Outline Course Syllabus

Corrosion Management in Refining

Key target attendees;

Materials & Corrosion Engineers

Mechanical Engineers

Design Engineers

Chemical & Process Engineers/Technologists

Inspection Engineers

Production Unit Management/Operations Leads

Maintenance Planners

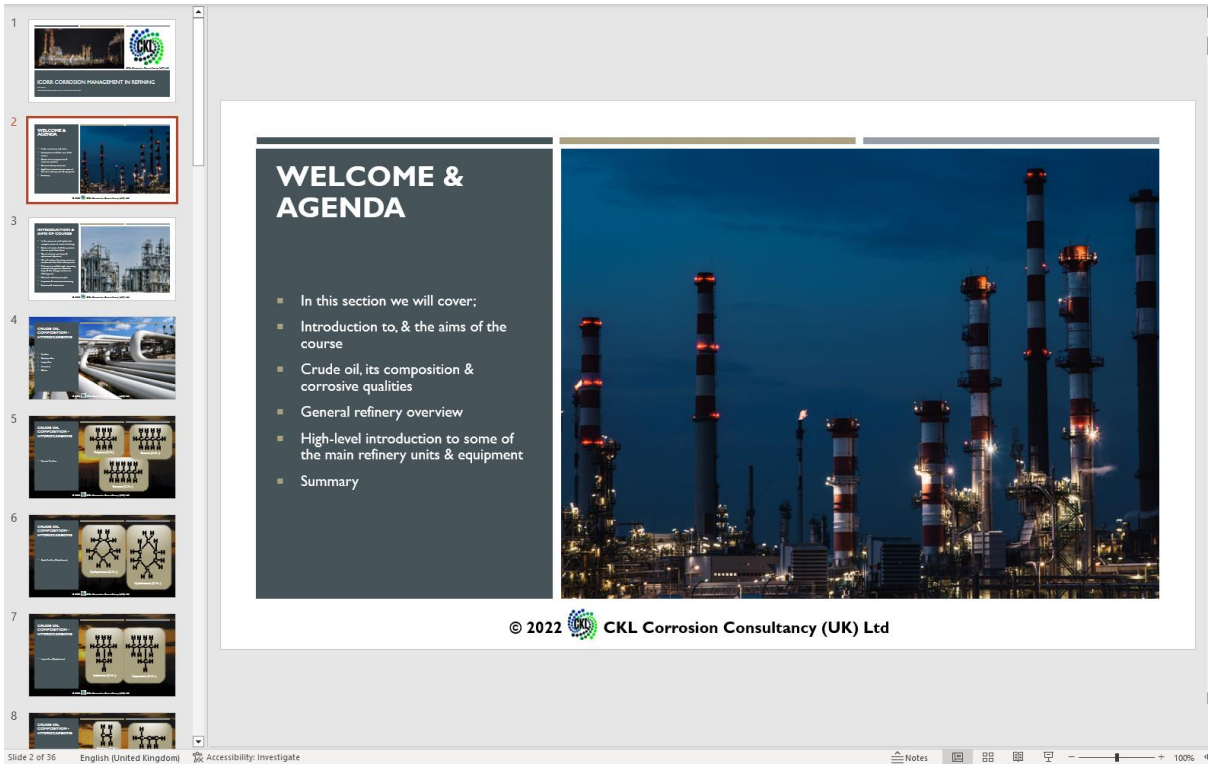
Procurement teams

Course Structure

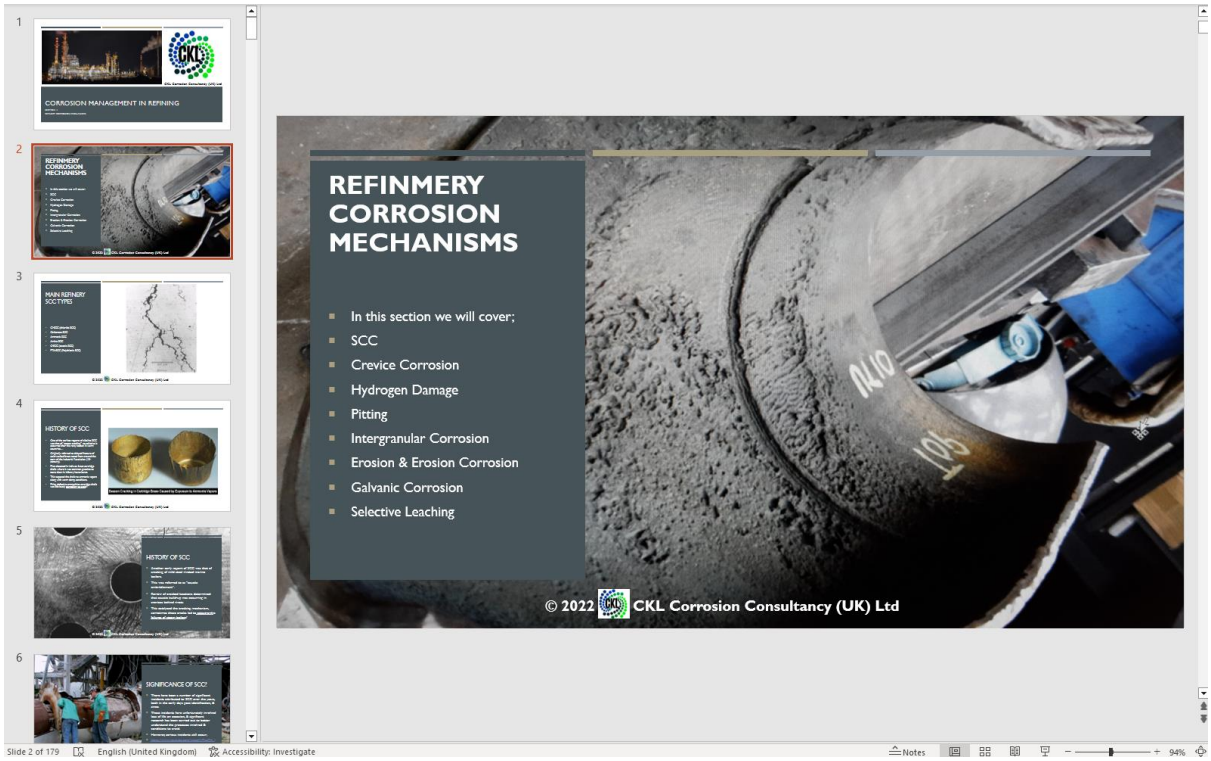
A corrosion control document-type (CCD) walkthrough of the refinery as follows;

Section 1.0 Introduction

Section around refining operations crude oil composition & refinery overview.

