Appendix 1

List of participants

Participants EFC WP15 meeting 6th September 2017 Prague (Czech Republik)

NAME	SURNAME	COMPANY	COUNTRY
Al Musharfy	Mohamed	Takreer	UNITED ARAB EMIRATES
Bour Beucler	Valerie	Nalco Champion	FRANCE
Camperos	Sheyla	Total	FRANCE
Chareyre	Bastien	Arcelor Mittal	FRANCE
Cisse	Sarata	Arcelor Mittal	FRANCE
Claesen	Chris J	Nalco Champion	BELGIUM
Fullin	Luna	Tenaris Dalmine	ITALY
Genchev	Georgi	Salzgitter Mannesmann Forschung GmbH	GERMANY
Holmes	Tracey	Special Metals	UK
Houlle	Patrice	Patrice Houlle Corrosion Service - MTI	FRANCE
Knudsen	Ole	SINTEF	NORWAY
Lorkin	David	Permasense Limited	UK
Lucci	Antonio	Rina Consulting	ITALY
Marcolin	Giacomo	Tenaris Dalmine	ITALY
Noak	Bronislav	Welding Research Institute	SLOVAKIA
Olahova	Natalia	Kubota Materials	BELGIUM
Omer	Faraj	Ras Lanuf Oil & Gas Processing	LIBYA
Patel	Niketan	Slovak Acadely of Science	SLOVAKIA
Preuss	Karsten	Shell Deutschland Oil GmbH	GERMANY
Rangel	Pedro	CEPSA	SPAIN
Ropital	François	IFP Energies nouvelles	FRANCE
Ruiz	Hermenegildo	CEPSA	SPAIN
Schempp	Philipp	Shell Deutschland Oil GmbH	GERMANY
Spaghetti	Alessandra	Sandvik	ITALY
Suleiman	Mabruk	Takreer	UNITED ARAB EMIRATES
Van Rodijnen	Fred	Oerlikon metco	GERMANY
van Roij	Johan	Shell Global Solutions International B.V.	NETHERLANDS
Vosecký	Martin	Nalco Champion	CZECH REPUBLIC
Wold	Kjell	Emerson	NORWAY
Zhang	Jian-Zhong	SABIC	UK

Appendix 2

EFC WP15 Activities

(Francois Ropital)

Welcome to the EFC Working Party Meeting

"Corrosion in Refinery and Petrochemical Industry" WP15

Prague 6 September 2017

EUROPÄISCHE FÖDERATION KORROSION
EUROPEAN FEDERATION OF CORROSION
FEDERATION EUROPEENNE DE LA CORROSION

Presentation of the activities of WP15

European Federation of Corrosion (EFC)

- Federation of 29 National Associations
- 21 Working Parties (WP) and 1 Task Force
- Annual Corrosion congress « Eurocorr »
- Thematic workshops and symposiums
- Working Party meetings (for WP15 twice a year)
- Publications
- for more information http://www.efcweb.org

EFC Working Parties

http://www.efcweb.org

- WP 1: Corrosion Inhibition
- WP 3: High Temperature
- WP 4: Nuclear Corrosion
- WP 5: Environmental Sensitive Fracture
- WP 6: Surface Science and Mechanisms of corrosion and protection
- WP 7: Education
- WP 8: Testing
- WP 9: Marine Corrosion
- WP 10: Microbial Corrosion
- WP 11: Corrosion of reinforcement in concrete
- WP 12: Computer based information systems
- WP 13: Corrosion in oil and gas production
- WP 14: Coatings
- WP 15: Corrosion in the refinery and petrochemical industry
  (created in sept. 96 with John Harston as first chairman)
- WP 16: Cathodic protection
- WP 17: Automotive
- WP 18: Tribocorrosion
- WP 19: Corrosion of polymer materials
- WP 20: Corrosion by drinking waters
- WP 21: Corrosion of archaeological and historical artefacts
- WP 22: Corrosion control in aerospace
- Task Force on Corrosion in CO_2 Capture Storage (CCS) applications
- Task Force on Corrosion reliability of Electronics

EFC Working Party 15 « Corrosion in Refinery » Activities

http://www.efcweb.org/Working+Parties-p-104085/WP%2B15-p-104111.html

Chairman: Francois Ropital Deputy Chairman: Johan Van Roij

The following are the main areas being pursued by the Working Party:

Information Exchange
Sharing of refinery materials /corrosion experiences by operating company representatives.

