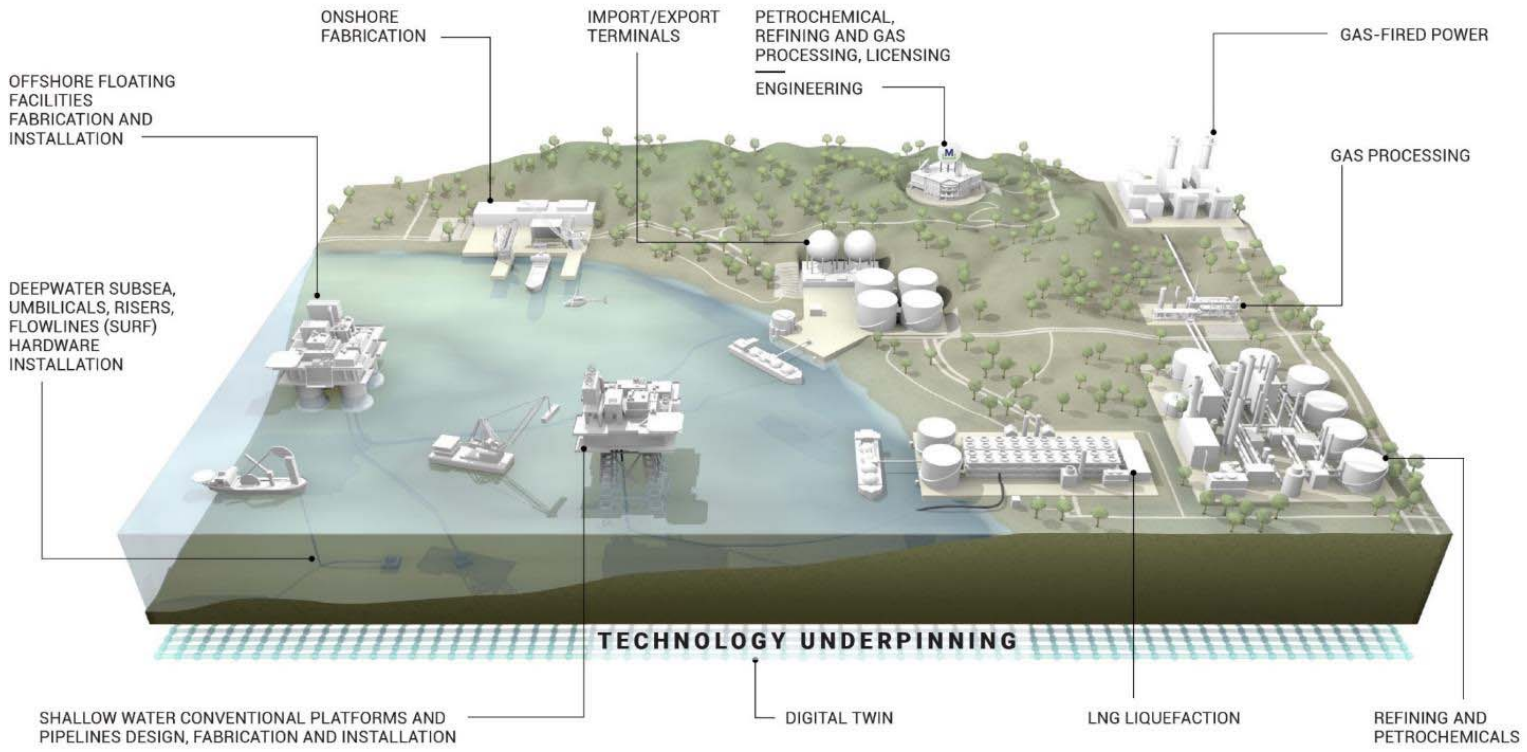
MCDERMOTT

Plant Life Expectancy Study
by Arjen Reinders Principal Metallurgy & Welding Engineer