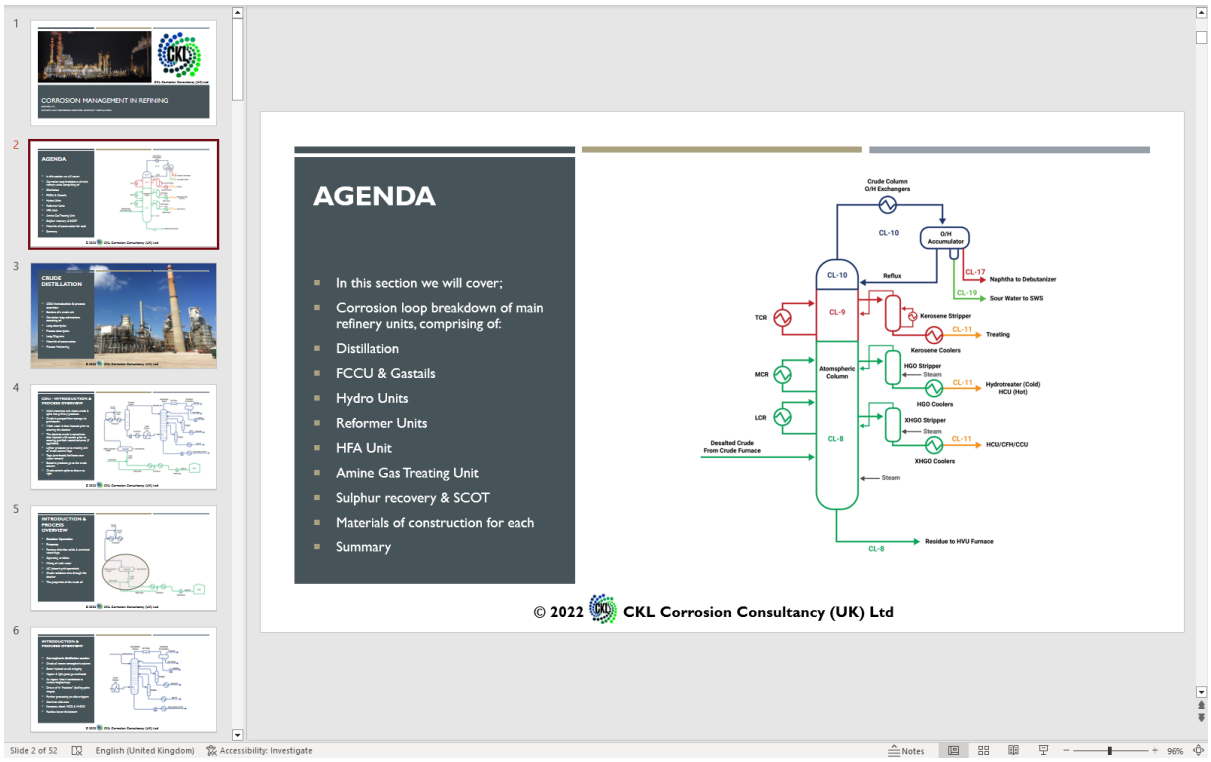


Section 2.0 Refinery Corrosion Mechanisms



Section 3.0 Unit/CCD Order

A corrosion control document-style overview of the main refinery units;



Units covered

- Desalting & distillation
- FCCU
- Gas tails
- HFA
- Sulphuric acid alkylation unit
- Hydro-processing units
- Reformers
- Acid Gas Treating Units (Amine)
- Sour Water Stripper
- Sulphur Recovery & SCOT units
- Boiler feedwater, Steam Generation & Distribution Systems
- Fired Equipment

The following is an outline structure of each of the above units (Sour Water Stripper used as an example);

Sour Water Stripper CCD Section

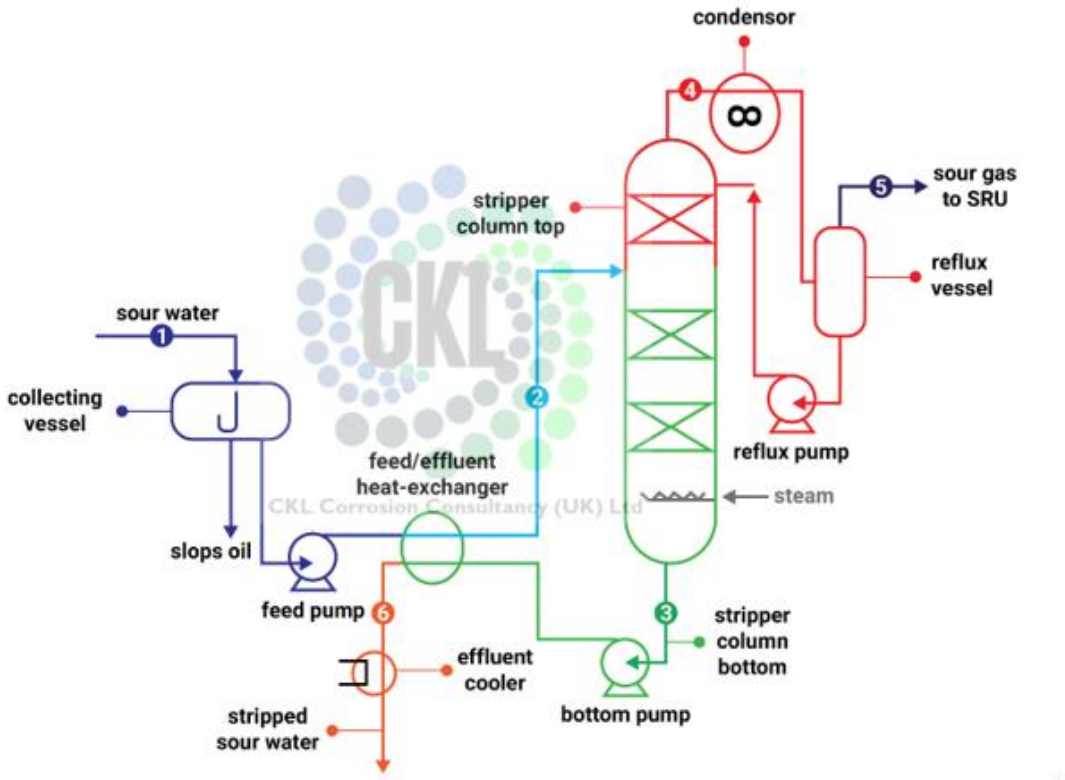
- **Introduction**
- **Process description**
    - Sour water sources
    - Sour water chemistry discussion

