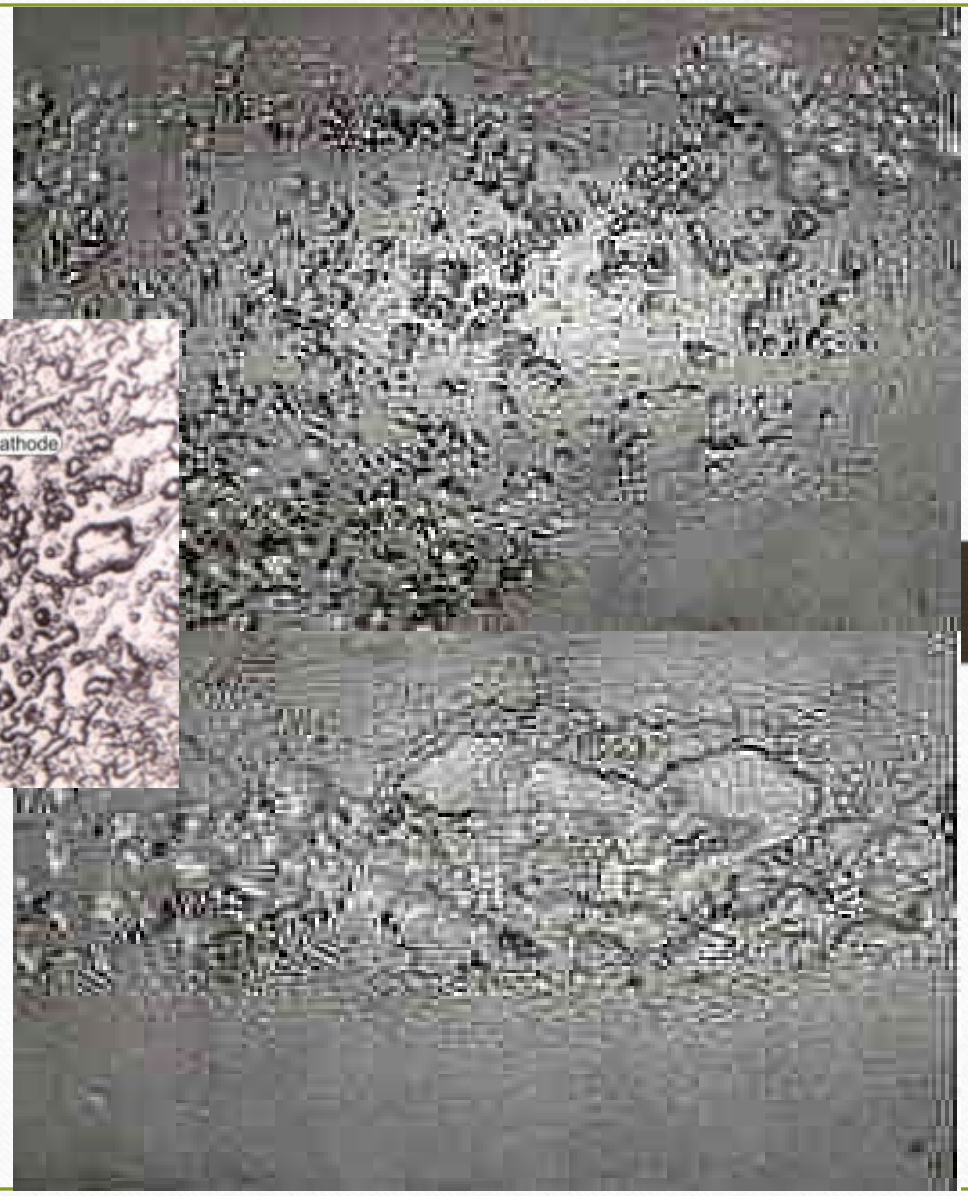
Forms small corrosion cell within material

Forms pit

Grows into hole

Pitting is dangerous can lead to failure of structure with low loss of metal

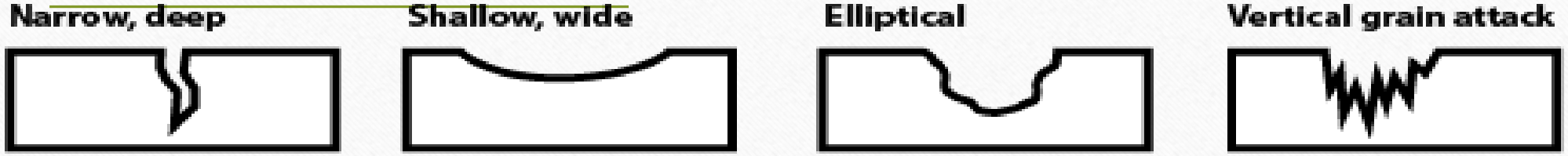




Pitting Corrosion

TYPES OF PITTING CORROSION:

TROUGH PITS



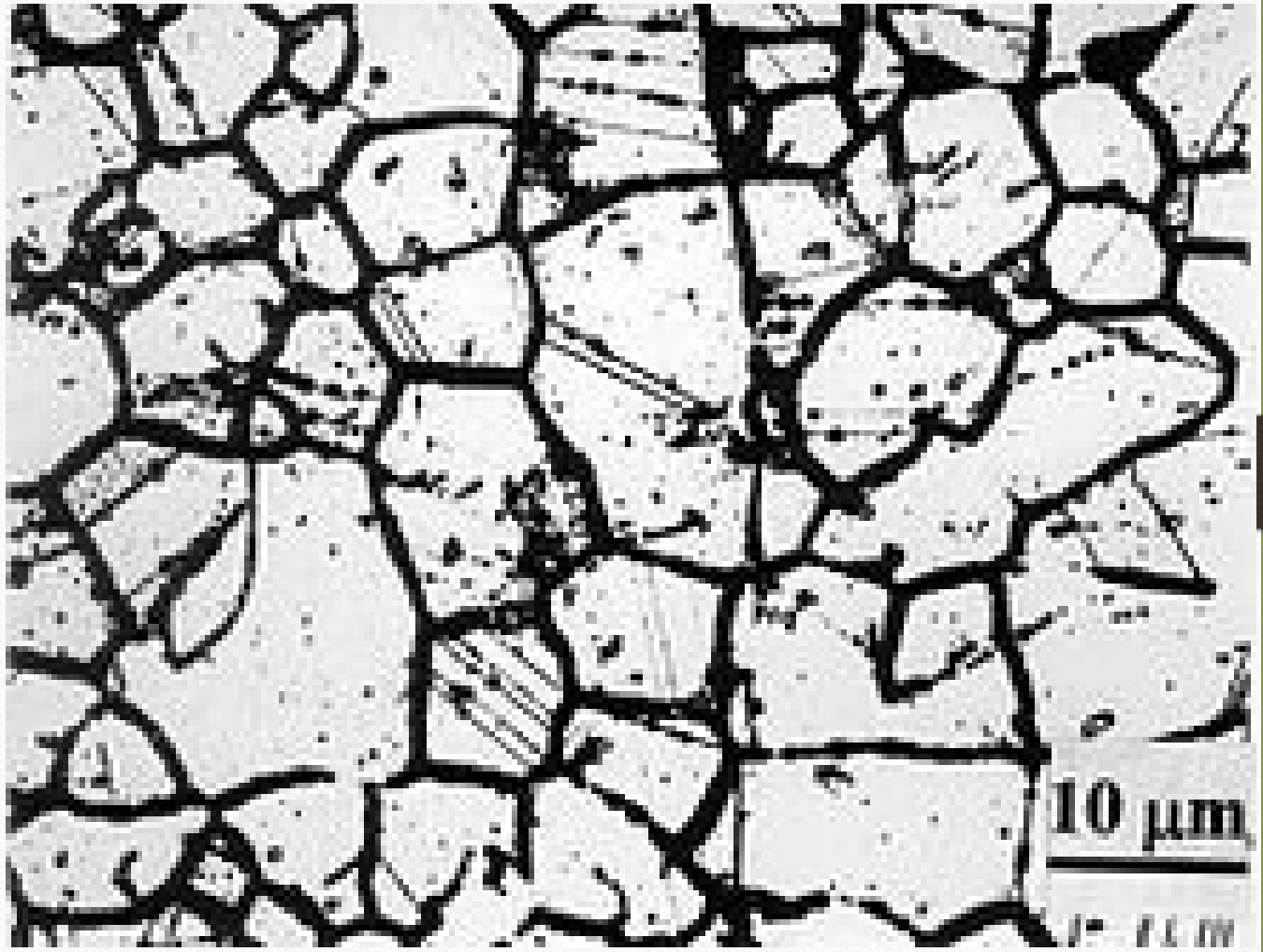
SIDEWAY PITS

Crevice Corrosion

- Similar to Pitting corrosion
- Occurs in a confined space
  - Under gaskets and seals
  - Inside cracks and seams
- More common in stainless steel and aluminum

Intergranular Corrosion

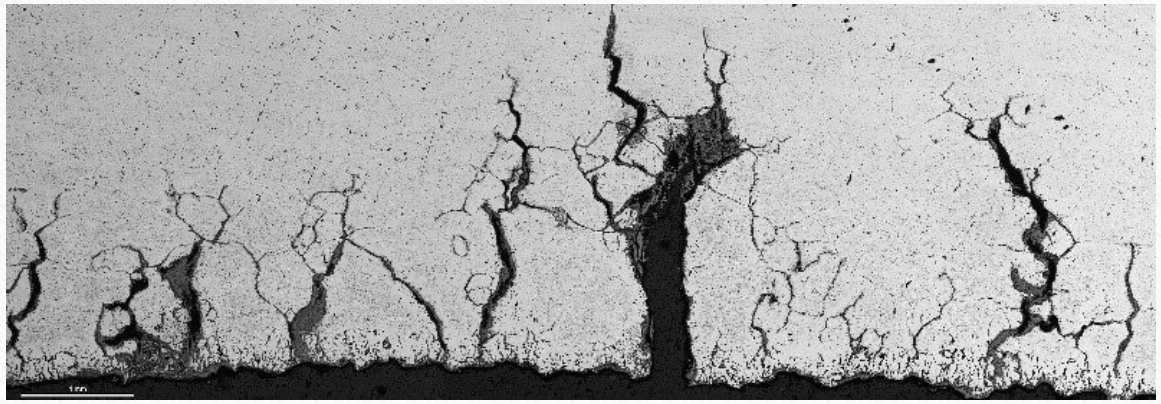
Intergranular corrosion (IGC), also known as **intergranular** attack (IGA), is a form of **corrosion** where the boundaries of crystallites of the material are more susceptible to **corrosion** than their insides



Stress Corrosion Cracking

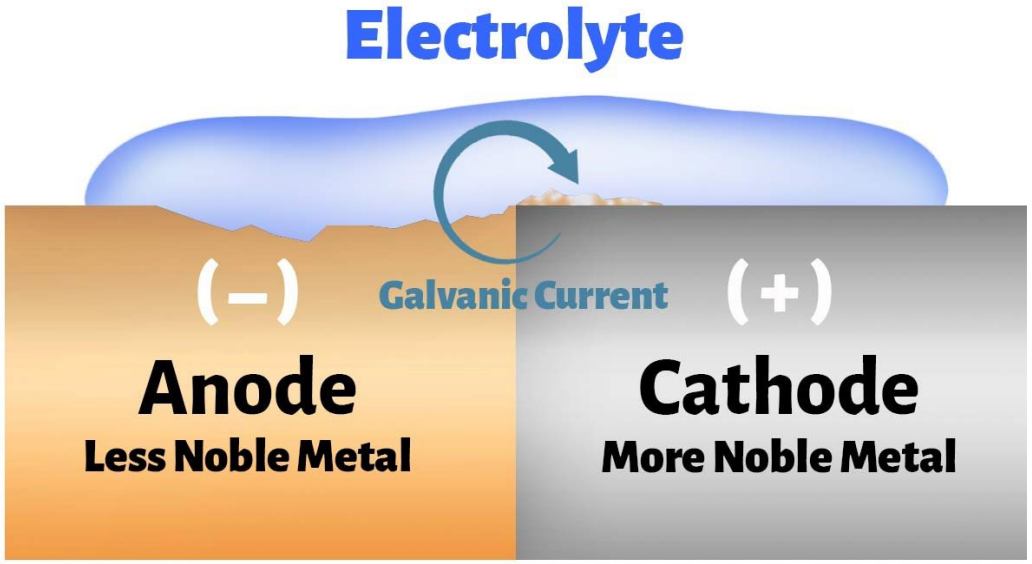
Stress Corrosion Cracking or SCC is from fatigue.