WE CONTRIBUTE IN DELIVERING INTEGRATED SOLUTIONS

UPSTREAM | **DOWNSTREAM**

SUBSEA | OFFSHORE | LNG | REFINING | PETROCHEMICALS | POWER



Remaining Plant Life

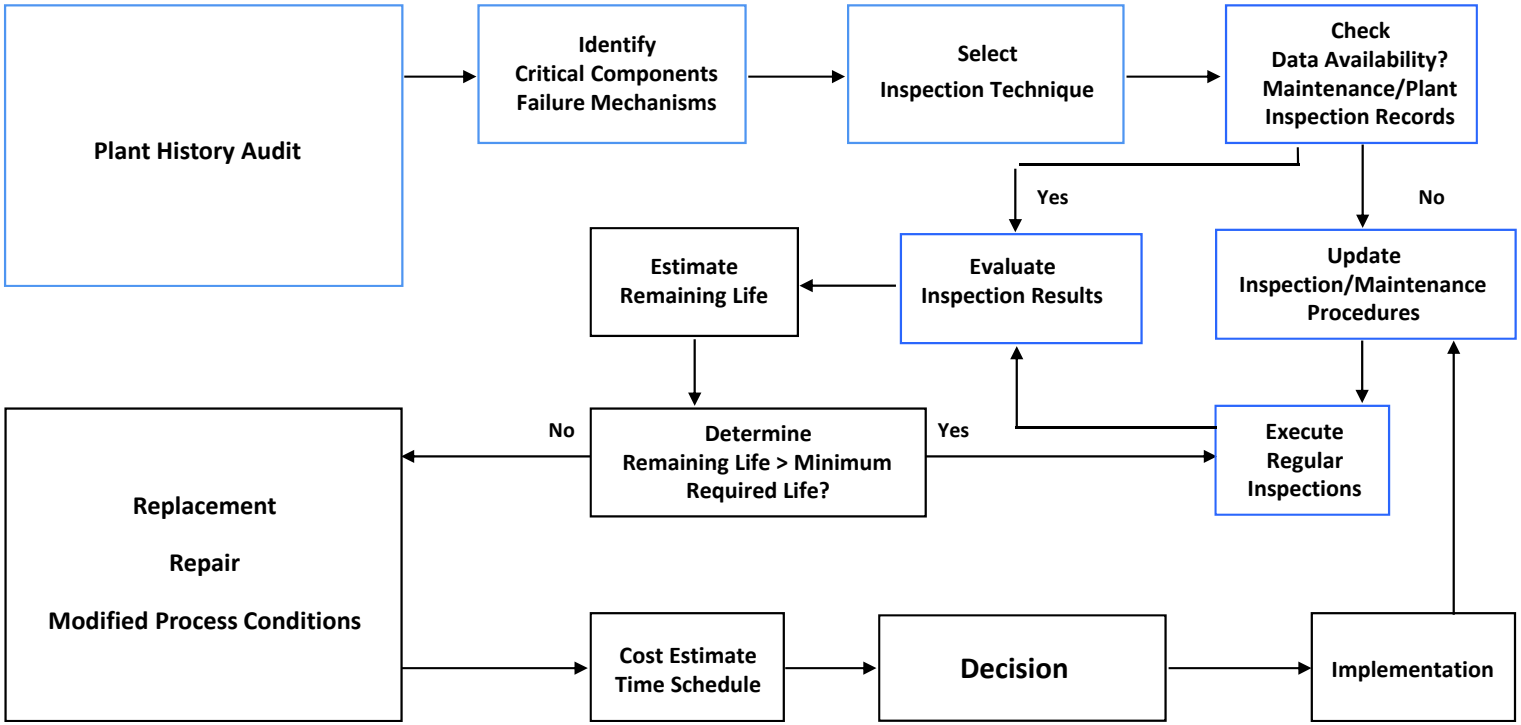
- Introduction
- Plant Life Expectancy Study (PLES)
- Activities
- Failure Mechanisms
  - Corrosion Under Insulation (CUI)
- Inspection Techniques
- MDR Experience Site Visits
- Overview of executed PLES
- Conclusions
- Questions

Introduction

- Name: Arjen Reinders
- Principal Metallurgy Engineer & Welding Engineer at McDermott
  - Since 2001 started with ABB Lummus Global
  - CB&I in 2007
  - McDermott since 2018
- IWE (certified) since 2016

Remaining Life – Introduction
We need to prevent this!