    - Sour water stripping overview
        - Sour water skim/flash drum
        - Feed/bottoms heat exchangers
        - Stripper column
        - Stripper overheads system
        - Effluent coolers
- **Generic corrosion loops**
    - Corrosion Loop #1 – Cold sour water feed
    - Corrosion Loop #2 – Hot feed
    - Corrosion Loop #3 – Stripper tower bottoms
    - Corrosion Loop #4 – Stripper tower top and overheads system
    - Corrosion Loop #5 – Sour gas
    - Corrosion Loop #6 – Effluent cooler

Note: for each of the above corrosion loop sections, 1 to 6, these are further broken down into the following subsections;

- Corrosion loop description
- Corrosion loop process description
- Corrosion loop typical materials of construction/basis of material choice
- Corrosion loop potential Corrosion & Fouling mechanisms (a list with a brief description)

Corrosion Loop



Sour Water Stripper CCD END

Section 4.0 Material Selection Principles

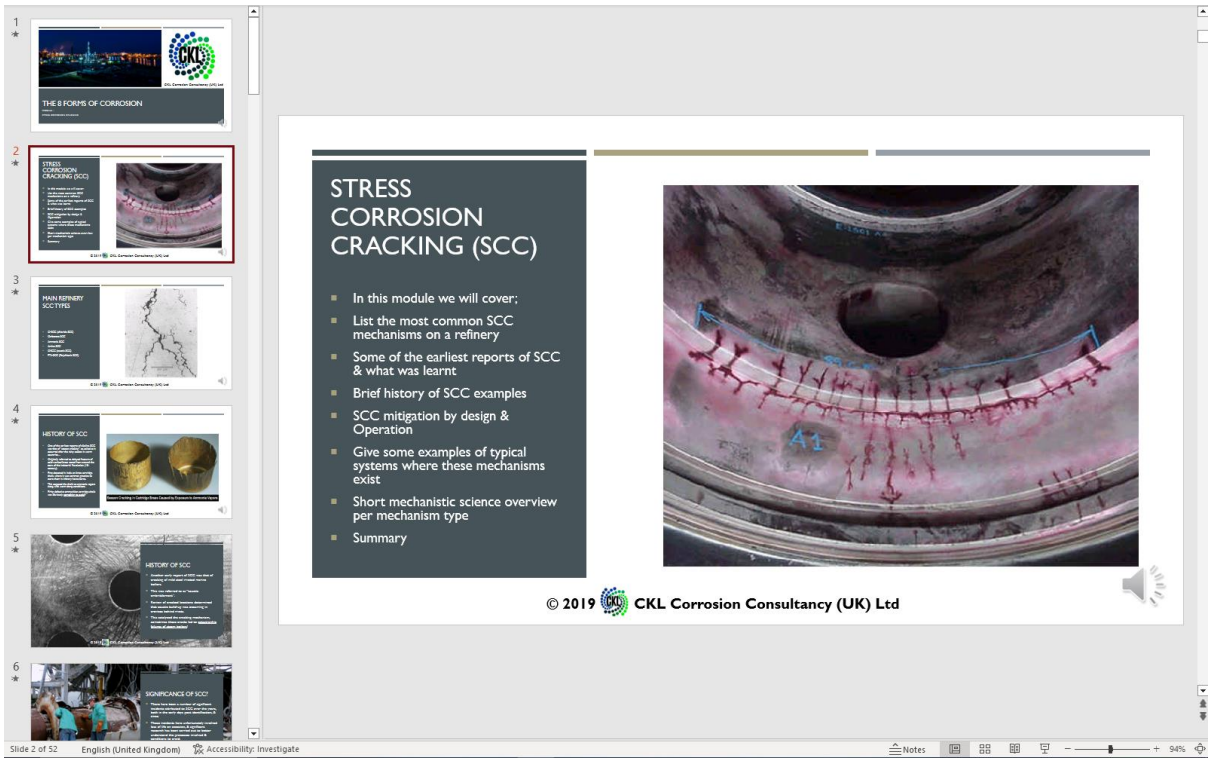
Section explaining the rationale for selecting appropriate refinery materials, including steels, alloys, refractory materials, plastics etc. Welding engineering overview, PWHT's, fabrication etc.

Section 5.0 Inspection & Corrosion Monitoring

The role of the inspection integrity function, brief overview of RBI, links into corrosion loops, IOW's, & ultimately written schemes of examination. Also refer to a number of different on-line corrosion monitoring techniques.

Section 6.0 Summary

Close out & recap on the key points across the course – discussion, any further questions etc.