Caused by loading and unloading of a material.



Galvanic Corrosion

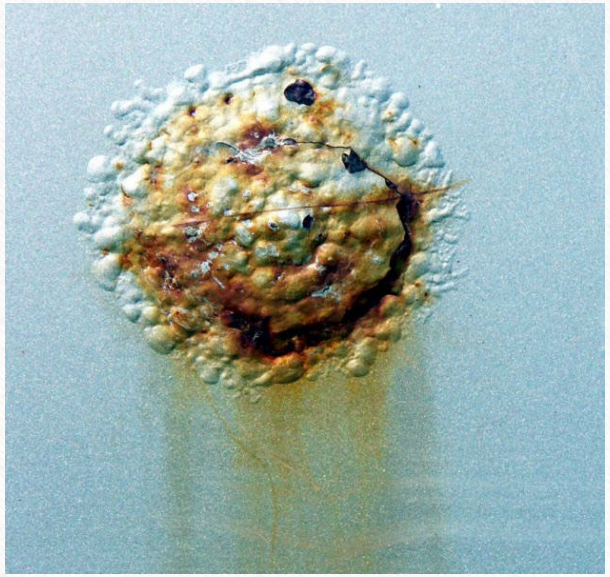
Galvanic corrosion is an electrochemical process in which one metal corrodes preferentially when it is in electrical contact with another, in the presence of an electrolyte. A similar galvanic reaction is exploited in primary cells to generate a useful electrical voltage to power portable devices.

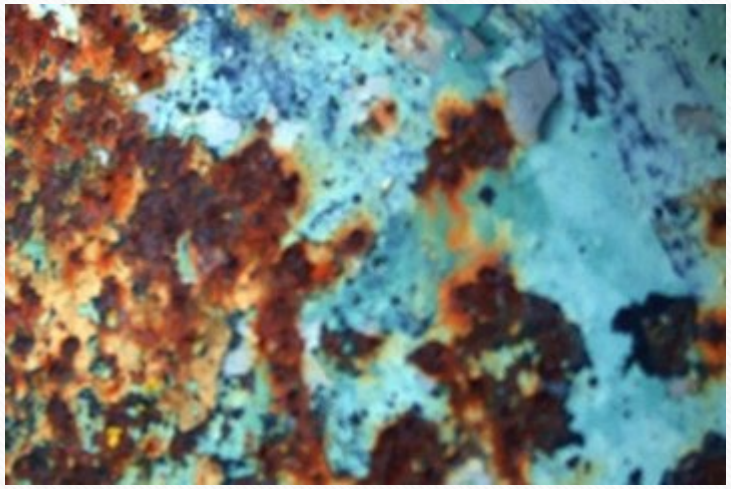


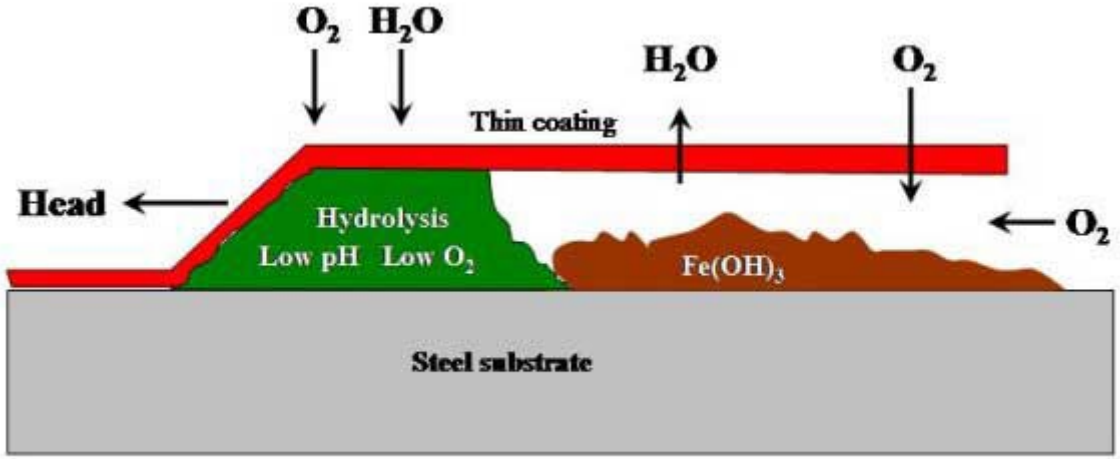
Galvanic/Bimetallic Corrosion of dissimilar metals.

Filiform Corrosion

Corrosion that occurs under thin coatings.







Cross sectional view of a corrosion filament on a steel substrate

CORROSION VERSUS RUSTING

CORROSION	RUSTING
Corrosion is the process of deterioration of a substance due to chemical, electrochemical or other reactions that take place on the surface of that substance	Rusting is the red or orange coating that forms on the surface of iron when exposed to air and moisture
Can occur on different surfaces such as skin, wood, metals, etc.	Mainly occurs on surfaces of iron and steel
Can happen due to exposure to air or spread of chemicals on the surface	Can happen due to exposure to air and moisture
Can be observed as a skin burn, wood surface destruction or rusting	Can be observed as red or orange coating on the surface

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Natures Corrosion

Acid rain results when sulfur dioxide (SO_2) and nitrogen oxides (NO_X) are emitted into the atmosphere and transported by wind and air currents. The SO_2 and NO_X react with water, oxygen and other chemicals to form sulfuric and nitric acids. These then mix with water and other materials before falling to the ground.