PLES Execution Plan



Plant Life Expectancy Study Activities

I. Plant Life Expectancy Definition
   - Contract
   - Exclusions (e.g. sub contractor works)

II. Document Review

III. Site Survey (Visual External Inspections)

IV. Plant History Audit
   - Interview with Operations
   - Interview with Inspection / Maintenance

V. Conclusion Report / Presentation of Results

Document Review

To understand the basis and the history of the plant.

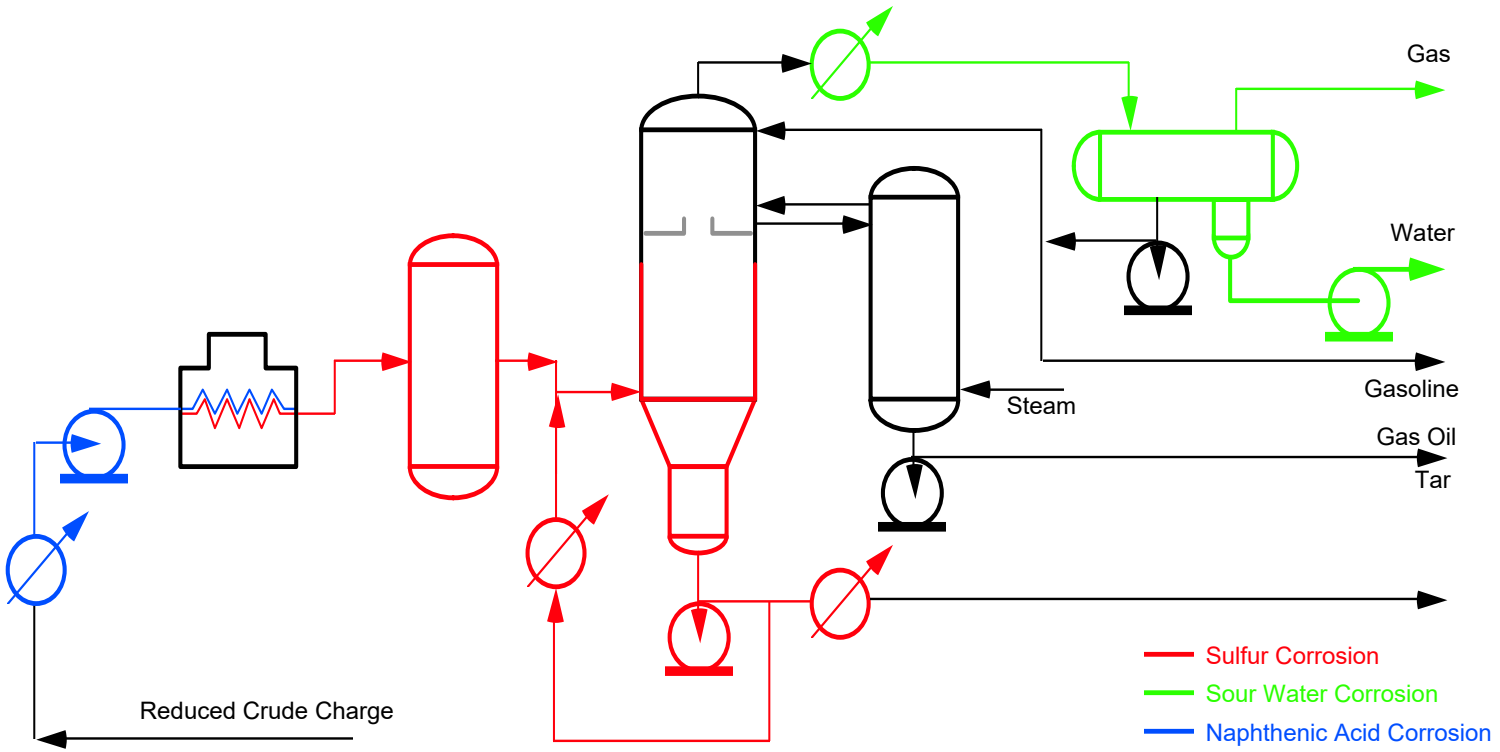
Review e.g.:

- Plant design data
- Inspection history
- Maintenance history
- Incident history
- Plant changes

Purpose and Report Deliverable

- Identify possible failure mechanisms
- Identify which equipment is at risk for each failure mechanism
- Identify the most suitable inspection technique and locations to detect the possible failure mechanism
- Estimate remaining life when sufficient data is available

Failure Mechanism Diagram – Crude Unit



Potential Failure Mechanisms Ethylene Unit (1)

- Corrosion Under Insulation (CUI)
- Wet H_2S Stress Cracking
- Hydrogen Induced Cracking
- Cooling Water Corrosion
- Amine Stress Corrosion Cracking
- Polythionic Acid Stress Corrosion Cracking
- Corrosion Fatigue
- Erosion
- Freezing Issues

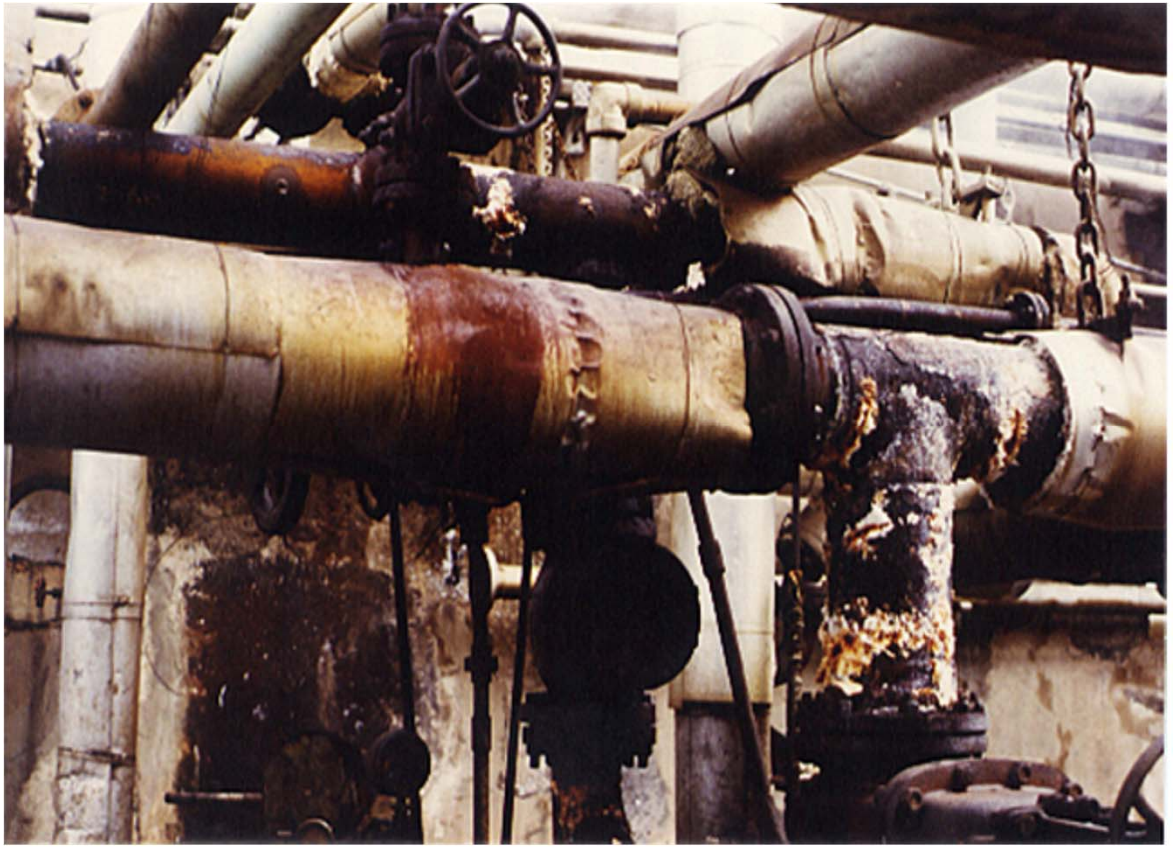
Potential Failure Mechanisms Ethylene Unit (2)