THE 8 FORMS OF CORROSION
CREVICE CORROSION
MAIN CREVICE ENVIRONMENTS
UNDER DEPOSITS INDUSTRY EXAMPLES
UNDER DEPOSITS INDUSTRY EXAMPLES
UNDER DEPOSITS INDUSTRY EXAMPLES
CREVICE CORROSION
In this module we will cover;
The most common crevice corrosion (CC) type environments
Give some examples of typical systems where these mechanisms exist
Short mechanistic science overview
CC mitigation by design
Summary
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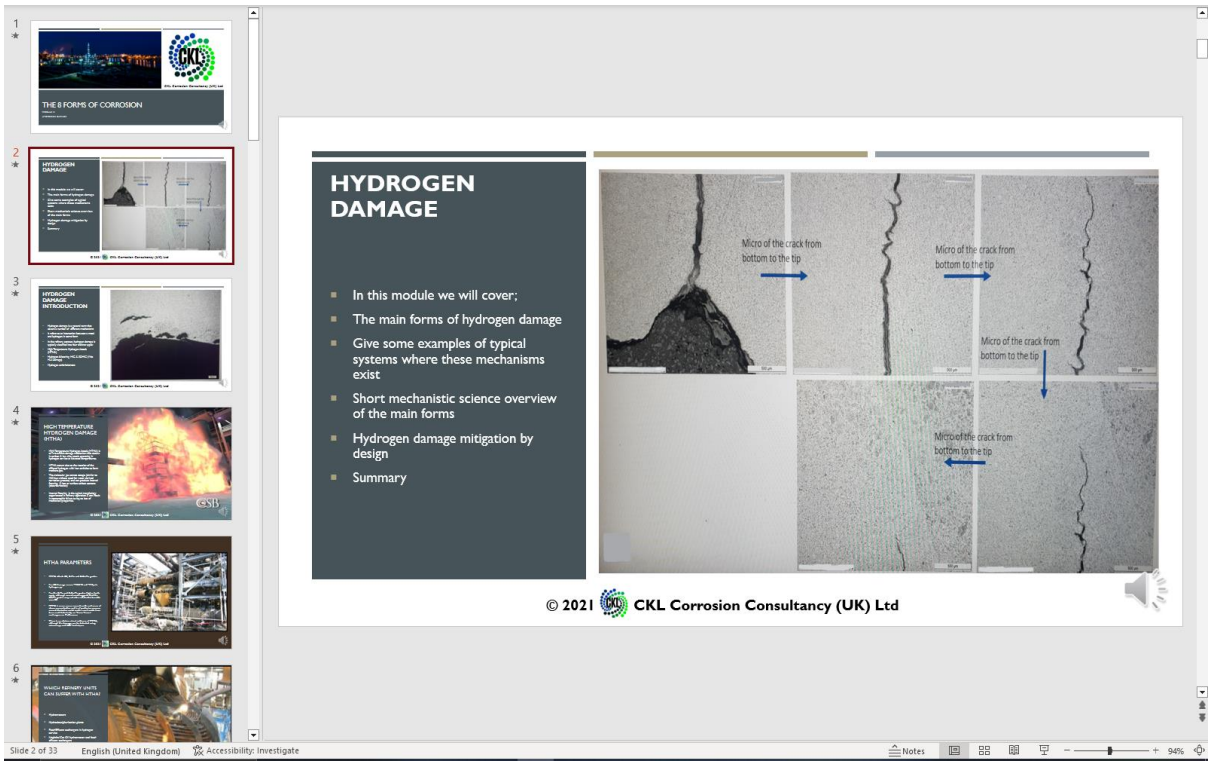
THE 8 FORMS OF CORROSION
HYDROGEN DAMAGE
HYDROGEN DAMAGE INTRODUCTION
HIGH TEMPERATURE HYDROGEN DAMAGE (HTHA)
HTHA PARAMETERS
HYDROGEN DAMAGE
In this module we will cover;
The main forms of hydrogen damage
Give some examples of typical systems where these mechanisms exist
Short mechanistic science overview of the main forms