Forum for Technology
Sharing materials/ corrosion/ protection/ monitoring information by providers

Eurocorr Conferences : Joint sessions with other EFC WP at Eurocorr (2018 Krakow-Poland, 2019 Seville Spain) on which topics

WP Meetings
One WP 15 working party meeting in Spring,
One meeting at Eurocorr in September in conjunction with the conference,

Publications - Guidelines

EFC Working Party 15 « Corrosion in Refinery »

List of the WP15 spring meetings :

10 April 2003	Pernis - NL (Shell)
8-9 March 2004	Milan -Italy (ENI)
17-18 March 2005	Trondheim- Norway (Statoil)
31 March 2006	Porto Maghera - Italy (ENI)
26 April 2007	Paris - France (Total)
15 April 2008	Leiden -NL (Nalco)
23 April 2009	Vienna - Austria (Borealis)
22 June 2010	Budapest - Hungary (MOL)
14 April 2011	Paris - France (EFC Head offices)
26 April 2012	Amsterdam - NL (Shell)
9 April 2013	Paris - France (Total)
8 April 2014	Mechelen - Belgium (Borealis)
14 April 2015	Leiden -NL (Nalco)
26 April 2016	Paris - France (Total)
13 April 2017	Frankfurt - Germany (EFC Head offices)

Publications from WP15

• EFC Guideline n°40 « Prevention of corrosion by cooling waters » available from Update in relation with Nace document 11106 "Monitoring and adjustment of cooling water treatment operating parameters" Task Group 152 on cooling water systems

• EFC Guideline n° 46 on corrosion in amine units *revision in progress*

•EFC Guideline n° 42 Collection of selected papers

•EFC Guideline n° 55 Corrosion Under Insulation *New edition nov. 2015*
http://store.elsevier.com/product.jsp?isbn=9780081007143&pagename=search

•Future publications : suggestions ?

- •best practice guideline on corrosion in sea water cooling systems (joint document WP9 Marine Corrosion and WP15) *(will be discussed this afternoon)*
- •best practice guideline to avoid and characterize stress relaxation cracking ?

WP15 Corrosion Atlas Web page

https://www.efcweb.org/Working+Parties/WP+Corrosion+in+the+Refinery+Industry/WP+15+Refinery+Corrosion+Atlas.html

Information : Future conferences related to refinery corrosion

•28-30 November 2017
Stainless Steel World Conf 2017 Maastricht NL

•15-19 April 2018
CORROSION 2018 NACE Conf Phoenix AZ

9-13 September 2018
EUROCORR 2018 Krakow Poland

8-13 September 2019
EUROCORR 2019 Seville Spain

Look at the Website: www.efcweb.org/Events

Appendix 3

Methodology for monitoring non-uniform corrosion mechanisms

(David Lorkin)

Methodology for Monitoring Non-Uniform Corrosion Mechanisms

David Lorkin
EMEA Sales Director, Permasense

EMERSON

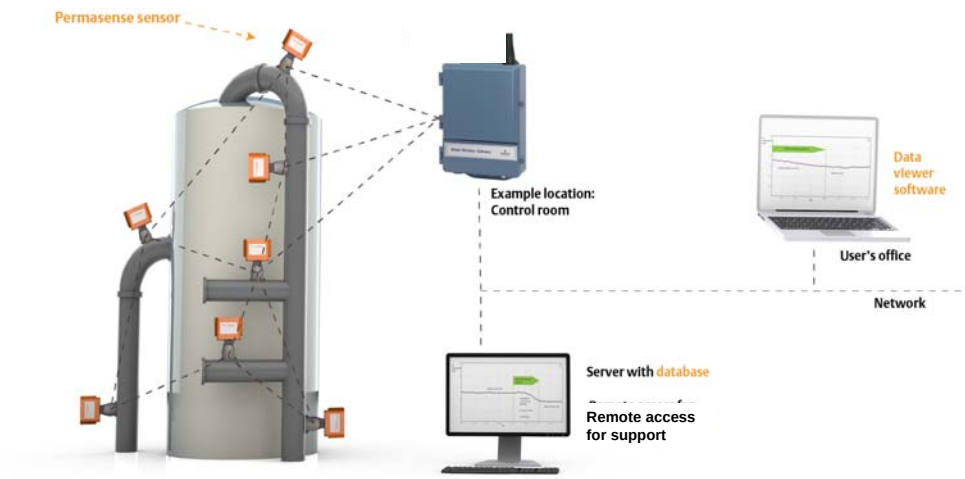
Process Industry Challenges Managing Safety, Integrity and Risk in a Tight Margin Environment

