Distinguished Lecturer Program

Primary funding is provided by

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The Society is grateful to those companies that allow their professionals to serve as lecturers

Additional support provided by AIME

SPE International

Society of Petroleum Engineers
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Distinguished Lecturer Program

SPE International

The Science and Engineering of Internal Corrosion Control in the Upstream Petroleum Industry

… mainly about managing water …

Mohsen Achour

ConocoPhillips

Society of Petroleum Engineers Distinguished Lecturer Program
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Why Corrosion is Important

Project funded by DOT in 1998

Corrosion Consequences

Autotechnology.net

Aug. 19, 2000 - New Mexico

- Pipeline ruptured
- Natural gas ignited
- 12 people killed
- $ 1MM property damage

Dec. 12, 2012 - West Virginia

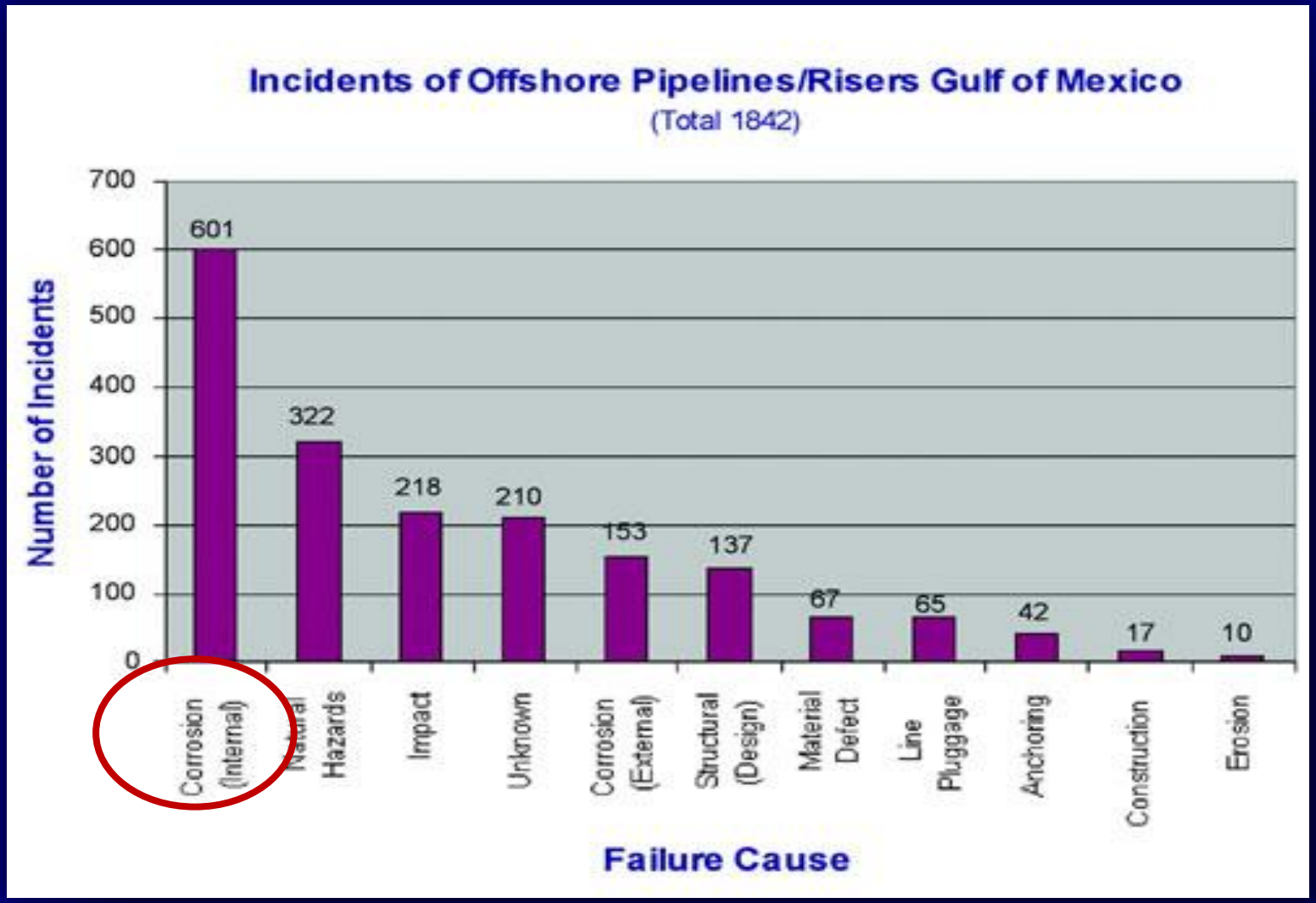
- External corrosion
- 15-mile stretch fire
- 4 homes destroyed
- No casualties

Corrosion Consequences (cont'd)

Associated Press

- 2006 - Prudhoe Bay oilfield: Infield line leaked 200,000 gallons of oil into tundra
- *Incident impactful to the operator liability/reputation*
- Operator was subject to severe fines both at the federal and state levels

2000 – 2010 Statistics



TDWilliamson.blogspot.com

… Mainly About Managing Water …

“Water is the driving force in nature”

