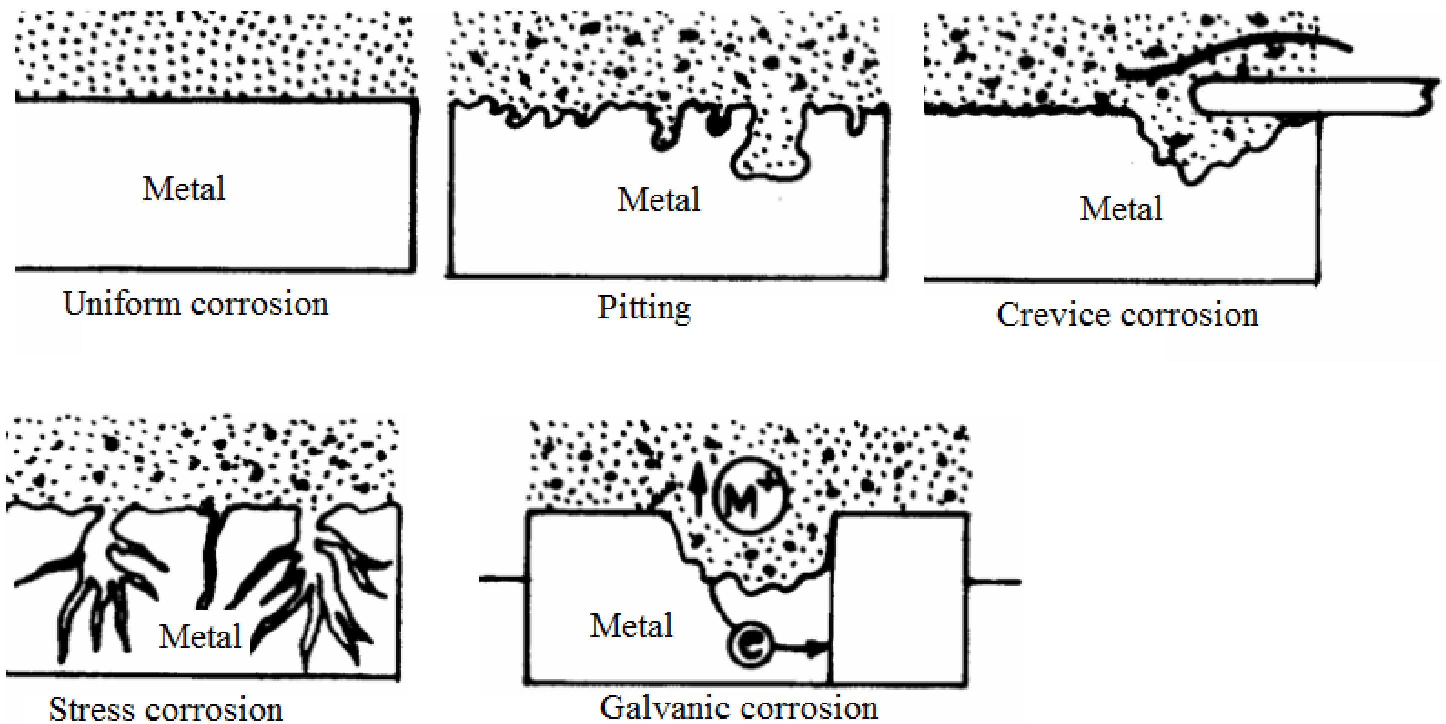
Chapter (6-D)

Corrosion Control Based on Corrosion Types or Forms



Prevention of Uniform Corrosion

1. Galvanizing (zinc coating)
2. Painting
3. Electroplating
4. Cathodic protection

PREVENTION OF GALVANIC CORROSION

1) Select metals, close together, as close as possible, in the galvanic series.

2) Do not have the area of the more active metal (anodic) smaller than the area of the less active metal.

3) If dissimilar metals are to be used, insulate them.

4) Use inhibitors in aqueous systems whenever applicable.

5) Apply coatings with judgment.