- Higher feedstock quality variability
- Higher plant availability requirements
- Longer runs between maintenance shutdowns
- Tighter HSE regulations
- Tighter CAPEX budgets
- Shortage of experienced inspectors

- Increased safety
- Increased reliability
- Increased availability
- Increased margin $

- Leaks/ loss of containment
- Overly conservative operations

Fixed Non-Intrusive Sensors Deliver Continuous Wall Thickness Measurements of the Highest Quality Directly to Desk



Part A: Detection of Localised Corrosion Using Arrays of Point Measurement Sensors

Reliable Detection of Localised Corrosion With UT Sensors

- An individual sensor measures at single point
- Sensors can be deployed:
  - Sparsely across a corrosion loop
  - In array configuration in high-risk areas if exact location of attack is not known

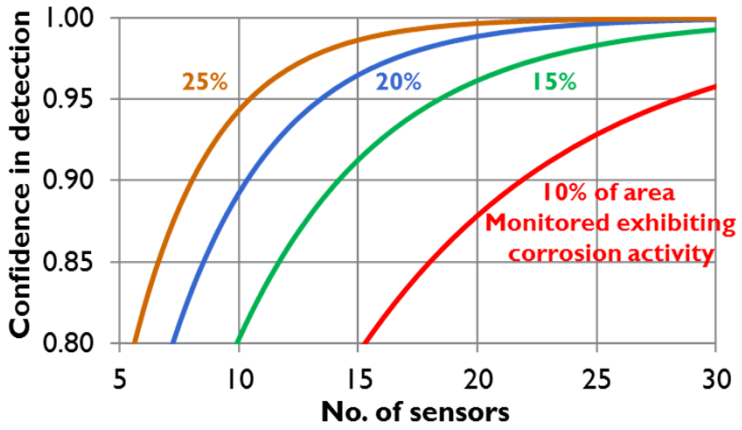
Best-practice for Selecting Number of Sensors When Expected Corrosion is Localised

1. Use prior knowledge to identify high-risk areas that are at risk from localised attack:
   - Previous inspection records
   - Corrosion models (service, metallurgy, geometry)
   - RBI type studies
   - Other risk analysis studies (e.g. for changing crude slate)
2. Determine expected corrosion mechanism

Example of high-risk area to be monitored by sensor grid

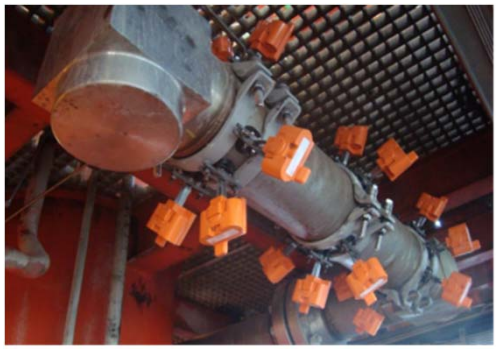
Stages of localised corrosion attack with increasing percentages of high-risk area affected

High Confidence of Detection With Surprisingly Few Sensors



Array Installation Examples

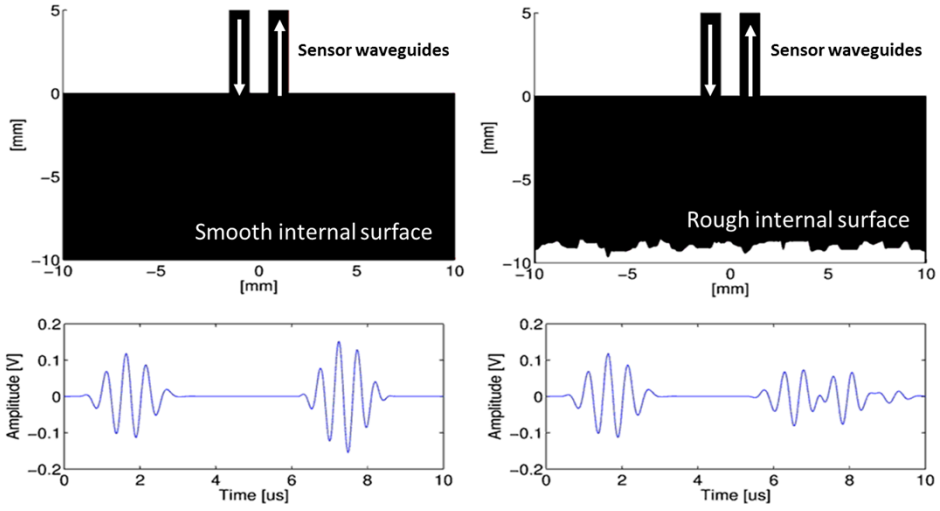
Six sensors installed in close proximity to detect Napthenic Acid attack in refinery



