Appendix 6

Genguard and advanced cooling solution

Roy Holliday (GE)

Corrosion Inhibition in Cooling Water

GE
Water & Process Technologies

Roy Holliday

April 2009

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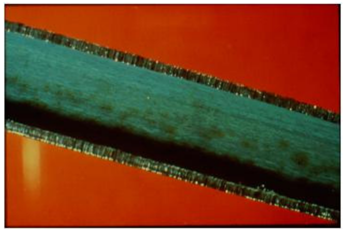
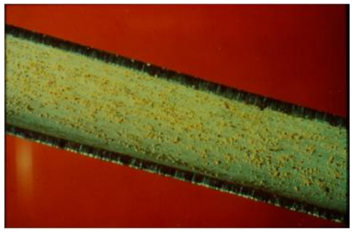
What do you need to inhibit corrosion?





Corrosion inhibitor(s)

Is that all?

The right water chemistry for the corrosion inhibitor?

Better - The correct corrosion inhibitor for the water chemistry and metallurgies!

Maintain solubility and/or activity of the corrosion inhibitor(s)

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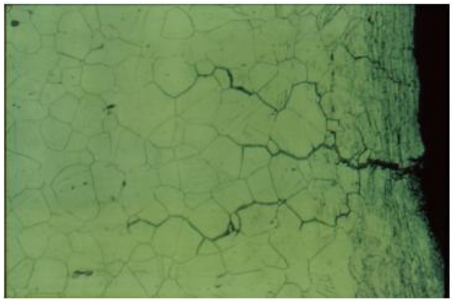
Do you need anything else?

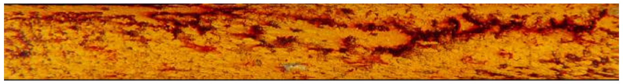
Stress corrosion cracking

- Inhibitor?
    - Control concentration of causal chemical
    - Metallurgy
    - Cleanliness!



Under deposit or crevice corrosion

- Inhibitor
- Cleanliness!



Pitting corrosion and tuberculation

- *Inhibitor*
- *Cleanliness!*

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Summary

Corrosion inhibitor
- Suited to
  - Metallurgy
  - Water Chemistry

Treatment Programme
- Suited to
  - Metallurgy
  - Water Chemistry
  - System Design
  - System Operation

Corrosion Inhibition
Maintain inhibitor(s) soluble
Scale Inhibition
Deposit Control

Treatment Programme

Neutral pH

- Phosphate
- Zinc Phosphate

Normally requires
pH control
Polymer

Alkaline pH

- Phosphate
- Zinc
- Zinc Phosphate
- Organic
- Molybdate

Restricted cycles
LSI, pH, Ca
Requires
Calcium inhibitor
Polymer

Treatment Programme

$CaCO_3$ inhibition

- Traditionally Phosphonates
  - LSI limitation +2.5
- AEC
  - Contains no P
  - LSI up to +2.85

Restricted cycles
LSI, pH, Ca
Requires
Calcium inhibitor
Polymer

Alkaline pH

- Phosphate
- Zinc
- Zinc Phosphate
- Organic
- Molybdate

Treatment Programme

Neutral pH
- Phosphate
- Zinc Phosphate

$Ca_3(PO_4)_2$

$Zn_3(PO_4)_2$

$Zn(OH)_2$

Restricted cycles
LSI, pH, Ca
Requires
Calcium inhibitor
Polymer

Normally requires
pH control
Polymer

Alkaline pH
- Phosphate
- Zinc
- Zinc Phosphate
- Organic
- Molybdate

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Treatment Programme

Polymer is a key component

Restricted cycles
LSI, pH, Ca
Requires
Calcium inhibitor
Polymer

Normally requires
pH control
Polymer

Functionality

Keep corrosion inhibitors soluble/available

- Scale Inhibition

Crystal Growth Inhibitor

Deposit control

- Dispersion

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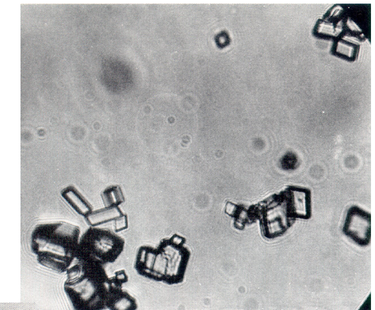
Treatment Programme

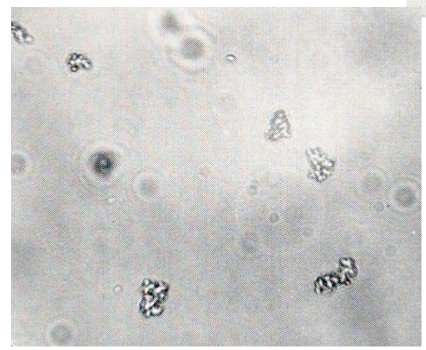
Crystal
Growth
Inhibitor

What is the result of an effective Crystal Growth Inhibitor?



Small deformed crystals

Easily dispersed
Kept in suspension



Crystal
Growth
Inhibitor

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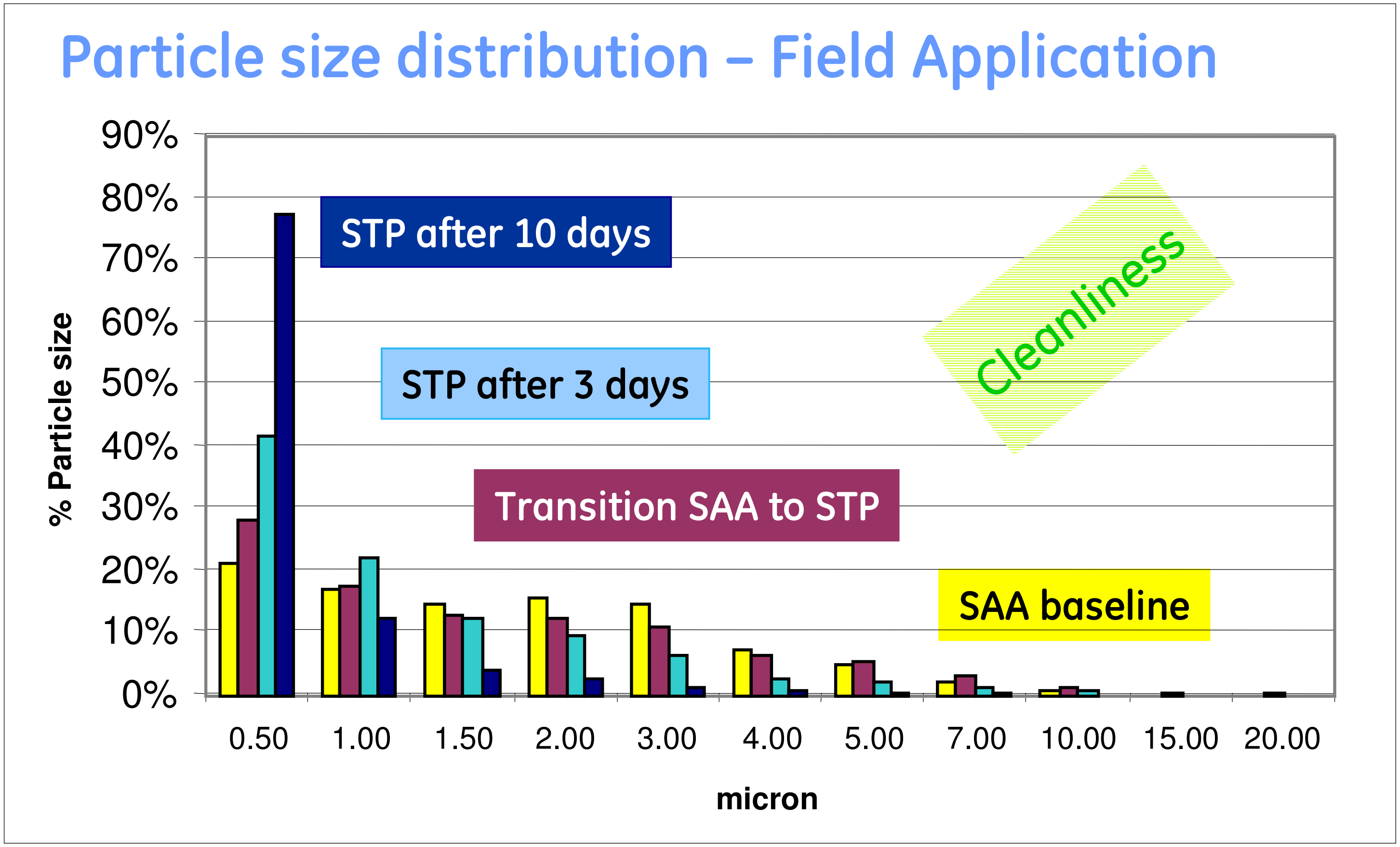
New STP Polymer compared to Sulphonated Acrylic Acid Polymers



STP polymer generated much finer particles than the SAA polymer resulting in a lower potential for scale formation / precipitation

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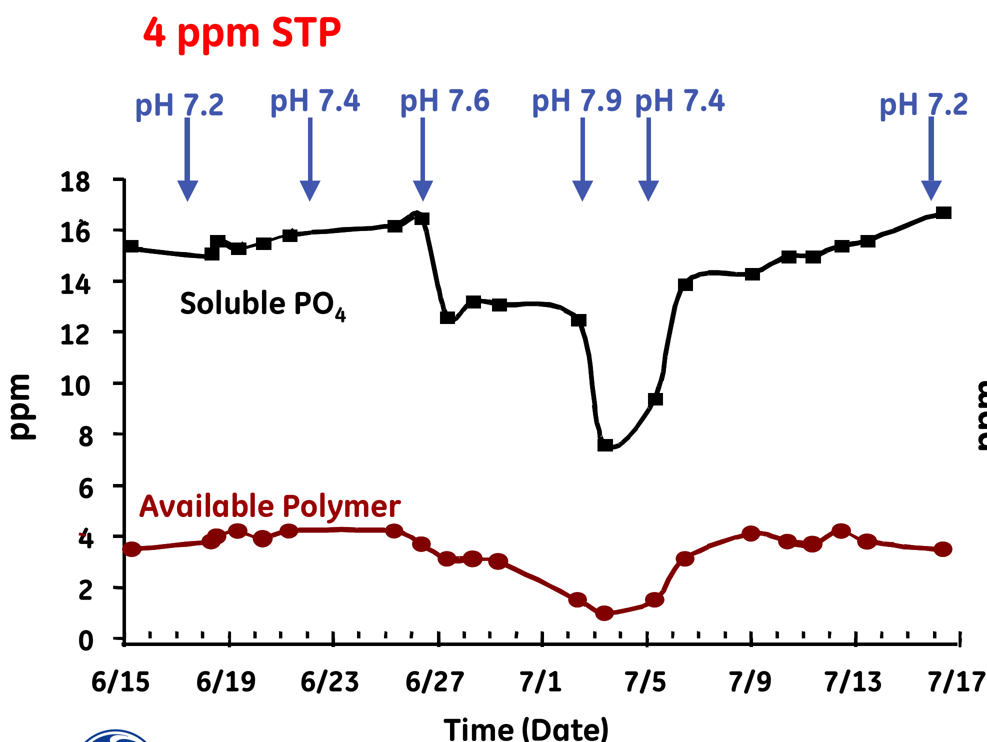
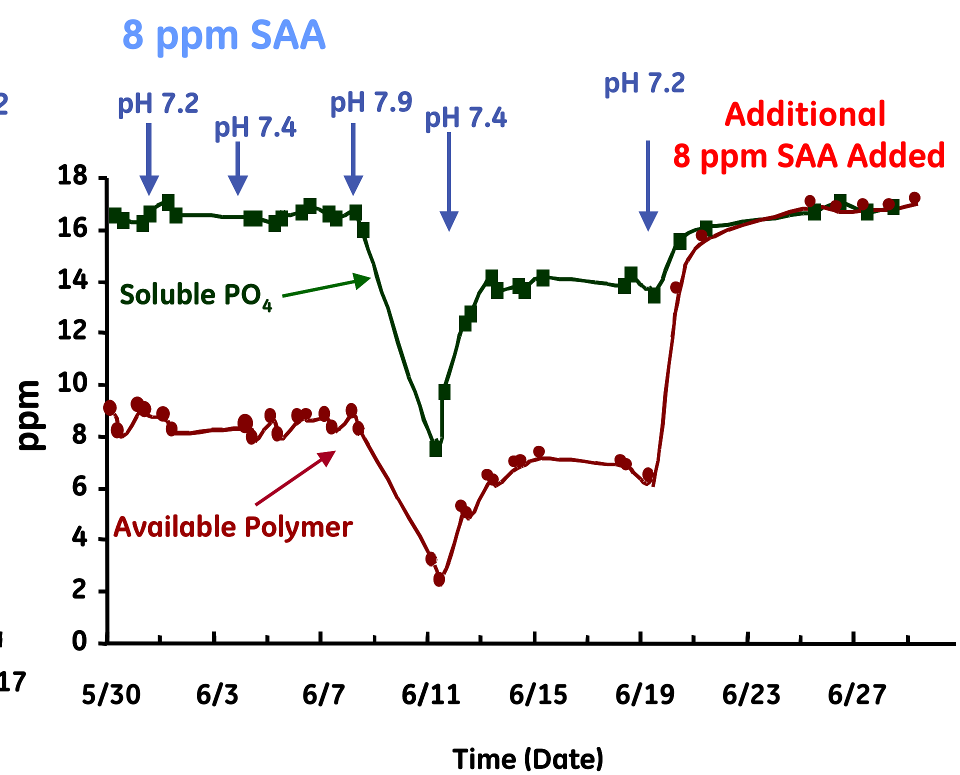
New STP Polymer compared to Sulphonated Acrylic Acid Polymers