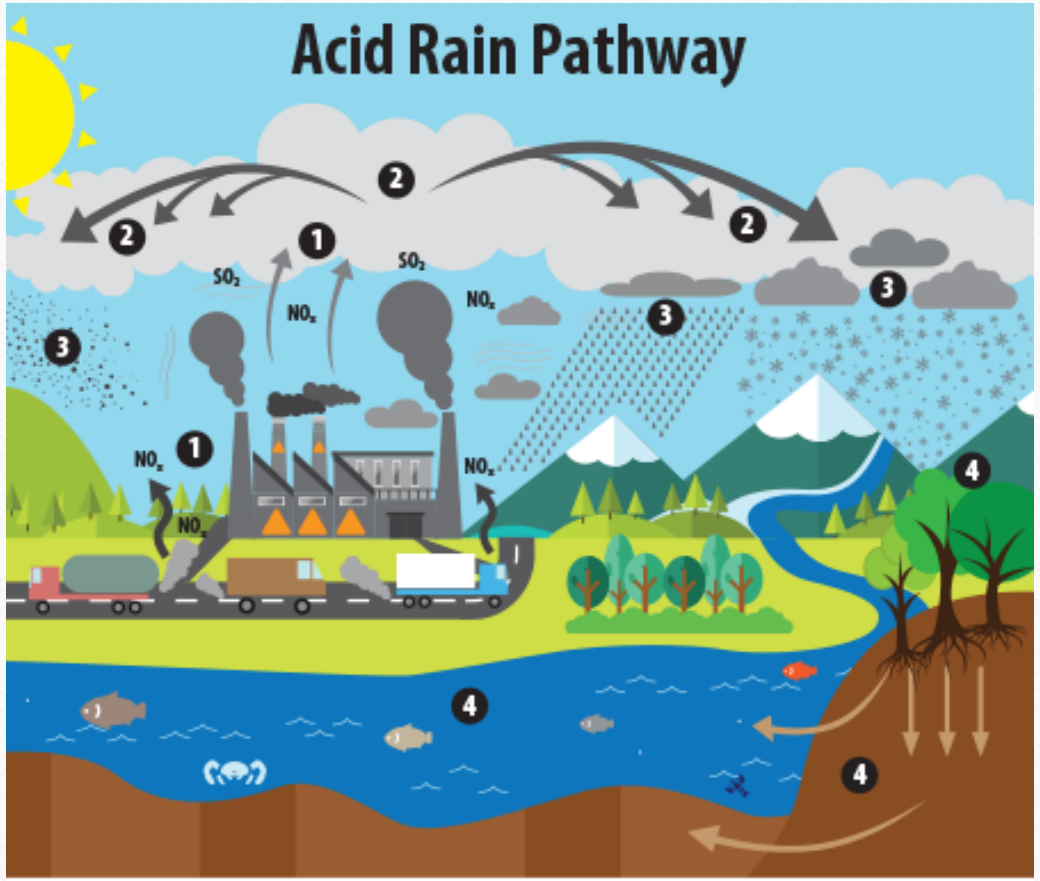
While a small portion of the SO_2 and NO_X that cause acid rain is from natural sources such as volcanoes, most of it comes from the burning of fossil fuels. The major sources of SO_2 and NO_X in the atmosphere are:

Burning of fossil fuels to generate electricity. Two thirds of SO_2 and one fourth of NO_X in the atmosphere come from electric power generators.

Vehicles and heavy equipment.

Manufacturing, oil refineries and other industries.

Winds can blow SO_2 and NO_X over long distances and across borders making acid rain a problem for everyone and not just those who live close to these sources.

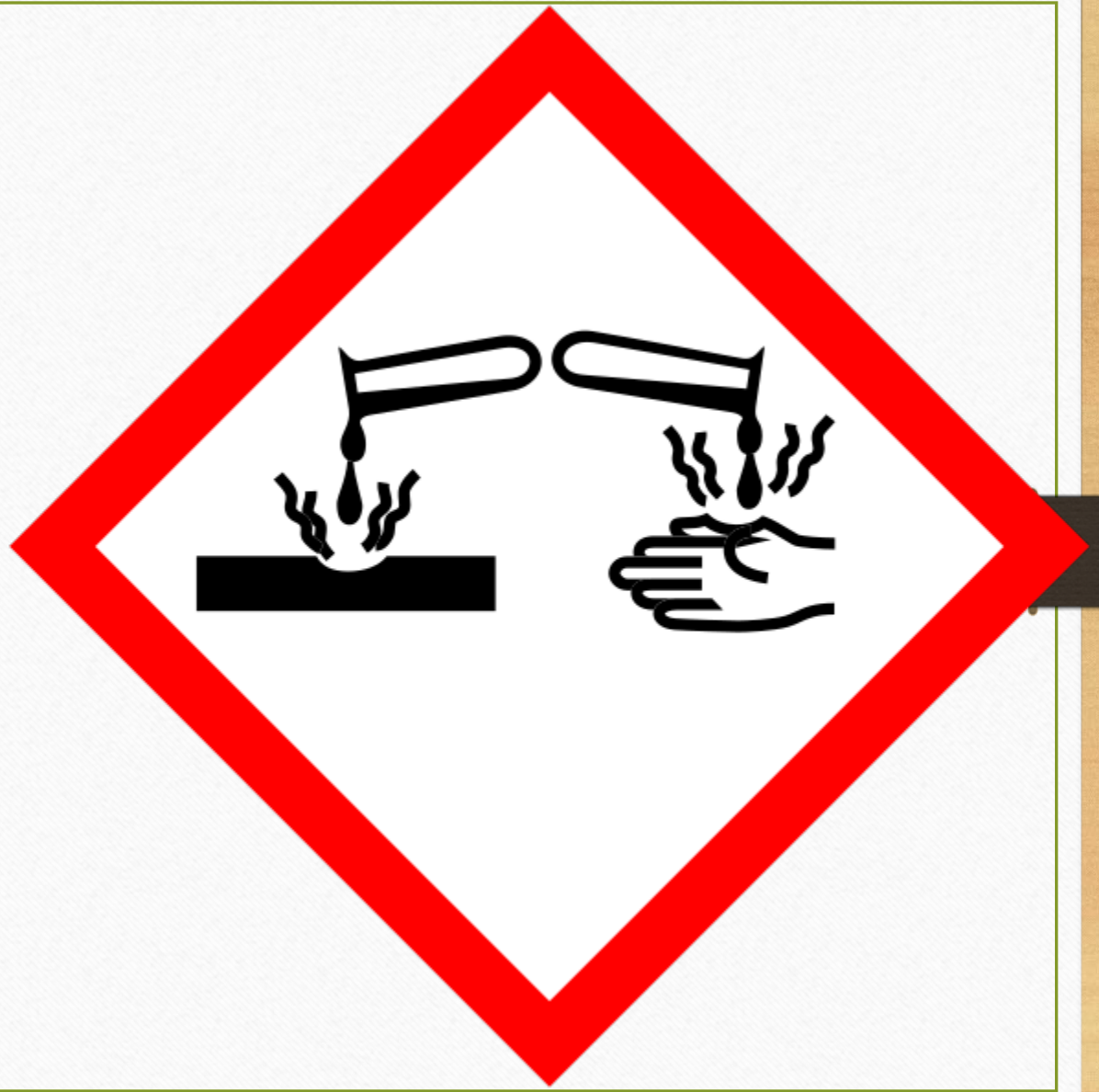


This image illustrates the pathway for acid rain in our environment:
(1) Emissions of SO_2 and NO_x are released into the air, where (2) the pollutants are transformed into acid particles that may be transported long distances. (3) These acid particles then fall to the earth as wet and dry deposition (dust, rain, snow, etc.) and (4) may cause harmful effects on soil, forests, streams and lakes.

