Annual Corrosion Forum (ACF)

Aberdeen Branch - August 2021

Sponsor: TRAC Oil and Gas

Title: “Please just tell me what to look for!” Bridging the Corrosion Engineer – NDT Technician Gap

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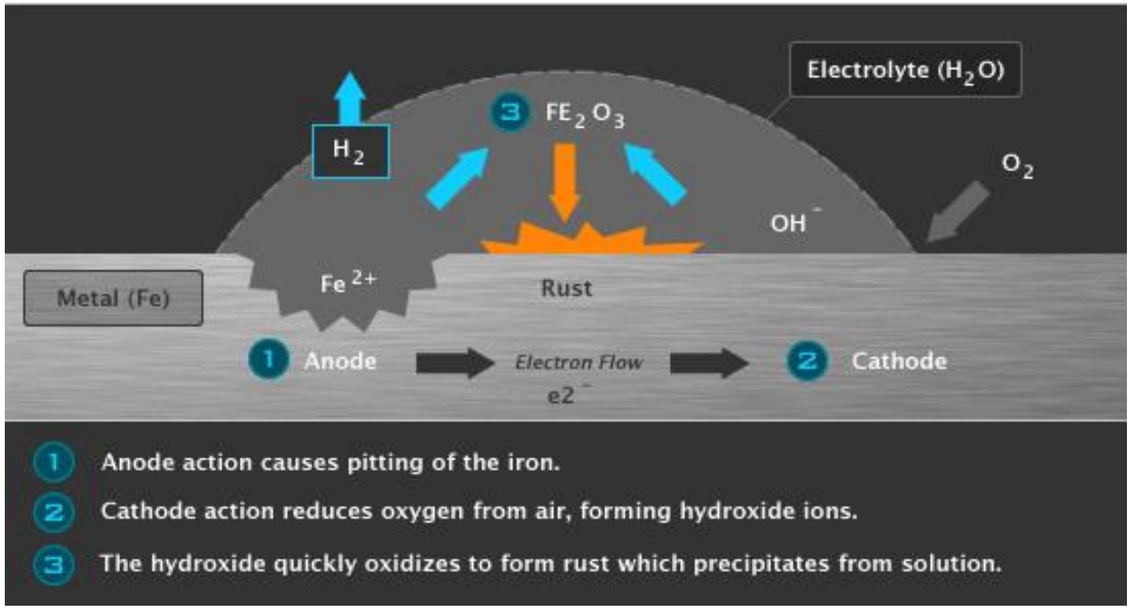
Position: Director
Company: Eden Asset Integrity Ltd.

This is a Corrosion Engineer’s view of corrosion.



How metal or other materials react with their environment.

Corrosion is often described in terms of a chemical reaction such as CO2 Corrosion or a metallurgical effect such as Stress Corrosion Cracking.

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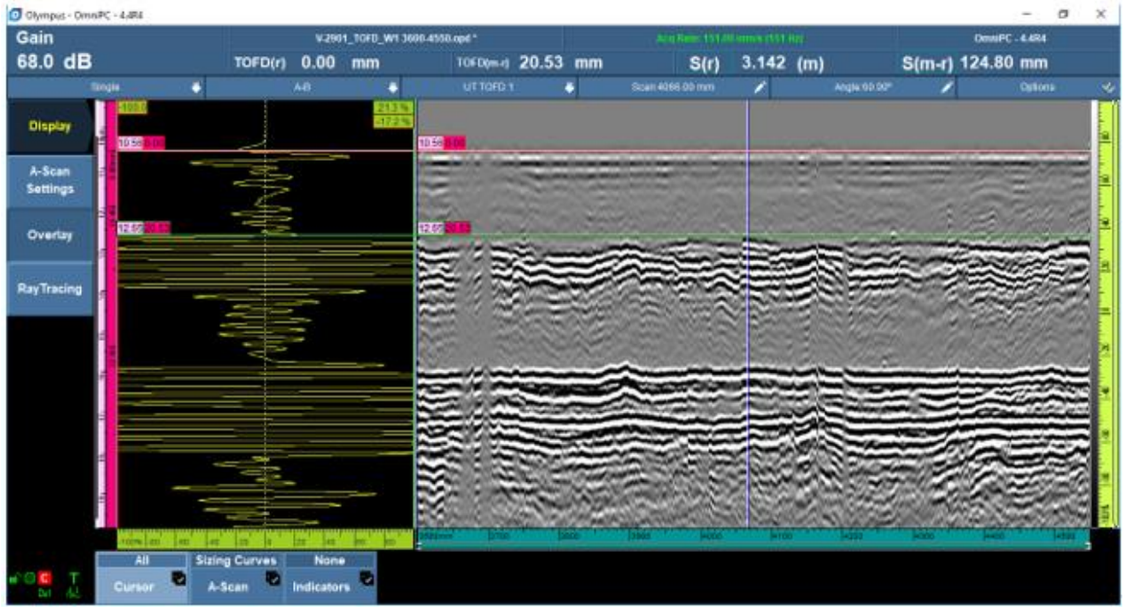
This is a NDT Technician’s view of corrosion.



