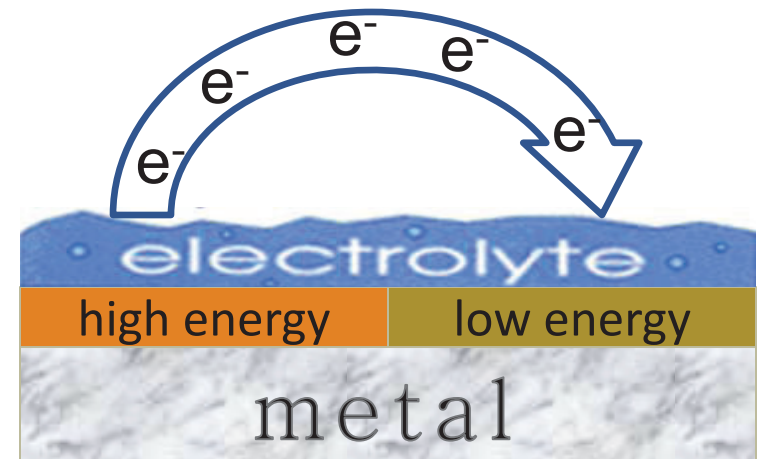
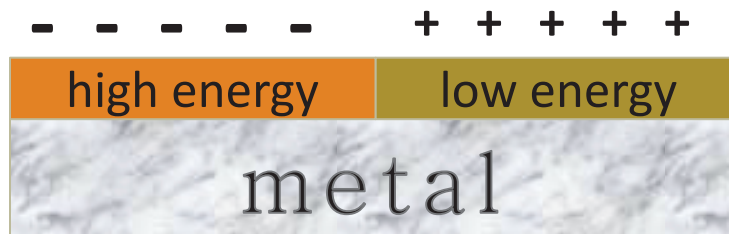


# Corrosion Basics



Corrosion is an Electro-Chemical Process

- Flow of electrons from high energy to low energy
- Electron flow creates chemical reaction (oxidation)



# Corrosion Basics



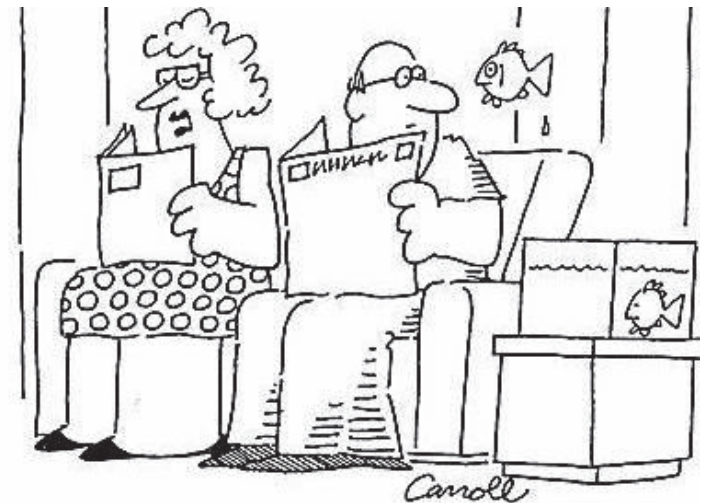
## *What Causes RUST and CORROSION?*

Corrosion is influenced by part & process factors:

- Electric Potential (high & low energy areas)
- Type and nature of the metal
- Metal and part processing

And many environmental factors:

- Relative humidity
- Contaminants
- Temperature



"IS IT HUMID IN HERE OR IS IT JUST ME?"

# Corrosion Basics



High & low energy areas create **electric potential**

- Metals which have higher electric potential are more susceptible to corrosion.
- Metal grains and micro structure are a major influence.

