U-3ARC
TRAINING WEBINAR N°44

Corrosion in HVAC systems

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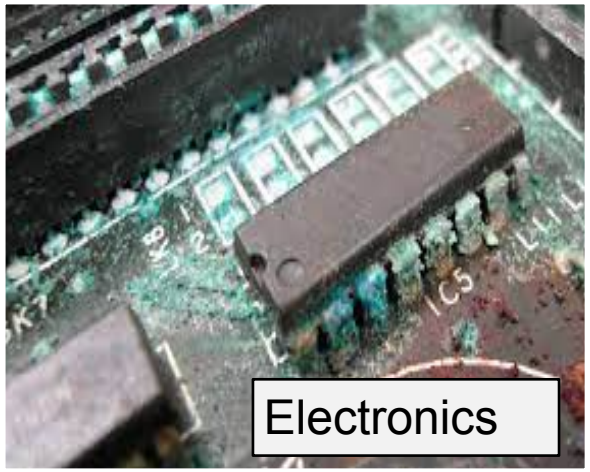
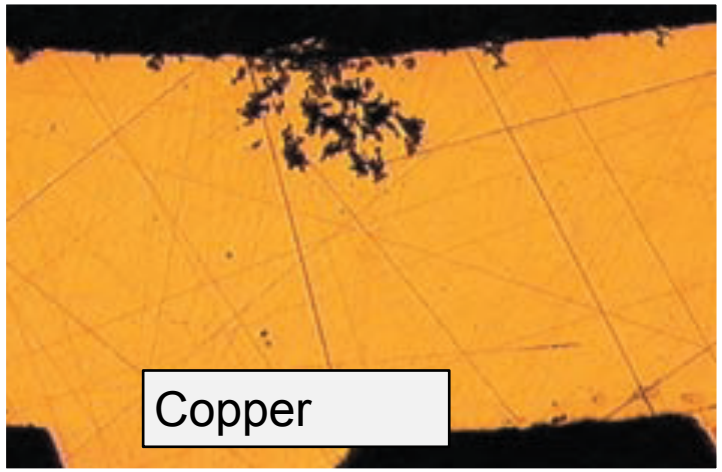
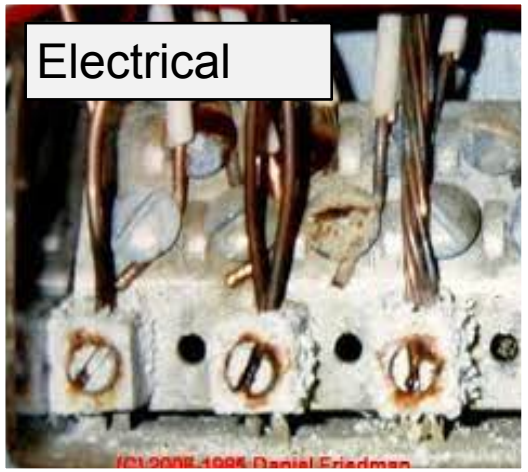
Few examples


Electronics


Copper


Electrical


Steel pitting


Hardware


Fins


Heat Exchanger

Definition

Corrosion (from the Latin word *corrodes*, meaning "to gnaw")
is the irreversible damage or destruction of
material due to a chemical or electrochemical reaction
impacting the intended use of the material.

Occurs on exposed surfaces, and is the gradual change in the original properties by the chemical in the environment.

Corrosion can occur in materials other than metals also, such as Polymers by the chemicals in the environment & due to exposure to the radiation such as UV.

Corrosion degrades the useful properties of materials and structures, including strength and appearance.