Hydrogen damage mitigation by design
Summary
Micro of the crack from bottom to the tip
Micro of the crack from bottom to the tip
Micro of the crack from bottom to the tip
Micro of the crack from bottom to the tip
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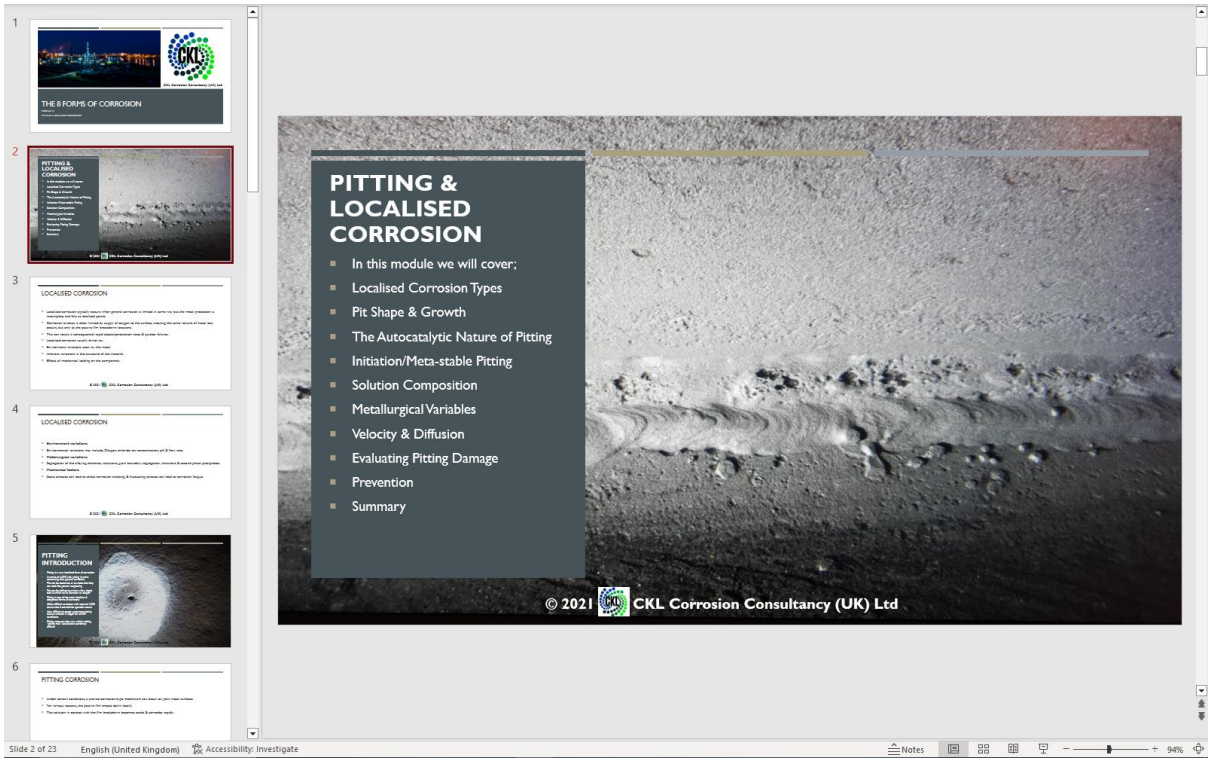
1
THE 8 FORMS OF CORROSION
2
PITTING & LOCALISED CORROSION
3
LOCALISED CORROSION
4
LOCALISED CORROSION
5
PITTING INTRODUCTION
6
PITTING CORROSION
PITTING & LOCALISED CORROSION
In this module we will cover;
Localised Corrosion Types
Pit Shape & Growth
The Autocatalytic Nature of Pitting
Initiation/Meta-stable Pitting
Solution Composition
Metallurgical Variables
Velocity & Diffusion
Evaluating Pitting Damage
Prevention
Summary
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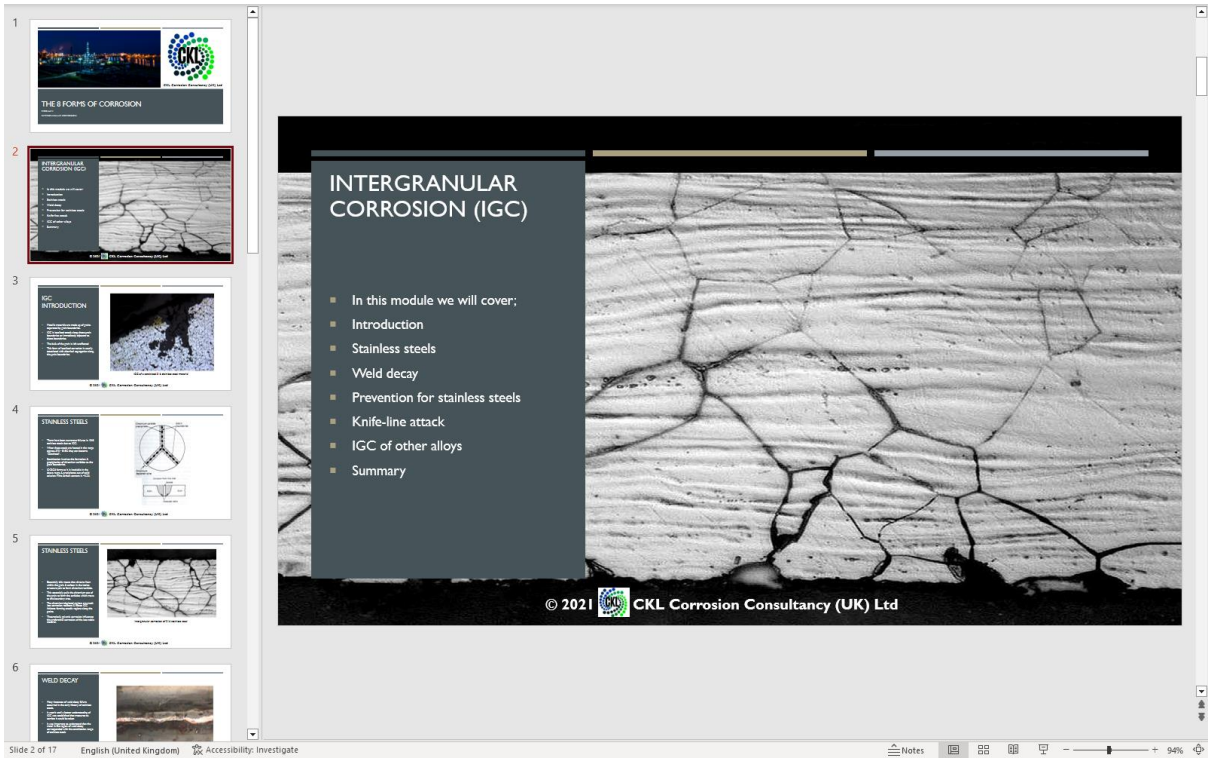
1