Effect of pH Excursion on Calcium Phosphate Control
Neutral pH programme





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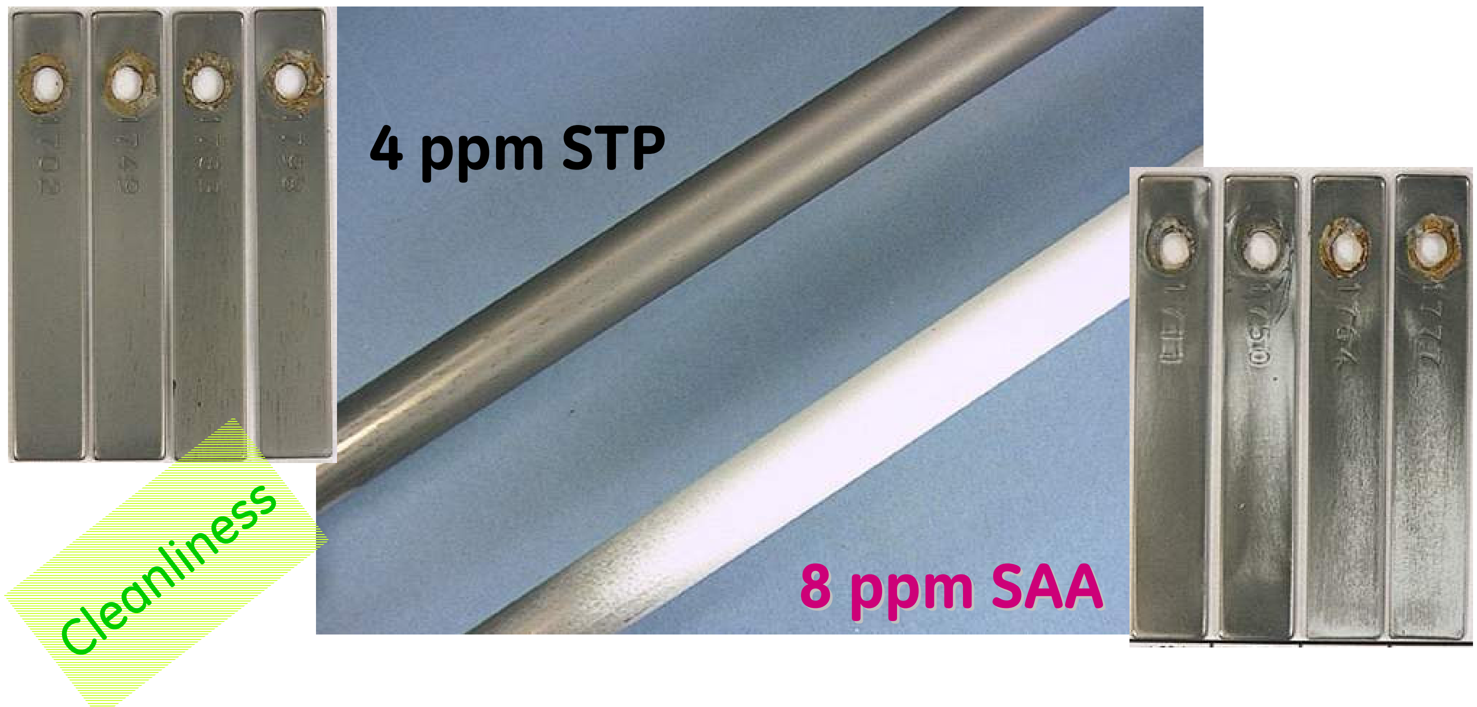
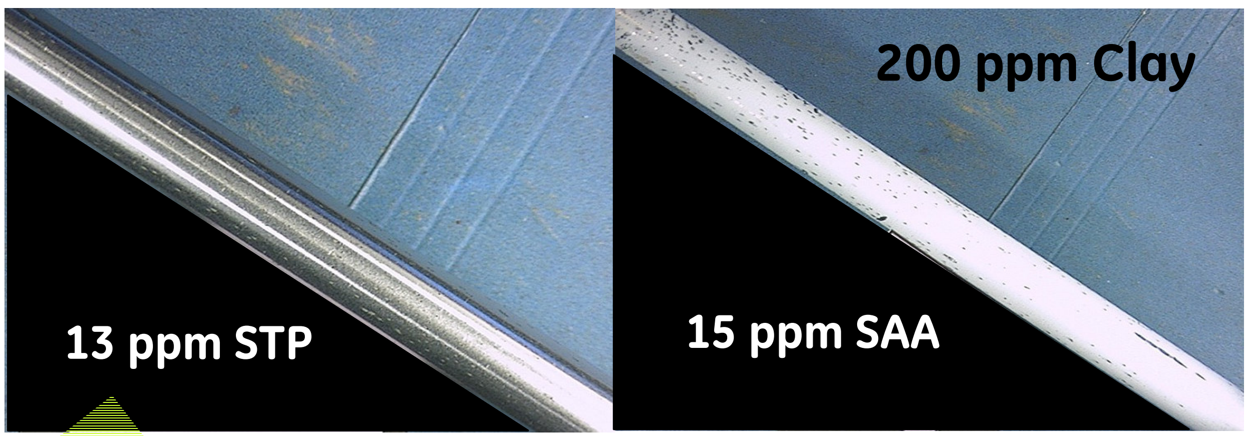
New STP Polymer compared to Sulphonated Acrylic Acid Polymers

Effect of pH Excursion on Calcium Phosphate Control
Neutral pH programme



New STP Polymer compared to Sulphonated Acrylic Acid Polymers

Dispersion of Suspended Solids



Cleanliness

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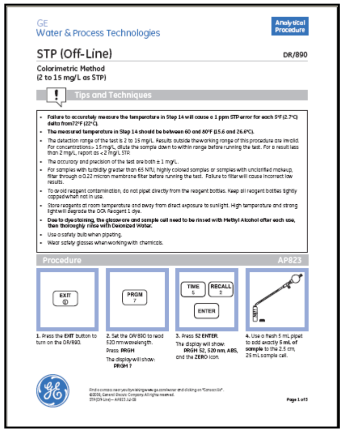
Testing and Monitoring

Polymer Monitoring and Control

On Line

- **Measures the polymer directly**
  - **No background fluorescence issues**
  - **No molybdate tracer to measure**
  - **No additional chemical manufacturing costs**
- **Simple calibration**
- **Responds to System Stresses**

Off Line



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Analytical Procedure

STP (Off-Line) DR/890

Colorimetric Method
(2 to 15 mg/L as STP)

Tips and Techniques

- **Failure to accurately measure the temperature in Step 14 will cause a 1 ppm STP error for each 5°F (2.7°C) delta from 72°F (22°C).**
- **The measured temperature in Step 14 should be between 60 and 80°F (15.6 and 26.6°C).**
- The detection range of the test is 2 to 15 mg/L. Results outside the working range of this procedure are invalid. For concentrations > 15 mg/L, dilute the sample down to within range before running the test. For a result less than 2 mg/L, report as < 2 mg/L STP.
- The accuracy and precision of the test are both ± 1 mg/L.
- For samples with turbidity greater than 65 NTU, highly colored samples or samples with unclarified makeup, filter through a 0.22 micron membrane filter before running the test. Failure to filter will cause incorrect low results.
- To avoid reagent contamination, do not pipet directly from the reagent bottles. Keep all reagent bottles tightly capped when not in use.
- Store reagents at room temperature and away from direct exposure to sunlight. High temperature and strong light will degrade the DCA Reagent 1 dye.
- **Due to dye staining, the glassware and sample cell need to be rinsed with Methyl Alcohol after each use, then thoroughly rinse with Deionized Water.**
- Use a safety bulb when pipeting.
- Wear safety glasses when working with chemicals.

Procedure AP823

1. Press the **EXIT** button to turn on the DR/890.
2. Set the DR/890 to read 520 nm wavelength. Press: **PRGM** The display will show: **PRGM ?**
3. Press **52 ENTER**. The display will show: **PRGM 52, 520 nm, ABS**, and the **ZERO** icon.
4. Use a fresh 5 mL pipet to add exactly **5 mL of sample** to the 2.5 cm, 25 mL sample cell.

Page 1 of 5

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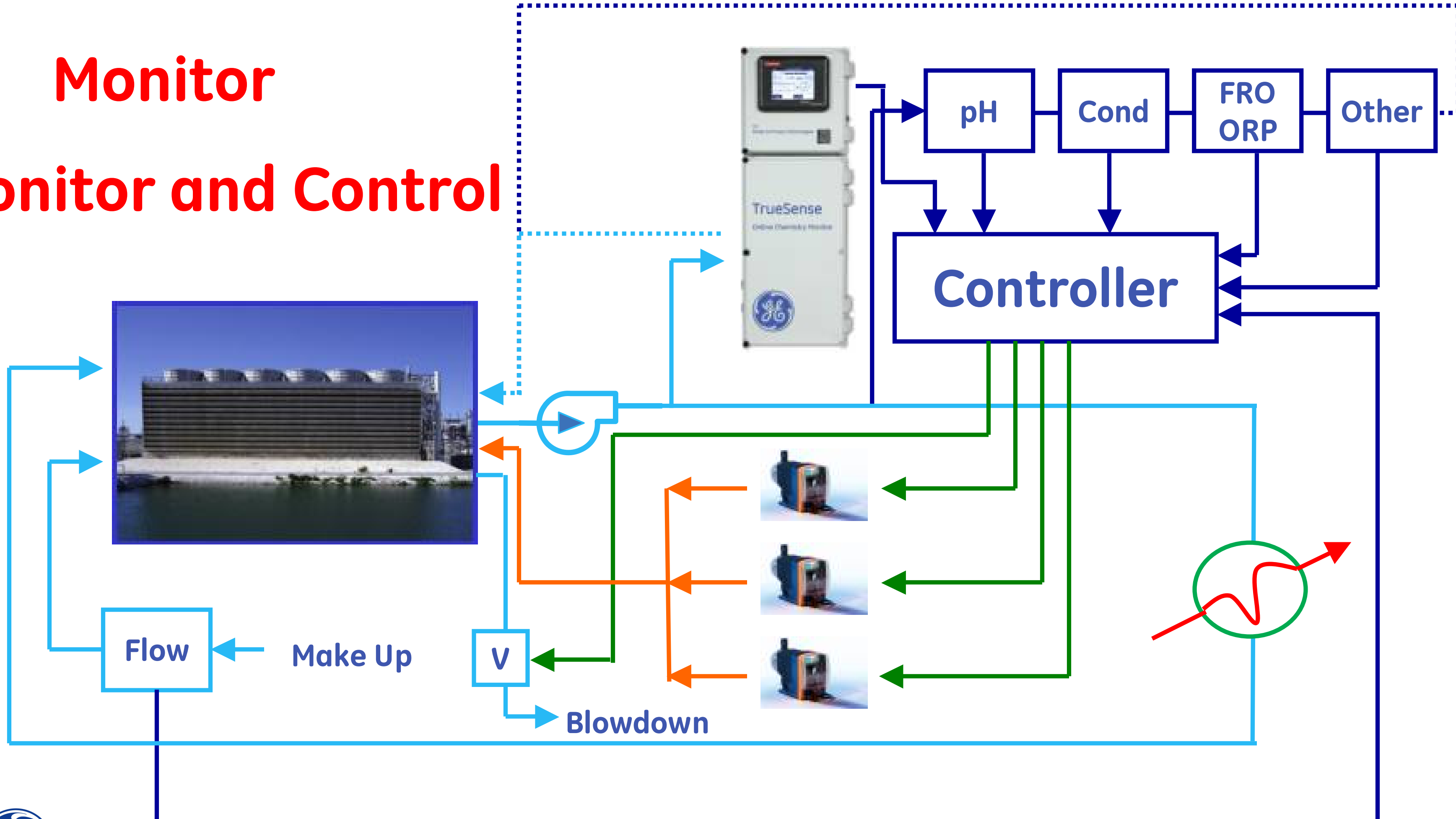
Testing and Monitoring

