

# Corrosion in Seawater

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# Use of seawater in O&G production

- Cooling
- Fire fighting
- Seawater injection
- Ballast
- Fresh water production
- Pressure testing of pipelines



# Water treatment

- To prevent bio-fouling in seawater systems
  - Chlorination by chlorine gas or hypo chlorite, typically up to 0.5 ppm residual chlorine ( $\text{Cl}_2 + \text{HOCl} + \text{OCl}^-$ )
  - Combined Cu and chlorine, typically 5 ppb Cu and 0.1 ppm residual chlorine
- To prevent corrosion in pipelines
  - Oxygen scavenger
  - Biocide
  - Corrosion inhibitors



# Materials for seawater systems

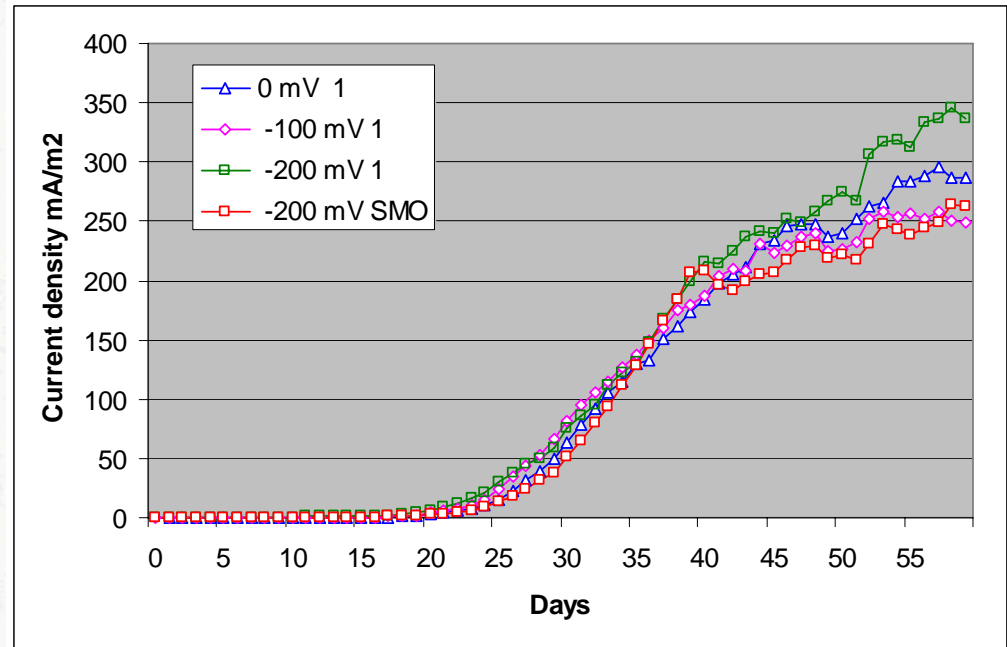
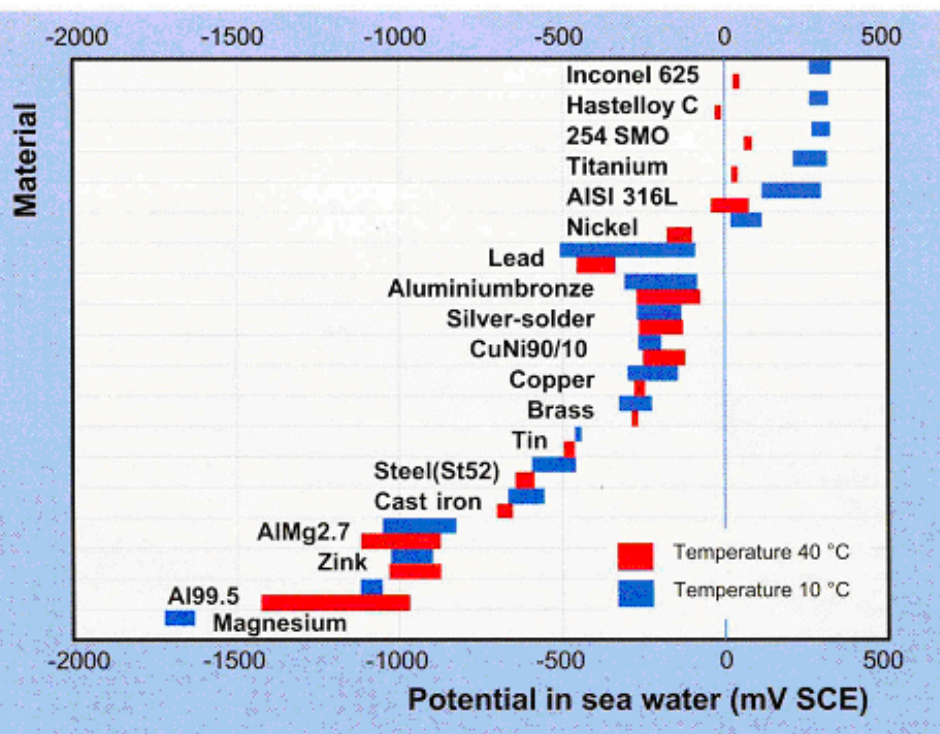
- For piping:
  - CS, cement lined CS, galvanised CS, Cu alloys, high alloyed SS (PREN>40), titanium, GRP
- For vessels:
  - Titanium, GRP, CS with rubber lining
- For components:
  - Titanium, GRP, CS clad with nickel alloys, solid nickel alloys, SS, Cu-alloys, NiAl bronze