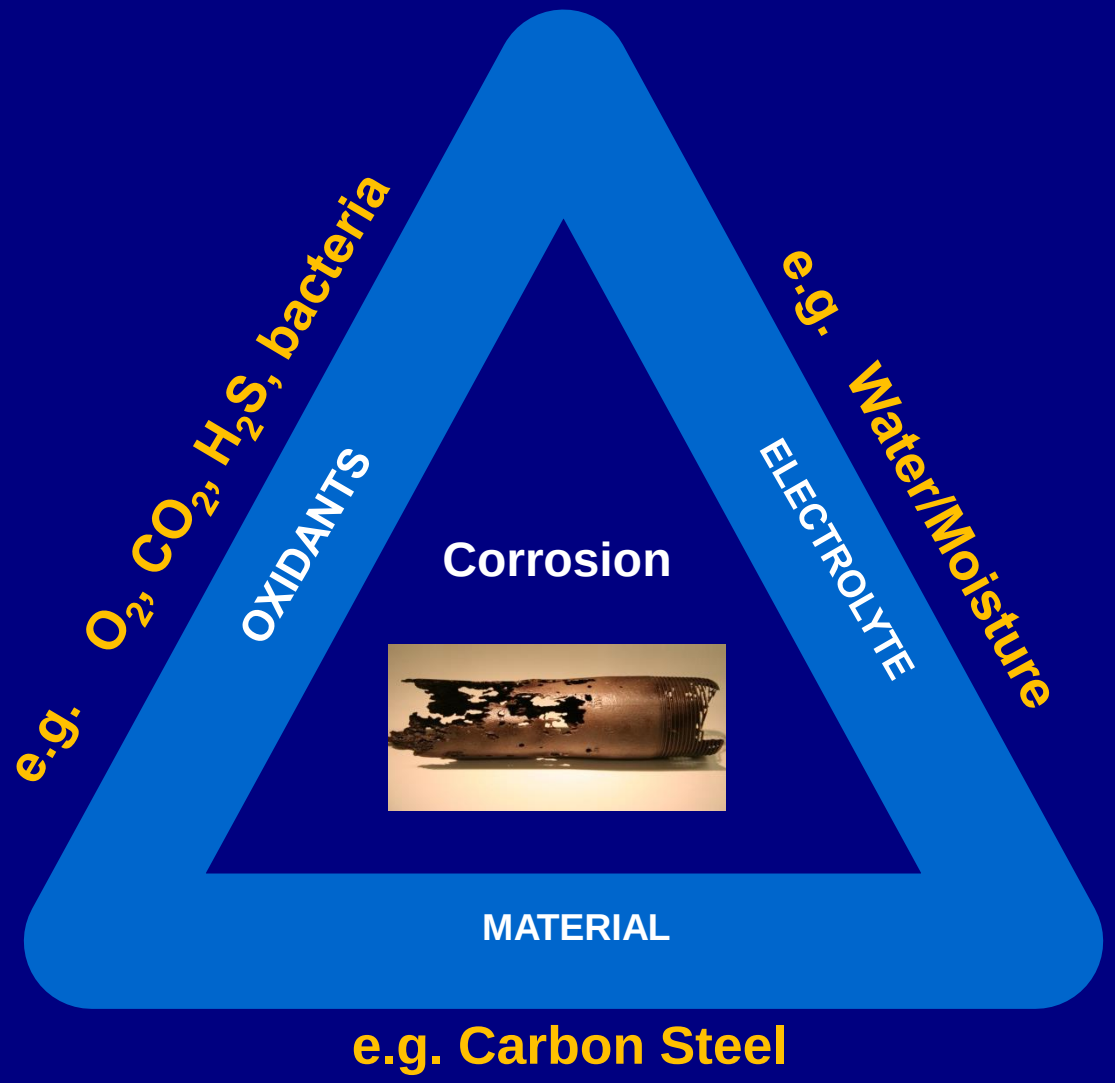
Leonardo da Vinci: *painter, sculptor, architect, musician, scientist, mathematician, engineer, inventor, anatomist, geologist, cartographer, and writer … perhaps the most diversely talented person ever to have lived!*

“Water is the driving force in corrosion”

Mohsen Achour: *unknown!*

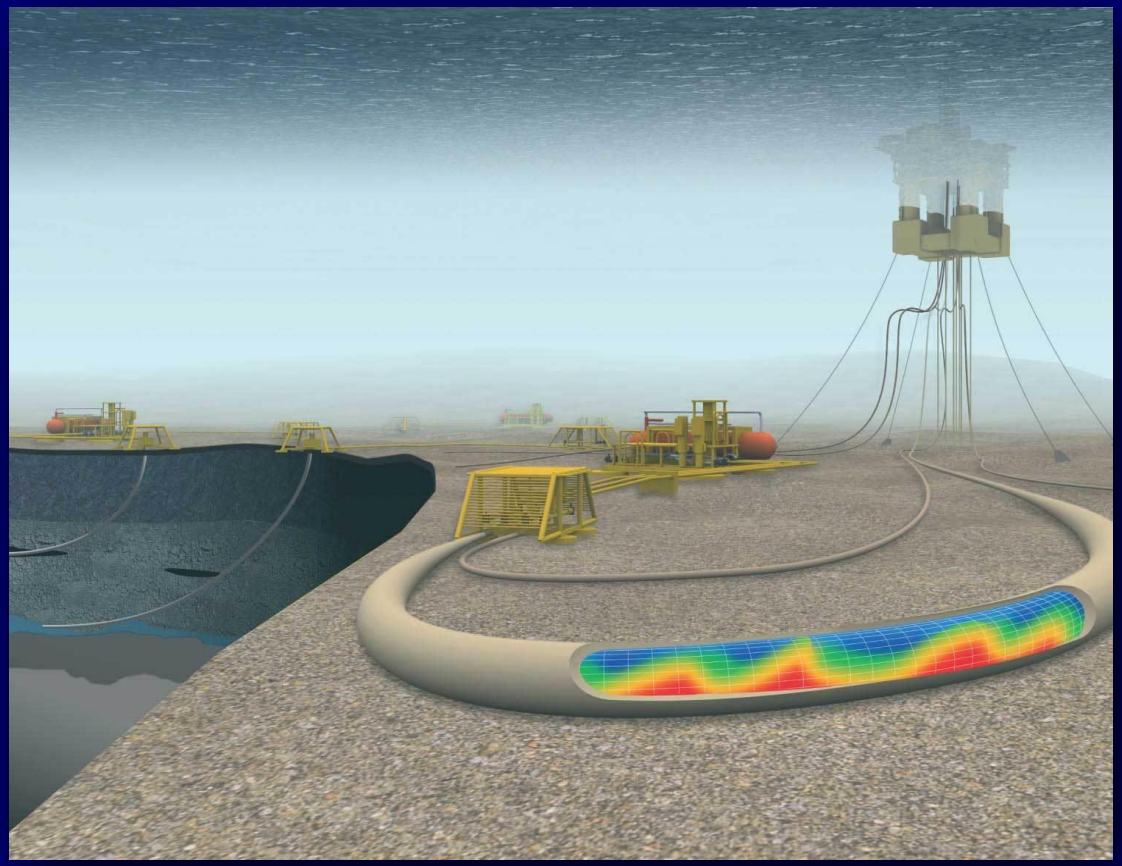
“Water is the Driving Force in Corrosion”