Polymer Monitoring and Control

Monitor

Monitor and Control

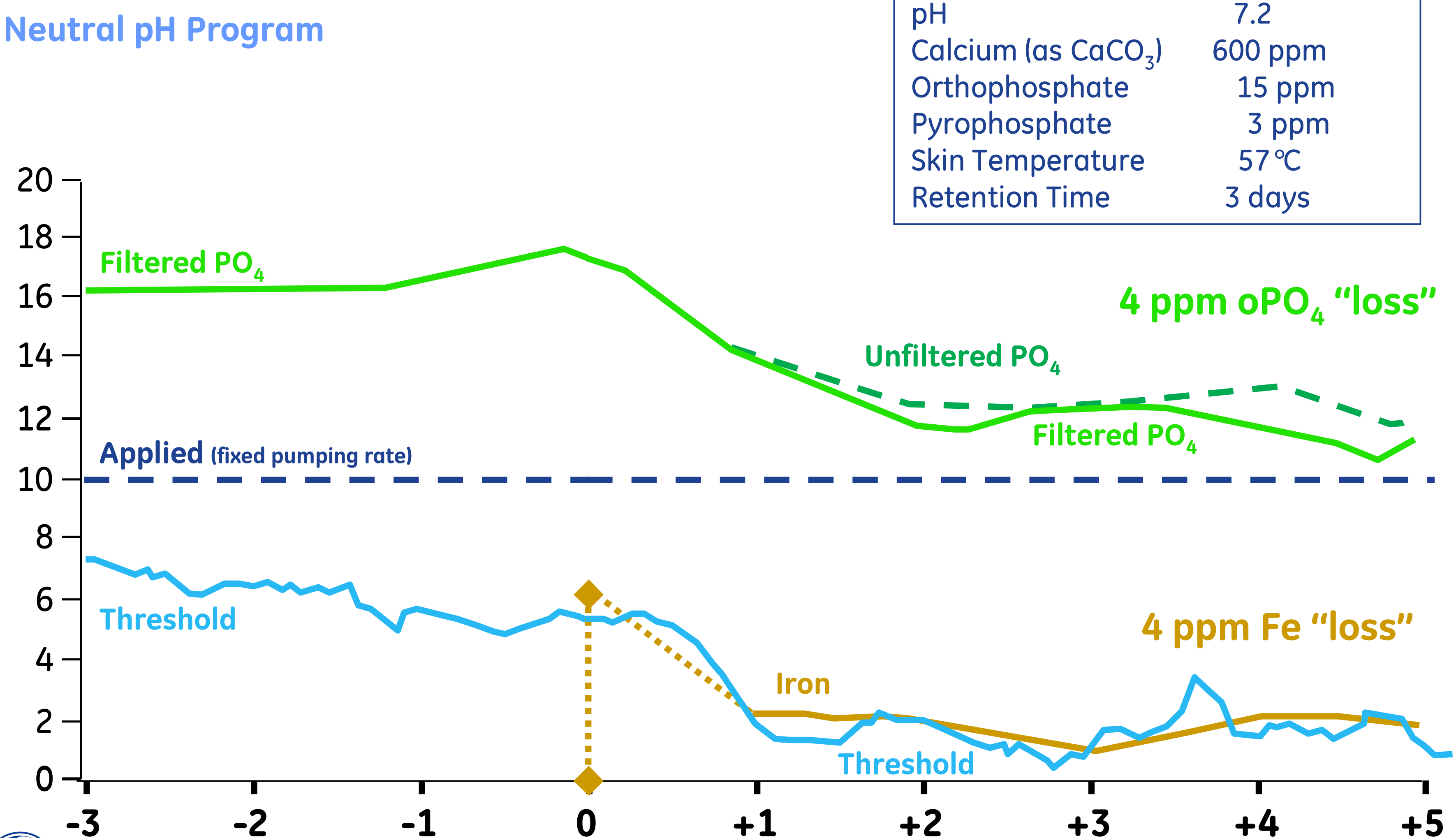


Threshold Polymer Concentration

A function of		Applied Polymer	=	Threshold Polymer	+	Stressed Polymer
pH	↑	→		↓		↑
Temperature	↑	→		↓		↑
System Half-life	↑	→		↓		↑
Calcium	↑	→		↓		↑
Phosphate	↑	→		↓		↑
Iron	↑	→		↓		↑
Aluminium	↑	→		↓		↑
Suspended Solids	↑	→		↓		↑

TrueSense Online Dynamic Laboratory Study
Without Polymer Control

Standard Water Conditions	
pH	7.2
Calcium (as $CaCO_3$)	600 ppm
Orthophosphate	15 ppm
Pyrophosphate	3 ppm
Skin Temperature	57 °C
Retention Time	3 days



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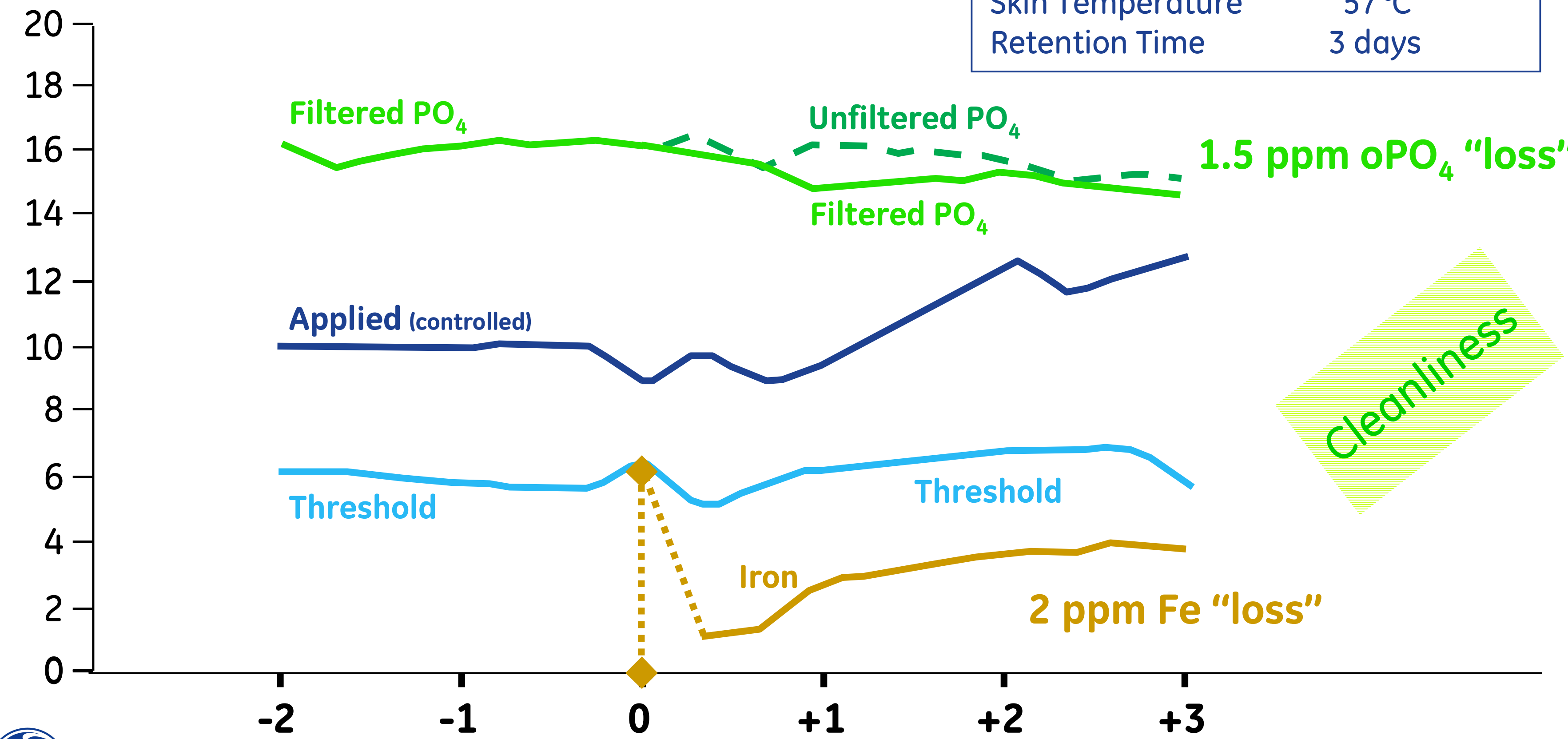
Threshold Polymer Concentration

A function of		Applied Polymer	=	Threshold Polymer	+	Stressed Polymer
pH	↑	↑		→		↑
Temperature	↑	↑		→		↑
System Half-life	↑	↑		→		↑
Calcium	↑	↑		→		↑
Phosphate	↑	↑		→		↑
Iron	↑	↑		→		↑
Aluminum	↑	↑		→		↑
Solids	↑	↑		→		↑

TrueSense Online Dynamic Laboratory Study
With Polymer Control

Neutral pH Program

Standard Water Conditions	
pH	7.2
Calcium (as $CaCO_3$)	600 ppm
Orthophosphate	15 ppm
Pyrophosphate	3 ppm
Skin Temperature	57 ℃
Retention Time	3 days



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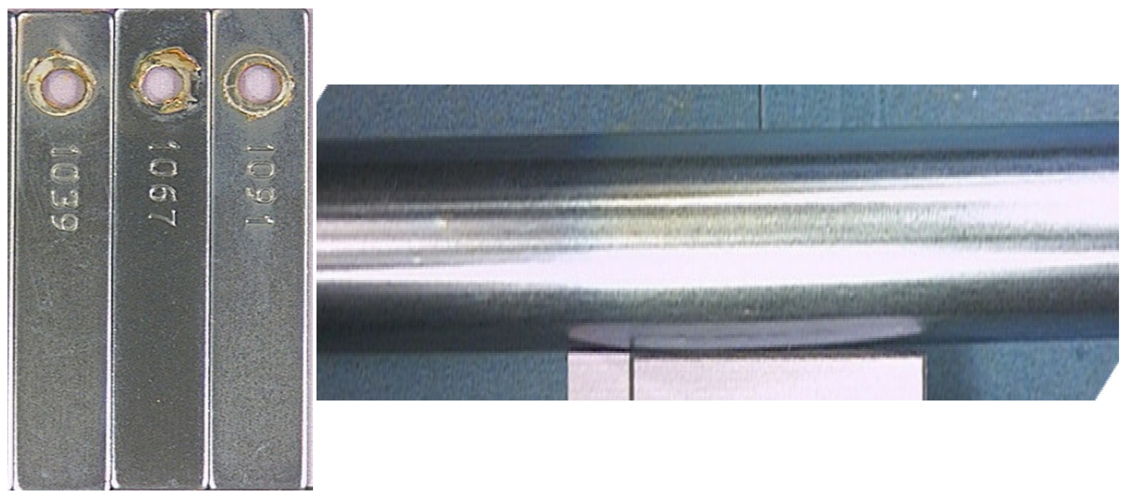
And Corrosion Inhibition?

4 ppm SAA

LCS - 0.6 mpy
ADM - 0.2 mpy

2 ppm STP

LCS <0.5 mpy
ADM <0.2 mpy



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GE Advanced Cooling Solution

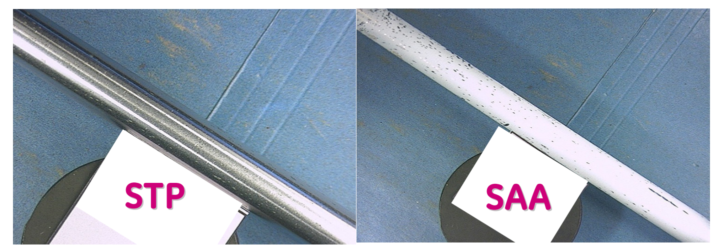
What is GenGard?

- **Features GE's patented Stress Tolerant Polymer (STP)**
- **Superior Performance**
  - Under Neutral pH Conditions
  - Under Alkaline pH Conditions
- **Halogen Stable**
- **Analysable**
  - Off-line
  - On-line
- **No Heavy Metals**

GenGard / STP Technology Benefits

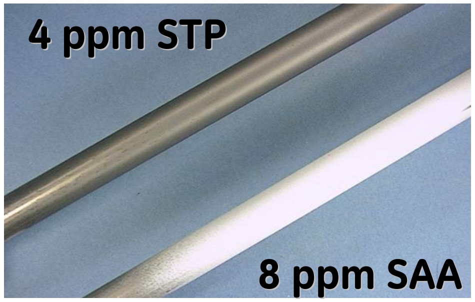
Improved Productivity & Equipment Reliability

Superior Performance
- Phosphate Inhibition
- Zinc Inhibition
- pH upset recovery
- Crystal particle size
- Dispersion



GenGard / STP Technology Benefits

Reduce Chemical Usage



Active polymer concentration

GenGard / STP Technology Benefits

Threshold polymer concentration

- Controlled dosing
- Relative to requirements
- Responsive to variations and demands

Optimum and Controlled Dosing

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Appendix 7

Max Amine acid gas removal program

Andre Vanhove (GE)

CORROSION CONTROL IN REFINERY AMINE TREATING UNITS

GE
Water & Process Technologies

David Owen
Andre Vanhove

Types of Amine Systems

Primary Amine Unit	Removes H_2S and CO_2
Tail Gas Unit	Removes H_2S Selectively
Hydrogen Plant Amine Unit	Removes CO_2
Natural Gas Plant	Removes H_2S and / or CO_2
Sulfiban Unit	Removes H_2S, HCN & CO_2

Key Operating Variables

Pressure

Temperature

Amine Concentration (wt%)

Amine Circulation Rate

Hydrocarbon Feed Rate (gas or liquid)