# Field experience

- Cement lined CS
  - Problems in field joints
- Cu alloys
  - Selective corrosion (Zn in brass)
  - Erosion/cavitation corrosion in Al-Bronze
  - High velocities and contaminations for Cu-Ni
  - Galvanic corrosion when connected to SS
- SS (PRE > 40)
  - Severe crevice corrosion problems (6 Mo)
  - Uncertain temperature limits

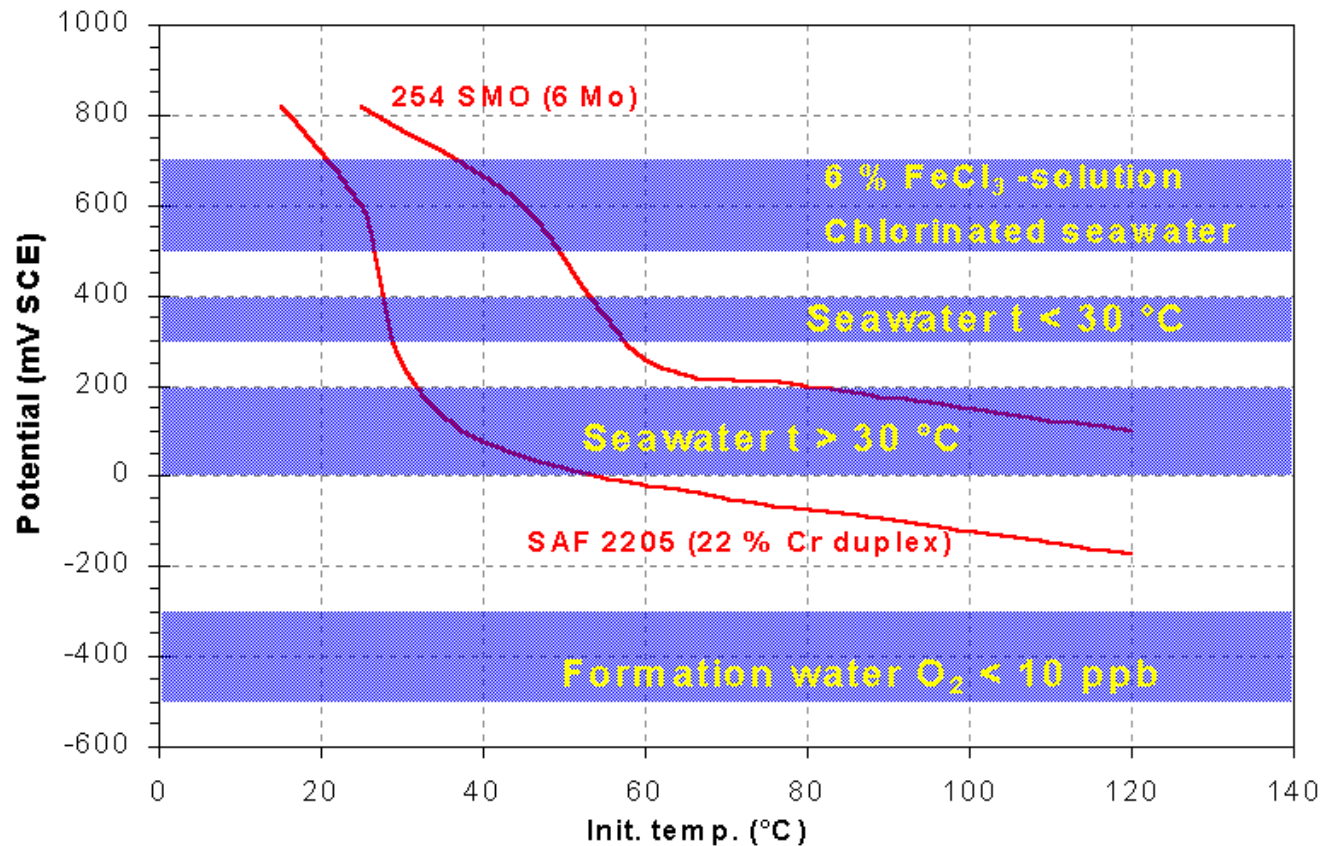
# The discovery of the biofilm!