HazCom 2012 Symbol

Standardized International Symbols

- All must be white background, red boarder and black symbols



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Application Process

How much sat is enough to accomplish the goal?

Direct Liquid Application (DLA)

- **Pencil Sized Streams: 2-300 Mm Spacing**
- **Too much pressure is wasting material**

Pressure Washing Tool

Simple cart with nozzles to get at areas under the truck not normally accessible.

Can purchase or make your own.

Just attach to pressure washer.

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PERFORM POST WINTER EQUIPMENT MAINTENANCE AND REPAIRS

Cleaning in This Era

- Disinfecting high-touch areas
  - Exterior Door Handles both Driver and Passenger-Sides.
  - Interior Door Handles both Drivers and Passenger-Sides.
  - Steering Wheel
  - Gear Shifter
  - Center Console
  - Controls
  - Dashboard
- Trunk or Rear Door (if applicable)
- Vehicle Equipment
- Keys

Chemical Damage

Heat generated by resistance in electrical connections will draw moisture containing corrosive material into the wires and connections.

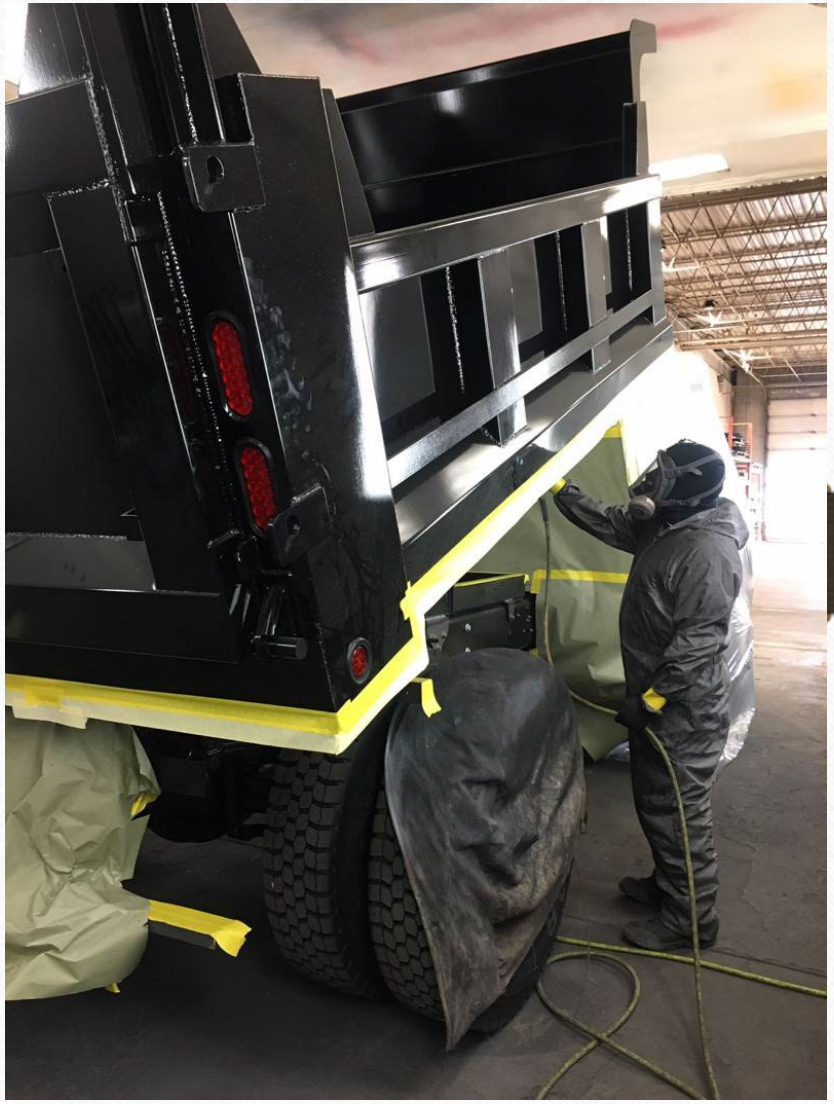
Tinned Copper VS Bare Copper

- Benefits of Tinned Copper
  - Resists Humidity
  - Handles High Temperature
  - Handles Environments

Barriers - Painting

The simplest method to prevent corrosion is to paint the metal surfaces.

This creates a barrier that water, air and chemicals can't attack.



Undercoating

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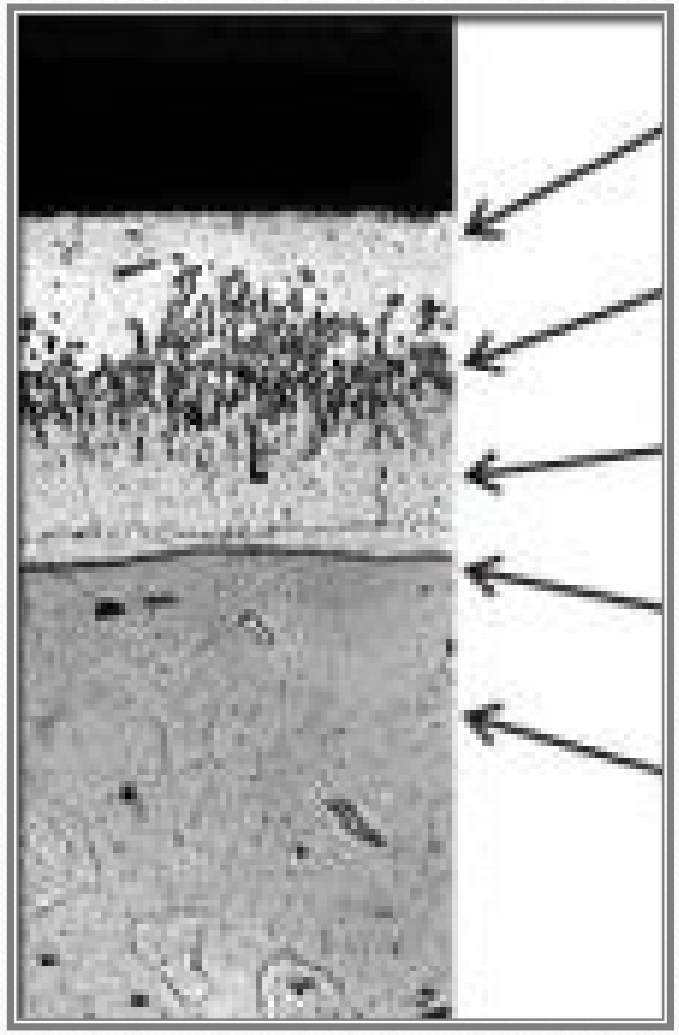
Barriers – Sacrificial Metals