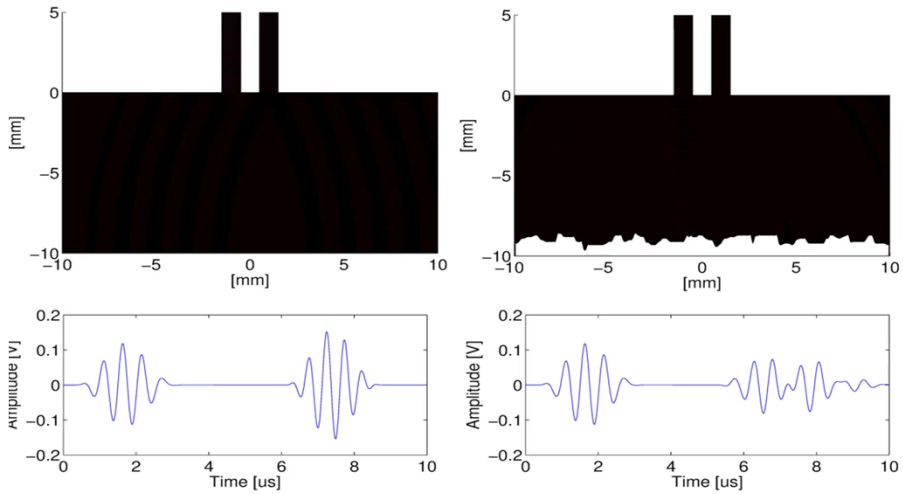
Eighteen sensors installed to monitor for sand erosion on an unmanned gas production platform

Part B: Improved Ultrasonic Signal Processing When Internal Surface is Rough

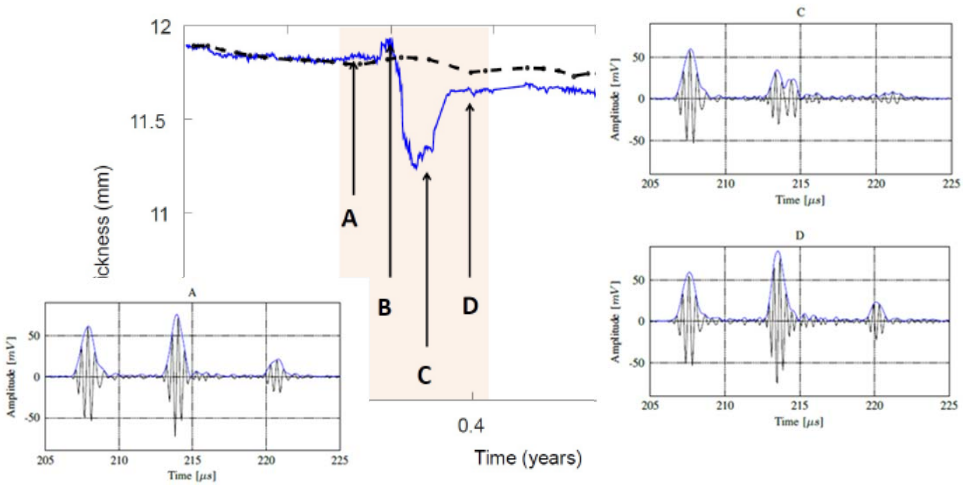
Rough Internal Surface Morphology Distorts the Recorded Ultrasonic Signal