- We can never eliminate corrosion, we can only hope to control it
- Managing water/electrolyte is key to corrosion control when environment is fixed and materials are selected



Ideal Water to Minimize Corrosion

Deoxygenated, degassed, bacteria free, high alkalinity (high pH), low/no solids, cold and flowing just right.



Courtesy of Kongsberg®

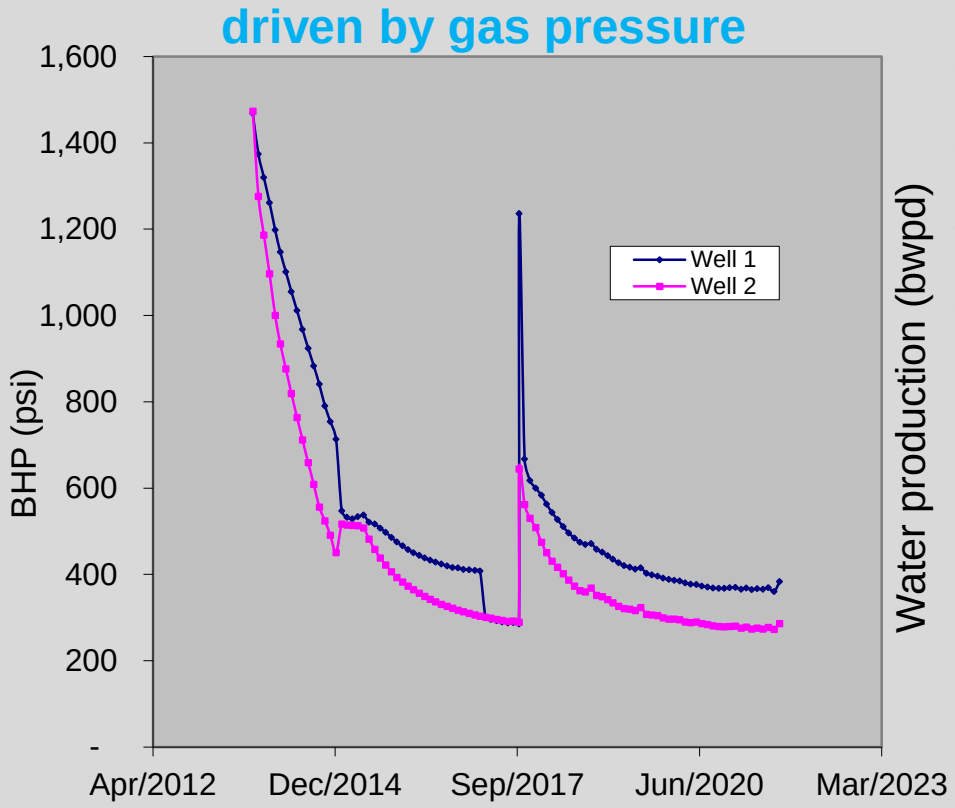
- Casing
- Production tubing
- Flowlines
- Gathering lines
- Risers
- Trunk lines
- Gas lines
- Oil export lines
- Injection lines
- Water lines
- Facilities

