CORROSION

SR.INSTRUCTOR/STC/KPA

CORROSION

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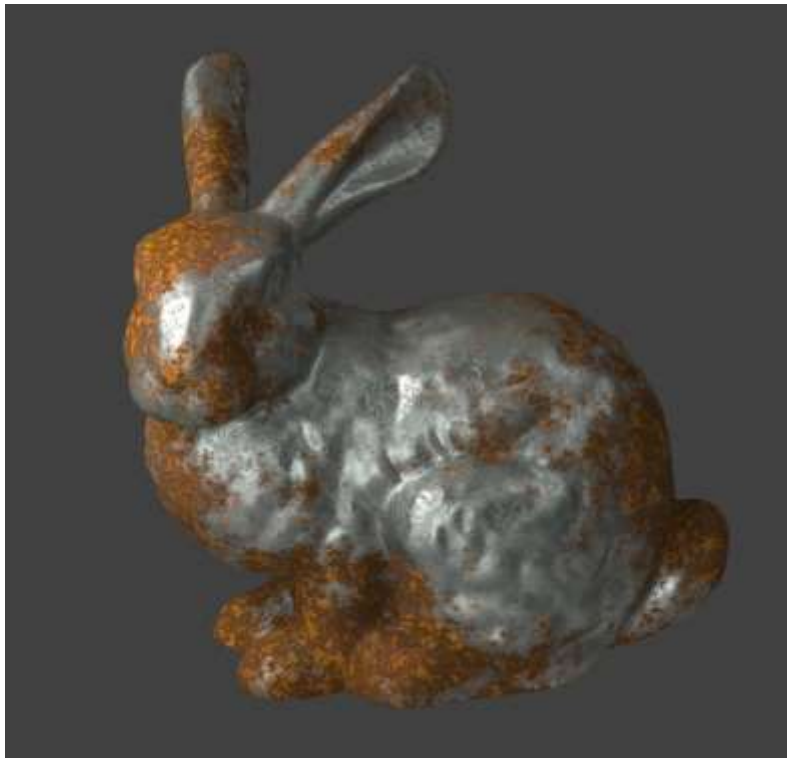


CORROSION

Corrosion

CORROSION

- “Corrosion is a slow but spontaneous deterioration of material by chemical or electro-chemical reaction with its environment”.

- It is a natural process, which converts a refined metal to a more chemically-stable form, such as its oxide, hydroxide, or sulfide

- Metals when Exposed to environment containing liquids, gases etc the surface of metal starts chemically reacting with environment and detoriates.

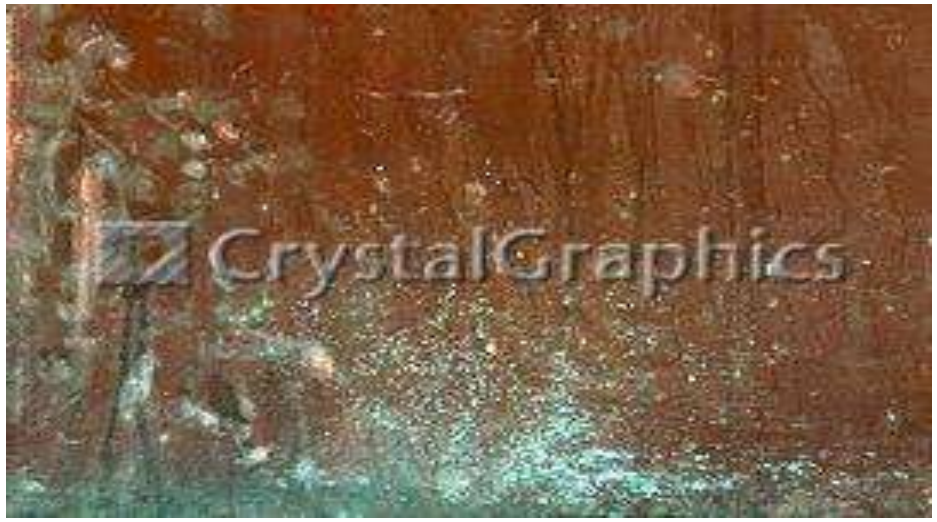
- Chemical reaction is -$4Fe+3O_2 = 2Fe_2O_3$

Corroded steel bolt

Formation reddish brown layer of Ferric Oxide on the surface of iron (rusting of iron, $\mathbf{Fe_2O_3.nH_2O}$).