Galvanizing can be as easy as a spray can!

Barriers - Galvanizing

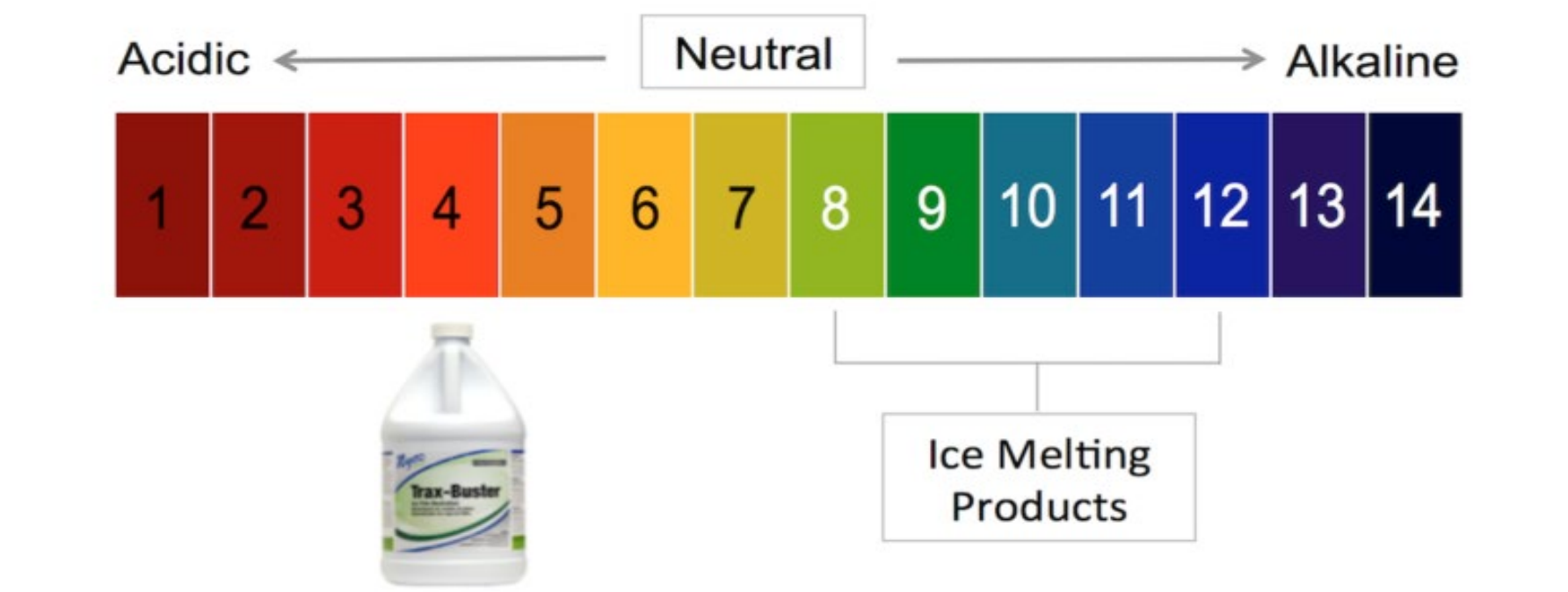
Galvanizing



Barrier – Hot Dip Galvanizing

A galvanizing process done with a hot solution.

Neutralizers?




This makes NEUTRO-WASH™ a cost effective way . . .
. . . to extend your equipment's life!
NEUTRO-WASH™

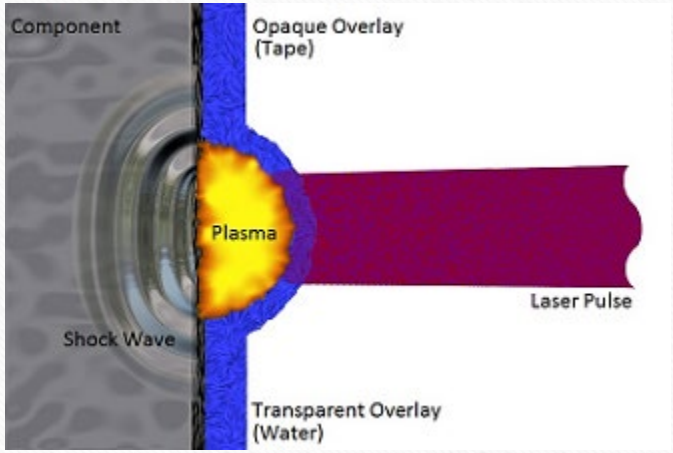
Look for Options!

