INSTITUTE OF CORROSION

Corrosion Awareness Day 2023

Corrosion and Chemicals Management

Jen Watson

Senior Account Manager

Champion X

ChampionX: Our purpose and our business

CHAMPIONX

United behind a **common purpose**

We are a global leader in **chemistry solutions**, **artificial lift systems**, and **highly engineered equipment and technologies** that help companies drill for and produce oil and gas safely, efficiently, and sustainably around the world.

Our expertise, innovative products, and digital technologies provide enhanced oil and gas **production**, **transportation**, and **real-time emissions monitoring** throughout the lifecycle of a well.

Our **world-class safety culture** fuels our purpose of Improving Lives through our commitment to deliver sustainable operations.

GOAL ZERO YOU LEAD

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Business segments overview

CHAMPIONX

Drilling Technologies	Production & Automation Technologies	Digital, Control, Automation & Optimization	Chemical Technologies	Emissions Technologies
Polycrystalline diamond cutters and bearings ▪ Drill bits ▪ Mud motors ▪ Rotary steerable tools ▪ Turbines ▪ Directional drilling tools	**Artificial Lift** ▪ Equipment ▪ Services ▪ Automation & optimization	**Digital** ▪ Wellsite automation ▪ Asset integrity monitoring ▪ Downhole monitoring ▪ Predictive analysis	**Oilfield performance** ▪ Reservoir ▪ Production ▪ Midstream ▪ Water **Specialty drilling performance** ▪ Drilling ▪ Cementing ▪ Well stimulation	**Emissions monitoring solutions** ▪ Ground-based continuous monitoring (SOOFIE®) ▪ Aerial and ground-based OGI ▪ Drone monitoring ▪ Aerial monitoring

Methods of Corrosion Control

- Using corrosion-resistant alloys (CRAs)
- Water removal (by pigging or dehydration)
- Cathodic protection
- Coatings
- **Oxygen and H_2S scavengers**
- **Biocides for preventing MIC**
- **pH stabilization**
- **Drag reduction**
- **Corrosion inhibitors for internal corrosion**

Oxygen and H_2S scavengers

- Scavengers are used to remove unwanted gases from produced liquids, gas and sludge
- Typical applications
  - Oxygen scavengers
    - Seawater injection to help achieve an oxygen spec of <10ppb
    - Hydrotesting (integrity check) of pipelines
  - H_2S scavengers
    - Produced gas to ensure H_2S limit is within Health and Safety, commercial, and corrosion limits
    - Sludges/Slurries
    - Cargo tanks vapour space or fluids

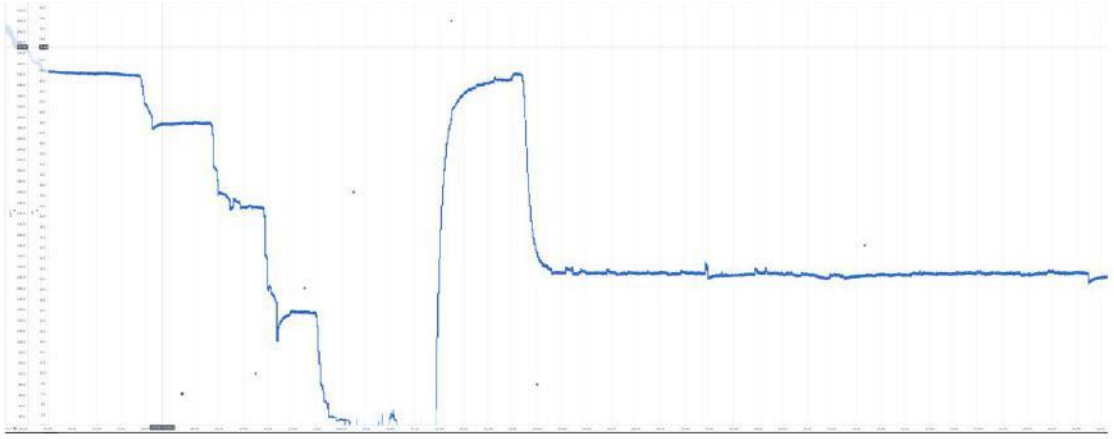
Oxygen and H_2S scavengers Typical chemistries