Grain boundaries – high energy

Grain centers – low energy



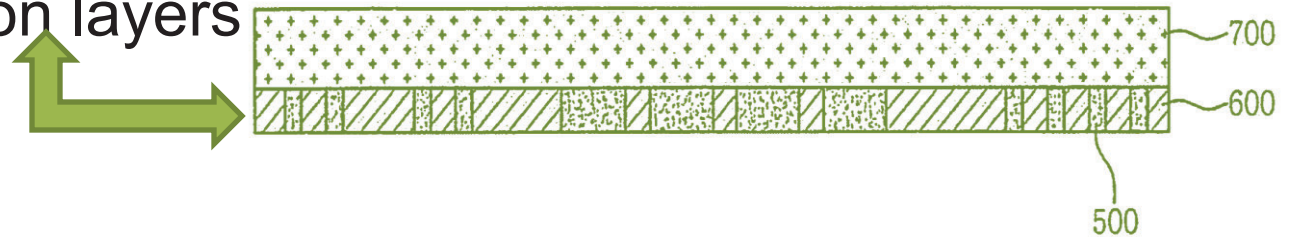
# Corrosion Basics



## Part Corrosion Factors: **Metal Type**

### Base Metal

- React to oxidation differently
- Depends upon layer structure and porosity
- Ferrous metals have fragile & porous oxidation layers



### Alloys

- Alloys increase complexity of inhibitor chemistry
- Thousands of alloy combinations





# Corrosion Basics



## *What Causes RUST and CORROSION?*

### Type and nature of the metal

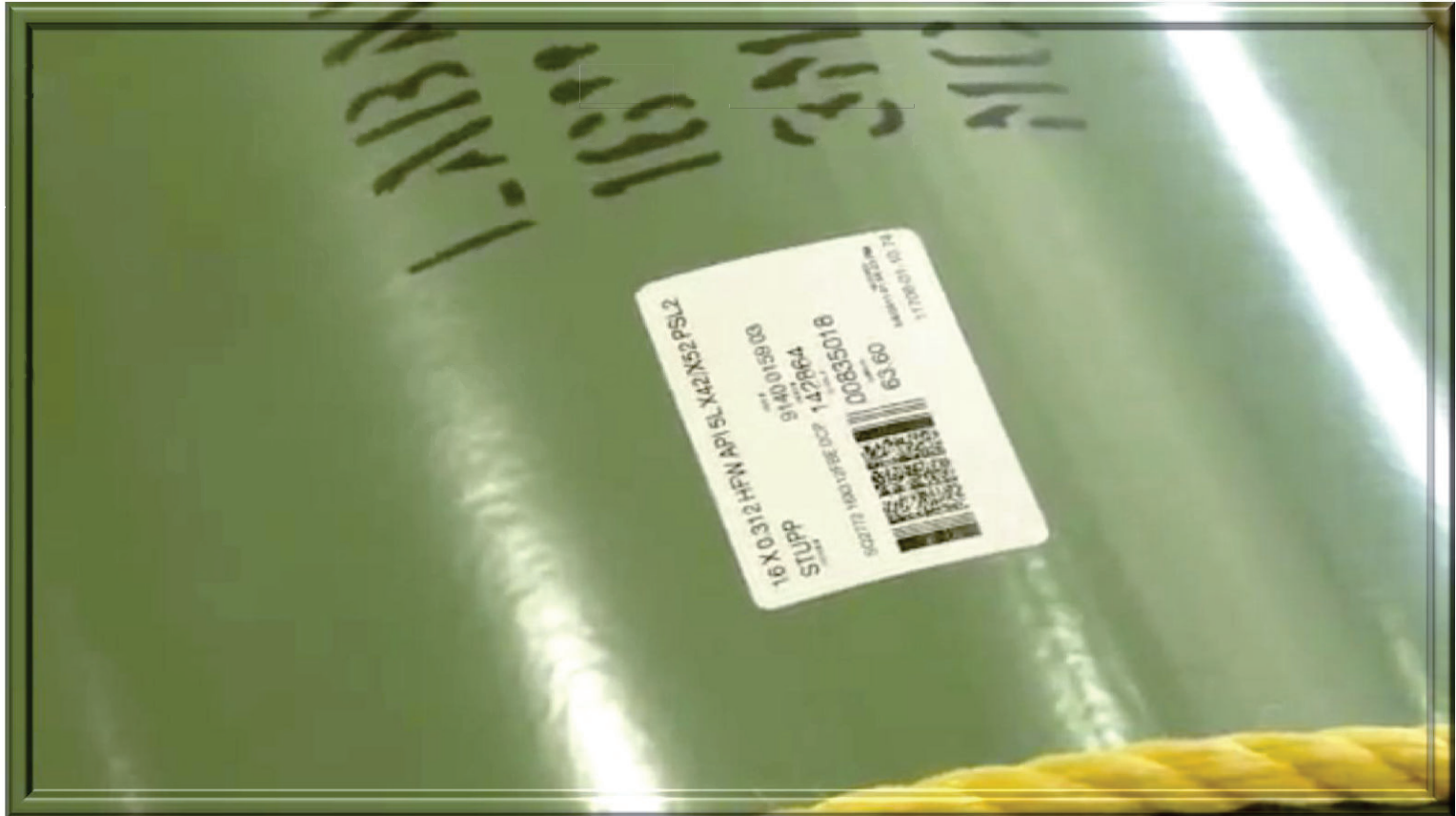
- Ferrous based - permeable to air and water
- Aluminum corrodes extremely slow because aluminum oxide forms a protective coating
- Stainless steel forms a passivation layer of chromium(III) oxide.
- Similar passivation occurs with magnesium, copper, titanium, and zinc.