THE 8 FORMS OF CORROSION
2
INTERGRANULAR CORROSION (IGC)
3
IGC INTRODUCTION
4
STAINLESS STEELS
5
STAINLESS STEELS
6
WELD DECAY
INTERGRANULAR CORROSION (IGC)
In this module we will cover;
Introduction
Stainless steels
Weld decay
Prevention for stainless steels
Knife-line attack
IGC of other alloys
Summary
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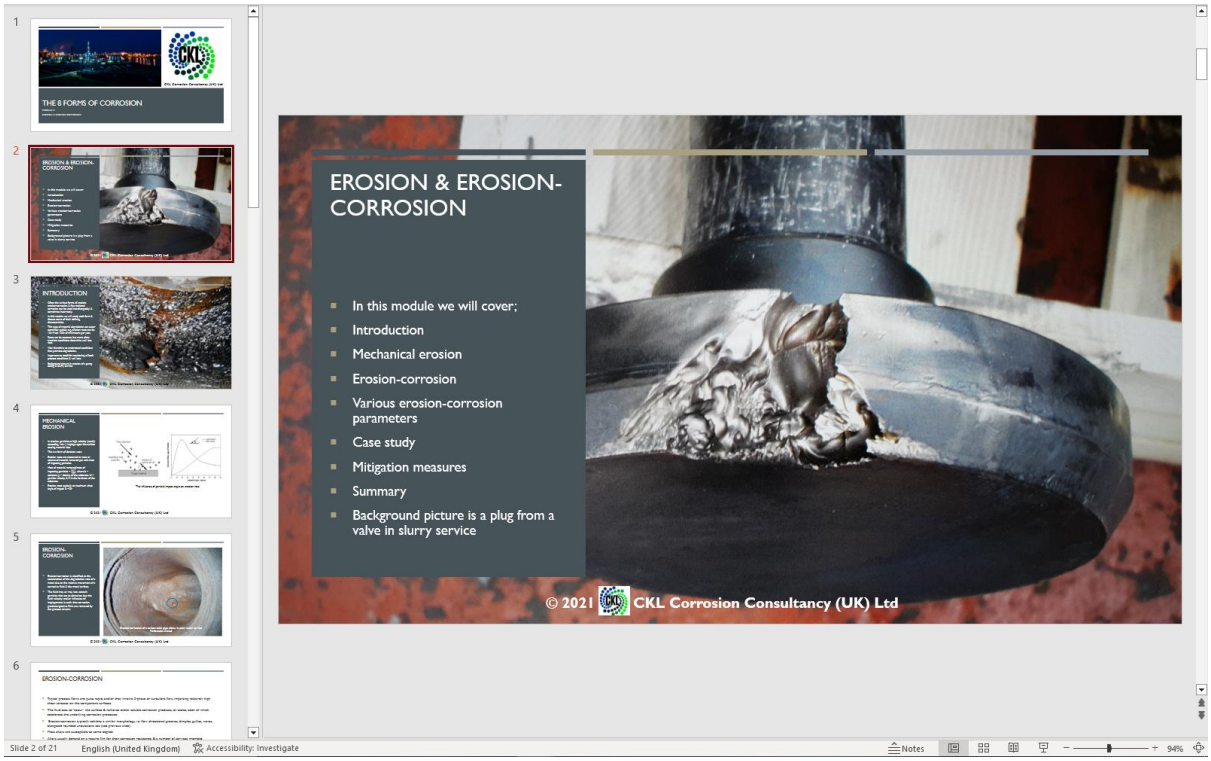
EROSION & EROSION-CORROSION
In this module we will cover;
Introduction
Mechanical erosion
Erosion-corrosion
Various erosion-corrosion parameters
Case study
Mitigation measures
Summary
Background picture is a plug from a valve in slurry service
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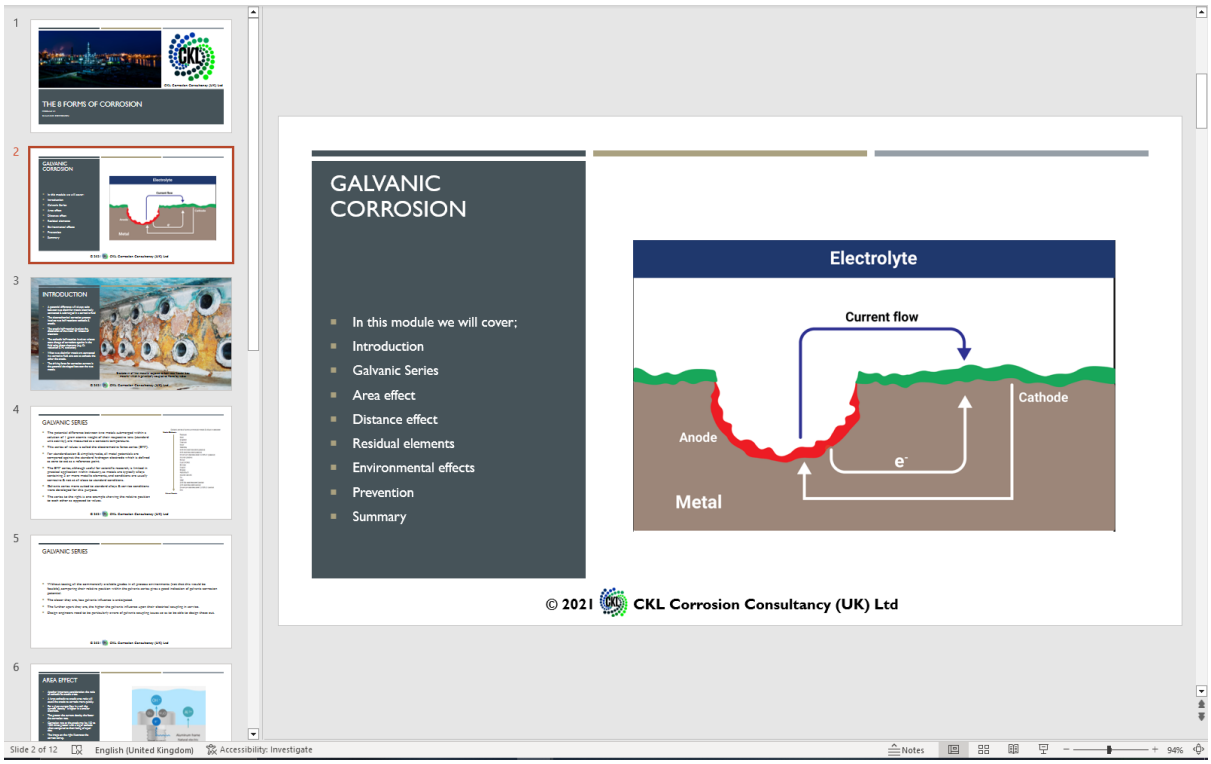
GALVANIC CORROSION
In this module we will cover;
Introduction
Galvanic Series
Area effect