Variability in Water Chemistry

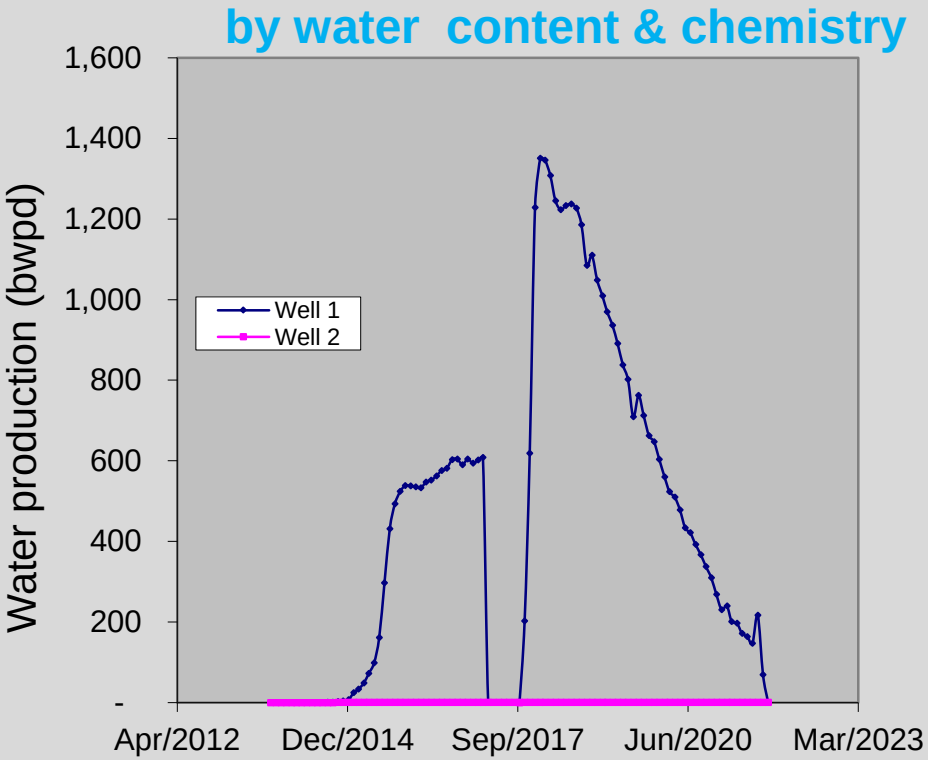
Component (mg/lit)	Gas production water	Oil production produced water	Oil production produced water	Seawater
Sodium	665	29910	50200	11050
Potassium	10	325	500	410
Magnesium	8	540	500	1323
Calcium	9	2120	20200	422
Barium	10	270	920	0.02
Chloride	900	52110	120120	19875
Bicarbonate	366	235	473	145
Sulfate	1	10	8	2782
Weak Acids	e.g. CO_2, H_2S, organic acids … affecting pH calculations and corrosion/scale potential			

Account for systematic variations in the production environment

Corrosion Control in Gas pipelines



Pressure depletion



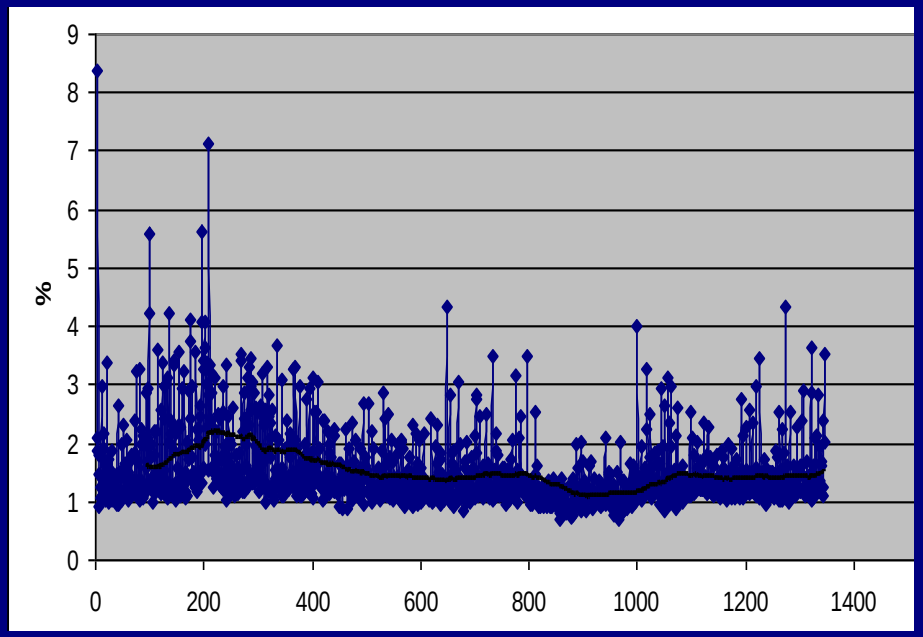
Water production

<u>Science</u>: Thermodynamics, flow modeling, pressure depletion , water chemistry, dehydration

<u>Engineering</u>: Dry vs. wet gas , slug dynamics, inhibition program , corrosion monitoring , In Line Inspection (ILI), top of line corrosion.

<u>Best Practice:</u> Assume dry is wet, design for pigging, inspect at start up for ILI baseline survey, reinforce and monitor dew point spec.

Corrosion Control in Oil Export Line



Online BS&W (%) vs. time (hrs)

Cleaning pig

Science: Hydrocarbon chemistry , Flow modeling, Pressure and temperature profiles, Water chemistry

Engineering: Velocity range, Oil/water wetting, Inhibition program , MIC, Monitoring / ILI, **Pipeline layout and profile**, Understand/monitor 3rd party input