- Do not coat the anodic member of the couple as it would reduce the anodic area and severe attack would occur at the inevitable defect points in the coating.
- Therefore, if coating is to be done, coat the more noble of the two metals in the couple which prevents electrons being consumed in a cathodic reaction which is likely to be corrosion-rate controlling.

PREVENTION OF GALVANIC CORROSION

6) Avoid joining materials by threaded joints.

7) Use a third metal active to both the metals in the couple. Sacrificial material, such as zinc or magnesium, may he introduced into this assembly. e.g. zinc anodes are used in cast-iron water boxes of copper alloy water-cooled heat exchangers.

8) In designing the components, use replaceable parts so that only the corroded parts could be replaced instead of the whole assembly.

Above all, understand materials <u>compatibility</u> which is the key to control galvanic corrosion.

PREVENTION OF CREVICE CORROSION

1) Use welded joints in preference to *bolted or riveted joints.*
2) Seal crevices by using non-corrosive materials.
3) Eliminate or minimize crevice corrosion at the design stage.
4) Minimize contact between metals and plastic, fabrics and debris.
5) Avoid contact with hygroscopic materials.
6) Avoid sharp corners, edges and pockets where dirt or debris could be collected.
7) Use alloys resistant to crevice corrosion, such as *titanium or Inconel.*

Increased Mo contents (up to 4.5%) in austenitic stainless steels reduce the susceptibility to crevice corrosion.

PREVENTION OF CREVICE CORROSION (Cont'd)

8) Apply cathodic protection to stainless steels by connecting to adjacent mild steel structure.

9) For better performance of steels in seawater, allow intermittent exposure to air to *allow the removal of protective films.*

10) Use inhibiting paste, wherever possible.

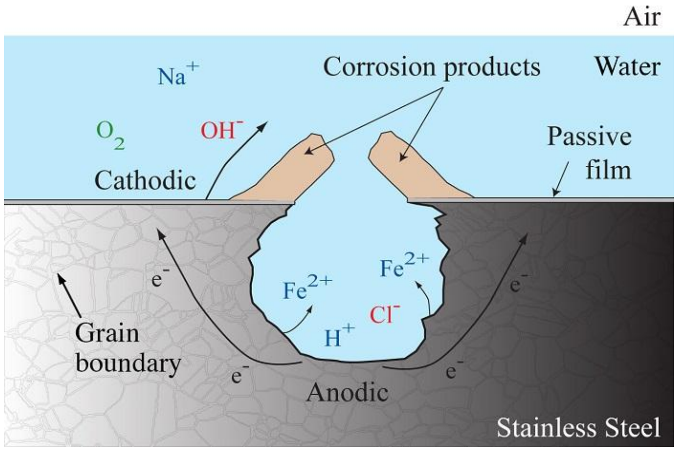
11) Paint the cathodic surface (not the anode).

12) Remove deposits from time to time… i.e. *Clean!*

13) Take precautions against **microbial corrosion**, which creates crevices and is damaging to low Mo stainless steels.

PREVENTION OF PITTING CORROSION

1) Use materials with appropriate alloying elements designed to minimize pitting susceptibility, e.g. molybdenum (Mo) in SS.
2) Provide a uniform surface through proper cleaning, heat treating and surface finishing.
3) Reduce the concentration of aggressive species in the test medium, particularly chlorides.
4) Use inhibitors to minimize the effect of pitting, wherever possible.
5) Make the surface of the specimen smooth and shiny and do not allow any impurities to deposit on the surface.