- Increase in potential and cathodic capacity
- Time delay for removal of seawater in non resistant CRAs
- Temperature and time effect – galvanic series



# CPT and CCT as a function of potential

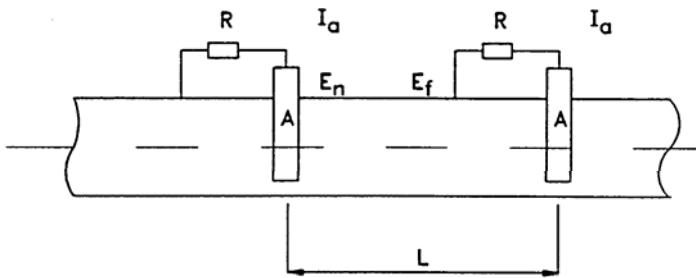
Critical temperature as a function of electrochemical potential for welded specimens



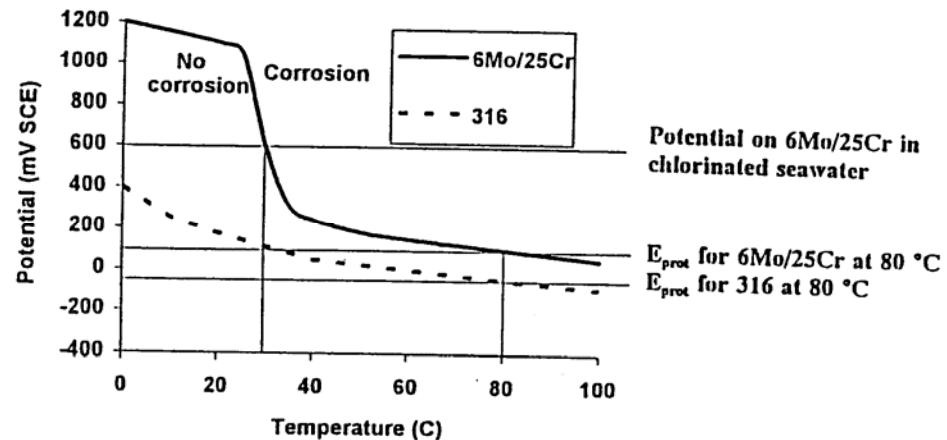
# RCP

- Requirements

- Chlorination to prevent formation of the biofilm that enhances the cathodic capacity
- Stainless steel with a repassivation T  $\sim 0$  mV SCE for actual temperatures (PREN > 40)



Schematics of the RCP method applied to a piping system.



# Heat exchangers

- Titanium limited delivery – long lead time!
- Ni-alloys as alternatives
  - C-276, A-686, A-59....
- Testing
  - Laboratory with artificial crevices
  - Testing with real assemblies – different results !