Hydrocarbon Composition

Steam Rate

Absorption-Regeneration

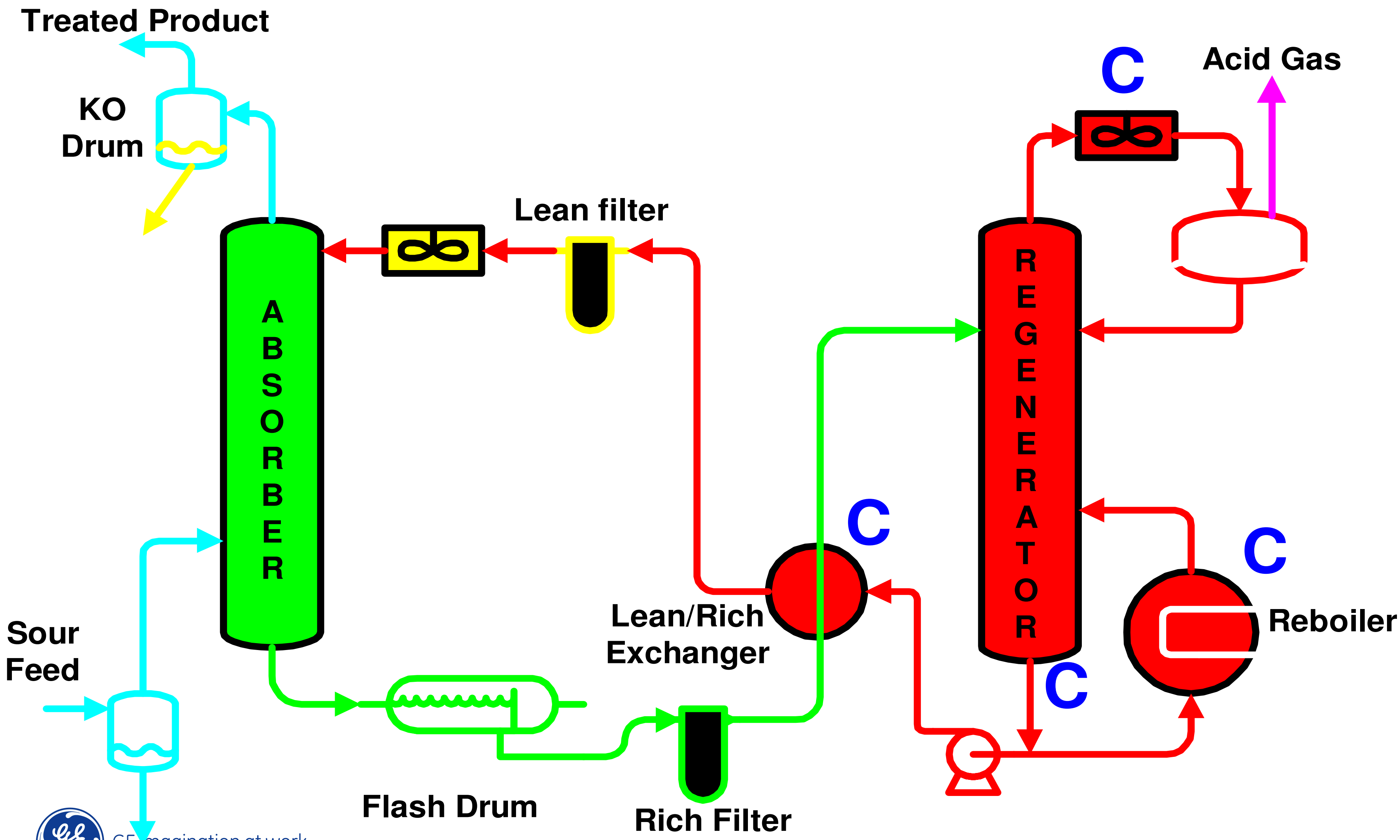
Acid Gas Absorption (High P, Low T)

$$H_2S + \text{Amine} \;\text{----->>}\; \text{Amine-H}^+ \;+\; HS^-$$

Amine Regeneration (Low P, High T)

$$H_2S + \text{Amine} \;\text{<<-----}\; \text{Amine-H}^+ \;+\; HS^-$$

Areas of Corrosion



Types of Amines

Common Amines

MEA	Monoethanolamine
DEA	Diethanolamine
DIPA	Diisopropanolamine
MDEA	Methyl Diethanolamine
DGA	Diglycol Amine

Formulated & Blends

Selection Criteria

- Bulk or Selective Acid Gas Removal
- Mercaptan Removal
- Required Heat Duty
- Required Concentration
- Hydrocarbon Solubility
- Ease of Reclaiming
- Cost

Corrosion Overview

Causes

Areas

Symptoms

Control Measures

Causes of Corrosion

- Rich Amine Flashing
- Lean Loading
- Circulation Rates and Velocities
- Heat Stable Amine Salts
- Amine Degradation Products

Areas of Corrosion

Reboiler/ Regenerator bottom piping

> Temperature, Low amine pH, HSAS dissociation , Degradation products, Lean loading too high or low

L/R Exchanger Lean Side

> Temperature, HSAS dissociation, Lean loading, Circulation rate

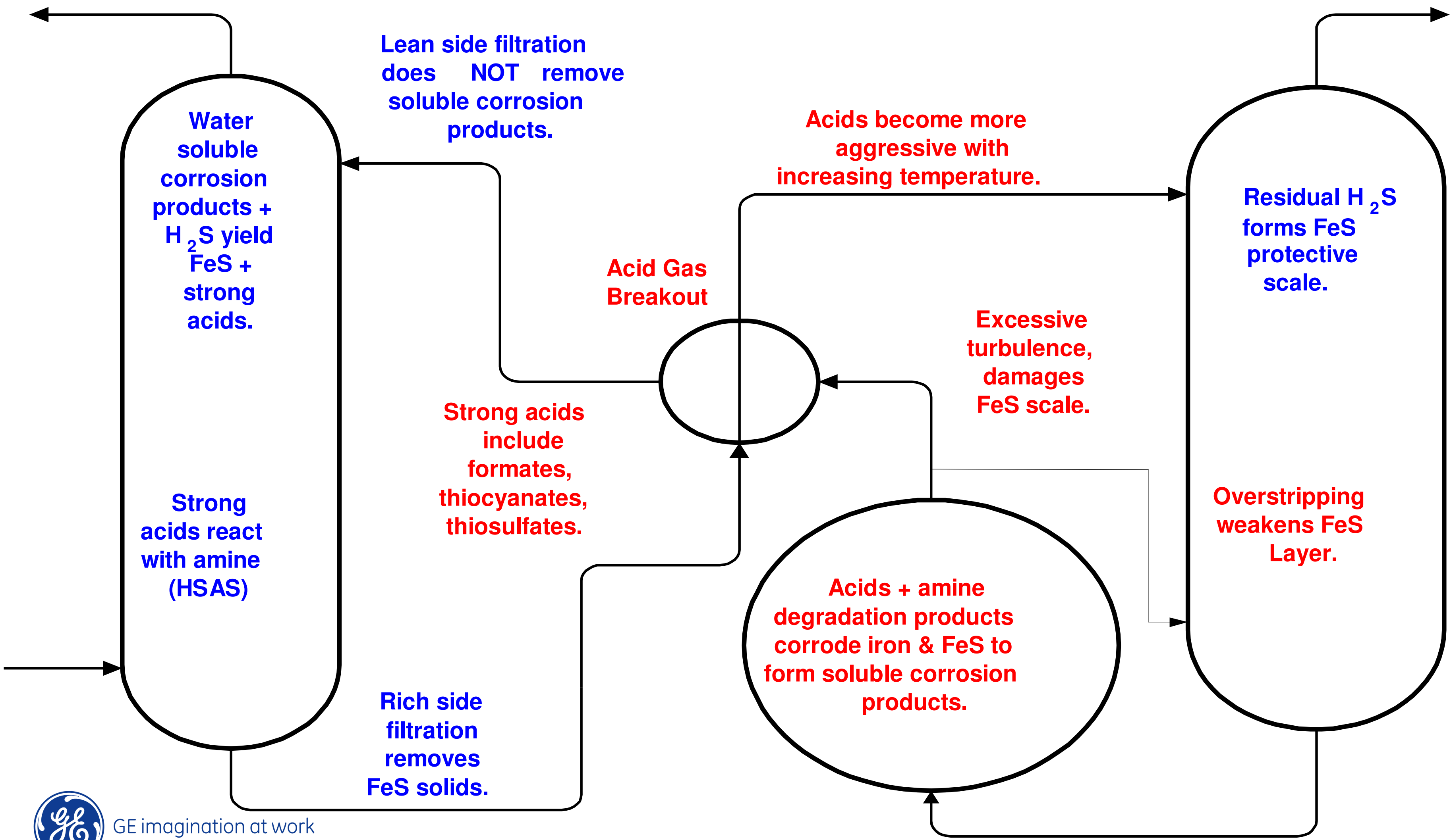
L/R Exchanger Rich Side

> Rich loading, Pressure reduction, Free acid gas, Circulation rate

Overhead Condenser

> Salt - Ammonium bisulphide - under deposit

Corrosion & Fouling Cycle



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Symptoms of Corrosion

- Amine leaks and Increased consumption
- Off spec products
- Diluted amine
- High metals concentrations - Fe, Mn, Ni, Cr
- Fouling
- Increased filter changes
- Grey-black amine colour
- Foaming

Corrosion Control Measures

Operational Issues

> Feed Preparation
> Temperature
> Steam Rate
> Pressure Changes
> Amine Concentration and Circulation Rate
> Oxygen Elimination

Corrosion Control Measures

- Regular Analysis of the lean amine
- Install Corrosion Probes /coupons
- Proper filtration
- HSS Management Programme
- Metallurgy and Fabrication
- Upstream Operations
- Corrosion Inhibitors

CORROSION CONTROL IN REFINERY AMINE TREATING UNITS

GE
Water & Process Technologies

David Owen
Andre Vanhove

Appendix 8

Update on active corrosion scenarios in refineries assessed by hydrogen flux monitoring

Frank Dean (Ion Science)

Hydrogen flux:
correlation with corrosion and
hydrogen damage risk in refineries.

EFC WP 15 Spring Meeting,
Borealis, Wien,
23 April, 2009.

Advanced Gas Sensing Technologies
www.ionscience.com

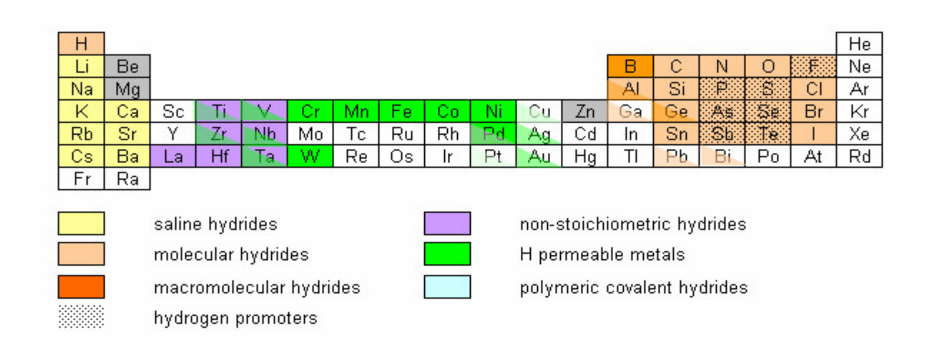
Hydrogen

Hydrogen flux in refineries

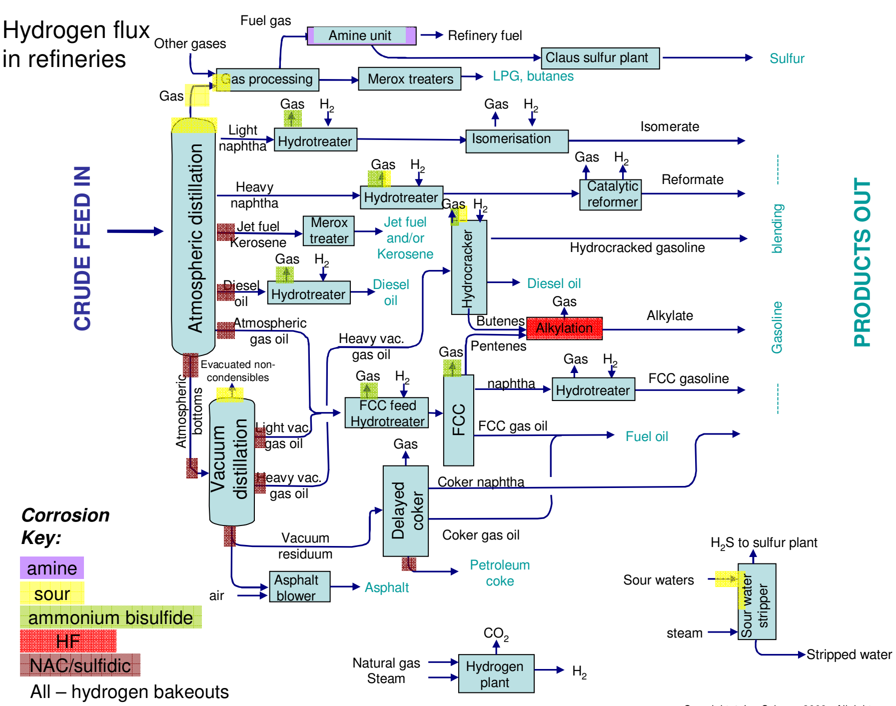
Linking flux with corrosion and crack risk