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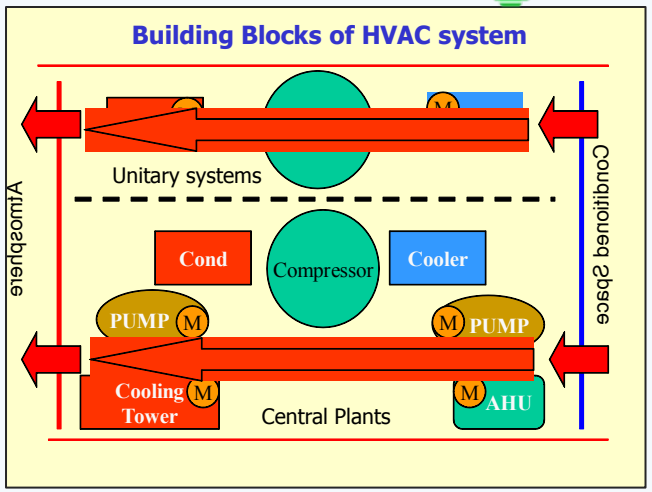
Corrosion in HVAC systems

- Different material are in contact with water, air and polluting substances and as a combination of all the three.
- Different metals are used in HVAC systems and in the construction of sub systems which can get corroded.
- The impact of pollutants in water and air depends upon the locations of installations such as rural, urban, saline, industrial, sea shores, dumping grounds, sewage water.
- It is important to understand the conditions and appropriate remedial action that needs to be taken.
- Degradation due to corrosion can lead to deterioration of performance, early failure and can lead to safety issues.



Material

- Steel
- Aluminium
- Copper
- Plastic
- Coated sheets
- Insulation

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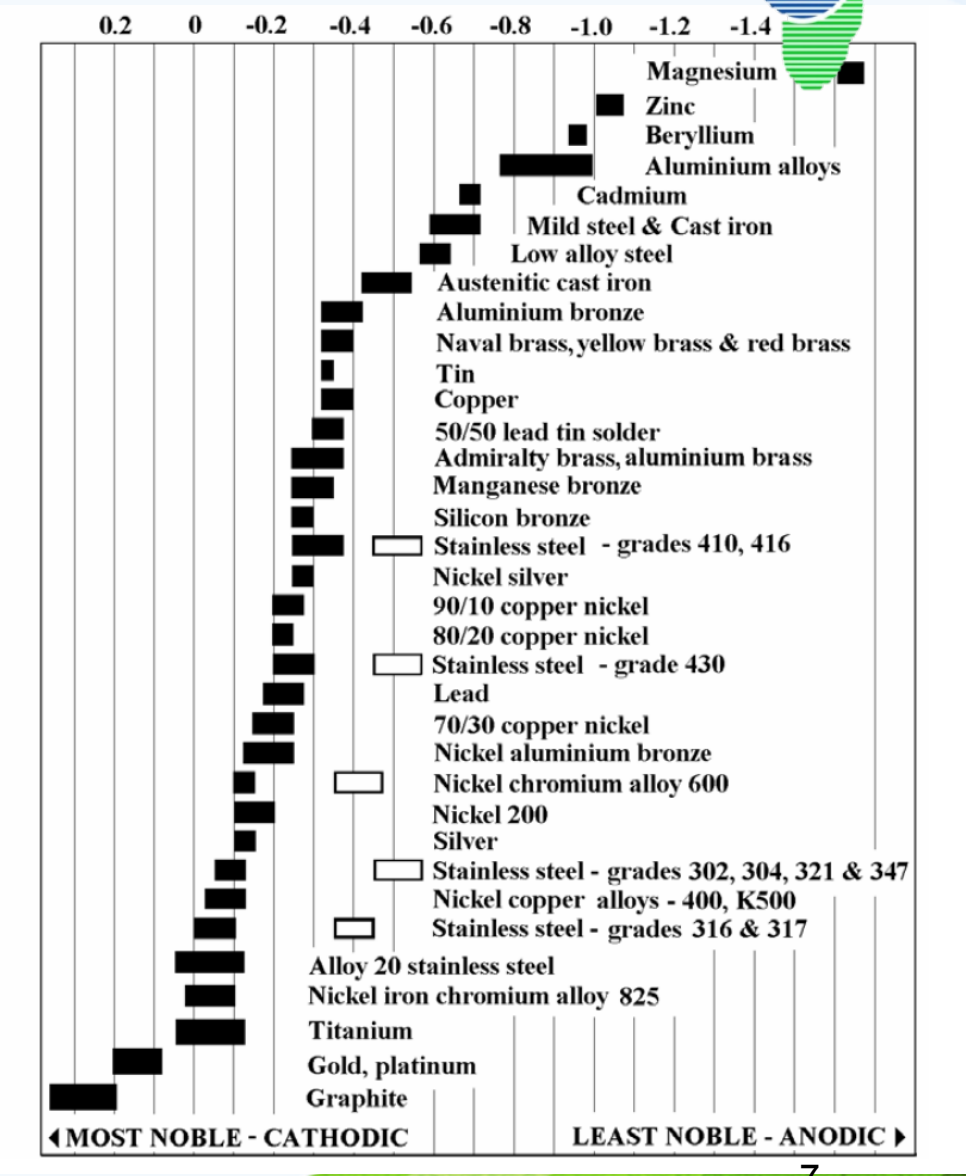
Case studies