An indirect representation of the inner surface of a pipe or pressure vessel wall.

Corrosion is described in terms of form and location, roughening, pitting, cracking etc.

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Risk Based Inspection starts with a Corrosion Risk Assessment, often these identify Corrosion Mechanisms but not the form and likely location of damage.

The problem is that the NDT Technician needs to know the form of damage, so that they can select the right technique and, because most NDT is still a sample of the total surface area, where to look. Without this information serious damage may be missed.

This presentation describes the form and location of some commonly encountered corrosion mechanisms and some less common ones encountered by the author over the past 25 years.

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The myth of Uniform Corrosion.

It is still possible to find corrosion monitoring procedures based upon the assumption that corrosion is uniform. This is possible where the fluid is a single phase and inherently corrosive, however produced fluids are normally two or three phase, only one of which, the aqueous phase, is corrosive. In addition the metallurgy is not uniform. Preferential weld corrosion is well understood but other, slight, variations can have a strong influence as will be described later.

So the form and location of corrosion will be strongly influenced by very local environmental variations including:

- Where surface wetting occurs.
- Where mineral or corrosion scale builds up or breaks down.
- Local increases in fluid velocity or changes in direction.
- Wherever a microbe just happens to settle down.

Therefore any inspection plan needs to specify a percentage area coverage and target this at the location where corrosion is most likely, otherwise serious damage can be missed.

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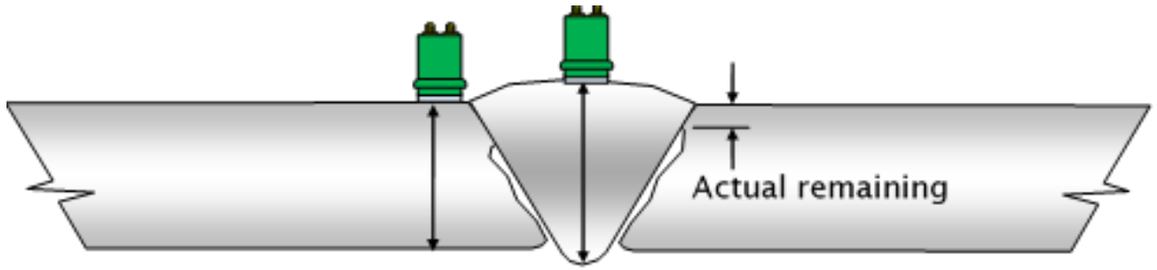
The limitations of NDT.

As shown in the example below, if the wrong technique is used serious damage can be missed. This is true of all methods, not just Ultrasonic techniques.

Question, is your NDT programme predominately ultrasonic thickness scans?



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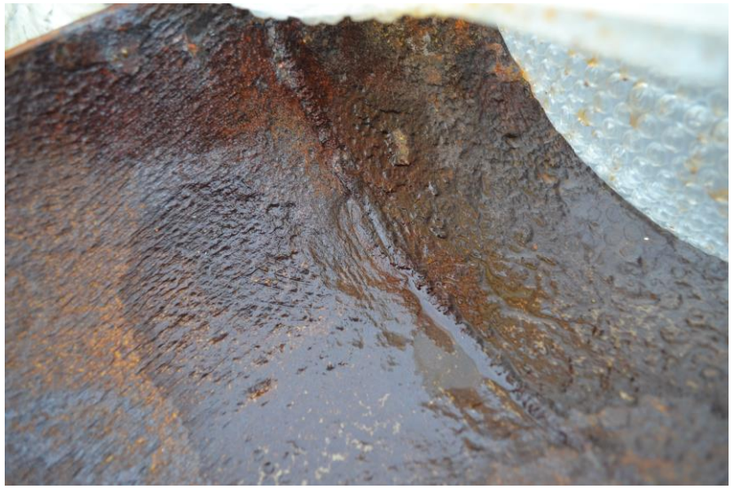
CO2 Corrosion

