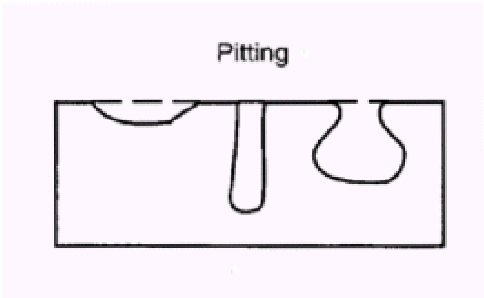
Different Types of Corrosion

- Recognition, Mechanisms & Prevention

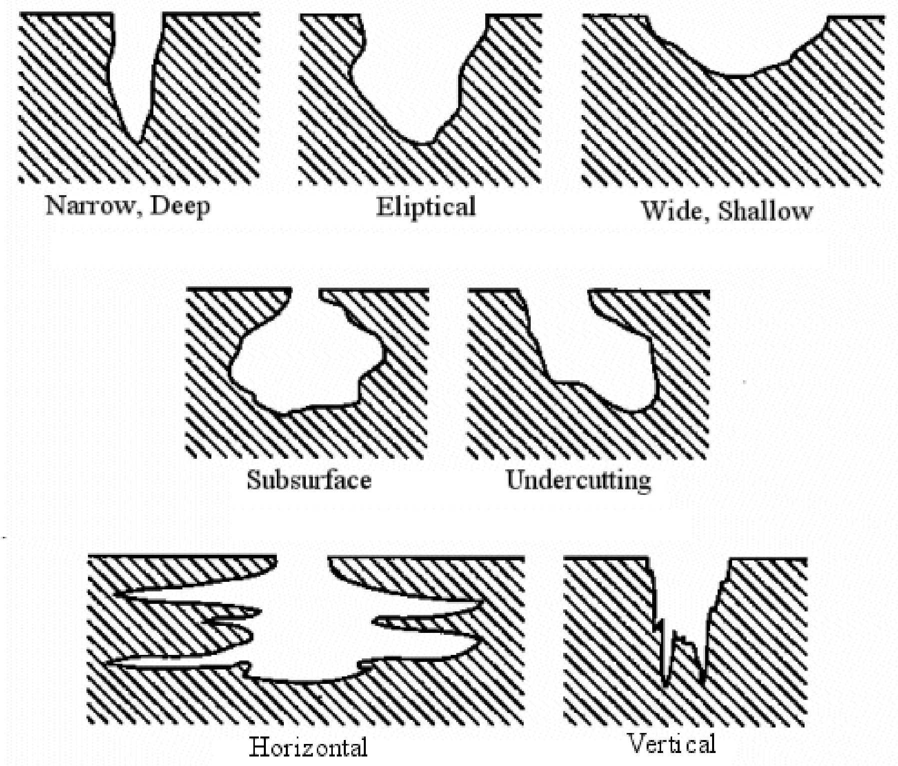
Pitting Corrosion

Recognition of Pitting Corrosion

What is pitting corrosion? Pitting Corrosion is the localized corrosion of a metal surface confined to a point or small area, that takes the form of cavities. Pitting corrosion is one of the most damaging forms of corrosion. Pitting factor is the ratio of the depth of the deepest pit resulting from corrosion divided by the average penetration as calculated from weight loss. The following photo shows pitting corrosion of a SAF2304 duplex stainless steel after exposure to 3.5% NaCl solution.



Pitting corrosion is usually found on passive metals and alloys such aluminium alloys, stainless steels and stainless alloys when the ultra-thin passive film (oxide film) is chemically or mechanically damaged and does not immediately re-passivate. The resulting pits can become wide and shallow or narrow and deep which can rapidly perforate the wall thickness of a metal.



ASTM-G46 has a standard visual chart for rating of pitting corrosion.

The shape of pitting corrosion can only be identified through metallography where a pitted sample is cross-sectioned and the pit shape, the pit size, and the pit depth of penetration can be determined.