- Plate Heat Exchanger
- Rusting of Compressor
- Expansion valve Railway AC unit
- Micro-channel Heat Exchanger
- Repeated PCB failures
- Sight Glass

Corrosion basics

- Galvanic corrosion starts with contact of dissimilar metals in presence of electrolyte, mostly water.
- If any one of the conditions (contact, dissimilar metals or electrolytes) is not present, galvanic corrosion cannot occur.
- Metals close to one another on the chart generally have mild effect. Metals separated further apart, the stronger is the effect of corrosion.
- Magnesium Anodic is least noble.
- Gold, Platinum are the most noble.
- Prevention: Break the electrical contact using plastic insulators or coatings between the metals.



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Types

MICRO

- Swimming pool areas
- Water treatment facilities
- Open sewage systems
- Diesel and vehicle exhaust emissions
- Landfills
- Fossil fuel burning power plants
- Animal farming

MACRO

- Adjacent to the sea coast
- Industrial sites
- Heavily populated urban areas

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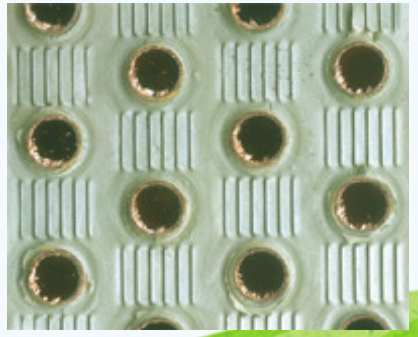
Heat Exchangers

- Galvanic corrosion due to Aluminium and Copper contact
- Degradation of Aluminium fins

Mitigation

- Coated fins
- Total coil coating
- Copper-Copper coils
- Tinning



- Field coating

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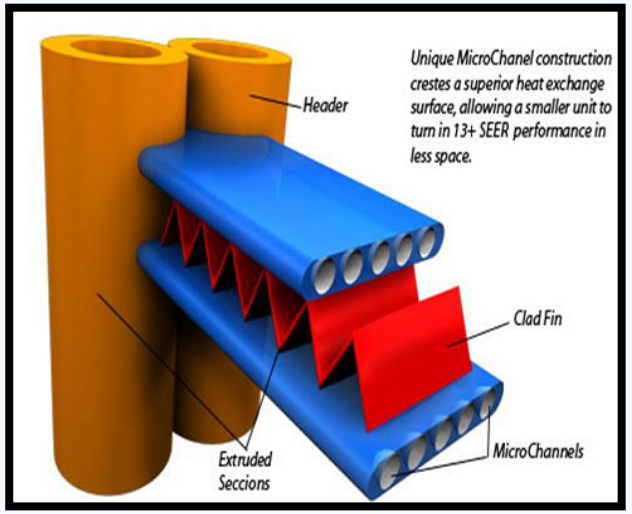
Micro Channel

- Microchannels offer higher heat transfer.
- Microchannels are Aluminium tube in multichannel geometry, brazed to Aluminium fins and headers.
- The header tubes, channels and fins are Zink coated which melts to form a welded joints & forms sacrificial material to prevent corrosion.
- The most susceptible joint is copper Aluminium joint of Liquid and Gas connection.
- E-coating is an normal practice for coil and epoxy coating for the copper joint.