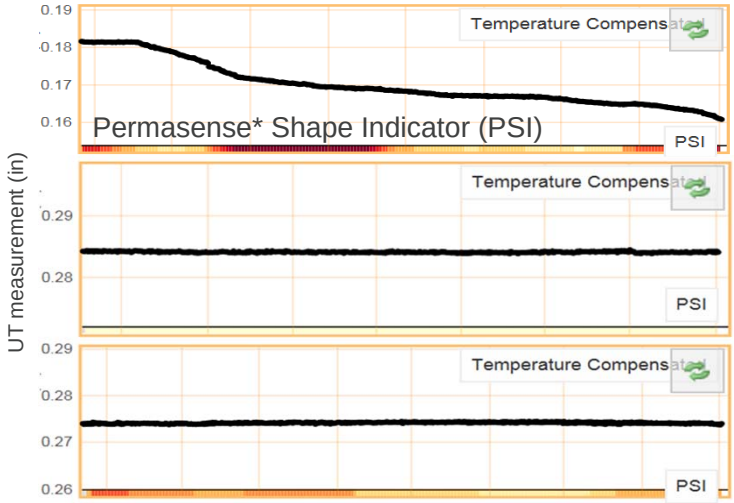
Rough Internal Surface Morphology Distorts the Recorded Ultrasonic Signal



Distortion Causes ‘Standard Signal Processing’ to Break Down



Permanent Sensors With Unique Adaptive Cross Correlation Signal Processing Can Take Advantage of Previous Measurements



Very high intermittent wall loss and roughness changes

No wall loss, no roughness changes

No wall loss, but intermittent roughness change

Summary

Part A:

- Permanently mounted UT sensors can measure changes in wall thickness with very high sensitivity (and therefore fast response).
- Localised corrosion mechanisms can be detected (with excellent probability of detection) with surprisingly few sensors installed in an array in high-risk locations.

Part B:

- Rough internal surface morphology at the measurement location distorts ultrasonic signals, causing 'standard' signal processing to break down.
- Proprietary signal processing simplifies data interpretation:
  - AXC wall thickness measurements are immune to changes in internal morphology.
  - PSI detects the changing internal surface morphology.

Acknowledgements

Professor Peter Cawley, Imperial College, for the statistical analysis of Part A.

Imperial College NDE group, especially Attila Gajdacsi, for their work on AXC and PSI signal processing shown in Part B, now commercialised.

Appendix 4

PSO (phosphino succinic oligomer) capabilities in cooling water high stress conditions

(Valerie Bour Beucler)

PSO (phosphino succinic oligomer) capabilities in cooling water high stress conditions

Valerie Bour Beucler

Cooling system high stress conditions and iron release

- Process leak (hydrocarbon contamination)
- Start up after turn around
- Iron contamination
- Corrosion inhibitors out of control
  - Selection and dosage
  - Working window
  - pH upsets

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Cooling water process leak

Hydrocarbon contamination

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Heat exchangers after process leak contamination

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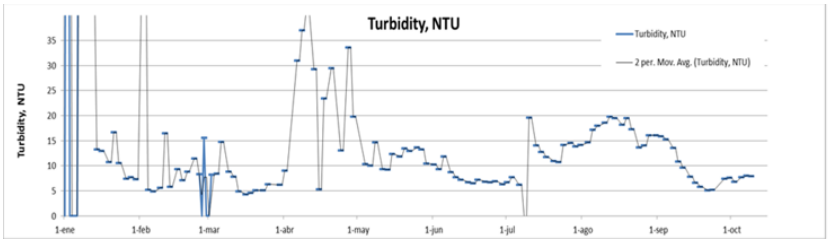
Turbidity increase related to hydrocarbon contamination