# Crevice assemblies

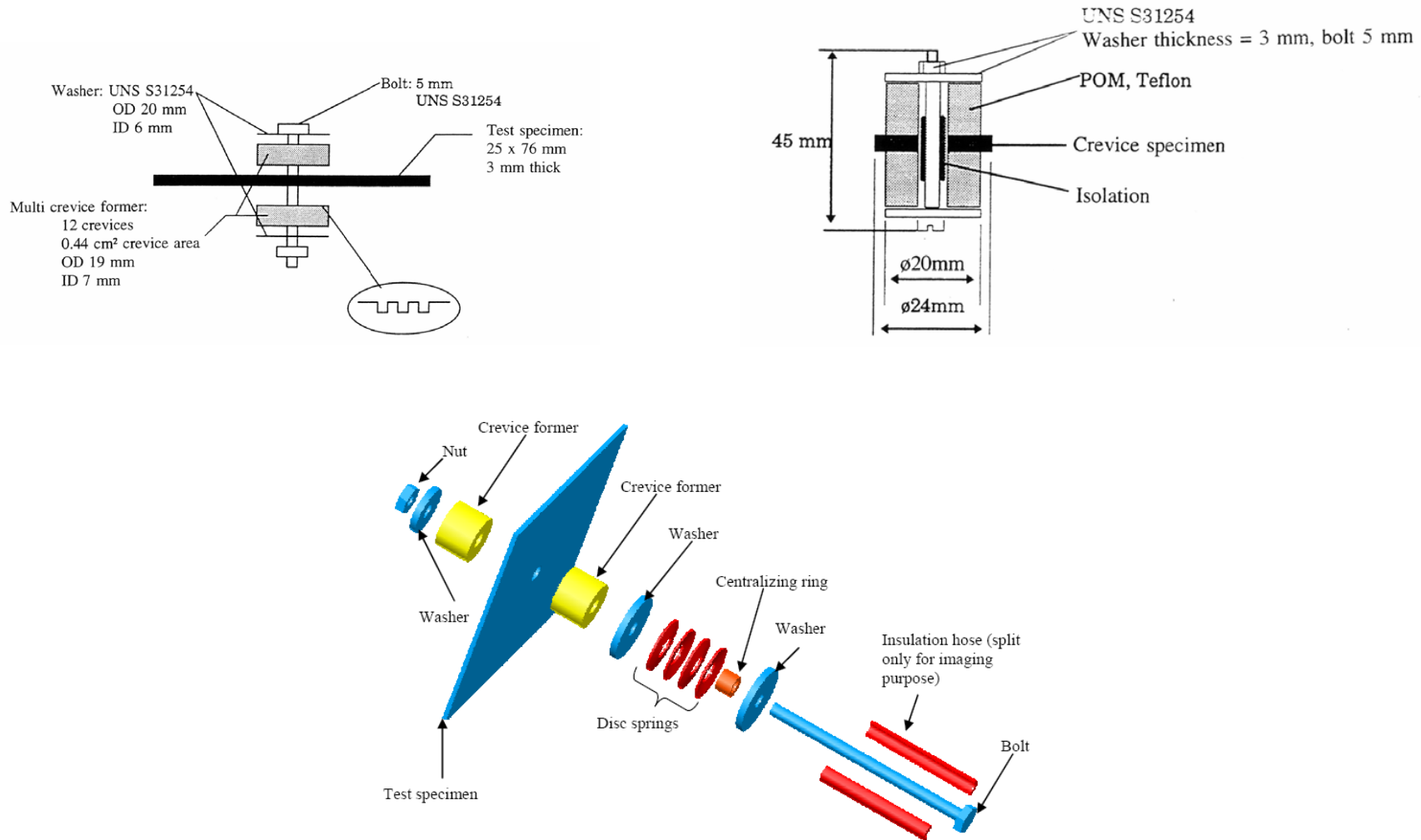


Figure 3.3 Crevice corrosion assembly developed during the CREVCORR project /8, 9/.

# Research

- A mature subject with many good results over the last 30 years
  - Biofilm
- Testing methodology
  - Assembly (crevice)
  - Real exposure
  - Environment (real or potentiostatic)
- Ni-alloys
- SS