CO2 Corrosion will be found in almost all hydrocarbon systems.
Form: General pitting, often but not always flat bottomed pits. Individual pits may stabilize and stop growing while new pits initiate elsewhere. Eventually the pits merge to form a roughened surface. Isolated deep pits may be present in this.
Susceptible areas: Locations with high fluid velocities or impingement.
Occasionally the pit form may be conical, which can be missed by manual compression wave UT



Sulphide (H2S) Corrosion

The forms of cracking caused by H2S are well understood but there are some other mechanisms that are less well known. If sulphide corrosion is the dominant mechanism the surface of the steel will become coated with iron sulphide rather than iron carbonate.
Iron sulphide is cathodic to iron, and, being porous has a very large surface area relative to the iron it covers. If this scale is intact it protects against corrosion, but local breakdown will lead to an aggressive galvanic corrosion mechanism.

In the example shown solid particles eroded through the sulphide scale leading to a runaway galvanic reaction.

Form: Large isolated pits or channels.
Susceptible Locations: As for erosion but may be random if there is a carbonate/sulphide scale mixture.

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Erosion and Erosion Corrosion.

Form: Large areas of material loss with a smooth profile.
Susceptible Locations: Areas of high velocity or where impingement can occur for example bends and Tees. But this is not always the case.

- In convoluted pipework the impingement point can shift away from the dead centre of bends, either to the side or even to the straight section downstream.
- Vortexes that form in branch connections can trap sand creating a local erosion hotspot in a nominally stagnant area.
- Intrusions such as thermowells, quills and weld roots can also create erosive vorteceas.

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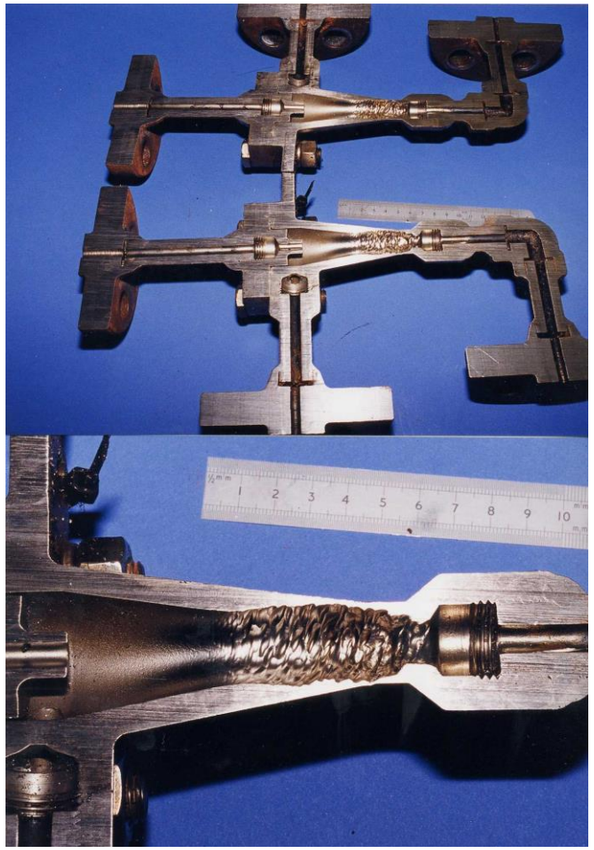
Examples



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Cavitation.

Very aggressive, can cause a failure within weeks.
Form: Very localised, concentrated pitting. (As opposed to the smooth surface formed by erosion).
Susceptible areas. Downstream of localised pressure drops, for example pump impellers, or downstream of flow control valve.
However I have encountered one example where cavitation took place in a small bore dead leg that was located immediately downstream of a flow control valve. This apparently created ideal conditions for bubble collapse.

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Microbially Influenced Corrosion.

Form: Large hemispheroidal pits
Susceptible locations: Anywhere the bugs decide to settle.

Due to the random nature of MIC sample inspection is not recommended unless it is confined to areas where water has collected in a nominally dry environment.

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Some Unusual Galvanic Mechanisms

Sometimes subtle metallurgical changes can result in an aggressive galvanic reaction. In the first of these examples, it was due to the difference between a bright machined surface and a passivated one; the second is a classic case of preferential weld root corrosion.

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End of Presentation – Your Questions Please