Exposed copper plate

Formation of green layer of Copper Carbonate (**$CuCO_3$**) on the surface of copper



GENERAL CAUSES OF CORROSION

- Most of the metals exist in combined state in nature (except-Ag , Pt , Au).
- Metals get reverted to combined form to decrease the free energy of the system, when come in contact with air, water, moisture, corrosive gasses, acid, base, salt etc.
- Corrosion is more severe in areas where there is accumulation of dirt, dust, sand or other contaminants.
- There is no material which can withstand all types of corrosive environments.

Effect Of Climatic Condition on Corrosion

- Least corrosive sites:
  - Dry inland sites, where RH is less e.g. Desert

- Most corrosive sites: Marine sites & Industrial atmosphere

CORROSION DAMAGES

- Loss of metal & its appearance,
- Loss of mechanical properties
- Fatigue strength, impact strength, ductility, malleability, etc.
- Maintenance cost
- Operating loss
- Contamination of products
- Loss of valuable product due to leakage
- Affects safety & reliability.

IMPORTANT FORMS OF CORROSION

- General/Uniform Corrosion .
- Galvanic Corrosion.
- Stress Corrosion Cracking.
- Concentration Cell Corrosion
- Pitting Corrosion.
- Crevice Corrosion
- Filiform Corrosion.
- FRETTING CORROSION

DESCRIPTION OF DIFFERTANT FORMS OF CORROSION

General /Uniform Corrosion

It is generally occurs due to direct Chemical attacks.

Four types of metal oxides are formed:-

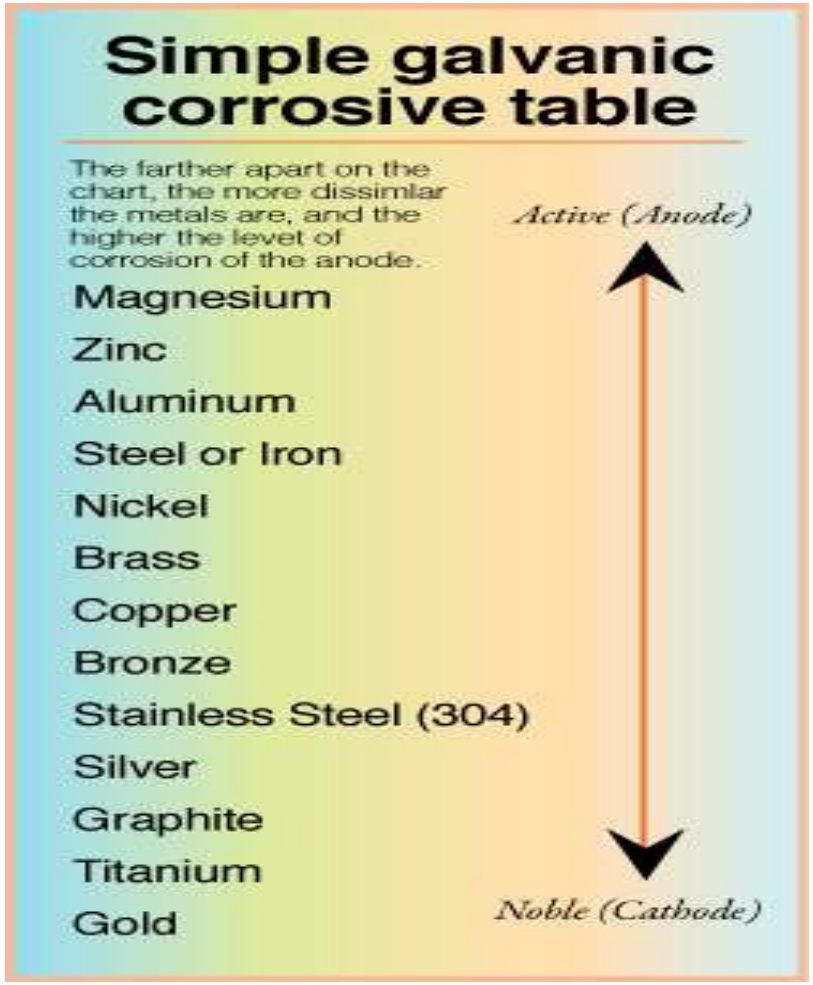
Stable: oxides of Al, Cu, Cr, Sn , Pb etc.
form oxide layer at room temp & acts as barrier , inhibit further corrosion

Unstable: oxides of Ag, Au, Pt etc. preventing further corrosion

Volatile: oxides of Mo, V, Sb etc.