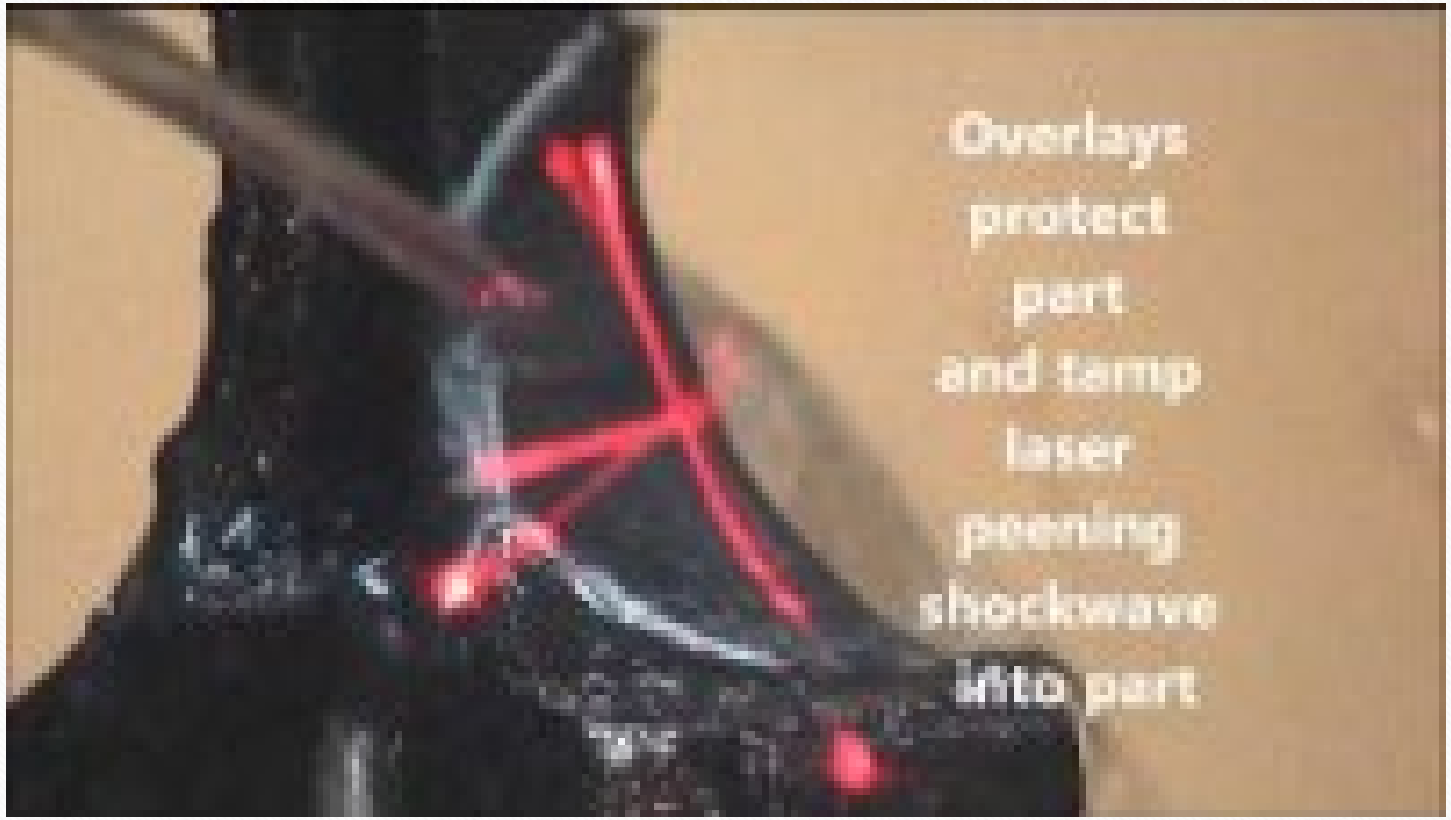
Corrosion Protection of the Future?

- Laser Peening
- Cracks that repair themselves
- Sol Gel Systems
- Conductive Polymers