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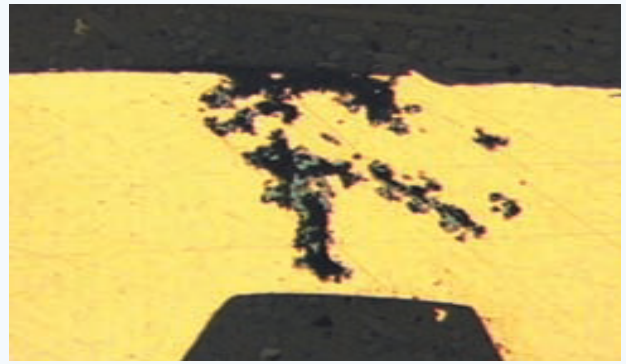
Formicary corrosion

- It is widely believed that Copper is close to noble metal and does not corrode, which is not true.



- Ant-Nest Corrosion occurs when oxygen, moisture and a specific corrodent, usually an organic acid, are simultaneously present on a copper surface.

- The nature of the attack is of a sub-microscopic nature; pits created by this type of corrosion are so fine, that they are not visible to the unaided eye.

- The corrosion initiates from the tube surface and progresses rapidly into the tube wall.

- Construction of new houses emit VOCs from Plywood, engineered wood products, flooring, latex paint and sheet vinyl flooring, has been identified as major sources for these compounds.

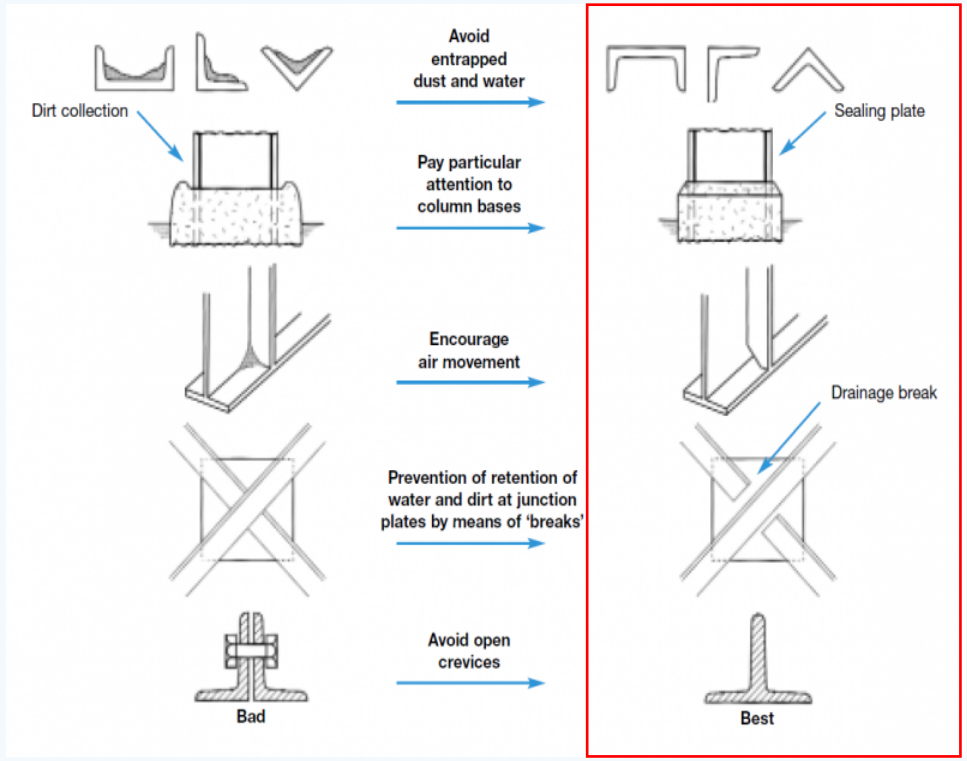
Brazing

Heat affected areas are most vulnerable

- Flux residue
- Excess oxidation
- Formation of Phosphoric Acid in DHP Cu, Cu Alloys
- Leaded brass pitting
- Copper coated mild steel
- Non inert & its reactions with inner surfaces