- Oxygen scavengers
  - Continuous injection into seawater deaerator towers
  - Sulfite, bisulfite, and metabisulfite salts, sometimes with added catalysts
  - Ammonium bisulfite is typically used in the North Sea
- H_2S scavengers
  - Triazine fast acting suitable for gas compression
  - MBO slower reaction time suitable for long residence time applications mixed fluids
  - Glyoxal slow reaction time, suitable for mixed fluids

How we monitor

- Oxygen removal performance

- H_2S reduction



Biocides

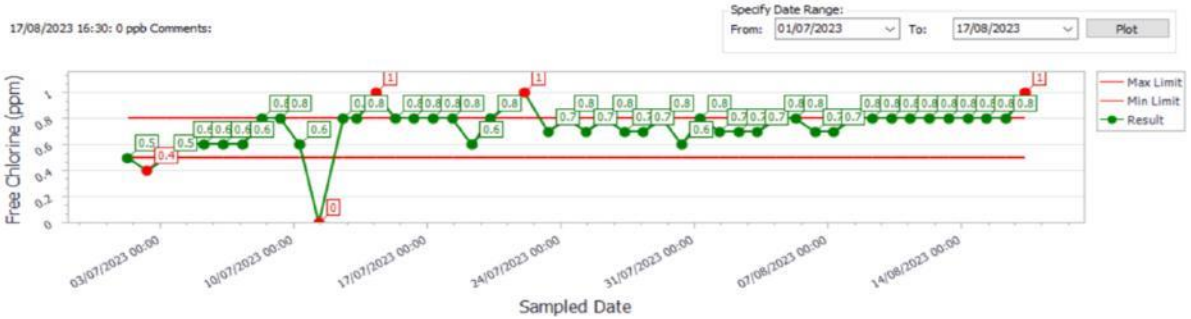
- Injected to eliminate bacterial growth within seawater, produced water and other process systems, vessels and pipelines
- To prevent
  - MIC caused by under deposit corrosion
  - Production of H_2S causing HISC (Hydrogen Induced Stress Cracking)
  - Fouling by slime forming colonies of bacteria

Biocides
Typical chemistries

- Oxidizing
  - Sodium hypochlorite(Chlorine)
    - Injected continuously as a primary biocide
- Non oxidizing
  - Glutaraldehyde(GLUT)/QUAT
  - Highly effective biocide
  - Batch dosing/Soaks
  - Addition of a surfactant such as QUAT will help penetrate biofilms and allow the Glut to do it's job
- Organic
  - Tetrakis Hydroxymethyl Phosphonium Sulfate(THPS)
  - Batch dosing/Soaks
  - Dissolves Iron sulfide
  - H_2S Scavenging properties

How do we monitor?

- Primary biocide - Free chlorine levels



- Secondary biocide, did we meet target concentration?

- Residual analysis, confirmation if target concentration has been achieved

pH Adjusters and Drag Reducers(DRA)

- pH Adjusters
  - Injected to Glycol regen systems
    - MEA
    - sour gas transfer in the fluids resulting in low pH
  - Cooling/Heating medium systems
    - Sodium hydroxide
    - Batch dose
- Drag reducers
  - Reduces severity of flow induced corrosion
  - Ultra High Molecular Weight Polymers(UHMW)
  - Corrosion inhibitors(Film forming corrosion inhibitors)
  - Continuous injection into Pipelines
    - reduce frictional energy loss and improve flow of fluids(water or oil)
    - decrease pumping costs
      - potentially removing the requirement for pump upgrades
      - improve environmental performance by reducing energy required to operate pump

How do we monitor?

- pH levels within cooling medium system

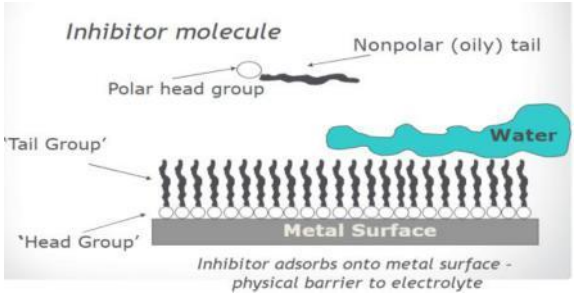
  - Are pumps running whilst taking less load from gas turbines?
- Less turbulent flow?