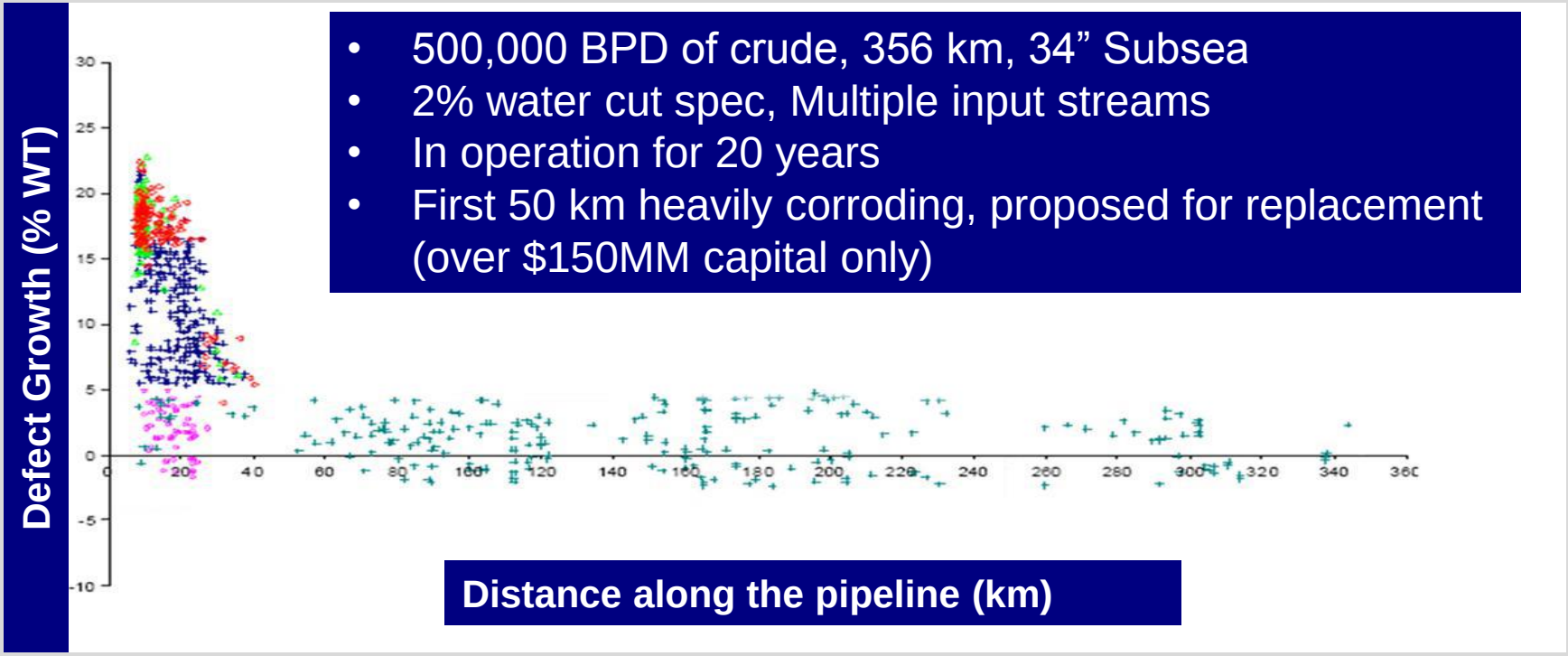
Best Practice: Assume BS&W upsets will occur, Design for pigging, ILI baseline profile, No short cuts in maintenance pigging and chemical treatment programs

Water is Unavoidable and Corrosive Inhibition can be Answer

but … need to understand:

- Water wettability of the steel wall
- Inhibitor performance testing and QA/QC
- Partitioning of inhibitor between oil & water
- Effect of solids ($BaSO_4$, $CaCO_3$, $FeCO_3$, FeS ...)
- Effect of inhibitor under dosing or over dosing
- Effect of emulsion
- Compatibility of inhibitor with other production chemicals (biocide, scale inhibitor, KHI …)
- Residual analysis & discharge into environment

Case History 1
Low Water Cut Oil Pipeline Corroding



- 500,000 BPD of crude, 356 km, 34” Subsea
- 2% water cut spec, Multiple input streams
- In operation for 20 years
- First 50 km heavily corroding, proposed for replacement (over $150MM capital only)

WT: wall thickness

red & blue: new defects, other colors: old defects

- Reviewed water cut history, changed chemical treatment
- Initiated aggressive cleaning and inspection program
- Saved replacement of the pipe section

Case History 2
Dry Gas Pipeline Corroding

Scenario

- 350 MMSCFD of dry gas
- 654 km, 22-28” Subsea lines
- Dew point spec 55F @ 700 psi
- Multiple subsea tie-in streams
- In operation for 7 years

- Filters plugged at arrival
- Metering system jeopardized
- Risking 27 yr sales contract
- Call for pigging facility inst. (over $100MM investment)