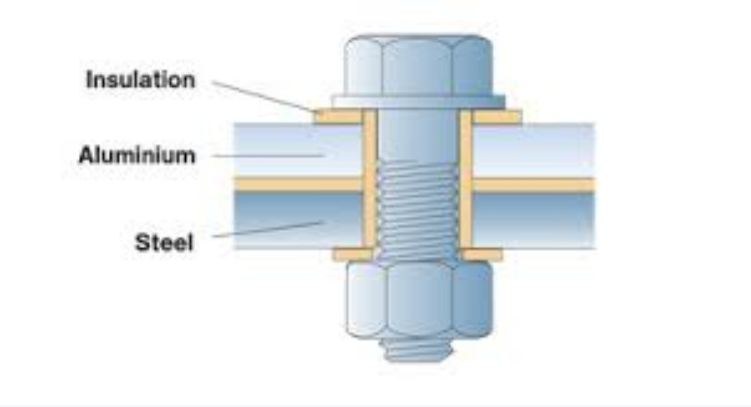
Corrosion in steel

- Starts in the presence of moisture and oxygen. In the absence of either, corrosion does not occur.
- Apart from the general corrosion, there are various types of localised corrosion that can also occur; bimetallic, pitting and crevice.
- The rate of the corrosion process depends on factors such as micro-environment in terms of humidity, wetness and atmospheric pollution
- **Mitigation**
  - ✓ Coating by sacrificial material, Electro plating, Hot dip galvanizing, Metal spray
  - ✓ Specific coating based on environment
  - ✓ Design considerations



Hardware

- In case of dissimilar metals to be joined, galvanic corrosion needs to be addressed by breaking the electrical connectivity.
- Non metallic washer below the screws, especially the self tapping screws, used in assembly of enclosures is recommended.
- The traditional method is to use Zink coating by hot dip or electrolytic process followed by passivation. However, this process has limitations due to uneven deposition.
- The Zinc Flake coating is adopted by AUTO industry, that gives superior protection.
- Over 1000 hours by ASTM B117 in Salt Spray test, gives adequate protection.



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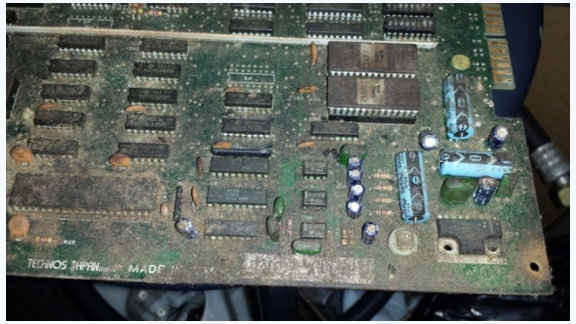
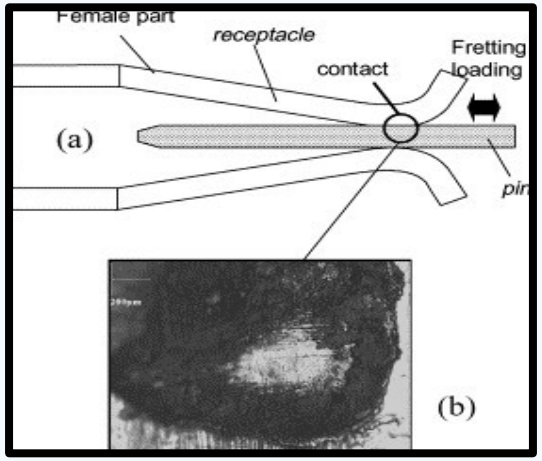
Electronic components

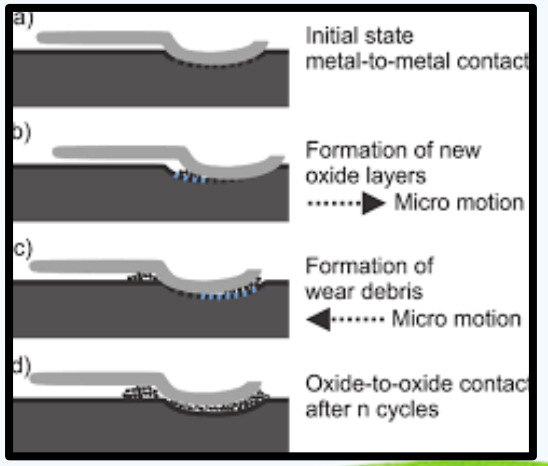
- Corrosion is one of the most common reasons for electronic failure due to environmental contaminants and conditions.
- Contaminants include ;
    a. Fine and coarse particles such as chlorides, sulphates, sodium, ammonium, potassium, magnesium, and calcium.
    b. Gases such as sulphur dioxide and nitrogen oxide in relatively humid environment.
- These chemicals attack the tracks on the PCB, connections and leads of sensors.
- Conformal coating gives best protection in most of the cases.
- In highly corrosive environment, the enclosure is kept in a positive pressure of air or Nitrogen.