Corrosion inhibitors

- Film Forming Corrosion Inhibitors (FFCI)
- Passivating (anodic)
- Cathodic
- Vapor phase or volatile

Main types of surfactants

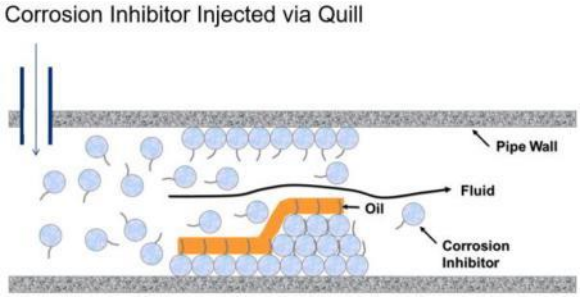
- Surfactants = Surface Active Agents or ‘amphiphiles’
    - Contain hydrophilic (water-loving) and lipophilic (fat-loving) groups
    - Key feature = ability to self-organise at surfaces
    - Chemical driving force = reduction in system energy



- Examples:
    - Cationic (head group with positive charge, e.g., quat. amine)
    - Anionic (head group with negative charge, e.g., carboxylate)
    - Non-ionic (head group without a specific charge, e.g., alcohol)
    - Amphoteric (e.g., betaine, charge varies with pH)

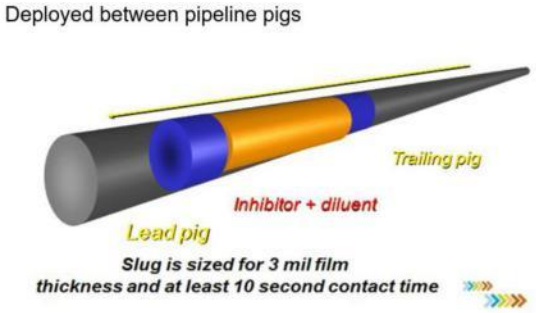
Corrosion inhibitors
How is it injected?

- Dosed continuously
  - Process pipework



- Subsea wellheads
  - CIMV's(Chemical injection metering valves)

- Batch treatment
  - during pigging of pipelines
  - cooling/heating medium
    - closed loop systems



How do we monitor?

- Monitor chemical injection concentration in field
- Calibrated rates at chemical pumps

- Test Corrosion inhibitor residual levels in the lab onshore
- Confirm it's going where it's supposed to at the correct conc.
- ILI (Intelligent Pigging Campaigns) will confirm if chemical has done it's job or not; and what other chemicals may be required e.g. biocides when severe localized pitting is found

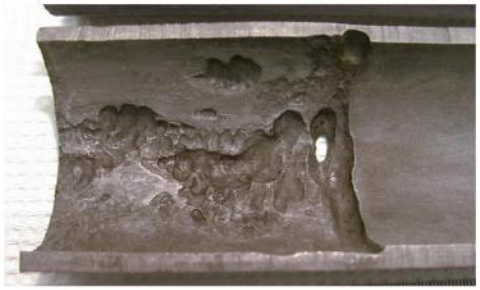
What if a system isn't treated?

- Examples:

Prevented by corrosion inhibitors

- Sour Corrosion (H_2S) Sweet Corrosion(CO_2)

Pits on Rod Body initiated by hydrogen sulphide and brine



CO_2 corrosion in production tubing

Barrier assurance Monitoring

- Chemical & Corrosion Control Matrices(CCCM)
  - Use as a basis for understanding threat and how it should be mitigated by chemical application or other barriers
  - Details barrier assurance requirements, sampling, chemical injection rate, residual oxygen levels, Biocide dosing frequency
  - Materials, systems and sample result specifications

Sea Water Lift and Injection System (WS/WI)