Correlation graphs

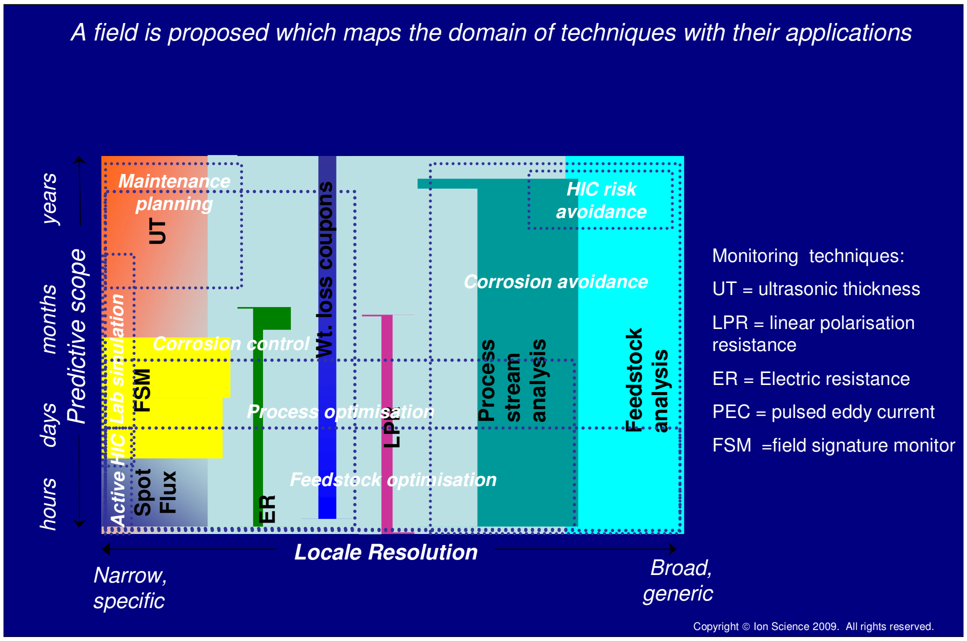
Hydrogen and the periodic table



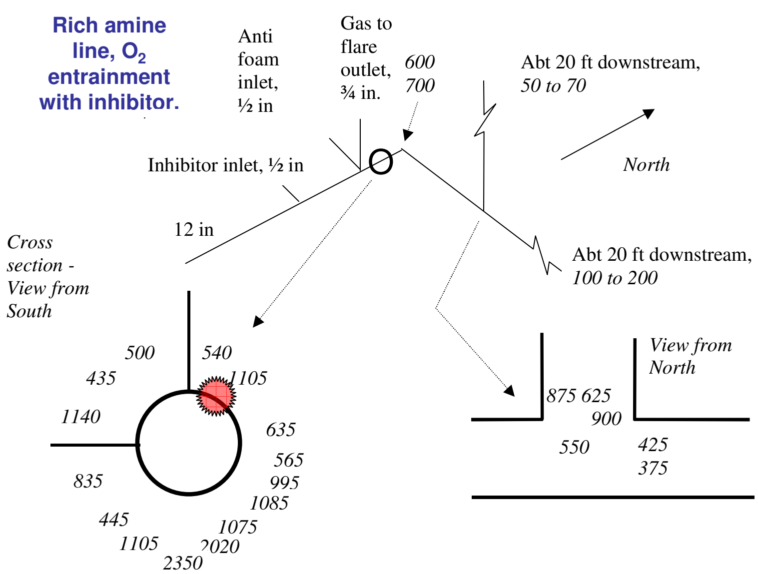
Hydrogen flux in refineries



Monitoring domains



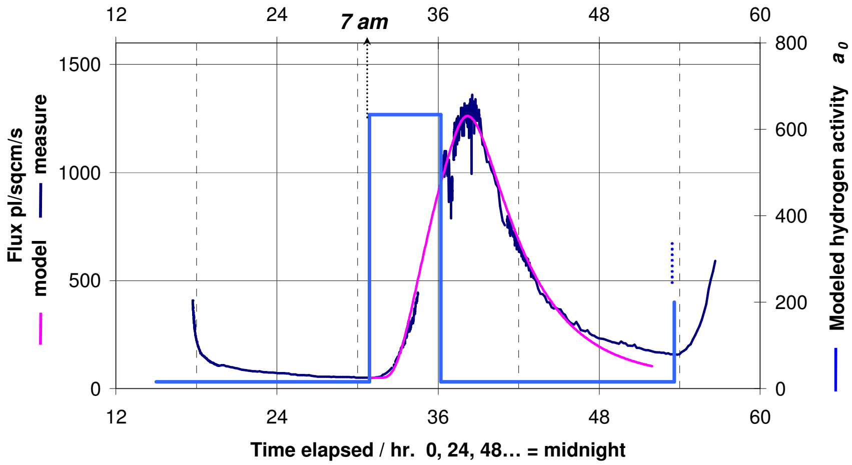
Find, diagnose, control (1a)



See F.W.H.Dean, Corrosion 2002, NACE, Paper 2344.

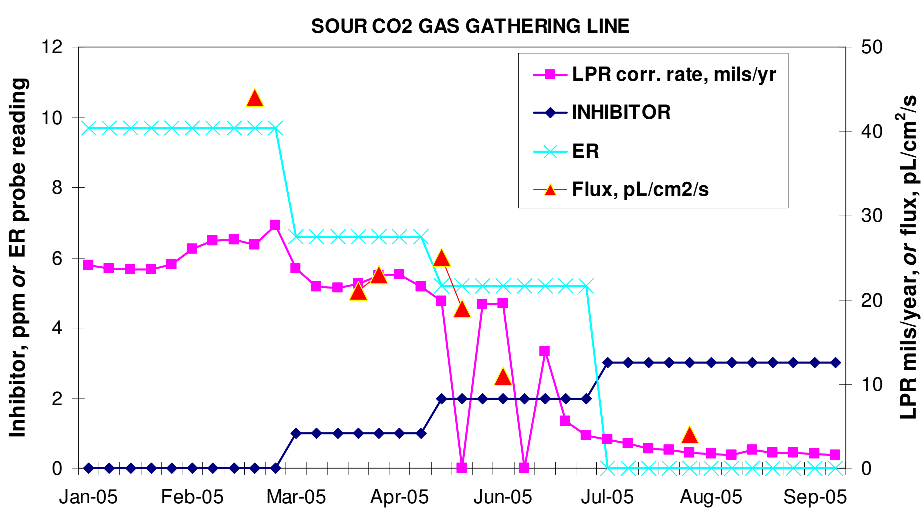
Find, diagnose and control (1b)

• Intermittent corrosion is modelled to obtain time of onset, identifed with O2 entrainment...



Use Hydrosteel 6000 to spot and diagnose cause of corrosion.

Illustration F.W.H.Dean, Corrosion 2002, NACE, Paper 2344.



Methane reactor subject sour corrosion.

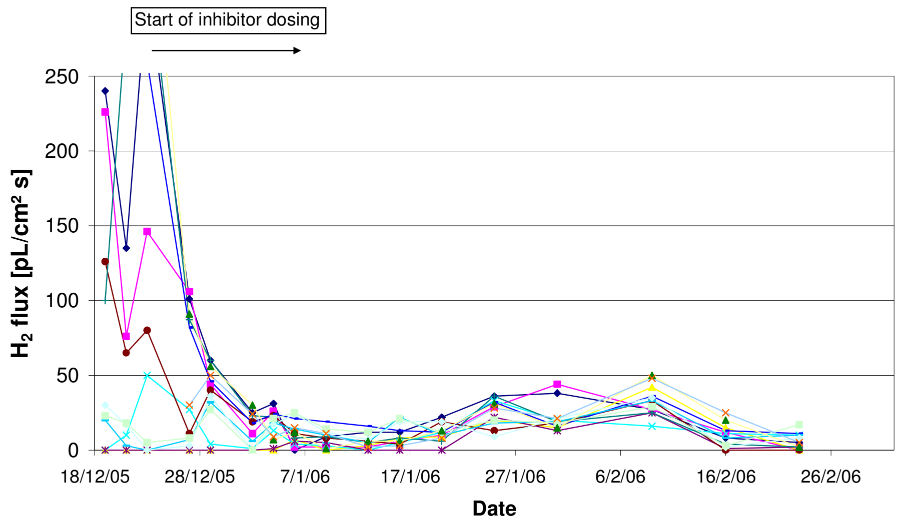
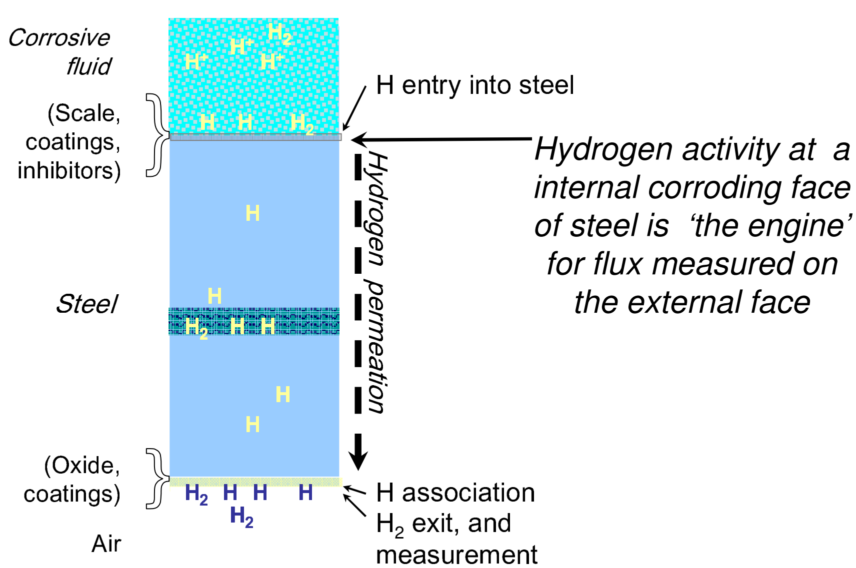


Illustration B.Otzitz, A.Gourzoulidou, Frank Dean, Klaus Bernemann, *Petroleum Technology Quarterly,* **2** (2009), 102.

Linking flux to corrosion and H damage risk (1)



Linking flux to corrosion and H damage risk (2)

Normalisation for temperatutre and thickness

$$\text{Flux } J = P.\, \boldsymbol{a_0} / w$$

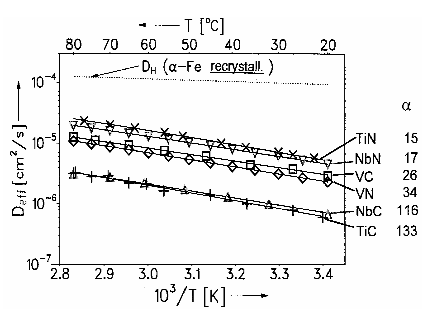
where P ($Ncm^3/cm/s/bar^{1/2}$) = permeability, $\boldsymbol{a_0}$ ($bar^{1/2}$), the hydrogen activity at entry face and **w** (cm) the thickness.

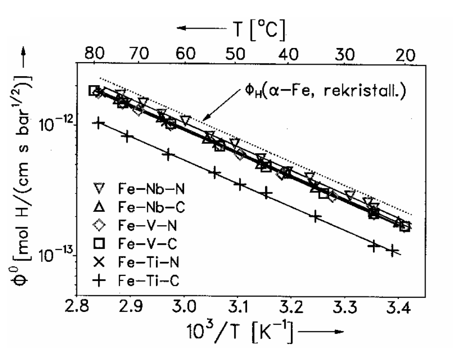
So, compensating for permeation of hydrogen through a steel of known temperature and thickness we obtain a measure of corrosivity and prospective damage risk.

$$P = P_0 \exp(-E_a / RT)$$

Linking flux to corrosion and H damage risk (3)

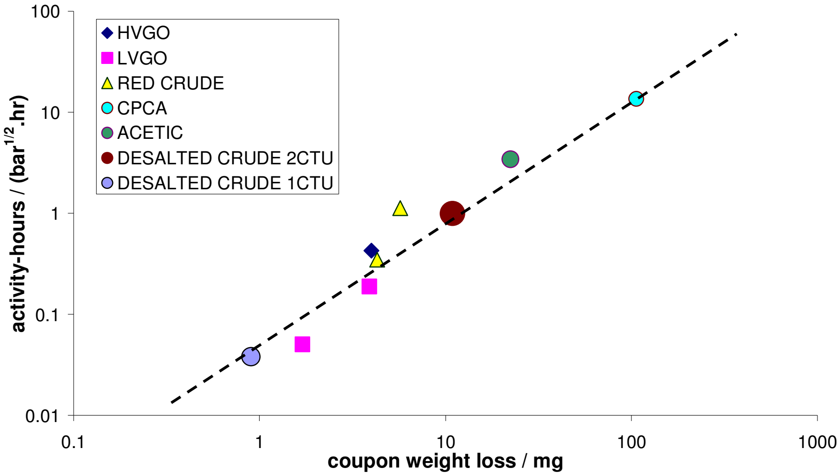
Is permeability P, determined from T, invariant between steels? Yes. P = D.S. As hydrogen diffusion coefficient D increases due to hydrogen trapping, so solubility S increases inversely. D values, for typical low alloy steels vary by some 10 fold, whereas permeabilities P vary some +-20%…





Illustrations: H.J.Grabke, E.Riecke, *Materiali in Tehnologije* , **34**(2000), 331-342.

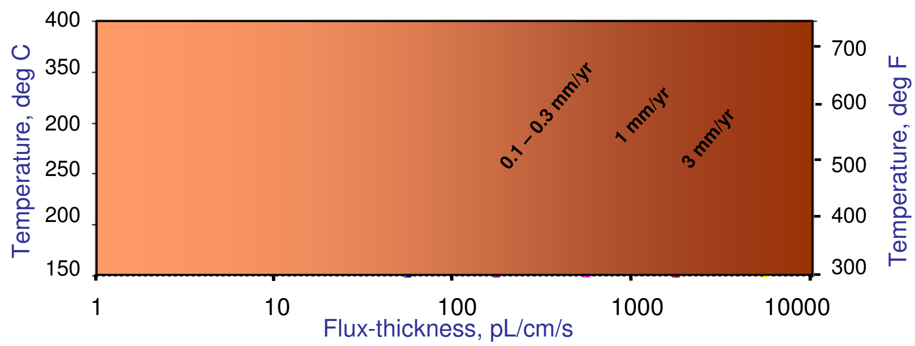
Experimental correlation of activity with corrosion rate (high T)



F.W.H.Dean, S.J.Powell, NACE Paper 06426, Corrosion 2006, NACE.

NAPHTHENIC ACID AND SULFIDIC CORROSION

A few 10's of pL/cm²/s indicates significant corrosion. A few thousand pL/cm²/s have been registered in very acid streams. Naphthenic acid is in fact a large family of acids found in crude oil. Corrosion generally occurs at pipe bends and reducer sections. The correlation below is based on limited lab experiments. The chart is also applicable to other acidic corrosion at temperatures above about 150 °C, 300 °F. Please contact Ion Science for further technical information.



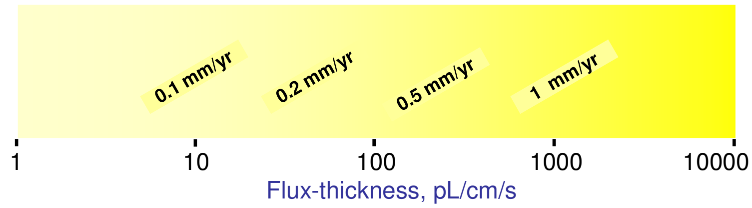
Instructions: Plot flux in pL/cm²/s x test site thickness in cm, to obtain a flux-thickness in pL/cm/s. Find this value on the x-axis. Look up temperature on the y-axis. The approximate corrosion rate through mild steel is indicated by the zone demarcated between lines.

eg, flux = 200 pL/cm²/s, thickness = 1 cm, => flux-thickness = 200 pL/cm/s. At T = 300 °C, corrosion rate is *approx* 0.5 mm/yr.