Electrical components fretting corrosion

- Fretting Corrosion is a form of accelerated atmospheric oxidation which occurs at the interface of contacting materials undergoing slight, cyclic relative motion and is observed in soft as well as hard metals.
- In electric contacts involving non-noble metals, fretting action can cause rapid increase in contact resistance, proceeding to virtual open circuits.
- Remedial solution : Synthetic and natural oils have been found to be effective in preventing / minimizing fretting corrosion, as they have the ability of excluding oxygen from the contact, thus preventing oxidation of wear debris and freshly exposed contact material.

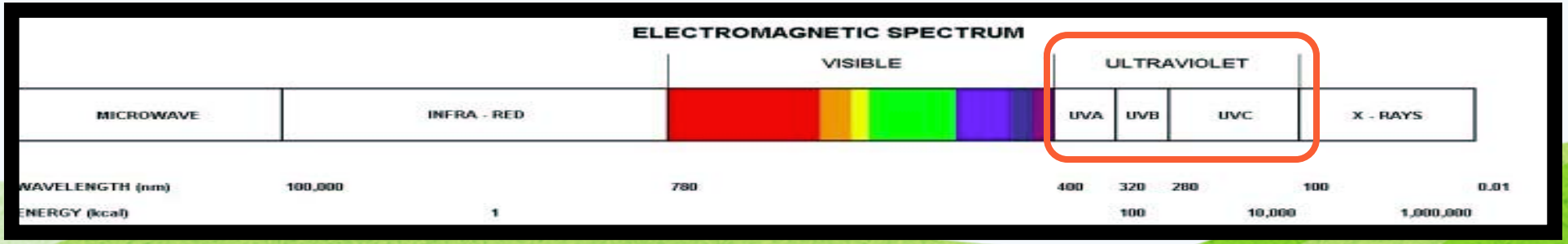




UV radiation

- UV exposure leads to discolouration, degradation, altering the properties of material, as it accelerates the diffusion of free hydrogen radicals through the polymer matrix and breaking the chain.
- Almost all synthetic polymers require stabilization, including protective powder coating used on sheet-metal parts.

- UV attack by sunlight can be prevented by adding UV stabilizing chemicals to the polymer when mixing the ingredients, prior to shaping the product by injection moulding. UV stabilizer usually act by absorbing the UV radiation.
- Polyester powder coating helps to retard degradation.
- Ambient temperature and humidity will accelerate any effect of the UV intensity level.