Porous: oxides of Li, K, Na, Mg, Ca, Sr ,Fe, etc.(entire metal is converted to metal oxide)

Galvanic Corrosion –An electro chemical action that occurs between two dissimilar metal which are in contact with other i.e. in the presence of an aggressive medium.



Galvanic corrosion in Railways

- Rivets & bolt
- Trough floor,
- Lavatory area
- Area adjacent to radiator in Diesel locos

GALVANIC CORROSION

- Prevention
  - Close metal in Electro Chemical series to be selected
  - Size of anode should be larger than cathode
  - Insulate dissimilar metal completely
  - Add inhibitor
- Galvanic corrosion is often prevented by the use of sacrificial anodes.
- By proper design and through electrically insulating dissimilar metals.

STRESS CORROSION

STRESS CORROSION:-Occurs due to simultaneous effect of static tensile stresses(mechanical operations like Bending, Hammering and annealing) & a specific corrosive environment”

Stresses may be due to applied loads/tension, residual stresses from the manufacturing process, or a combination of both.

Metal under stress becomes more anodic & tends to increase the rate of corrosion.

- Common alloys which fail by Stress corrosion-

Steel,SS(hot acid chloride) , brasses(NH_3), Ti-alloys(N_2O_4), etc.

Prevention:-

a) Relieving the stress below the threshold stress (heat treatment, Shot peening /blasting)

b) Elimination of critical environmental factors

c) Choice of metal/alloy

d) Cathodic protection

e) Use inhibitor

f) Coating

CONCENTRATION CELL CORROSIONS

- Concentration Cell Corrosion –It occurs when two metal surfaces are in contact with different concentrations of the same solution.

PITTING CORROSIONS

Pitting Corrosion –A kind of localized corrosion that occurs with pits at underneath surface formed due to corrosion product accumulation.

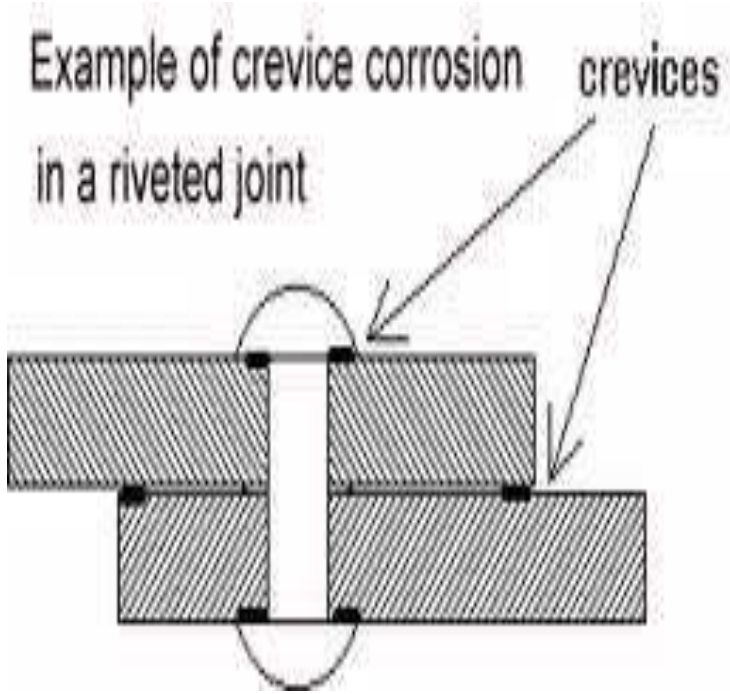
CREVICE CORROSIONS

- Crevice Corrosion – It is an accelerated corrosion in a narrow Crevice between two parts of a component one of which is made from a metal and are Non metal.

Corrosive attack at confined spaces or crevices under deposits of debris/ fouling/ stagnant water.

Contact between metal & nonmetallic surfaces/ rubber,wood, plastics, asbestoses, wax

occurs under loose fitted:-washers, gaskets, joints & clamps,Trough floor mainly near lavatory, etc.



FILIFORM CORROSION

- Filiform Corrosion-It occurs on painted surfaces due to penetration of coated surface by moisture in the form of Filament .
  "Occurs on painted or plated surfaces when moisture permeates the coating".

- Occurs when RH is high & temp range 20-35^{0}C in presence of oxygen.