SOUR CORROSION

Typically, a clear flux of more than 5 pL/cm²/s is used as a corrosion indicator before and after mitigation. 100 pL/cm²/s usually indicates moderate corrosion. Corrosion occurs in distillation units, overhead, eg in condensers, fin-fan units, coolers and sour flare lines. It can be very severe (>500 pL/cm²/s) and is often associated with hydrogen damage. It is usually episodic, occurring usually after equipment installation, inspection, or sometimes during process changes (eg air ingress, water washes, pH changes). The chart below may also be used to assess corrosion under deposits, eg in amine units.

Please contact Ion Science for further details.

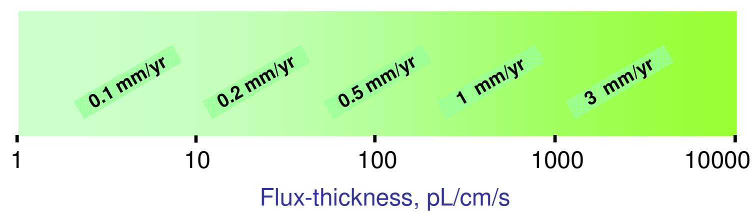


To use the indicator above: Multiply flux in pL/cm²/s by test site thickness in cm, to obtain a flux-thickness in pL/cm/s. Look along bottom of chart for corrosion rate. Note corrosion flux correlation varies in a complex way with other corrosion variables, not least temperature. This makes the correlation very approximate.

eg, flux = 20 pL/cm²/s, thickness = ½ in = 1.25 cm => flux-thickness = 25 pL/cm/s. Corrosion rate is *very* approximately 0.2 mm/yr.

AMMONIUM BISULFIDE – HCN CORROSION

Typically a clear flux of >10 pL/cm²/s can be used as a corrosion indicator. 100 pL/cm²/s is significant. 1000 pL/cm²/s is severe. Corrosion occurs in the overhead streams from hydrodesulfurization columns, hydrotreaters and catalytyic crackers, in presence of hydrogen cyanide from high nitrogen high sulfur containing feedstock. Can be very severe and associated with hydrogen damage. Occasional.

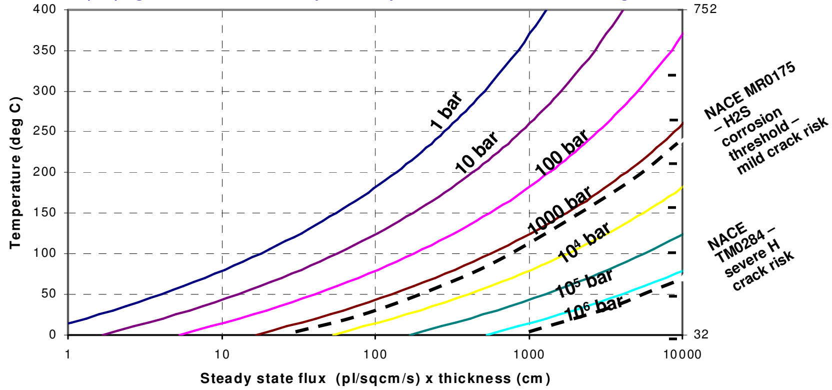


Instructions: Multiply flux in pL/cm²/s by test site thickness in cm, to obtain a flux-thickness in pL/cm/s. Look along bottom of chart for corrosion rate.

eg, flux = 20 pL/cm²/s, thickness = ½ in = 1.25 cm => flux-thickness = 25 pL/cm/s. Corrosion rate is *very approximately* 0.2 mm/yr.

HYDROGEN CRACKING

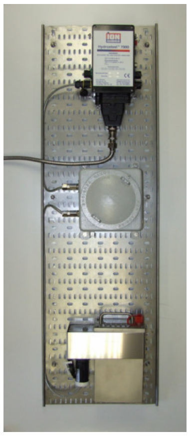
As a consequence of sour or HF corrosion, severe hydrogen activity may be generated in the underlying service steel. This activity dictates the hydrogen flux which permeates the steel and is measured on the external face and is a direct measure of crack severity. Generally, hydrogen cracks are initiatied in poor quality, non-sour service steels at activities as low as 10000 bar, whereas sour service steels can withstand at least 1,000,000 bar. After cracks have appeared, much lower activities are needed to propagate them, indeed, any flux may contribute to further crack growth.



Instructions: Plot flux in $pL/cm^2/s$ x test site thickness in cm, to obtain a flux-thickness in pL/cm/s. Find this value on the x-axis. Look up temperature on the y-axis. The hydrogen activity is indicated by the zone demarcated between lines.

eg, flux 800 $pL/cm^2/s$, thickness 1.5 cm, => Flux-thickness = 1200 pL/cm/s. At 30 ºC, activity = 10^6 bar, severe risk of cracking.

Hydrosteel 7000 T: transportable monitor



- Class 1 Division 2 approval
- User defined data freq.
- Up to 9 months use per battery charge
- easy to install
- easy to use
- easy to service
- light weight
- intrinsically safe
- IP 66 rated

www.ionscience.com

• Hydrogen flux indicates active sour, HF and high temperature corrosion and HIC risk from petrochemical processing equipment which is now linked to corrosion wall loss and hydrogen crack risk severity.

• The technology is well established in the assessing the effectiveness of process and chemical corrosion control measures.

• Field worthy flux measurement technology is now available in the form of a spot measurement tool, battery powered monitor and fixed monitor.

• The technology is also being used in hydrogen bakeout monitoring.

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Thank you for your attention.

Appendix 9

Online Corrosion Monitoring & Digital Radiography
Jim Costain (GE S&I)

Online Corrosion Monitoring & Digital Radiography

23rd April, Vienna
Jim Costain

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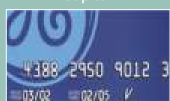
Businesses Segments

Energy Infrastructure	Technology Infrastructure	Capital	NBC Universal
			NBC UNIVERSAL
• Oil & Gas • Energy • Water & Process Technologies	• **Enterprise Solutions** • Healthcare • Aviation • Transportation	• Commercial Finance • GE Money • GECAS • Energy Financial Services • Corporate Treasury	• Network • Stations • Entertainment • Universal • Sports/Olympics

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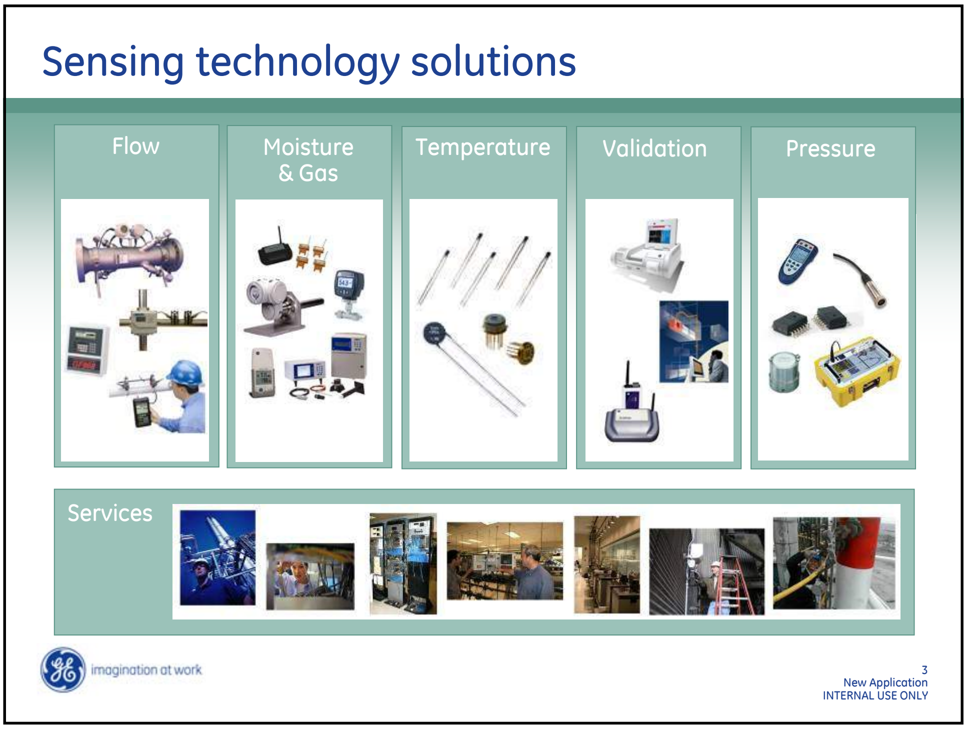
2
New Application
INTERNAL USE ONLY


Sensing technology solutions
Flow
Moisture & Gas
Temperature
Validation
Pressure
Services
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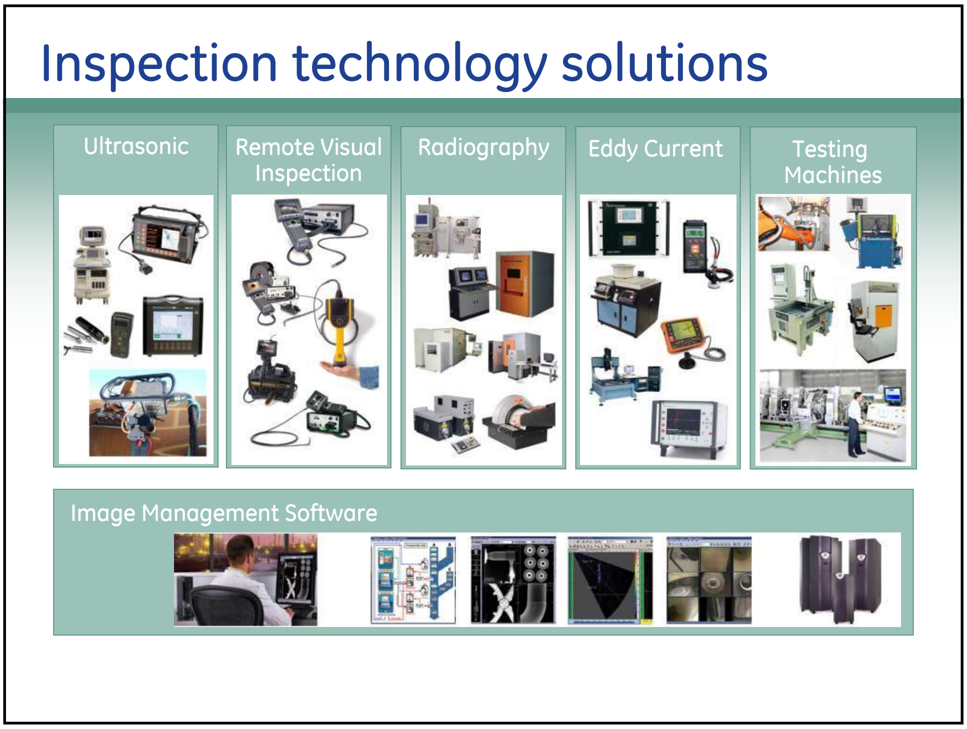
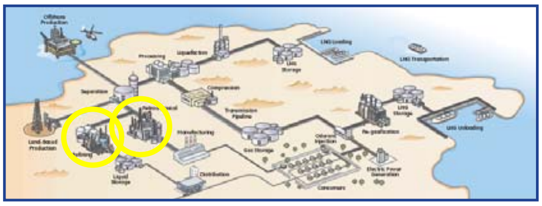
3
New Application
INTERNAL USE ONLY


Inspection technology solutions
Ultrasonic
Remote Visual Inspection
Radiography
Eddy Current
Testing Machines
Image Management Software

Downstream: Refinery/Chemical



Application:

General Corrosion Rates in High Temperature piping systems

Current methods:

Manual NDT wall thickness measurements for piping systems

Intrusive Coupons

New Solution:

- •Permanently Installed High Temperature UT Sensors monitoring pipe wall thickness at critical plant locations
- •High Accuracy Trending (2.5 micron) for daily report on corrosion rates
- •Ability to create custom rule packs (process variables vs wall thickness), custom alarming, drive changes in chemical inhibitor dosage.

Product: Rightrax HT

- •Optimization of cost/benefit relationship between crude slate, chemical injection cost, and plant reliability
- •Drive work orders through intelligent alarming
- •Reduced overall per data point inspection cost through permanent installation and wireless technology

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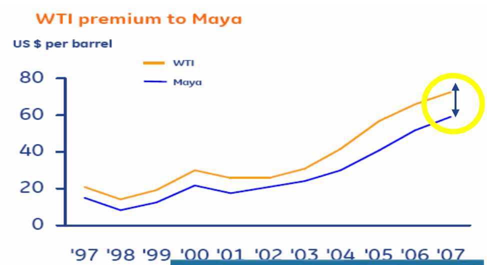
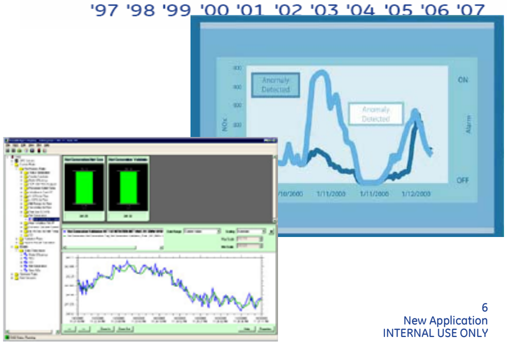
Online Corrosion monitoring

Elevate productivity through:

- •Reduction of overall inspection **cost**. Scaffolding, Prep, Outsourced Services
- •More **Actionable Information**. Frequent samples correlatable to process events. Link crude quality to pipe health. Enable "opportunity crude" decisions.
- •**Safety**. Reduce manual data collection in hazardous areas
- •**Pattern Recognition:** Kn³ can easily identify a sequence of events that may lead to a particular process upset using neural net technology for process recognition. Kn³'s added advantages of being able to manage data and apply rules makes it uniquely powerful.





