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To:	All Surveyors/Auditors
Applicable to flag:	All Flags
	Pitting Corrosion
Reference:	Hull Survey

Pitting Corrosion

Pitting corrosion is characterized by small holes or cavities known as pits on the surface of the metal. It is considered to be more dangerous than uniform corrosion and has been known to be the cause of catastrophic failures in many structures.

Pitting is widely known as one of the most dangerous types of corrosion. In contrast to the more common uniform corrosion, pitting is highly penetrative and is difficult to detect and predict. As a result, pitting corrosion failures can be sudden and often catastrophic, as demonstrated in the following case study.

What is Pitting Corrosion?

Pitting corrosion, also known as pitting, is a highly localized and aggressive form of corrosion that occurs on metal surfaces. Small areas of the metal corrode preferentially, forming pits, while the rest of the surface remains virtually free from attack. Visually, pitting is characterized by one or several small cavities or holes on the surface of the metal. Pits can come in several shapes and sizes; they can be deep and narrow, shallow and wide, or undercut beneath the surface.

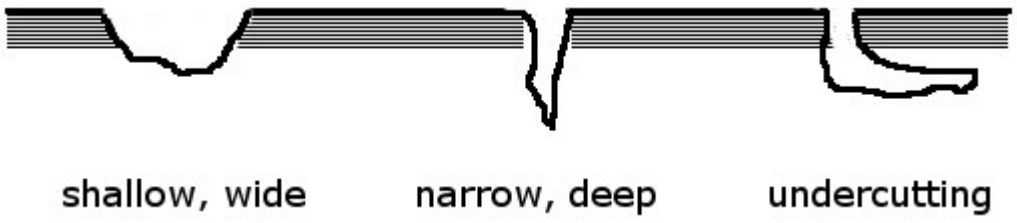

Figure 1. Some shapes of pitting on a metal substrate's surface.

Quite often, these pits are covered by further corrosion products, which make them difficult to detect with the naked eye. Therefore, what can appear to be minor uniform corrosion on the

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surface may actually be obscuring pits that have already penetrated the thickness of the material.

Small pits can lead to the catastrophic failure of entire structural or infrastructural systems. In addition to causing metal degradation and loss of thickness, pits can also lead to a significant localized build-up of stresses around the affected areas. The sudden stress increase that occurs in discontinuities such as pits is known as stress risers. Stresses can increase so much that the capacity (yield stress) of the material can be exceeded, leading to structural failure.

The formation of pits is often a precursor to other forms of localized failures such as metal fatigue and stress corrosion cracking (SCC).

Mechanism of Pitting Corrosion

For pitting corrosion to occur, it is essential that the metal be originally passivated. This is typically achieved by the naturally occurring protective oxide layer that forms on the surface of the metal.

Pitting corrosion is then initiated when a small portion of the film is inadvertently removed, thereby causing a loss of passivity in that area. The part of the metal where the protective film is removed now acts as an anode, while the surrounding areas (still protected by the film) serve as the cathode. The anode and cathode in the presence of an electrolyte (humid air or moisture) give rise to a local corrosion cell.

Because the rest of the metal remains protected, the corrosion cannot spread as it does during uniform corrosion. Instead, it remains confined to a small area where the corrosion penetrates the thickness of the metal.

Furthermore, reduction reaction rates and loss of thickness are typically faster and more aggressive compared to uniform corrosion, due to the highly undesirable area ratios, i.e., the ratio of the size of the anode to the size of the cathode.

Factors that Increase the Likelihood of Pitting Corrosion

Pitting corrosion is commonly triggered by:

- Localized damage to the protective oxide film – The oxide film can be damaged by mechanical means (e.g., by impacts or by abrasive material in pipeline flows). Similarly, damage can be caused by a breakdown of the passive layer due to unfavorable water chemistry. High pH, low dissolved oxygen content and high chloride concentrations are some of the chemical factors that can destabilize the oxide film.
- Poor coating application – Coatings that are applied incorrectly can leave areas of the metal substrate unprotected and susceptible to pitting corrosion. Areas where the coating is improperly applied will tend to adopt anodic characteristics and corrode preferentially.
- Foreign deposits on the metal surface – Deposits or debris on the metal surface can lead to the formation of local anodic or cathodic areas. For example, metal deposits from rusting steel water heaters can settle in copper pipes. The contact between the two different metal compositions can cause bimetallic corrosion, which can then degrade the oxide layer to form an anode at that location.

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Techniques to Minimize the Occurrence of Pitting Corrosion

Effective pitting corrosion prevention occurs during the planning stages of the project. Usually, the first line of defense is choosing the right materials. The probability of pitting corrosion can be significantly reduced by using high-strength, corrosion resistant alloys. Alloys composed of nitrogen, titanium, chromium and molybdenum are especially effective in environments with high concentrations of chloride ions.

Another method used to prevent pitting corrosion is cathodic protection. Cathodic protection involves connecting the metal to be protected to a reactive metal that corrodes more easily. The more reactive metal acts as the anode, and therefore sacrifices itself by corroding preferentially. Galvanized zinc coatings are an example of cathodic protection. In this case, when the coating is damaged such that the substrate is exposed, the zinc surrounding the damaged area will corrode first thereby preventing pitting of the underlying metal.

Finally, if possible, the environmental factors that promote corrosion should be minimized as much as possible. Temperature, humidity, pH levels and chloride content should be monitored and kept to acceptable levels.

Conclusion

Pitting corrosion, although relatively small in size, can result in catastrophic failures in a variety of structures. Its unpredictability and difficult detection make it more dangerous than uniform corrosion. Although implementing preventative measures can be challenging, knowing the factors that contribute to pitting is generally the first step.

REFERENCES:

- CONARINA Hull Survey

- ATTACHMENTS: No.

Kindest Regards,

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