New Methods for Corrosion Control

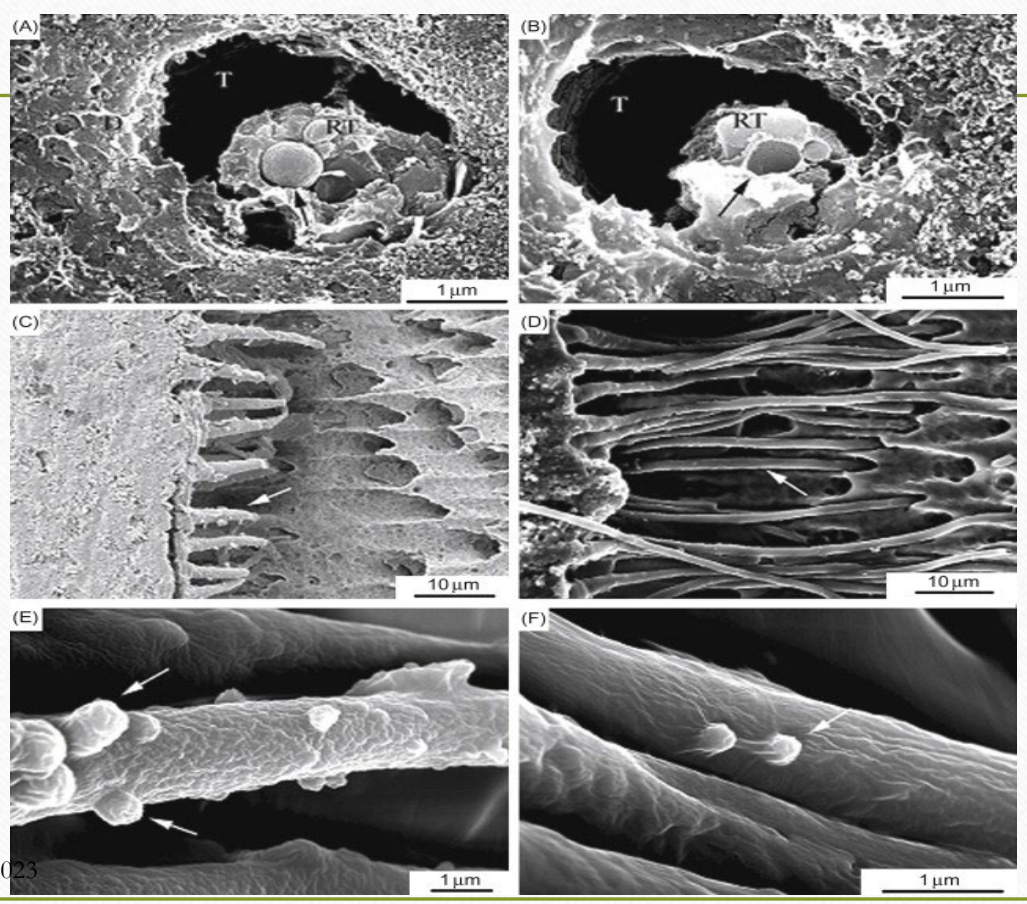
- Laser Peening

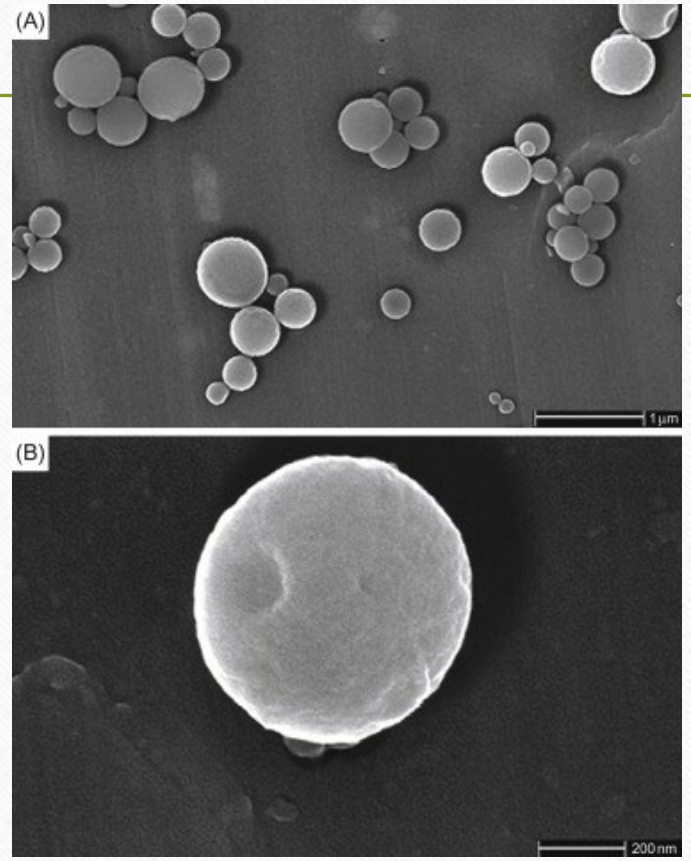



Overlays
protect
part
and tamp
laser
peening
shockwave
into part

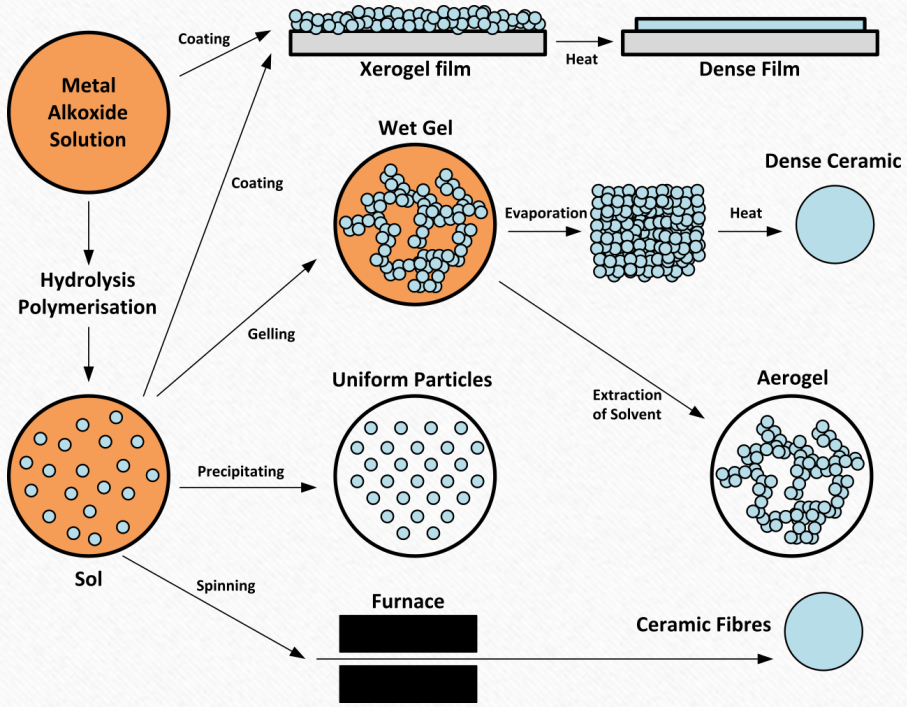
https://youtu.be/9j5u2dnU8_4

Cracks that Repair Themselves

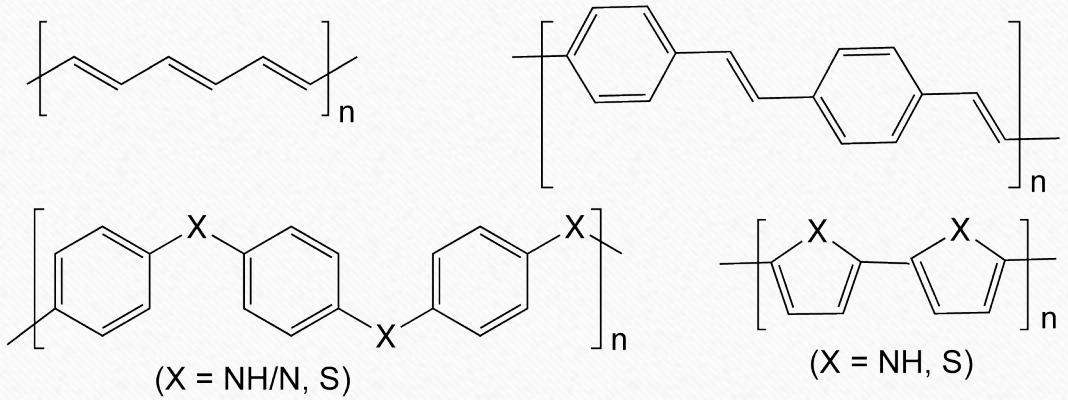




Sol-gel


Metal Alkoxide Solution
Coating
Xerogel film
Heat
Dense Film
Wet Gel
Coating
Dense Ceramic
Evaporation
Heat
Hydrolysis Polymerisation
Gelling
Uniform Particles
Extraction of Solvent
Aerogel
Precipitating
Sol
Spinning
Furnace
Ceramic Fibres

Conductive Polymers



What now…….

- Increase awareness of large corrosion costs and potential savings.
- Change the misconception that nothing can be done about corrosion.
- Change policies, regulations, standards, and management practices to increase corrosion savings through sound corrosion management.
- Improve education and training of staff in recognition of corrosion control.
- Advance design practices for better corrosion management.
- Advance life prediction and performance assessment methods.