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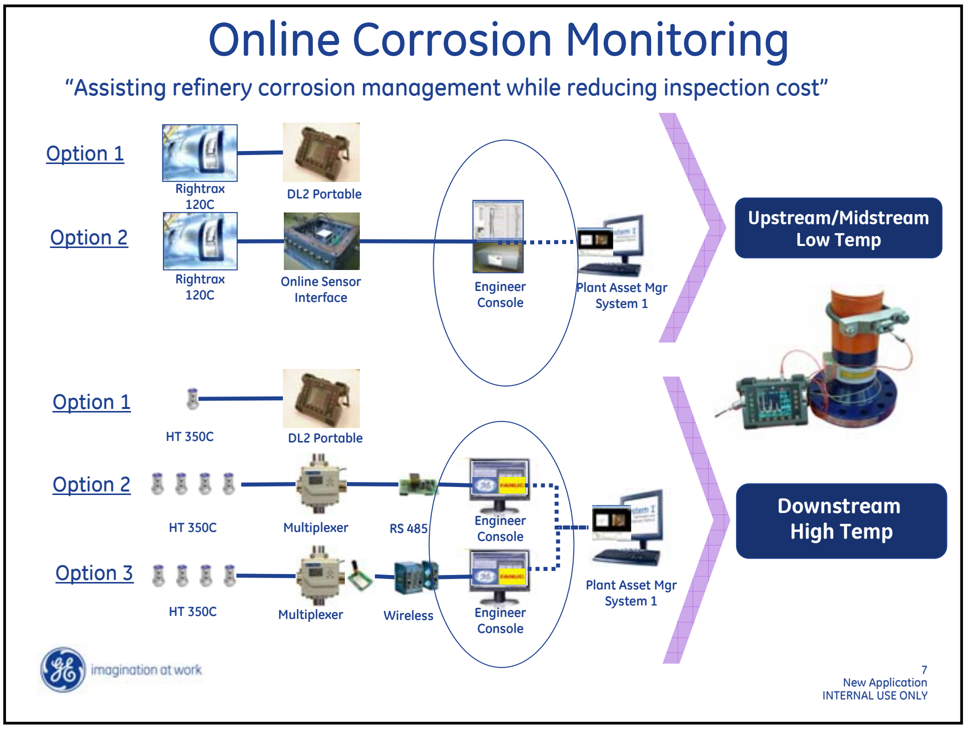
imagination at work


Online Corrosion Monitoring
"Assisting refinery corrosion management while reducing inspection cost"
Option 1
Rightrax 120C
DL2 Portable
Option 2
Rightrax 120C
Online Sensor Interface
Engineer Console
Plant Asset Mgr System 1
Upstream/Midstream Low Temp
Option 1
HT 350C
DL2 Portable
Option 2
HT 350C
Multiplexer
RS 485
Engineer Console
Option 3
HT 350C
Multiplexer
Wireless
Engineer Console
Plant Asset Mgr System 1
Downstream High Temp
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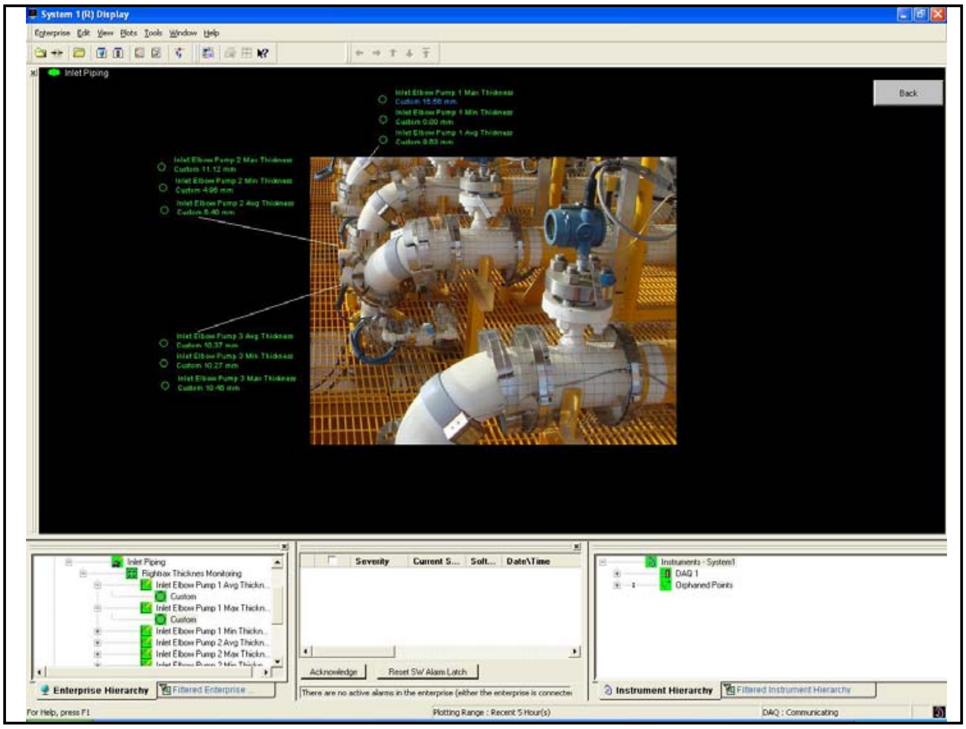
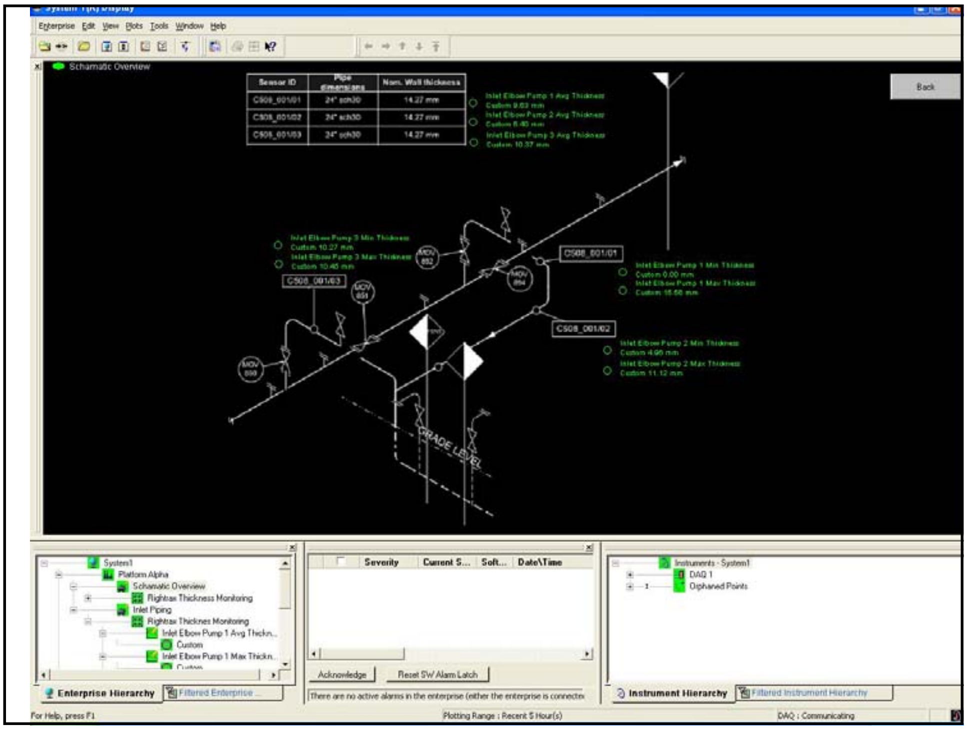
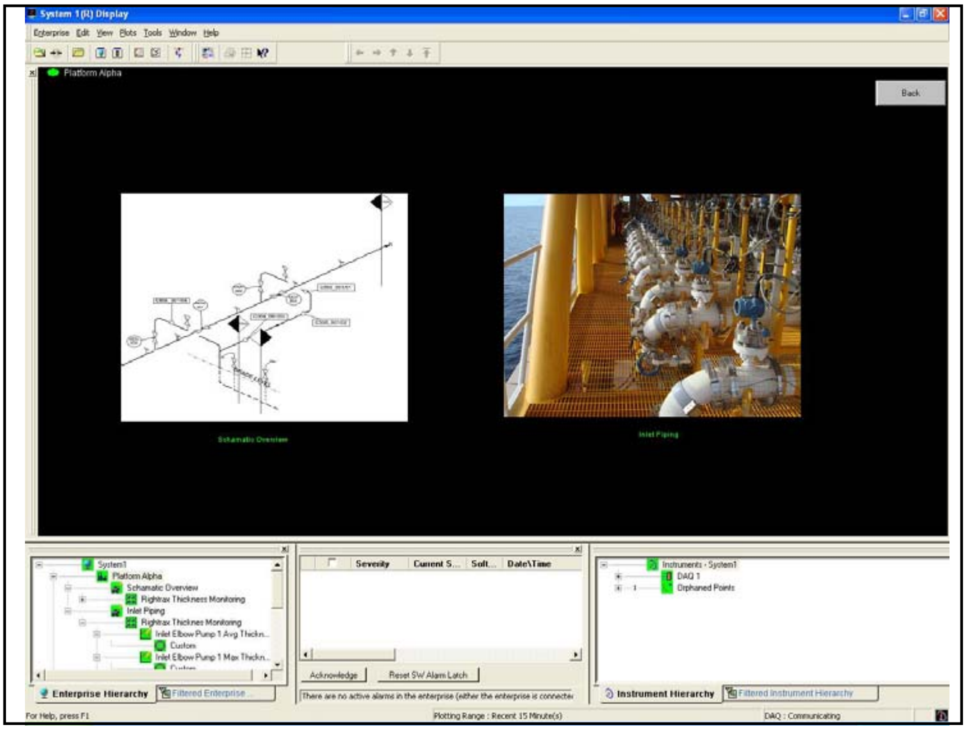
7
New Application
INTERNAL USE ONLY


System 1(R) Display
Inlet Piping
Back
Severity
Enterprise Hierarchy
Instrument Hierarchy
For Help, press F1
Plotting Range : Recent 5 Hour(s)
DAQ : Communicating


Schamatic Overview
Back
Sensor ID
Pipe dimensions
Nom. Wall thickness
24" sch30
14.27 mm
Inlet Elbow Pump 1 Avg Thickness
Inlet Elbow Pump 2 Avg Thickness
Inlet Elbow Pump 3 Avg Thickness
Inlet Elbow Pump 3 Min Thickness
Inlet Elbow Pump 3 Max Thickness
Inlet Elbow Pump 1 Min Thickness
Inlet Elbow Pump 1 Max Thickness
Inlet Elbow Pump 2 Min Thickness
Inlet Elbow Pump 2 Max Thickness
C508_001/01
C508_001/02
C508_001/03
GRADE LEVEL
System1
Platform Alpha
Schamatic Overview
Rightrax Thickness Monitoring
Inlet Piping
Inlet Elbow Pump 1 Avg Thickn...
Custom
Inlet Elbow Pump 1 Max Thickn...
Enterprise Hierarchy
Filtered Enterprise ...
Severity
Date\Time
Acknowledge
Reset SW Alarm Latch
Instruments - System1
DAQ 1
Orphaned Points
Instrument Hierarchy
Filtered Instrument Hierarchy
For Help, press F1
Plotting Range : Recent 5 Hour(s)
DAQ : Communicating


System 1 (R) Display
Platform Alpha
Back
Schamatic Overview
Inlet Piping
System1
Enterprise Hierarchy
Severity
Date\Time
Acknowledge
Reset SW Alarm Latch
There are no active alarms in the enterprise (either the enterprise is connecte
Instruments - System1
DAQ 1
Orphaned Points
Instrument Hierarchy
Filtered Instrument Hierarchy
For Help, press F1
Plotting Range : Recent 15 Minute(s)
DAQ : Communicating

Conclusion

- High Temperature Rightrax is a valuable new tool in the corrosion engineers tool box
- Reduce OpEx by reducing non value added spend such as scaffolding
- Linking wall thickness data to process variables and feedstock
- Improve personnel safety through the use of installed sensor

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11
New Application
INTERNAL USE ONLY

Computed Radiography (CR) Overview

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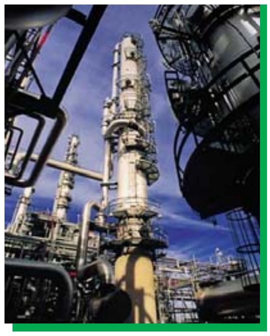
Computerized Radiography – the basics





- Flexible to fit around pipes
- Thin to access tight assemblies
- Robust cassettes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Using the Power of Digital Images

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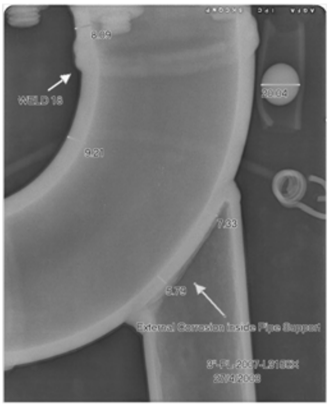
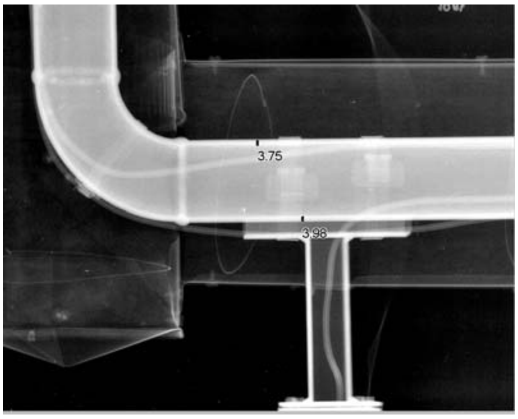
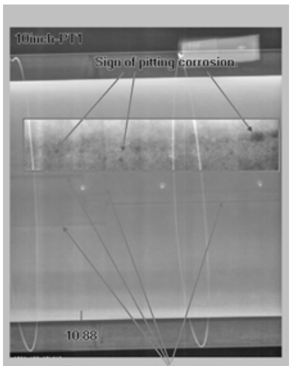
CUI inspection using CR

- Measuring Corrosion under pipe support

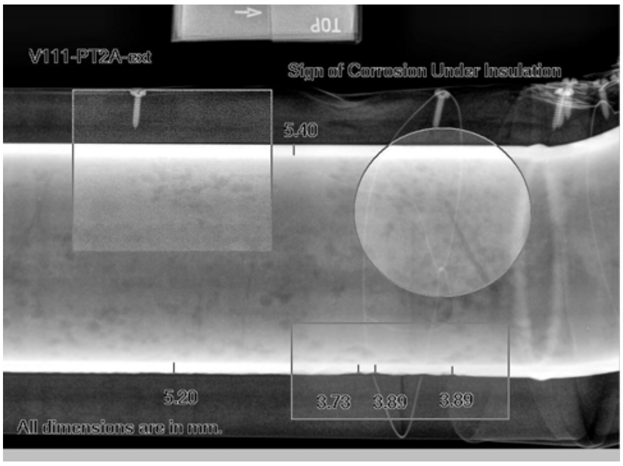




Corrosion Under Insulation (CUI)



Linear indication caused by insulation material.