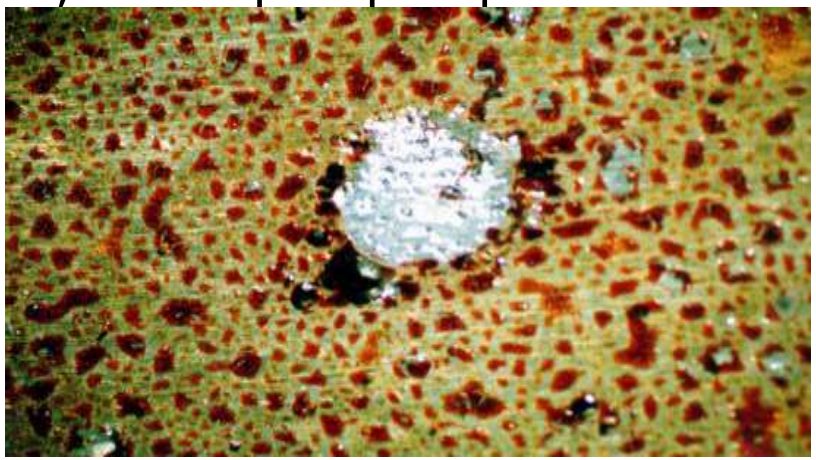
- Attack begins at cuts, pores or mechanical scratch in coating.

- Observed on:
  - Steel,
  - Mg & Al surfaces covered with Sn,
  - Phosphate, enamel & lacquer coatings.

FRETTING CORROSION

Appears as pit or grooves at the interface between, highly loaded tight fitting contacting metal surfaces subjected to vibrations/ Slip

- Damage due to combination of friction wear & oxidation
- The relative motion between the surfaces removes protective films & results in accelerated attack
- Causes fatigue fracture, pits act as stress raiser
- It is non uniform corrosion
- Occurs when protection film breaks down
- Observed in:
- Helical coil springs , Rail, axle, cylinder liner, engine block, water pump impellers etc.
- Prevention
  - Lubrication between the contacting surfaces
  - Provide Phosphate coating
  - Increase hardness
  - Reduce load
  - Avoid slackness



DIRECT CHEMICAL CORROSION

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  - Volatile: oxides of Mo, V, Sb etc.
  - Porous: oxides of Li, K, Na, Mg, Ca, Sr ,Fe, etc.(entire metal is converted to metal oxide)

DIRECT CHEMICAL CORROSION

Rusted Riveted Steam Engine Boiler

- ‘Attack on a metal is uniform over the entire exposed surfac
- Represents greatest destruction of metal on tonnage basis.
- Metal loss occurs more or less at same rate over entire metal surface .
- Smooth metal surface becomes rough, thin & ultimately fail

- Not of too great concern from technical point of view.

DIRECT CHEMICAL CORROSION

– Iron rusts quickly because atomic iron is much smaller in size than its oxide. So, the oxide forms a loose rather than tightly packed layer & flakes away.

In Railways it occurs in Rail, Wagons & other M S structures

Prevention:

- Proper material selection
- Protective coatings
- Inhibitor
- Cathodic protection

Corrosion prone areas- coaches, wagons, locos & tracks

CORROSION ON RAILWAY ROLLING STOCK

Indian Railway is one of the largest transport network in the world comprising a fleet of rolling stocks like Coaches, Locomotives Wagons, etc.

Rolling stocks are exposed to all weather conditions like variation in day & night temp., humidity, salinity, rainfall, etc. apart from industrial/ marine atmosphere, which makes it susceptible to corrosion.

CORROSION PRONE AREAS IN COACHES

CAUSES OF CORROSION IN COACHES

1. Leakage of water through lavatory flooring, Water seepage through flooring to trough floor, defective water pipe fittings
2. Flushing floor with water jet for cleaning
3. Surface not prepared properly before welding/painting.
4. Recommended material not used due to non-availability.
5. Accumulated dust :
   - On trough floor
   - On Inner Head stock.

AREAS CORRODED IN COACHES

AREAS	POSSIBLE CAUSES
AC sleeper coach:	
• Inner Head stock below from lavatory	- Dirt and water seepage lavatory
• Bottom of main door	- Dust deposition
• Turn under below lavatory deposition	- Water seepage & dirt
• Lower portion of lavatory partition pillar	- Water logging

AREAS CORRODED IN COACHES

Non-AC sleeper coaches:

- Outer Head stock - Dirt deposition & water seepage from lavatory
- Lower portion of side wall near lavatory - - do -
- Turn under near lavatory - - do -
- Trough Floor - water logging

AREAS CORRODED IN COACHES

Pantry car

- Lower portion of body pillar---- Water seepage all along and turn under, from pantry and side wall, lavatory partition lavatory pillar, under frame member below lavatory