Assessment/Solution

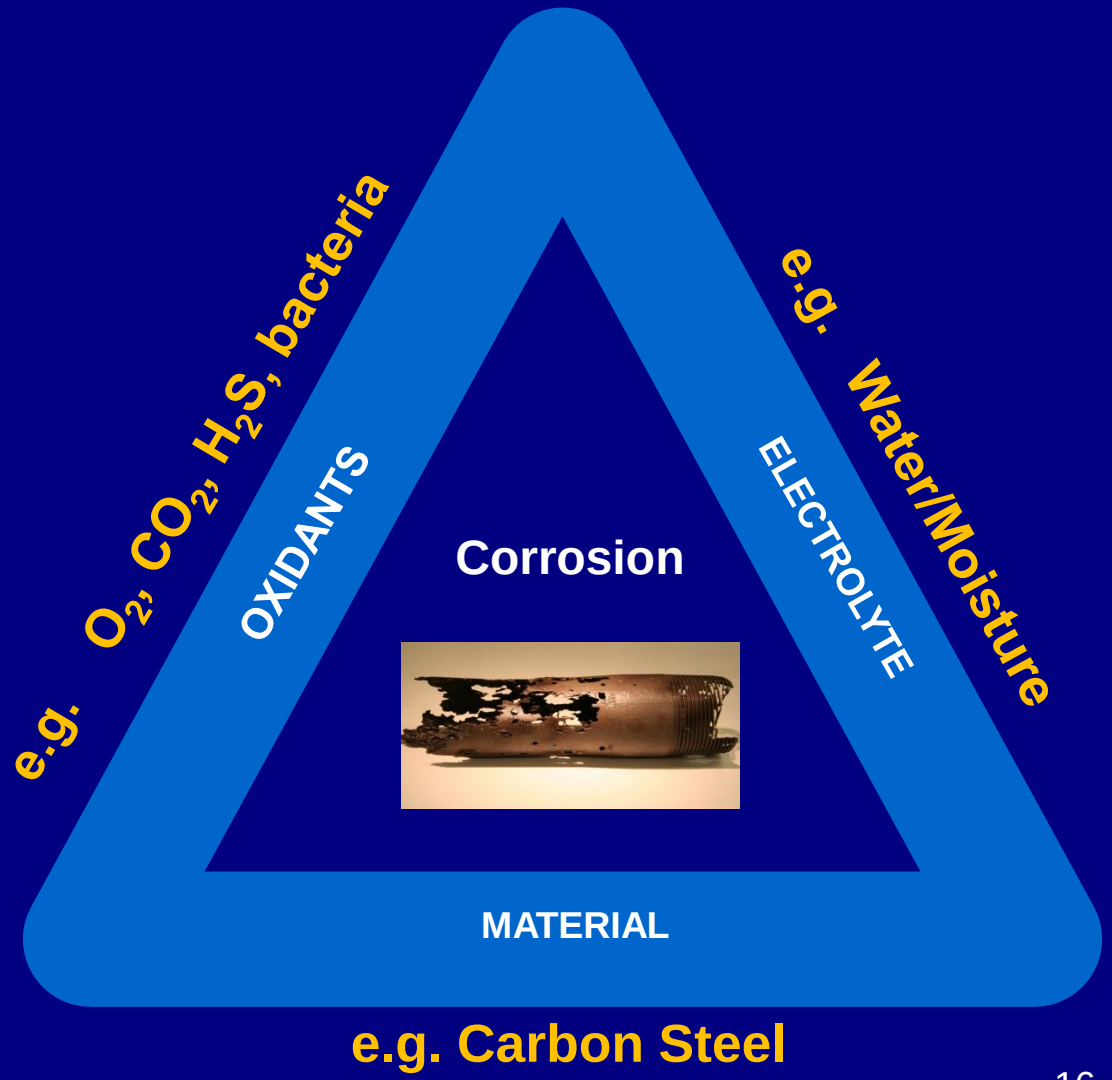
- Dew point spec violated
- Incidents of seawater ingress
- Pipeline not completely cleaned after hydrotest
- Salt and corrosion products

- Lowered dew point spec
- Installed monitoring points
- Tracked solids/ salt corrosion
- Showed proof of self cleaning
- Saved pigging installation

“Water is the driving force in corrosion”

A successful corrosion management program requires:

- Multidiscipline skills
- Corrosion conscious basis of design
- Sound engineering practices
- Operations Excellence
- Budgeting
- People



Thank you All

Thank you for your attention

Gracias por su atención

Grazio per l'attenzione

Благодарю вас за ваше внимание

Merci pour votre attention

Muito obrigado pela vossa atenção

Thak u voor uw aandacht

感谢您的关注

Tusen Takk for at du kom

Dhanyavaad

شكرا لانتباهكم

Questions ?

Distinguished Lecturer Program

Your Feedback is Important

Enter your section in the DL Evaluation Contest by completing the evaluation form for this presentation :

Click on: Section Evaluation

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Backup Slides

Carbon Steel & Inhibition
vs.
Corrosion Resistant Alloys (CRA)