PREVENTION OF PITTING CORROSION (Cont'd)

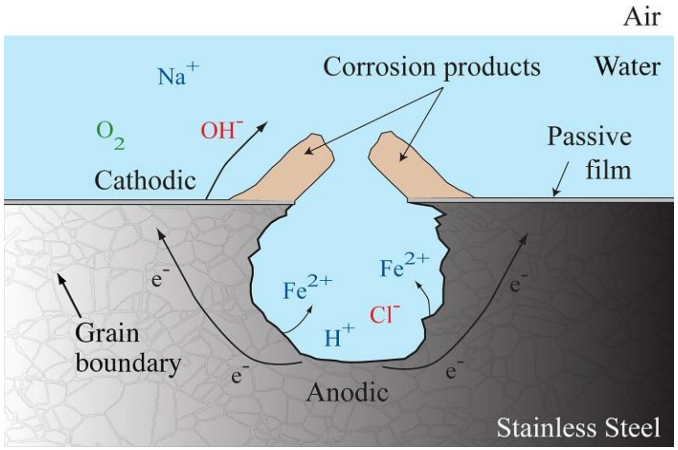
6) Minimize the effect of external factors on those design features that lead to the localized attack, such as the presence of crevices, sharp corners, etc.

7) Apply cathodic protection, wherever possible.

8) Coat the metals to avoid the risk of pitting.

10) Add anions, such as OH^- to chloride environment.

11) Operate at a lower temperature, if service conditions permit.



Prevention / Control of IGA corrosion

1. Use a low carbon grade of stainless steel
2. Use a stabilized grade of steel:
   - This includes a strong carbide-forming element (Nb or Ti) to lock up the carbon.
   - Saves Cr from precipitation
3. For existing components that have been sensitized:
   - heat treat to re-dissolve the carbides (this is very difficult in practice).

Prevention of Dezincification:

1- Make environment less aggressive (e.g., reduce O_2 content).

2- Use cathodic protection.

3- Use a better alloy (common cure / above not usually feasible):

- Red brass (<15% Zn) almost immune
- Admiralty Brass: 70 Cu, 29 Zn, 1 Sn;
- arsenical Admiralty: 70 Cu, 29 Zn, 1 Sn, 0.04 As

(Sn and Sn-As in deposited films hinder re-deposition of Cu).

4- For very corrosive environments likely to provoke dezincification, or for critical components, use the alloy:

- cupronickels: 70-90 Cu, 30-10 Ni (balance is Zn).

Prevention of SCC

1. Lowering the stress below the threshold value if one exists.

   This can be done by:

   1. annealing in the case of residual stresses
   2. thickening the section, or
   3. reducing the load.

   Examples:

   - Plain carbon steels may be stress-relief annealed at 590 to 650°C.
   - Austenitic stainless steels are frequently stress-relieved at temperatures ranging from 820 to 930°C.

2. Eliminating the critical environmental species by, e.g.

   de-gasification and demineralization (salt removal).

Prevention of SCC

3. Changing the alloy is one possible recourse if neither the environment nor stress can be changed.

- It is common practice to use Inconel (raising the nickel content) when type 304 stainless steel is not satisfactory.
- Although carbon steel is less resistant to general corrosion, it is more resistant to SCC than are the stainless steels.

- Thus, under conditions which tend to produce SCC, carbon steels are often found to be more satisfactory than the stainless steels.
- Heat exchangers used in contact with seawater or brackish waters are often <u>constructed of ordinary mild steel</u>.

Prevention of SCC

4. Applying cathodic protection to the structure with an external power supply or consumable anodes:

- Cathodic protection should only be used to protect installations where it is positively known that SCC is the cause of fracture, since hydrogen embrittlement effects are accelerated by impressed cathodic currents.

5. Adding inhibitors to the system if feasible:

- Phosphates and other inorganic and organic corrosion inhibitors have been used successfully to reduce SCC effects in mildly corrosive media. As in all inhibitor applications, sufficient inhibitor should be added to prevent the possibility of localized corrosion and pitting.

Prevention of Erosion-Corrosion

1) Design: avoid impingement geometries, high velocity, etc.
2) Chemistry: modify the corrosive medium to be less aggressive.
3) Materials (use Cr-containing steels);
4) Use hard, corrosion-resistant coatings.

Prevention of fretting Corrosion

- lubricate;
- avoid relative motion (add packing, etc.);
- increase relative motion to reduce attack severity;
- select materials (e.g., choose harder component).