- High Temperature Hydrogen Attack
- Creep
- Fatigue (high cycle)
  - Vibrations
- Thermal Fatigue
- Rebar Corrosion
- Low Temperature Embrittlement
- Carburization
- Oxidation
- Caustic Stress Corrosion Cracking

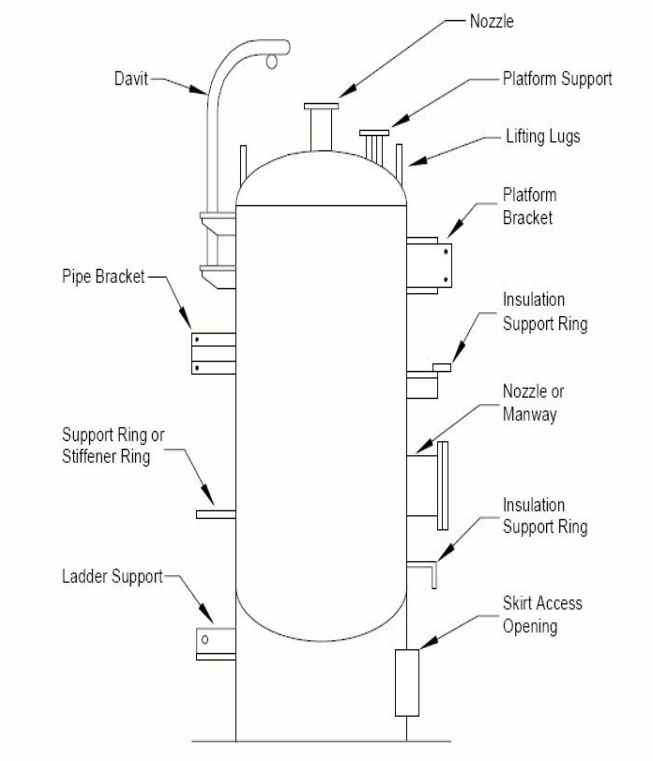
Corrosion Under Insulation (CUI)

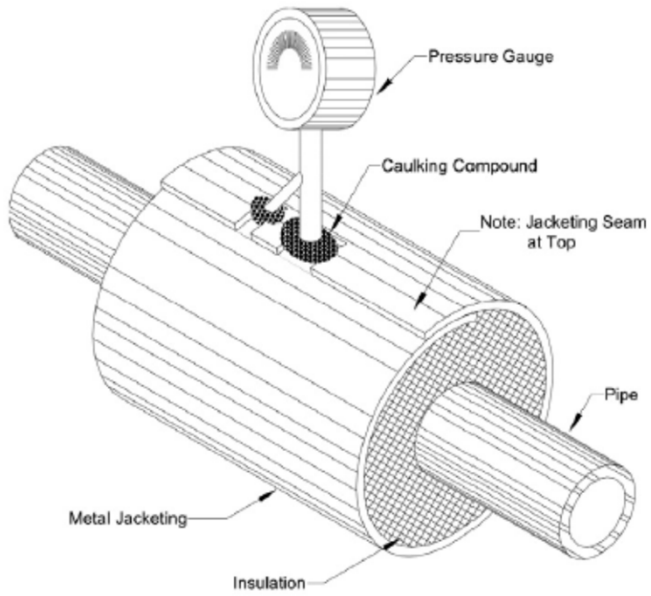
- All insulated equipment and piping operating between -10 and 175°C
- Weather proofing
  - Gaps/openings in insulation and weather proofing
  - Dried out and cracked mastic sealings
  - Protrusions through insulation
- Transition from insulation to fire proofing at skirt
- Insulation not properly restored after maintenance
- Water sources (condensation)