Type: gas pipeline, oil export, gathering/transfer line

Location: onshore/offshore, remote, populated area

Length: CAPEX/OPEX, life cycle cost analysis

Content: water, gas/oil, sweet/sour

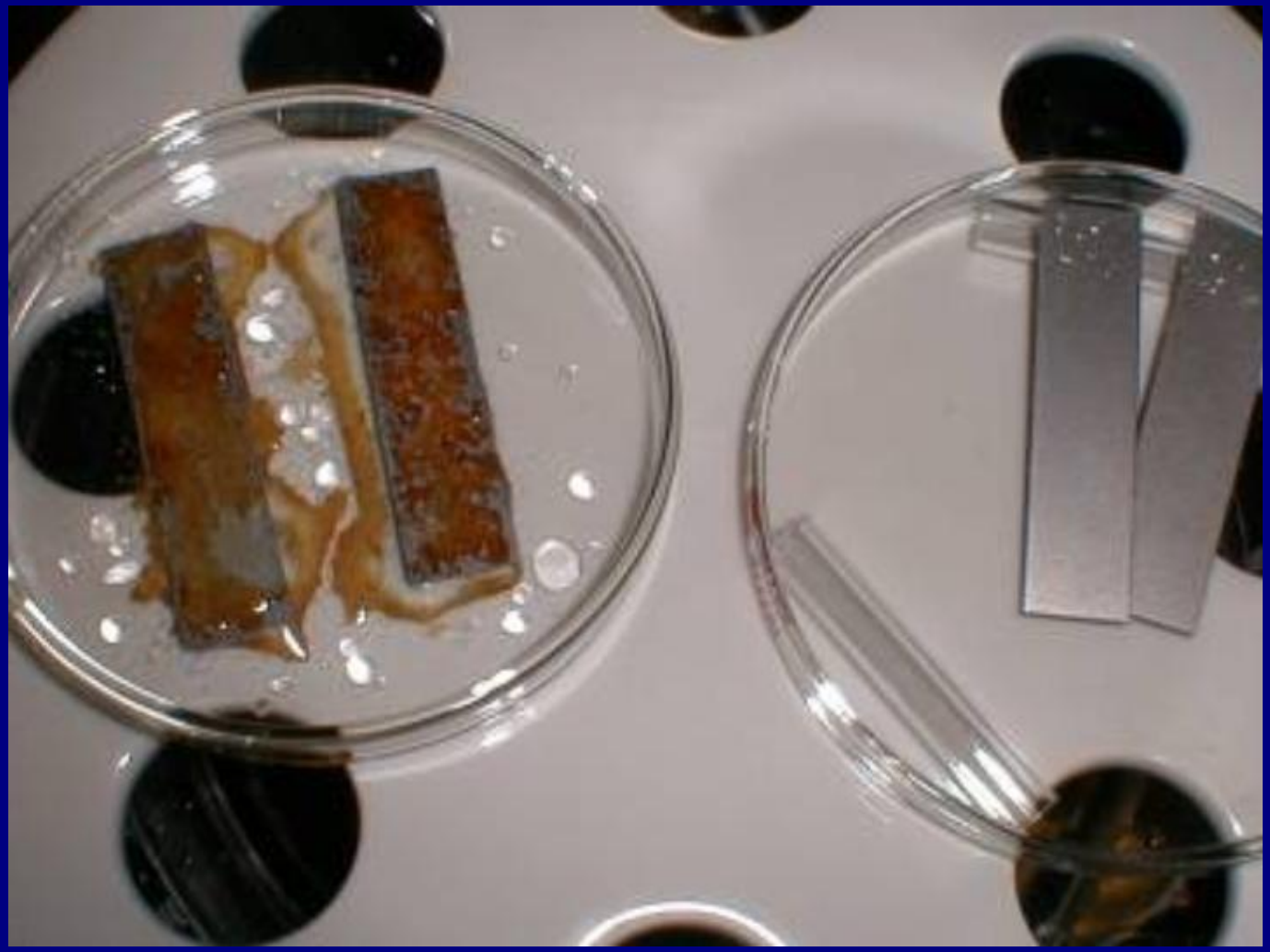
Operating conditions: T, P

Economics: $/barrel, market

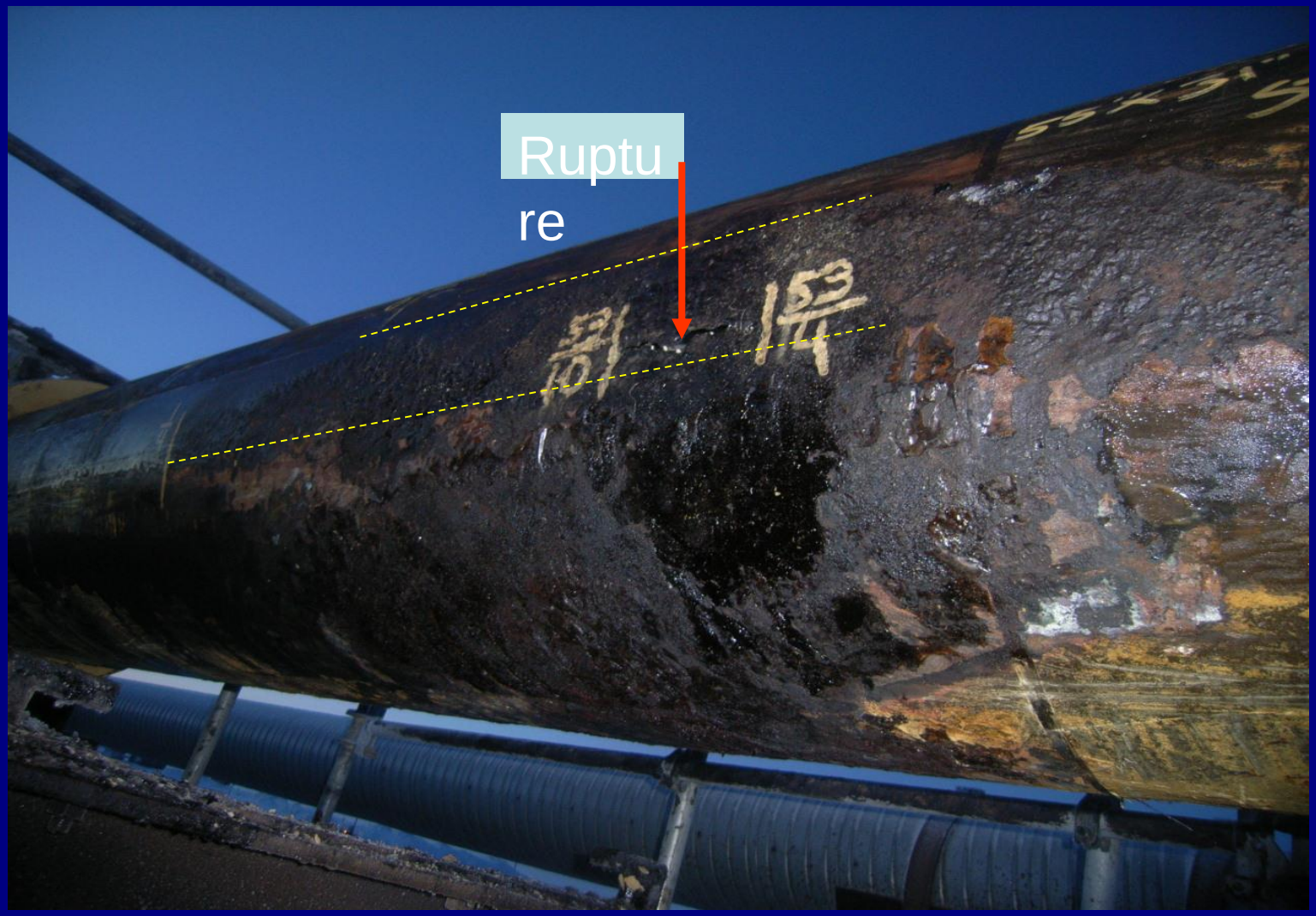
CRA: 13 Cr, Super 13 Cr, Duplex, Inconel, Hastelloy

Under Deposit Corrosion (UDC)