AREAS SUBJECTED TO HIGH RATE OF CORROSION IN PASSENGER COACHES

- Side wall bottom:
  - area below lavatory and at body side pillars.
- Head stock:
  - Outer head stock and tubular sections are heavily corroded due to lavatory.
- Body pillar :
  - bottom portion of pillar near doorways and lavatory area
- Cross bearer :
  - Joint between sole bar
- Body side door :
  - Bottom of door due to water containing luggage

AREAS SUBJECTED TO HIGH RATE OF CORROSION IN PASSENGER COACHES

- Battery box :
  - corrosion due to acid
- Roof :
  - rain water
- Trough floor :
  - adjacent to wash basin and lavatory
- Floor :
  - Pantry car area
- Equalizing stay :
  - Tube corrodes due to drain of lavatory water
- Brake beam:
  - Tube corrodes due to splash of lavatory water.

Corrosion prevention of Coaches

- To prevent water seepage: Mostly adhesive is used in PVC joining with side wall but the best way to use PVC welding.
- Before final flooring, metal turning, dirt/dust to be completely removed by air blowing to avoid chocking of water drain hole.
- Swabbing to be used for cleaning in stead of water jet cleaning
- At POH shop under frame to be cleaned by wire brush, air blowing & only after proper cleaning bituminous black paint to be used

Corrosion prevention of Coaches

- Turn under hole to be kept open
- Over head water tank to be drained out completely during POH to avoid pitting corrosion
- Welding of inner head stock should be proper
- Head stock, sole bar, bracket are of MS, where as Bio toilet tanks are of SS. To avoid galvanic corrosion it should be insulted by proper coating
- In body panel butt welding to be adopted in place of lap welding
- During welding care to be taken so that current should not pass through bearing.
- Painting to be done only after furnishing is completed

HEAVY CORROSION

Partition & trough
floor in lavatory area

HEAVY CORROSION

Rajdhani Exp. Coaches

A VIEW OF CORRODED COACH (BEML)

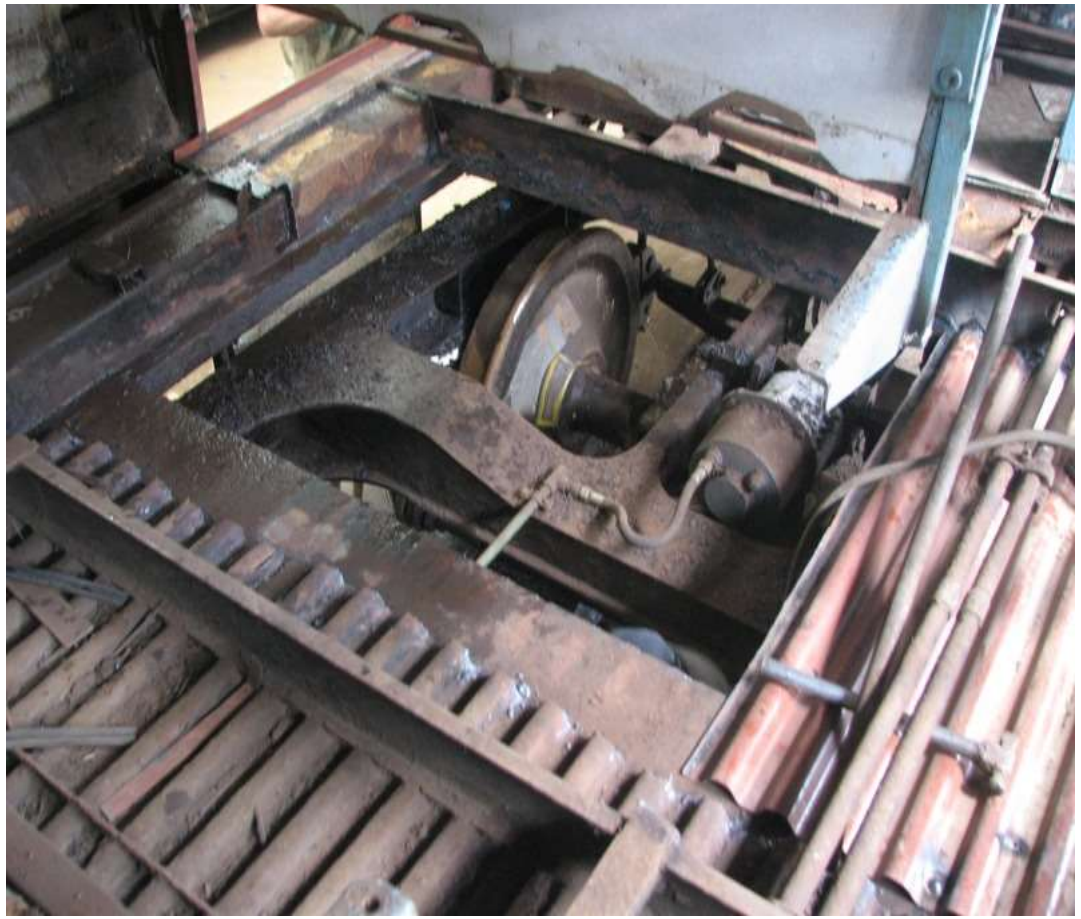
CORRODED SOLE BAR (BEML)