# Corrosion Basics



***What Causes RUST and CORROSION?***



# Corrosion Basics



Red rust hydrated oxides – high oxygen  
& water exposure



Heavy exposure to air and moisture, probably including a contaminate (salt).

Most likely atmospheric because no signs of rust runs on equipment.

Uniform corrosion, probably from very corrosive environment.



# Corrosion Basics



Yellow rust oxide-hydroxide – very soluble iron oxide

Rust in recessed areas with rust “runs and drips” (solvated rust)

Very high moisture content , puddled / standing water most likely present.

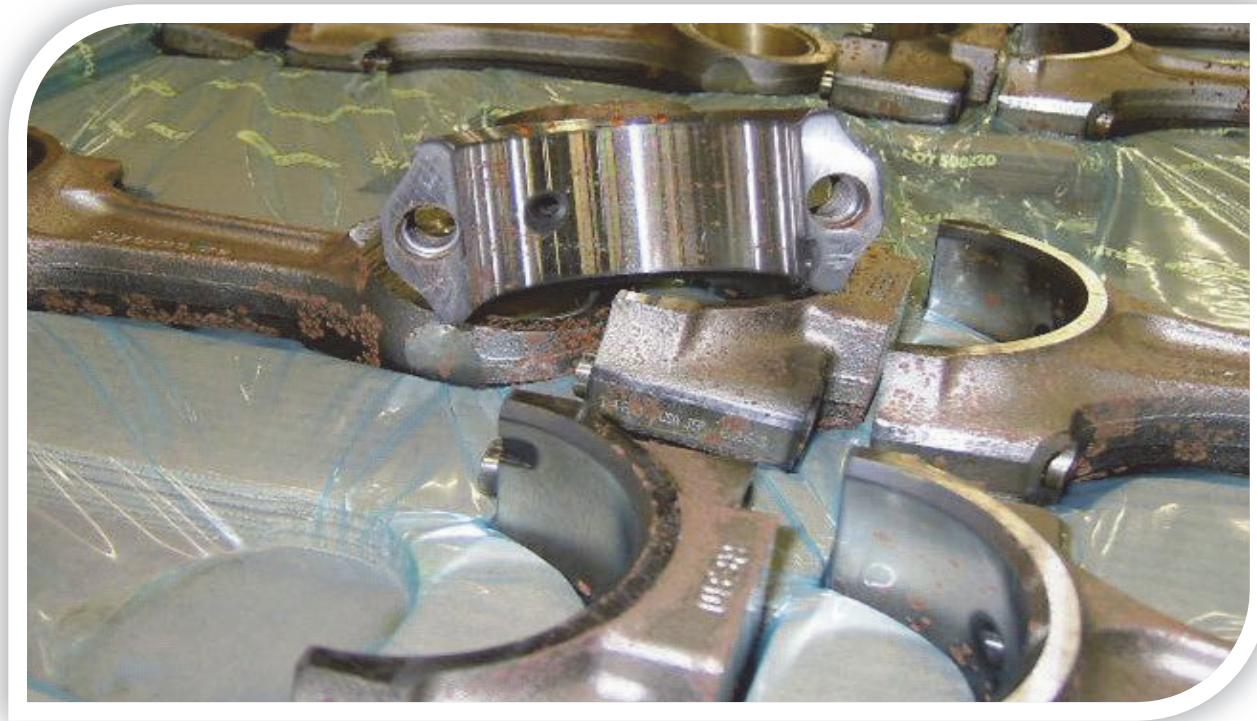




# Corrosion Basics



Brown rust ferric oxide - high oxygen lower moisture



Drier rust.

Most likely atmospheric.

Localized rust, possible contaminate on surface from process

# Corrosion Basics



Black rust from limited oxygen - Iron (II)oxide



Black thin film rust

Appears as black staining. Most likely had something covering black rust areas preventing oxygen from reaching the surface.

More stable rust layer that does not propagate as rapidly as other rust forms.



# Corrosion Basics



Multiple forms of ferrous corrosion can be present

Brown rust  