Salt Induced Corrosion

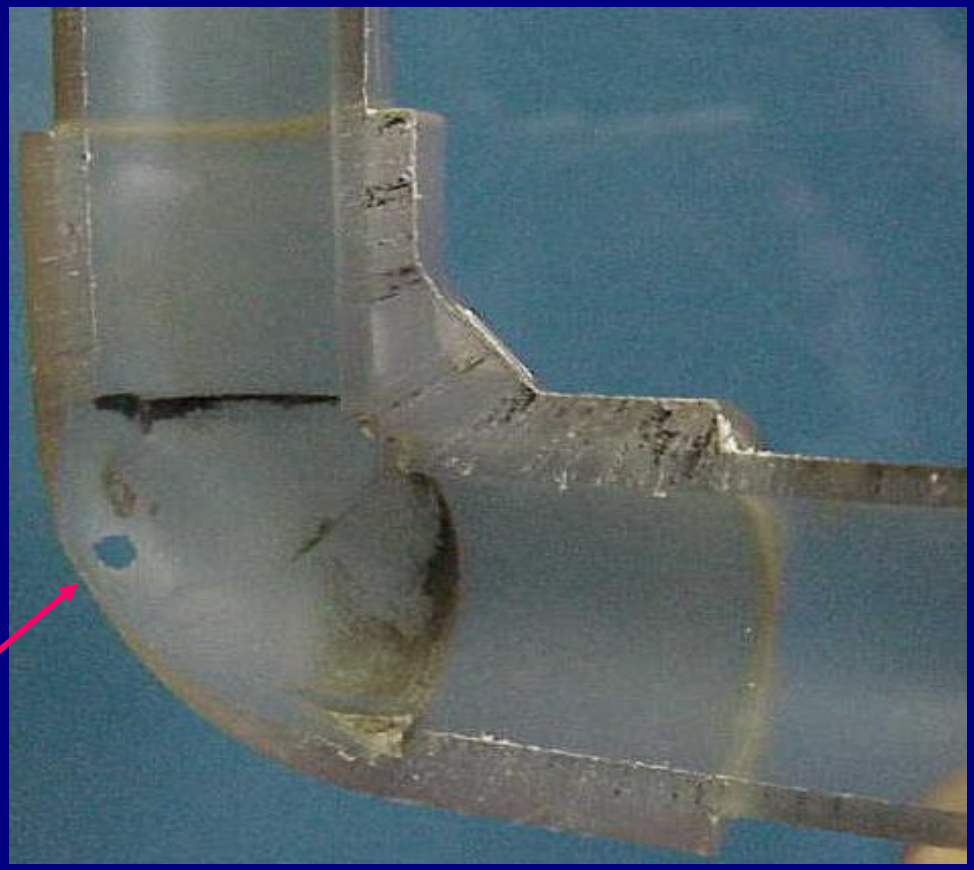


Corrosion Under Insulation (CUI)



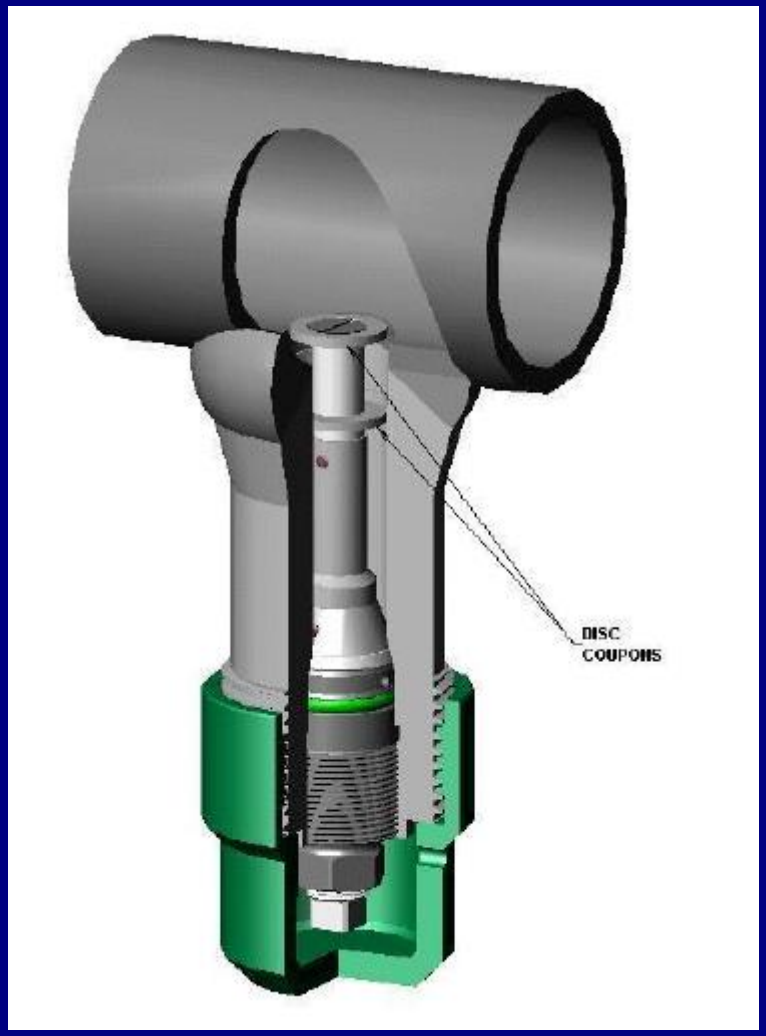
Courtesy of COP Alaska

Erosion – Erosion/Corrosion



Erosion

Corrosion Coupon



ER Probes

Electrical Resistance Probes

Jet Pig – Cleaning and inhibitor Application

Smart Pigging – MFL Tool