Why use CR?

- Exposures are typically 10% of those for film systems.
- Ability to reduce source strength and limit exposure area.
- Phosphor screens have a much wider exposure latitude than film, reduces re shoots.
- Phosphor screens are flexible and re usable, 2000+ images / screen (depending on the application and scanner type).
- No need for a darkroom or processing chemicals, no effluent water problem.
- Convenience, vehicle with full system can be located next to examination area for site applications.
- Data transfer, results can be cut to CD or DVD, or transmitted electronically to archive

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17
New Application
INTERNAL USE ONLY

Direct Radiography Overview

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Direct Radiography – the basics

- Amorphous Silicon Flat Panel
- Real time results
- Light weight panel (< 6.5 kgs) that can carry a load of 160 kgs.
- Large area: 16" x 16" and 8" x 8" as available options.
- Best in class contrast sensitivity and DQE 3X+ better than alternatives. Panel resolution of 200 microns.
- Single Ethernet cable connection for power and data
- DICONDE image output via Rhythm software.

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19
New Application
INTERNAL USE ONLY

The power of digital data

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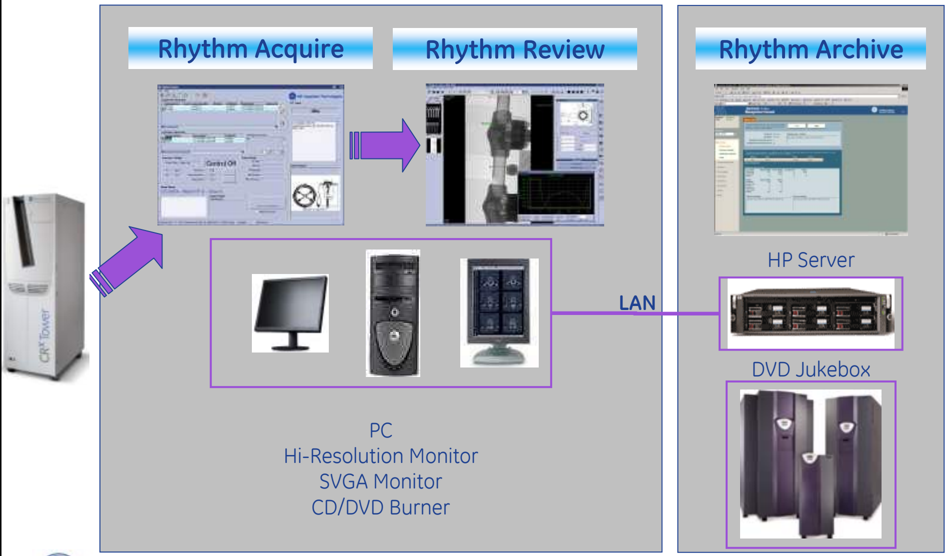
Rhythm – End To End Data Management



The importance of DICOM/DICONDE

Digital Imaging and Communication in Medicine (DICOM)

A standard that facilitates the interoperability of medical imaging equipment by network communication protocols and data storage formats for medical image data.

Not just an image

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Digital Imaging and Communication in NDE (DICONDE)

- DICONDE is an extension of the DICOM standard for the inspection industry.
- The first version of DICONDE standard released by ASTM in 2004.
- Avoid legacy data conversion costs when upgrading inspection systems (or useless data!)
- Archive data from multiple inspection equipment vendors in one system
- Support for data format beyond a single equipment vendor – “best of breed”
- Allows customers to review past inspection data with future software tools

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Conclusion

- CR is becoming a recognized NDT method for corrosion/erosion detection & sizing in the O&G industry
- DR is fast becoming ruggedized and fit for purpose in the field
- Rhythm is a truly multi modal software imaging suite
- DICONDE is being adopted fully by the NDE community

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Appendix 10

High temperature corrosion – a comparative over view of CUI protective coating systems

Steve Reynolds (Performance Polymers)

Performance Polymers

HI-TEMP COATINGS TECHNOLOGY

High Temperature Corrosion Protection

A Comparative Overview Of CUI Protective Coating Systems

Steve Reynolds
Steve Fenton
www.pp-bv.com

- Corrosion under insulation is one of the costliest problems attacking the industry today. According to one specifier from a major oil company, CUI problems account for more unexpected downtime than all other possible causes combined.

Corrosion under insulation is a unique problem. A CUI protective coating in this environment needs to be able to withstand multiple abuses and also have certain application characteristics in order to make it a viable solution.

Deficiencies Associated with Generic High Heat Coatings

- Thin film resulting in pinpoint rusting / corrosion
- Ineffective Corrosion Under Insulation
- Inability to be applied while the unit is online & hot
- Limited thermal shock capabilities
- The need for high levels of surface preparation
- Heat cure issues
- Short recoat windows in often hostile conditions
- High VOC
- Sacrificial coatings (aluminum or zinc based)

Properties a CUI Coating Must Have In Order To Be Successful

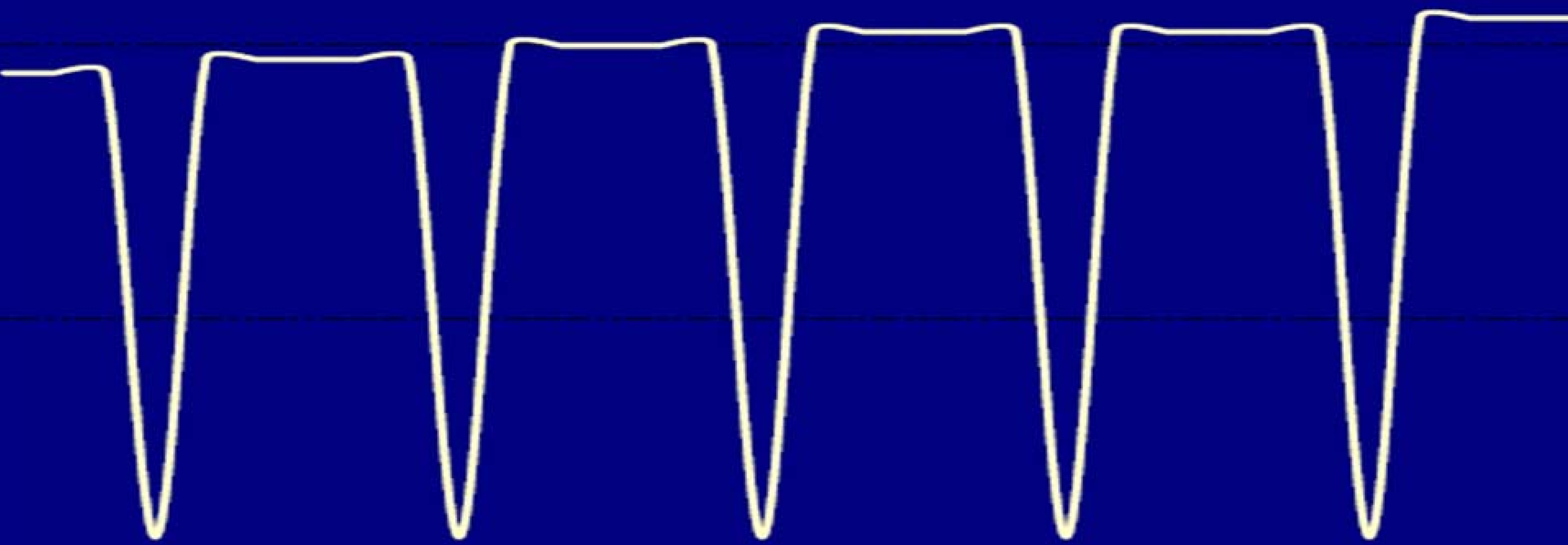
1) Resistance to Boiling Water
2) Heat and Thermal Shock Resistance
3) Application to Hot Steel (site maintenance)
4) Application to Ambient Steel (OEM, fabrication)
5) High Film Build Capability, Direct to Hot Steel
6) Simple to Use
7) VOC and Environmental Compliance

	Inert Multi-polymeric Matrix	Thermal Spray Aluminum	Traditional Elevated Temperatur e Silicones	Multi-polymer Primer	Inorganic Zinc	Novalac Elevated Temperature Epoxies
Max Operating Temp	750ºC	630ºC	540ºC	425ºC	400ºC	220ºC
Max DFT per Coat (in Microns)	150	200	37	150	75	100
Recoatable with self	Yes	No	Yes	Yes	No	Yes
Max DFT (in microns)	500 +		112	200		200 Max Recoat interval is critical
Single Component	Yes	n/a	Yes	No	No	No

	Inert Multi-polymeric Matrix	Thermal Spray Aluminum	Traditional Elevated Temperature Silicones	Multi-polymer Primer	Inorganic Zinc	Novalac Elevated Temperature Epoxies
Anodic Metal sacrifices in Electrolyte	No	Yes	Yes (Aluminum)	Yes (Aluminum)	Yes (Zinc)	No
Immersion in Salt Water	Yes	Fails	Fails	NR	Fails	Yes
Hot Apply ºC	Yes 260ºC	Yes	Yes 93ºC	Yes 120ºC	No	Yes 150ºC
Surface Tolerant	Yes SSPC SP-2	No	No	No	No	No
Stainless Steel	Yes	No	No	Yes	No	Yes
Easy repair with Self	Yes	No	Yes	Yes	No	Yes
Protects at Ambient	Yes	Yes	No	Yes	Yes	Yes
Cryogenic Service	Yes	Yes	No	Yes	No	Yes

Surfaces at Elevated Temperatures

Cyclic (all) or continuous



Service is all Cyclic over TIME ➔

Result of Sacrificial Corrosion

Novalac Epoxy

After 3 months service

Originally White

Cracking

Excessive DFT in places.


Overheated Epoxy

Consequences of Leaking Insulation

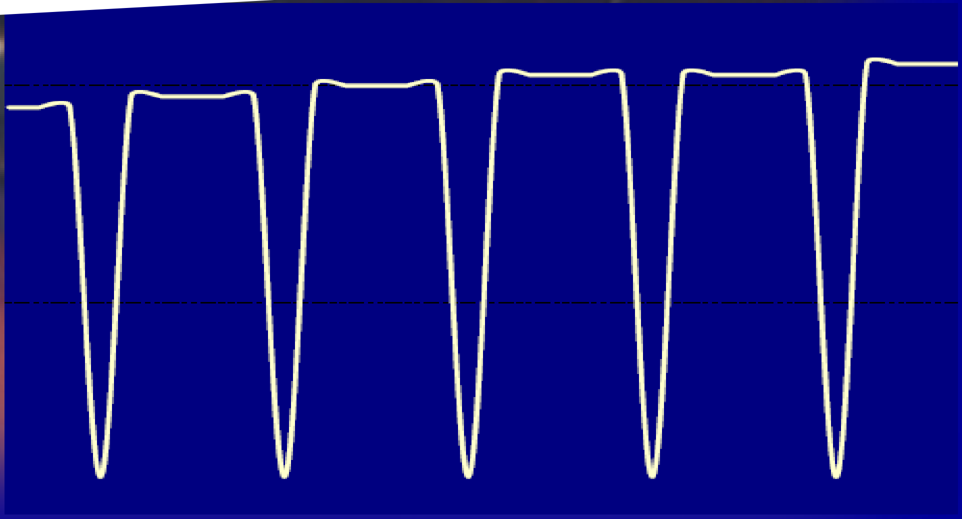
Insulation Leaks
…. Eventually


08 10 2001

New Interest In High Temperature Coating Systems

- many older refineries and chemical plants
  - upgrade for higher quality products
  - improved efficiency
  - or simply expand,

In doing so they raise operating temperatures



End User Cost / Benefit Analysis

- The economics of rehabilitation and repair are mainly driven by the cost of the labour, access costs and the **down time** that is associated with making repairs.

- Extended maintenance cycles also dramatically reduce whole life cycle costs, as does taking CUI programs out of essential shutdown processes. – they can form ongoing schedules to further reduce costings.


r in
nert
olyMeric
echnology
t resistant coatings


Thank you for your attention
Questions ?