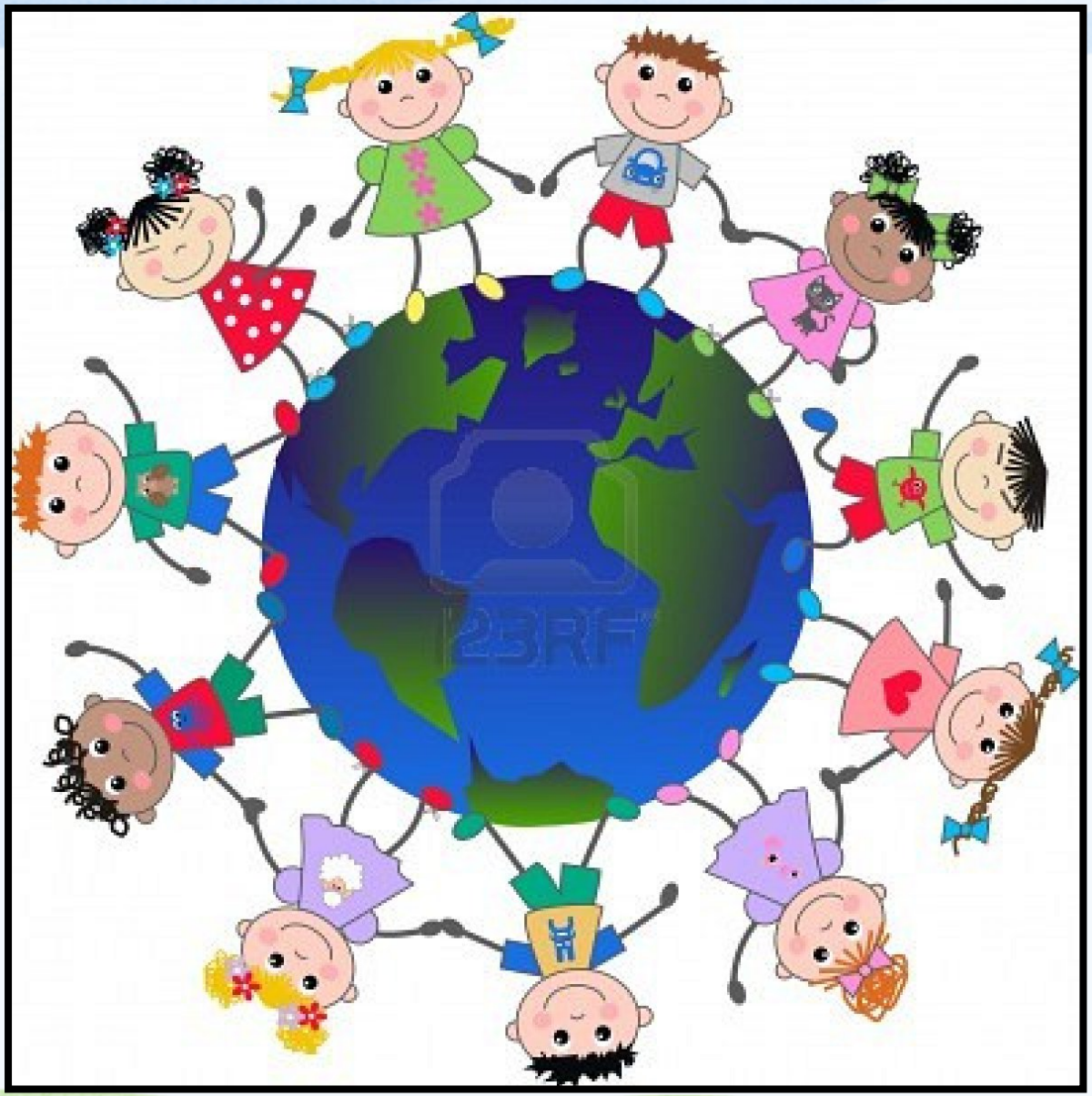


REFRIGERANTS that decompose in presence of moisture and high temperature

- Strong inorganic acids such as HCl and HF are formed from the decomposition of refrigerants.
- Weaker organic acids produced from decomposition of the lubricants.
- Moisture reacts with polyol ester (POE) lubricants to form organic acids and alcohols.
- Iron, Aluminium & Copper react with both inorganic and carboxylic acids to form salts or can catalyse hydrolysis reaction at higher temperatures.
- Counterfeit refrigerants can cause huge damage to the system as the properties get altered and impacts the performance.
- R40 refrigerant is highly corrosive with Aluminium and forms explosive mixture leading to fire.

Summary

- Corrosion can impact performance, reduce life and cause safety issues
- **Corrosion resulting in refrigerant leakage has huge impact on environment, as the refrigerants contribute significantly to GLOBAL WARMING**
- Evaluate MICRO and MACRO environments
- MICRO conditions requires special consideration
- Design consideration is the first step
- Certain processes like welding and brazing, need to be controlled
- Ensure that all components and sub systems are covered
- Field remedies will require experts, process control is essential



We have a responsibility to secure the future of the Next Generation…

THANK YOU FOR YOUR ATTENTION

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