Distance effect
Residual elements
Environmental effects
Prevention
Summary
Electrolyte
Current flow
Cathode
Anode
e-
Metal
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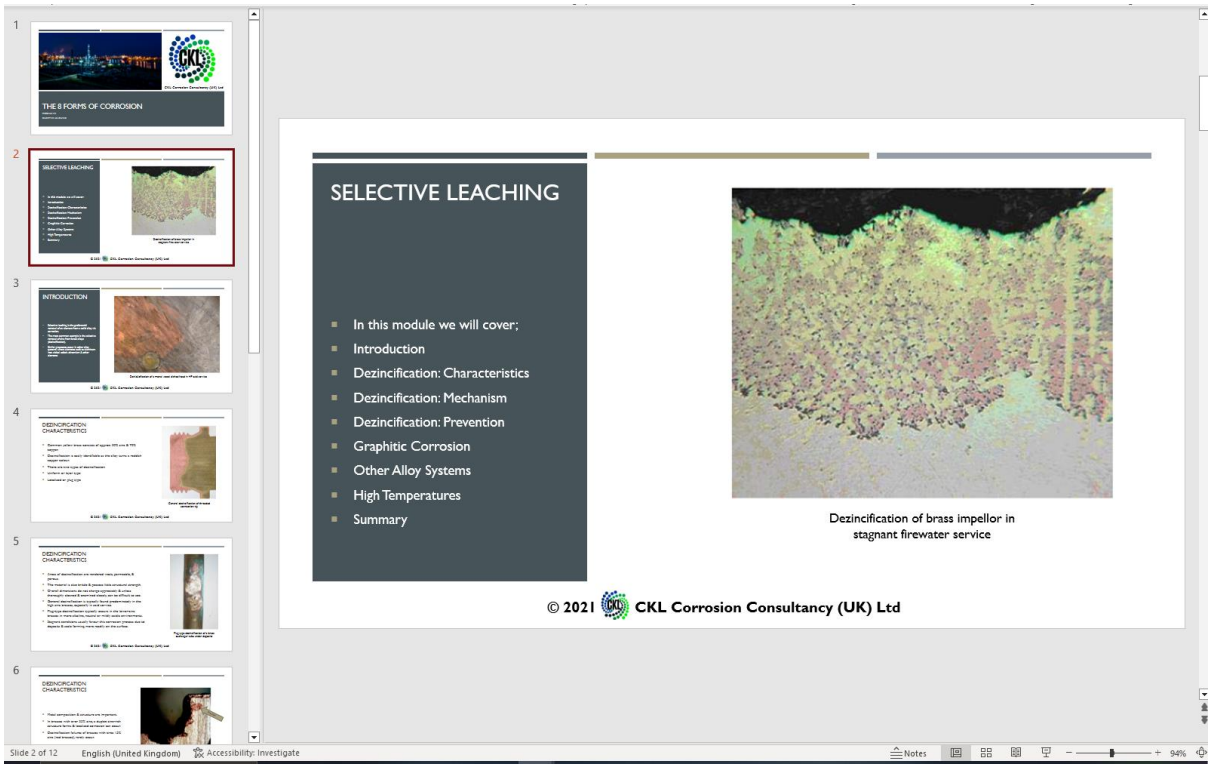
SELECTIVE LEACHING
In this module we will cover;
Introduction
Dezincification: Characteristics
Dezincification: Mechanism
Dezincification: Prevention
Graphitic Corrosion
Other Alloy Systems
High Temperatures
Summary
Dezincification of brass impellor in stagnant firewater service
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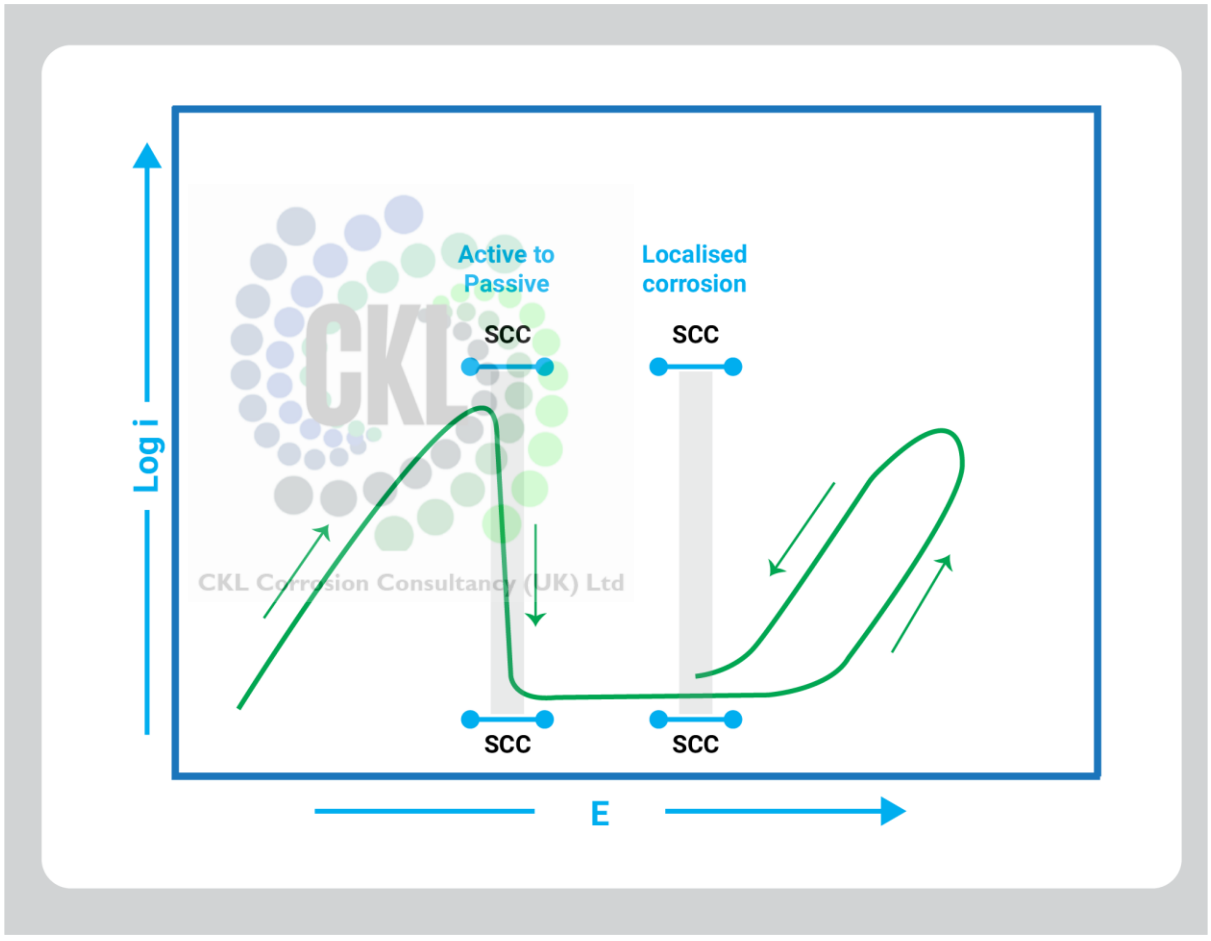
Log i
Active to Passive
Localised corrosion
SCC
SCC
SCC
SCC
E
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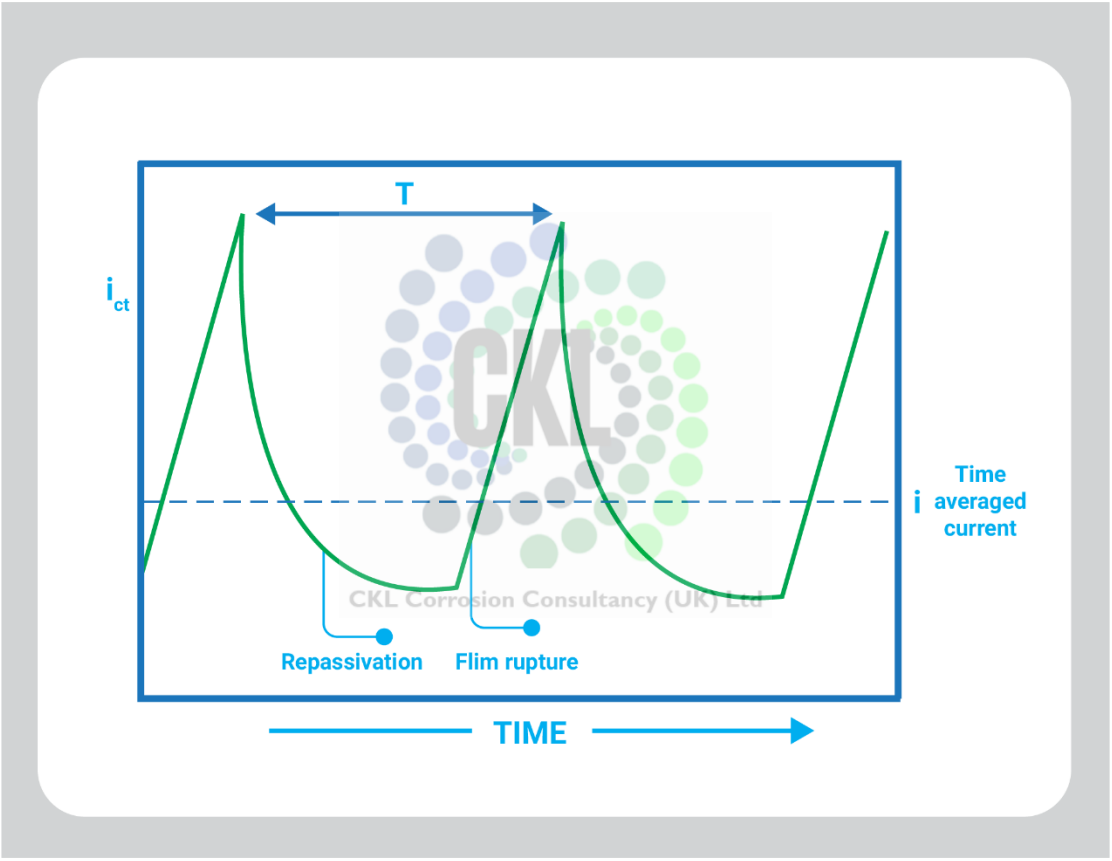
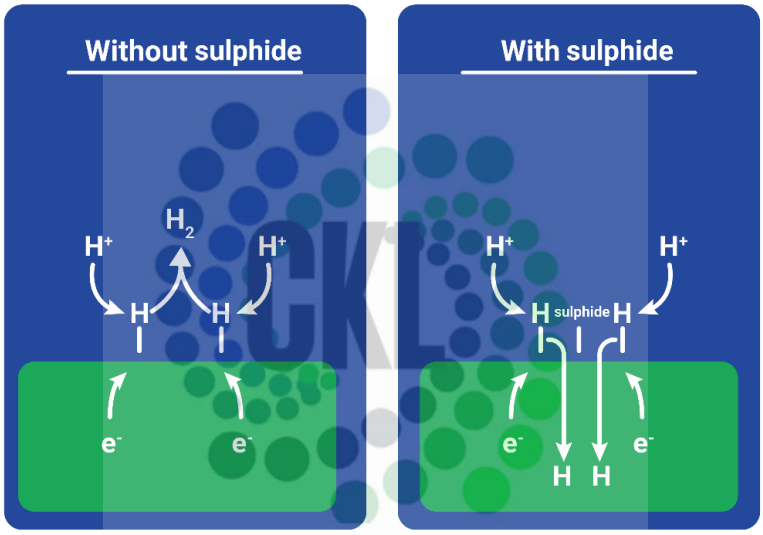
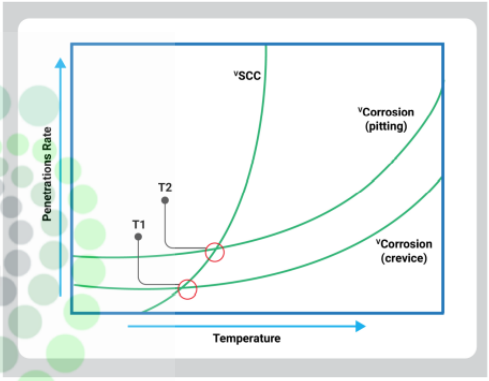




