Corrosion in Seawater

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Statoil
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

- 254 SMO (6 Mo)
- 8% FeCl₃ solution
- Chlorinated seawater
- Seawater t < 30 °C
- Seawater t > 30 °C
- SAF 2206 (22% Cr duplex)
- Formation water O₂ < 10 ppb
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)
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