lower  
moisture  
content, Most  
likely  
atmospheric

Black rust  
from wet  
paper resting  
tightly  
against metal  
surface.



Yellow rust high  
moisture content,  
water most likely  
present.



# Corrosion Basics



## Process Corrosion Factors

Cold Working

Creates electric potential differences

Machining

Exposes grain boundaries and creates microscopic peaks and valleys.

Heat Treating

Creates potential differences and can be a source for contaminants.



# Corrosion Basics



## Process Corrosion Factors

Cleaning – Poorly maintained cleaning solutions are a source of corrosion and may cause “flash rust”.

Handling & Packaging – Contamination from human handling or contact with untreated packaging materials.



# Corrosion Basics



## Process Corrosion Factors

Contaminants – Act as catalysts of the corrosion process.

- Corrosion is accelerated by electrolytes.
- Corrosion is strongly affected by the presence of acid.





# Corrosion Basics



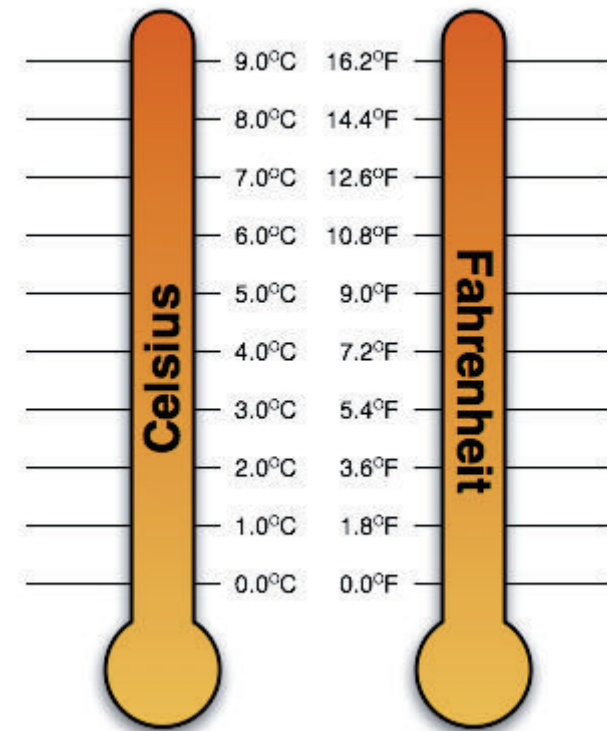
## Environmental Corrosion Factors

### Temperature

– A 10 °C rise (18 °F) doubles corrosion rate.  
Temperature variations also cause electrical potentials.