CORRODED H/S & U/F MEMBERS

Head Stock

CORRODED BATTERY BOX

CORRODED TROUGH FLOOR AREA



CORRODED B/P & D/P FLOOR

Corroded Body Pillar Structure

Corroded Door passage floor area

CORRODED L/W & LAV

Corroded Lavatory Wall

Corroded Lavatory

CORRODED S/B, LAV, S/W & T/U

Corroded Sole Bar & Lavatory

Corroded Side Wall & Turn Under

CORRODED W/T AREA

Coach Water Tank area

Coach Water Tank Area

CORROSION PRONE AREAS IN WAGONS

MAJOR LOCATIONS OF CORROSION OF WAGONS

- Side panel
- End panel
- Head stock
- Body pillar/stanchion
- Base of side stanchion
- Portion of side panel at ends near corner angle
- Interior surface of wagon
- Floor
- Plate over joint of side panel & floor
- Door frame & hinge
- Sole bar at/near doorways
- Under frame components

CORROSION PRONE AREA BOXN

- Side panel
- Overlapping joint

Reasons for corrosion

1.Contaminated water mixed with chemical substances of loaded Materials.

2. Running through coastal areas.

3. Deposition of rain water.

CORROSION PRONE AREA

- End panels adjoining with floor plates

Deposition of rain water mixed with the chemical substances of loaded commodities.

CORROSION PRONE AREA

- Sole bar
- Door Hinge
- Floor

Corrosion causes:-

1. Due to flowing of rain water from floors near door way.
2. Door hinges get corroded in contact with flowing rain water from floor.
3. Floor gets corroded due to deposition of rain water and water mixed with chemical substances contaminated with chemical substances of loaded materials.

CORROSION PRONE AREA ON BOXN

- Inside end panel

CORROSION PRONE AREA ON BOXN

- Joint area between Door way stiffener with side stanchion

CORROSION PRONE AREA ON BOBRN

Door

Corrosion prevention of wagons

- Proper cleaning/removing of waste found in wagons before IOH/POH
- Welding/ Painting to be done only after proper surface preparation
- After use for corrosive material e.g. salt, urea , wagon is to be washed with water
- If pitting is observed, plate to be changed.

CORROSION PRONE AREAS IN DIESEL LOCO.COMPONENTS

CORROSION IN DIESEL LOCOS

Corrosion on various diesel loco components:

- cylinder liners
- Engine blocks
- Expansion tank
- water pump impellers
- water pipelines.
- Joints