Insulation Condition



Areas for Water Ingress Under Insulation





Source: NACE SP0198 Control of Corrosion Under Thermal Insulation and Fireproofing Materials

More details can be found in API RP 583 Corrosion Under Insulation and Fireproofing

Inspection Techniques - Examples

1. Visual Testing (VT)
   a) External + Insulation
   b) Internal
2. Ultrasonic Testing (UT)
   a) Wall Thickness
   b) Crack Detection
3. Magnetic Particle Testing (MT) / Liquid Penetrant Testing (PT) – Surface Cracks
4. Replica Testing – Creep Detection
5. Vibration Monitoring - Compressors

MDR Experience – Site Visits

Typical findings during site visits:

1. Insulation condition (old, new, cold)
2. Leakages
3. Housekeeping
4. Painting condition
5. Condition of supports and foundations
6. Steam and condensate leakages
7. Missing bolts/fixation for equipment

MDR Experience – Insulation Condition (old)

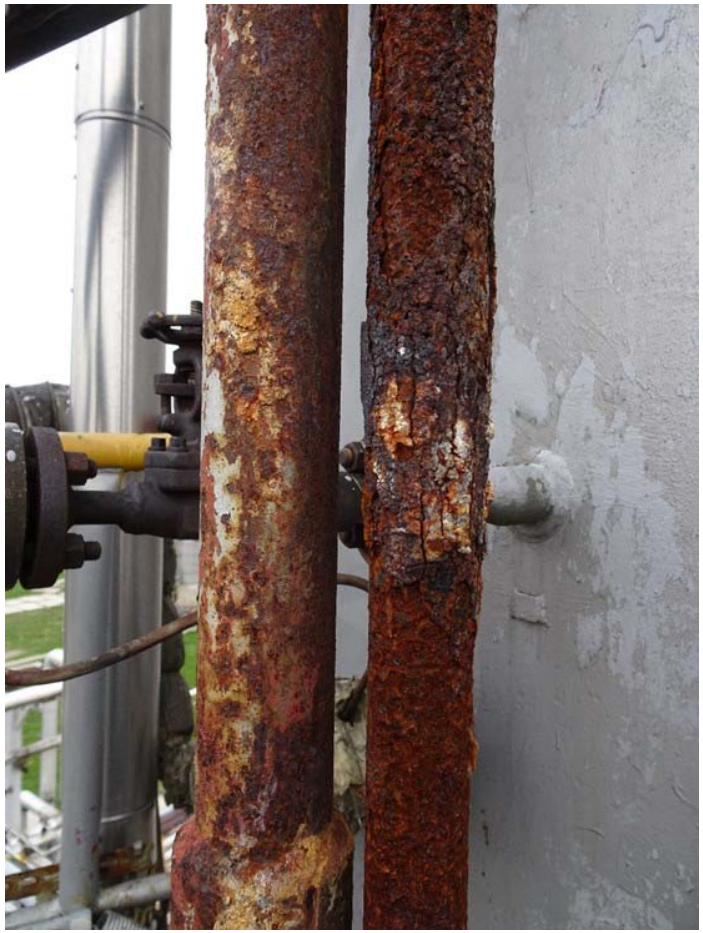
MDR Experience – Insulation (new)

MDR Experience – Insulation (cold)

MDR Experience – Leakages

MDR Experience - Housekeeping

MDR Experience – Painting Condition



MDR Experience – Supports and Foundations

MDR Experience – Steam and Condensate Leakages

MDR Experience – Missing Bolts / Fixations

Overview of PLES executed by MDR The Hague

- Total PLES – 25 studies; including:
  - Petrochemical plants, e.g. Ethylene units
  - Refineries, e.g. CDU, VBU, HDS
- All over the world e.g.:
  - Mexico
  - Romania
  - Chili
  - China
  - The Netherlands
  - Etcetera

Conclusions

- Know your plant
- Know the Failure Mechanisms
- Apply suitable Inspection Technique
- Collect Data
- Estimate Remaining Lifetime
- PLES is a very useful method, for:
  - Debottlenecking
  - Revamp
  - Support for investment decision

Questions?