### Relative Humidity

– Provides the electrolyte

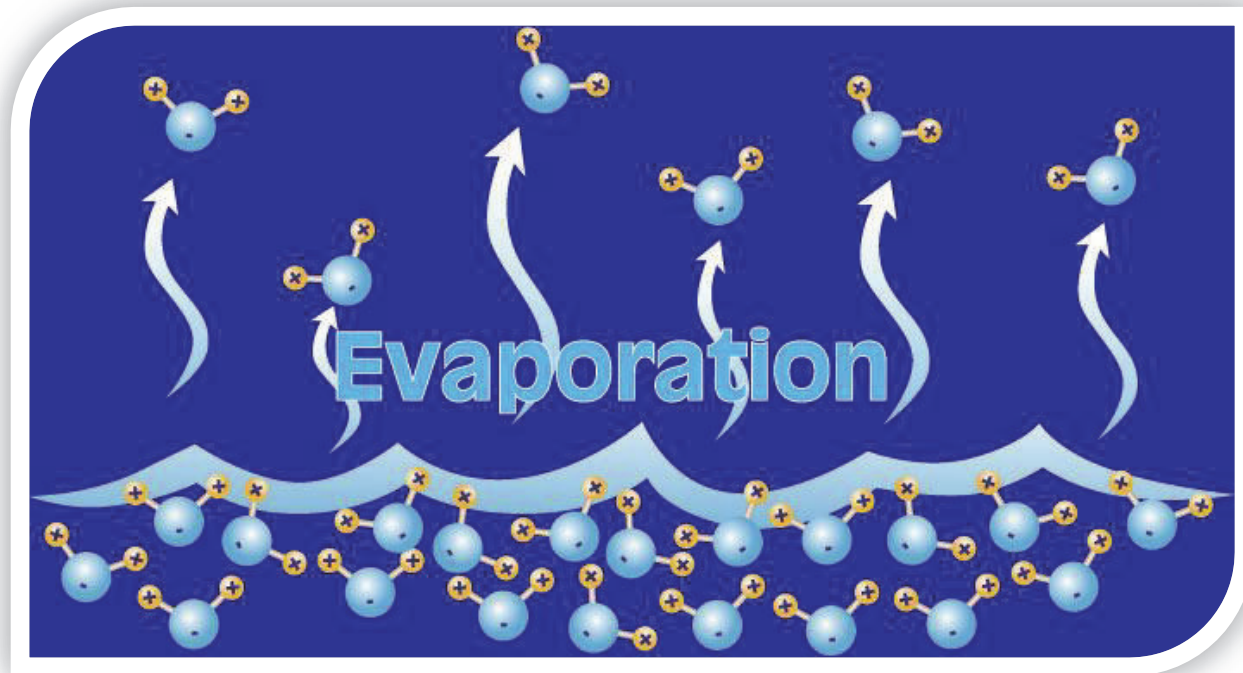


# Corrosion Basics



## Environmental Corrosion Factors

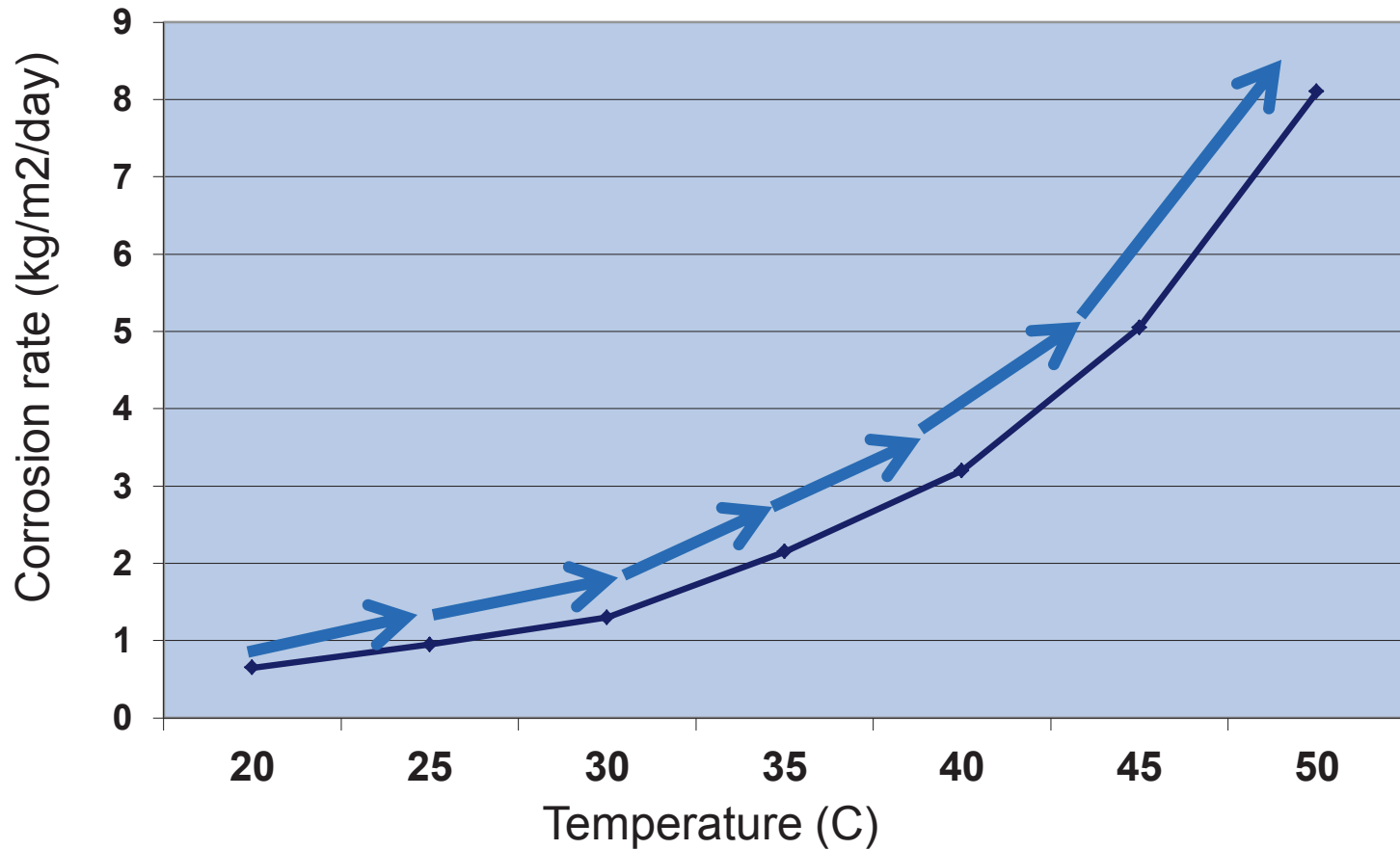
**Combined factors** – Condensation and evaporation cause temperature gradients and bring contaminants in contact with the metal surface.



# Corrosion Basics



Temperature & corrosion rate for low alloy steel







# Corrosion Basics



## Many Possibilities That Cause Corrosion

- Approximate 70% of corrosion is caused inside the plant.
- Before it is packaged!
- Part - Configuration and Metal type:
  - Steels, Aluminum, Copper, Nickel, Brass, Alloys
- Process - working, machining, heat treating,
- Cleaning, handling and packaging
- Environmental – contaminants, humidity, temperature

# Corrosion Basics



How quickly does VCI provide protection?

It depends ....

**Size of enclosure**



**Temperature** - VCIs volatilize more quickly at higher temperatures.

**Humidity** - ARMOR VCI molecules disassociate rapidly in moisture.





# Corrosion Basics



The adsorption process is not instantaneous.  
It requires time to form the inhibitor layer.