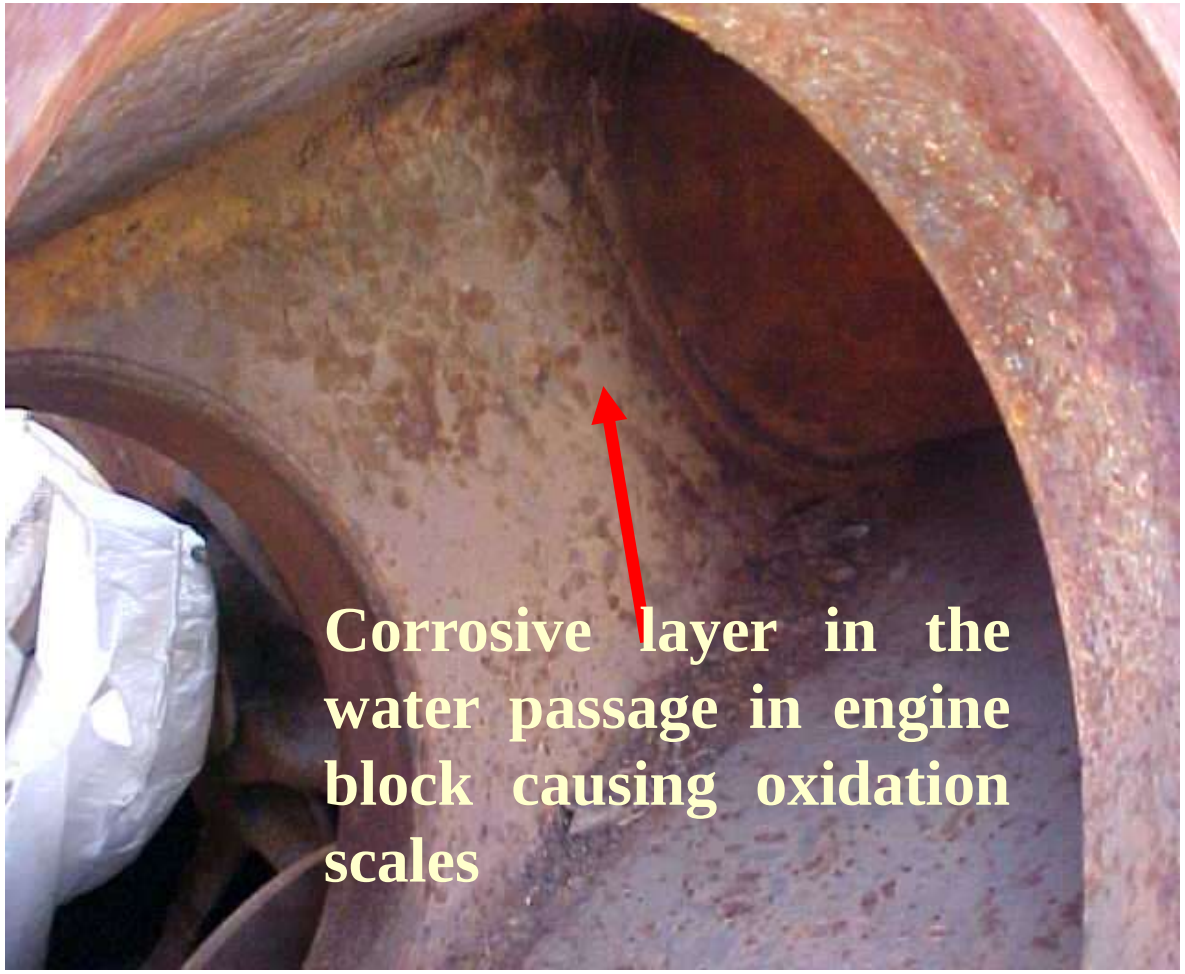
- Fretting corrosion on axle box roller bearings, Axle, wheel hub.

CORROSION ON CYLINDER LINERS

cavities at the top deck of cylinder liner (Cavitation erosion)

General corrosion on cylinder liner (Rusting)