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Tag	Location	Description	Activity	Frequency	Target	Background to target	Materials of construction to which target applicable	Threat being managed by this activity	Remedial Action	SPU defined Key Performance Indicator (Yes / No)
SP-[illegible]	16"-WS-440002-T0IA-NI QD-ET-PR-PID-440-0001-01 (Rev.C5)	Biocide injection point on the inlet line to Seawater Deaeration Tower Y-44007.	Secondary biocide injection online treatments.	System specific min. every two weeks. In most cases weekly treatments are required to maintain control of bacterial levels.	500ppmv	Industry practice for corrosion control and type of biocide selected. On a monthly basis the performance of the biocide treatment shall be reviewed and optimized as directed by the bacterial monitoring results.	Ti	Microbially influenced corrosion (MIC).	Review and optimise. If off spec for more than two months carry out a biocide soak at opportune time	Yes
SP-[illegible]	16"-WS-440002-T0IA-NI QD-ET-PR-PID-440-0001-01 (Rev.C5)	Biocide injection point on the inlet line to Seawater Deaeration Tower Y-44007.	Corrective secondary biocide injection soak treatment.	As required (see background to target)	900 ppmv	Corrective treatment to be applied when bacterial target has been exceeded for two consecutive months and regular	Ti	Microbially influenced corrosion (MIC).	Review results of soak and repeat if necessary.	No
SP-[illegible]	2"-WI-4500015-E10D-NI QD-ET-PR-PID-450-0002-01 (Rev.R0)	Sidestream off suction manifold for Water Injection Pumps P-45001-A/B/C, no sidestream available	Biofilm monitoring - ATP	Every two weeks (min.)	Acceptable Corrosion KPIs [illegible]	BP GN 06-16 Corrosion Management of Water Injection	25 Cr DSS	Microbially influenced corrosion (MIC).	Review and optimise	Yes
SC-854003	24"-WS-8540040-EXD-NI QD-ET-PR-PID-854-0001-01 (Rev.C5)	Sample connection on inlet header for Seawater Filters F-85402-A/B/C. (combined on lift sample used fortnightly for bugs)					25 Cr DSS			
SC-440001	Nozzle N8 on Y-44007 QD-ET-PR-PID-440-0001-01 (Rev.C5)	Sample connection below Stage 1 packing in Seawater Deaeration Tower Y-44007 not sampled, taken from booster pumps instead	Bacterial monitoring - ATP	Every two weeks (min.)	Acceptable Corrosion KPIs [illegible]	GN 06-16 Corrosion Management of Water Injection Systems - Champion II test work	DA tower - CS lined Pipework - 25 Cr DSS	Microbially influenced corrosion (MIC).	Optimise biocide treatment.	No
SC-440002	Nozzle N8 on Y-44007 QD-ET-PR-PID-440-0001-01 (Rev.C5)	Sample connection below Stage 2 packing in Seawater Deaeration Tower Y-44007 not sampled, taken from booster pumps instead								
SC-440005	24"-WS-4400008-EXD-NI QD-ET-PR-PID-440-0003-01 (Rev.C5)	Sample connection on outlet line from Seawater Deaeration Tower Y-44007 to Seawater Deaeration Booster Pumps P-44003-A/B/C (not sampled [illegible]								
SC-440003	16"-WS-4400021-E03D-NI QD-ET-PR-PID-440-0003-01 (Rev.C5)	Sample connection downstream of the discharge manifold for Seawater Deaeration Booster Pumps P-44003-A/B/C. (no change)								
SC-450001	20"-WI-4500005-E03D-NI QD-ET-PR-PID-450-0002-01 (Rev.R0)	Sample connection on line from Produced Water and Seawater Inlet Manifold to Water Injection Pumps P-45001-A/B/C (no change)								
SC-854003	24"-WS-8540040-EXD-NI QD-ET-PR-PID-854-0001-01 (Rev.C5)	Sample connection on inlet header for Seawater Filters F-85402-A/B/C	Monitor residual chlorine level when SW Lift Pumps are online. Primary biocide (hypochlorite) injection	Daily	0.5 ppm (upper limit 1 ppm up to 20C; 0.8 ppm at 20 - 30C)	Upper limit set to avoid pitting corrosion.	25 Cr DSS	Target value: Macrofouling. Upper limit: Pitting corrosion	Check status of electrochlorinator / hypochlorite injection and adjust as	Yes

Process	May-23	Jun-23	Jul-23	Status, reported by exception	Actions
Oil process				examples:High water content in crude oil to rundown	Improve separation, optimise demulsifier injection rasie interface levels in separator
Gas process				No issues H2Sand Dewpoint in spec	no action
Water handling				No issues oxygen, bacteria, residual bisulphite all in spec	no action
Utilities				Heating medium corrosion inhibitor concentration under target	Add Corrosion inhibitor as soon as possible
Chemical and corrosion management				Oxygen scavenger pump decline in performance	Raise maintenance order for urgent repair

Thanks for listening

Contact details
jennifer.watson@championx.com

Thank you for your attention...

Q & A