- As fast as 6 hours
- As long as 6 days
- Practical application: 20 to 30 hours

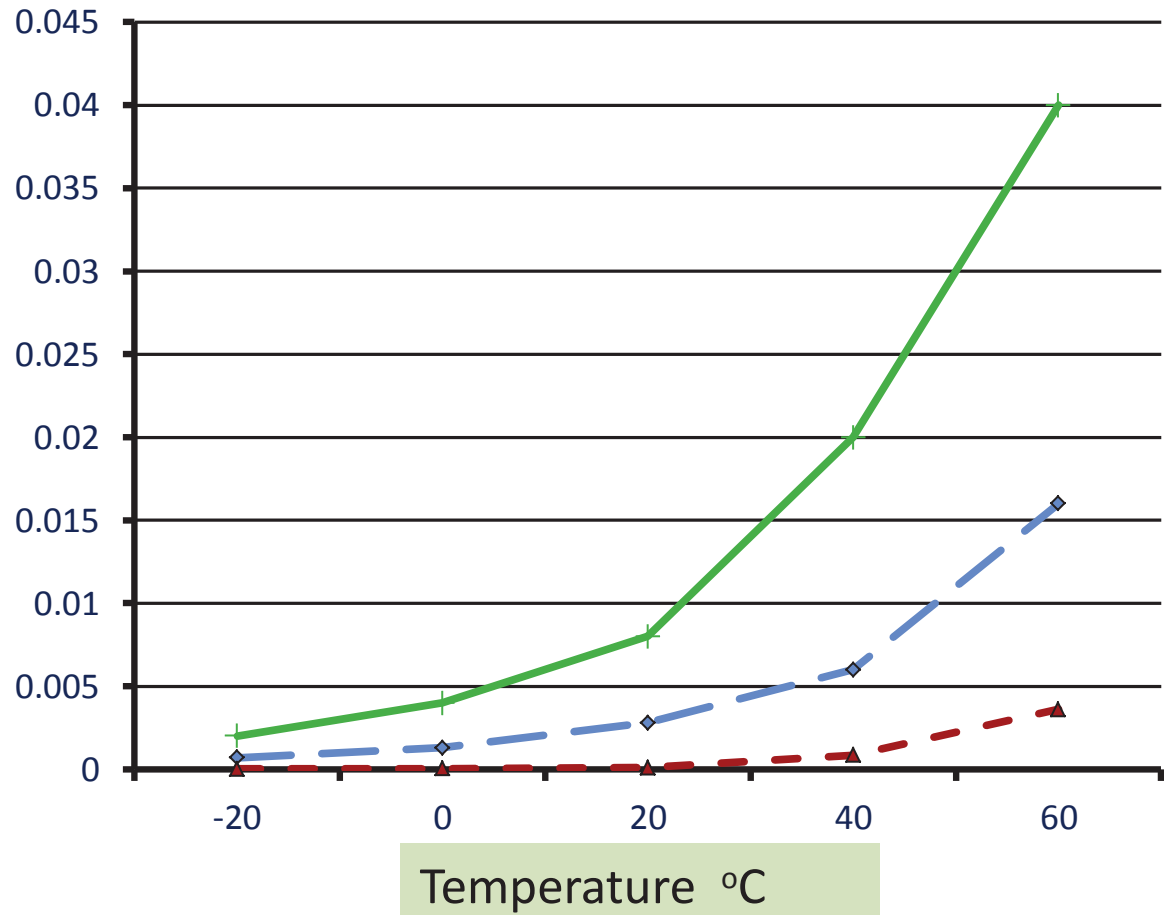
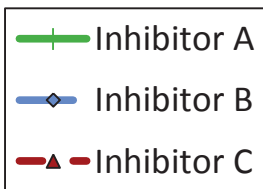
ARMOR VCIs utilize “mixed inhibitor technology”.  
They are formulated to saturate the vapor space  
quickly and have a lasting effect



# Corrosion Basics



Vapor Pressure  
Vs  
Temperature  
For three VCIs  
(mm Hg)





# Corrosion Basics



## Benefits of ARMOR Proprietary VCI:

- Self-adjusts to the environment (Temperature & Humidity)
- Migrates to distant metallic surfaces and recessed areas VCI
- Molecular film does not alter any important metal properties
- Vapors replenish inside the contained package