CL-SCC – CHLORIDE SCC

- Mechanism Fundamentals
- This figure shows the rates of penetration (v) of a metal by SCC, pitting, & crevice corrosion as a function of temperature.
- If the local corrosion rate is faster, it will "out-run" SCC, i.e. crack tip blunting.
- As the rate of SCC rises steeply with temperature, it takes over from pitting/crevice corrosion at a certain critical temperature (see T1 & T2 below).
- This temperature is referred to as T_{crit} and is ~55 deg C for austenitic SS & ~95-105 deg C for duplex given similar chemistry conditions.

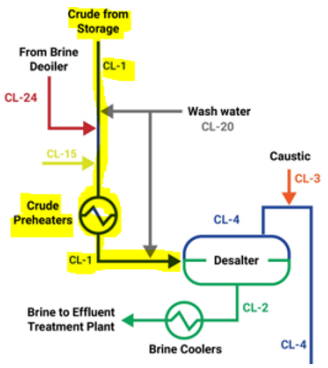


INDUSTRY EXAMPLES

- Amine SCC
- Cause?
- Mitigation?

CORROSION LOOPS

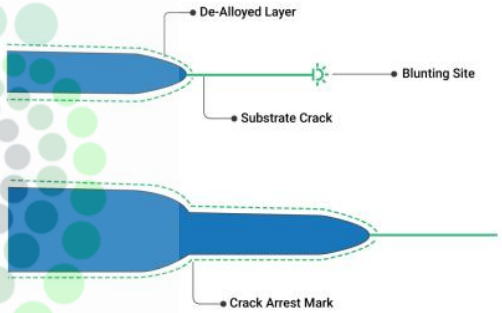
- **Loop 1**: Crude from storage to desalter inlet.
- **Corrosion/Fouling**
- Brine corrosion
- Sulphide stress cracking
- Hydrogen blistering, HIC & SOHIC
- CUI
- Iron sulphide fouling
- Mineral salt fouling
- Asphaltene fouling



CL-SCC – CHLORIDE SCC

- Mechanistic Description

- Film Induced cleavage often accompanies de-alloying processes. The element that is thought to de-alloy in this case is the nickel within the aggressive acidic crack environment.
- This mechanism produces trans-granular cracking.
- The figure to the right shows a brittle de-alloyed layer, which cracks under tensile load.
- The crack looses energy as it runs into the material & stops.
- As the material continues to strain the crack tip blunts & the crack opens under applied stress. The crack surfaces then begin to de-alloy & the process begins again.



HIGH TEMPERATURE HYDROGEN DAMAGE (HTHA)

- High Temperature Hydrogen Attack (HTHA) is an irreversible damage mechanism that occurs in carbon & low alloy steels operating in hydrogen service at elevated temperatures.
- HTHA occurs due to the reaction of the diffused hydrogen with iron carbides to form methane gas.
- The molecular gas cannot escape (similar to HIC but without need for water derived corrosion process), and can produce internal fissuring & loss or surface carbon content (decarburisation)
- Internal fissuring is the typical morphology experienced in refinery operation & can result in catastrophic failure owing to loss of mechanical properties.