Mechanisms of Pitting Corrosion

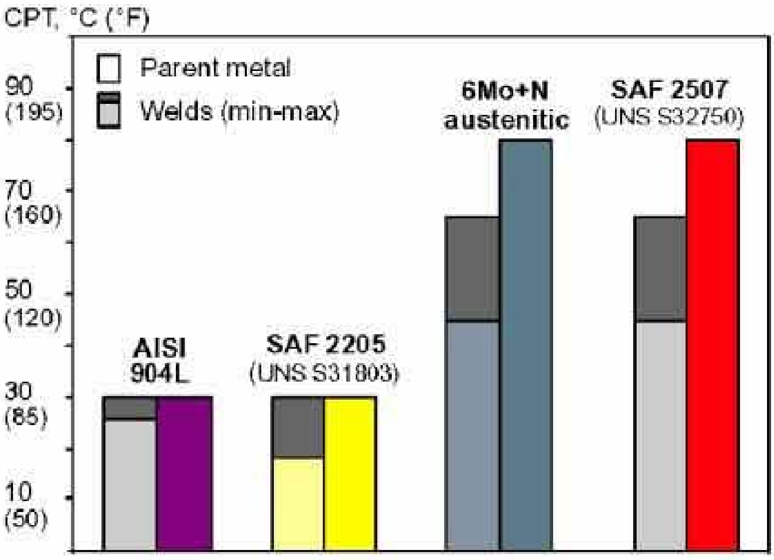
What causes pitting corrosion? For a defect-free "perfect" material, pitting corrosion is caused by the ENVIRONMENT (chemistry) that may contain aggressive chemical species such as chloride. Chloride is particularly damaging to the passive film (oxide) so pitting can initiate at oxide breaks.

The environment may also set up a differential aeration cell (a water droplet on the surface of a steel, for example) and pitting can initiate at the anodic site (centre of the water droplet).

For a homogeneous environment, pitting IS caused by the MATERIAL that may contain inclusions (MnS is the major culprit for the initiation of pitting in steels) or defects. In most cases, both the environment and the material contribute to pit initiation.

The ENVIRONMENT (chemistry) and the MATERIAL (metallurgy) factors determine whether an existing pit can be repassivated or not. Sufficient aeration (supply of oxygen to the reaction site) may enhance the formation of oxide at the pitting site and thus repassivate or heal the damaged passive film (oxide) - the pit is repassivated and no pitting occurs. An existing pit can also be repassivated if the material contains sufficient amount of alloying elements such as Cr, Mo, Ti, W, N, etc.. These elements, particularly Mo, can significantly enhance the enrichment of Cr in the oxide and thus heals or repassivates the pit. More details on the alloying effects can be found in the technical paper on "Stainless Steels and Alloys: Why They Resist Corrosion and How They Fail".

A material's resistance to pitting corrosion is usually evaluated and ranked using the critical pitting temperature (CPT) in accordance with the ASTM Standard
G48-03: Standard Test Methods for Pitting and Crevice Corrosion of Stainless Steels and Alloys by Use of $FeCl_3$. The critical pitting temperature is the minimum temperature (°C) to produce pitting corrosion and CPT is usually higher than the critical crevice temperature (CPT).



Prevention of Pitting Corrosion

How to prevent pitting corrosion? Pitting corrosion can be prevented through:

- Proper selection of materials with known resistance to the service environment
- Control pH, chloride concentration and temperature
- Cathodic protection and/or Anodic Protection
- Use higher alloys (ASTM G48) for increased resistance to pitting corrosion

Modeling and Prediction of Pitting Corrosion

CRA-Compass®: Your Guide to Corrosion Resistant Alloys
- Corrosion Prediction, Selection and Application Limits for Resistance to Pitting, Crevice Corrosion and SSC/SCC

Overview of CRA-Compass for Waters and Brines

This module deals with the application limits of 55 common corrosion resistant alloys used in water systems including natural seawater, chlorinated seawater, brines, produced water, formation water, brackish water, groundwater, fresh water, and potable water. Users can define their own alloys for CRA-Compass to evaluate the application limits for their resistance to pitting, crevice corrosion, and stress corrosion cracking (SCC) under the specified operating conditions. The performance of the CRAs in coastal/marine environment is also included in this module. More detailed information on CRA-Compass is available here.

CIPAL-Compass: Copper-Induced Pitting in Aluminium Alloys

This software predicts pitting depth, pitting rate and time to perforation of aluminum alloys in contact waters and process fluids that contain trace amount of copper ions.

For more details on Pitting Corrosion

Where can I learn more about pitting corrosion? More details on pitting corrosion are included in the following corrosion courses which you can take as in-house training courses, course-on-demand, online courses or distance learning courses:

Corrosion and Its Prevention (5-day module)
API 571 Damage Mechanisms Affecting Fixed Equipment in the Refining and Petrochemical Industries (5 days)
Corrosion Inspection, Testing and Monitoring: Techniques and Applications (5 days)
Corrosion, Metallurgy, Failure Analysis and Prevention (5 days)
Marine Corrosion, Causes and Prevention (2 days)
Materials Selection and Corrosion (5 days)
Stainless Steels and Alloys: Why They Resist Corrosion and How They Fail (2 days)
Corrosion in Fire Protection Systems (FPS): Detection, Mitigation and Prevention (1 day)
Microbiologically Influenced Corrosion (MIC): Recognition, Mitigation and Prevention (1 day)
Corrosion Control and Prevention in Seawater Desalination Plants (1 day)

If you require corrosion expert witness or corrosion consulting service on pitting corrosion, our NACE certified Corrosion Specialist is able to help. Contact us for a quote.