ENGINE BLOCK WATER PASSAGE AREA



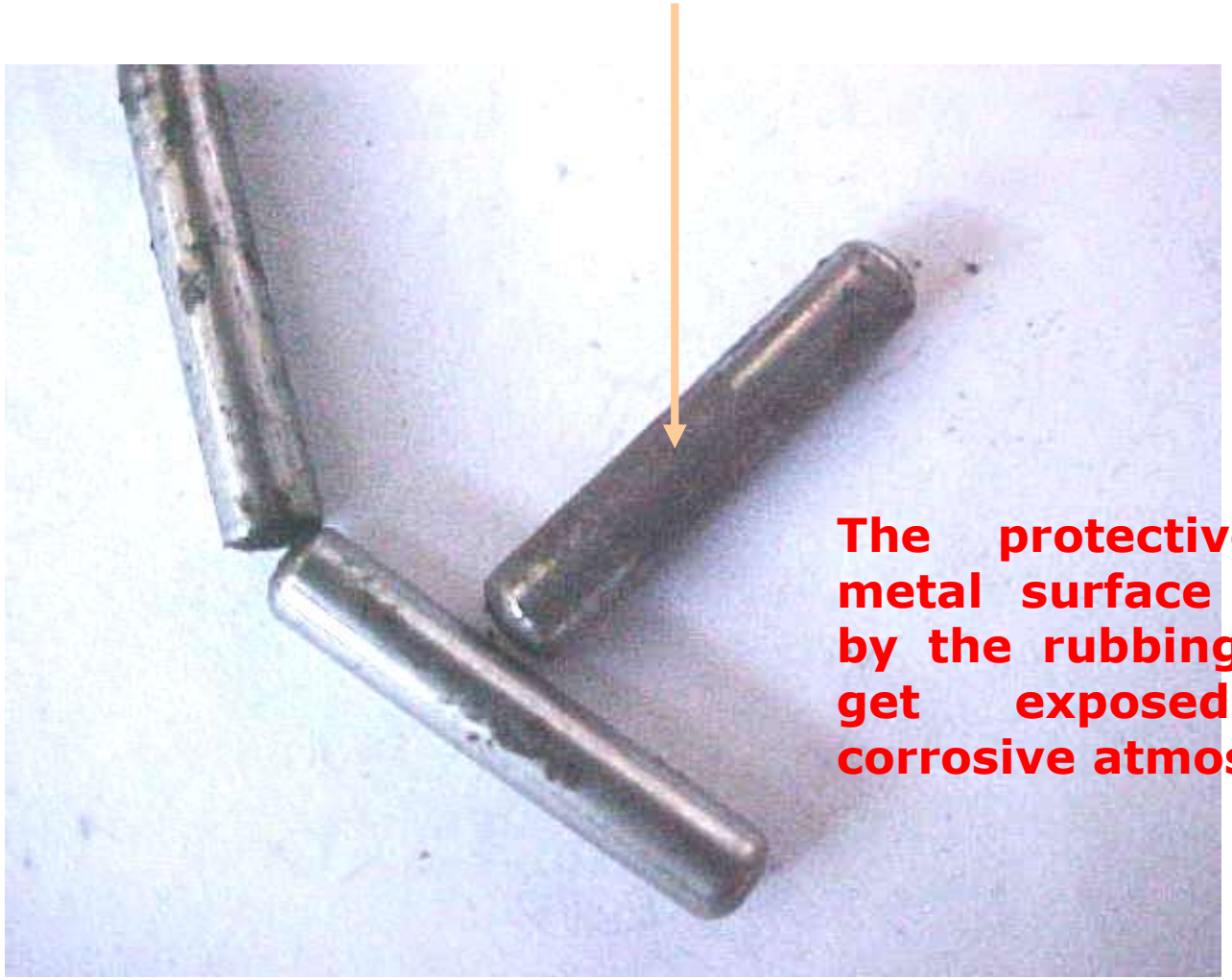
CORROSION IN WATER PUMP IMPELLER AND SLEEVE

INTERNAL CORROSION IN THE WATER PIPELINES

Corroded inner layer of dresser joint of WDS6 locomotive

Dressor joint of WDM2 locos

FRETTING CORROSION OF NEEDLE BEARINGS



The protective film on metal surface is removed by the rubbing action and get exposed to the corrosive atmosphere

CORROSION IN DIESEL LOCO COMPONENTS

Corroded Radiator

Corroded Lube oil Cooler

CORROSION IN DIESEL LOCOCOMPONENTS

Corroded Expansion Tank

Corrosion prevention of locos

- D M water to be used in cooling water system
- Proper concentration of corrosion inhibitor to be maintained
- Cooling water to be drained out completely
  - If chloride content is more than 50 ppm.
  - If Total hardness is more than 200 ppm.
  - If cooling water is turbid due to insoluble materials.
- Cooling water system to be cleaned with TSP once in year or when ever contaminated with oil
- Vibration of components e.g. piston, radiator, water riser pipe etc to be minimized.
- Washing of battery box with water whenever loco comes to Shed/WS

CORROSION PRONE AREAS IN RAILS
(the most imp. component of Rail system)

CORROSION OF RAILS

Can be broadly classified as:

General Rail Corrosion :

- There is reduction in overall cross section of rail because of general corrosion and sometimes abnormal reduction in some parts of web & foot leading to stress concentration and rail fractures consequently.

- Severe in :
  - coastal areas due to salinity.
  - Industrial area due to chemical pollution &
  - sidings where corrosive goods are handled.

CORROSION OF RAILS

Rail corrosion at Fastening locations :

- Crevice corrosion between liner and rail foot.
  - In yards due to drainage problem,
  - Where passenger trains run in early morning hours, due to lavatory discharge
- Fretting corrosion at bolted tie plates on railroad rails
  - (frequent tightening of these plates is required because the parts are not lubricated and fretting corrosion proceeds rapidly).
- Pitting corrosion

CORRODED RAILS

CORROSION IN RAIL

Corrosion of rails below liner

Corrosion prevention of Rail

- Avoid water logging in the yard .
- Proper & regularly tightening of the plate bolt to avoid fretting corrosion.
- Bio toilet to be adopted and proper treatment of discharge water to be ensured.

THANK YOU