This situation will increase polymer and free chlorine demand

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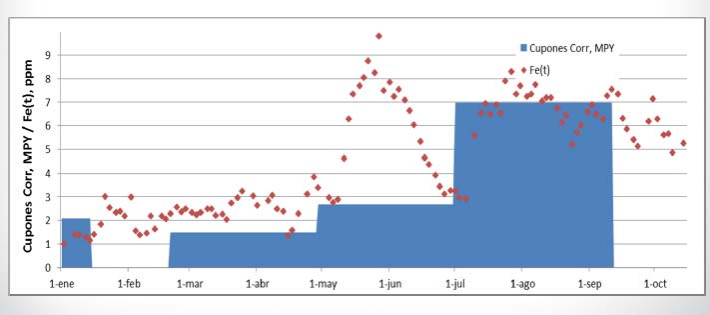
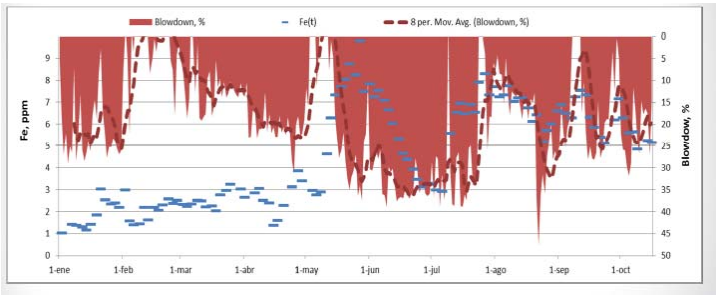
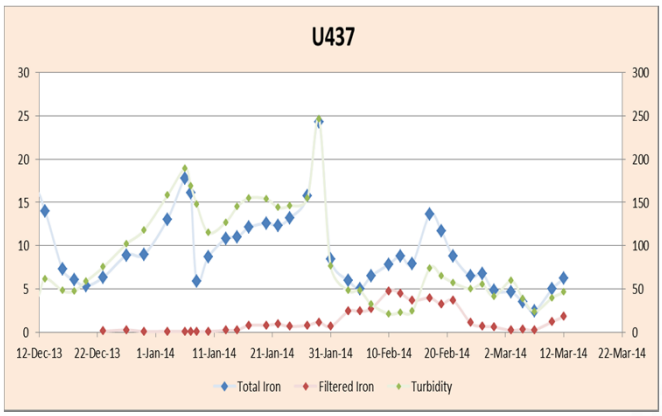
Iron and corrosion rate increase



Blowdown effect and limitation



Process leak and CWS impact



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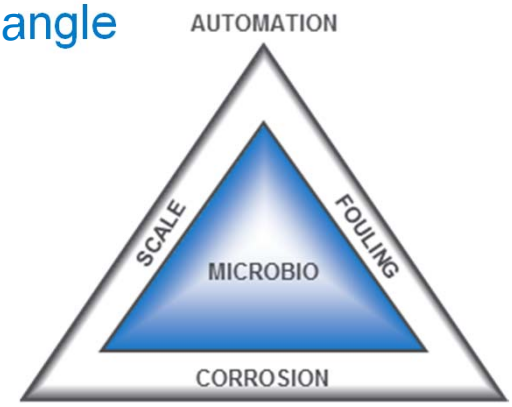
Cooling Systems – The Triangle



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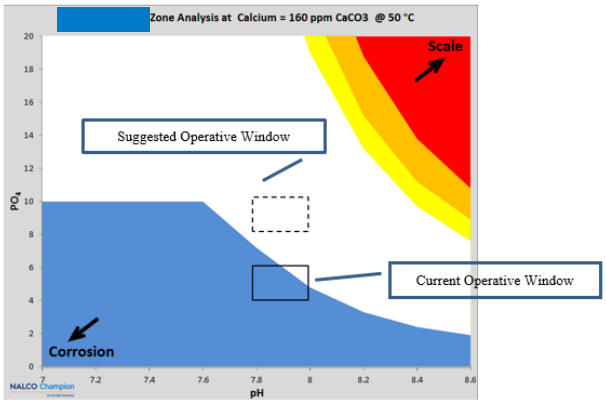
Action plan

- Dosage of non oxidizing biocides to have microbio under control
- Stop ortho-phosphates and increase pH to decrease water corrosivity
- Adjust polymer (3DTrasar)
- Injection of PSO (phosphino succunic oligomer) in shock dosage of more than 50 mg/L.
- Analytical plan regarding filtrated and unfiltrated iron, turbidity, PSO, OPO4, pH, conductivity, polymer, blowdown
- Corrosion rate monitoring

PSO cathodic corrosion inhibitor

- Powerful cathodic corrosion inhibitor
  - Combined to anodic corrosion inhibitor
- No precipitation whatever the pH
- No reversion with time, temperature or oxidants
- No environment restriction
- Nalco Patent
- Antiscaling properties
- Thermal stability of the PSO molecule
  - Increase passivation power,
  - Do not cause additional ortho phosphate
  - Nor ortho phosphate type of deposits like calcium phosphate or iron phosphate.

Operating window adjustment



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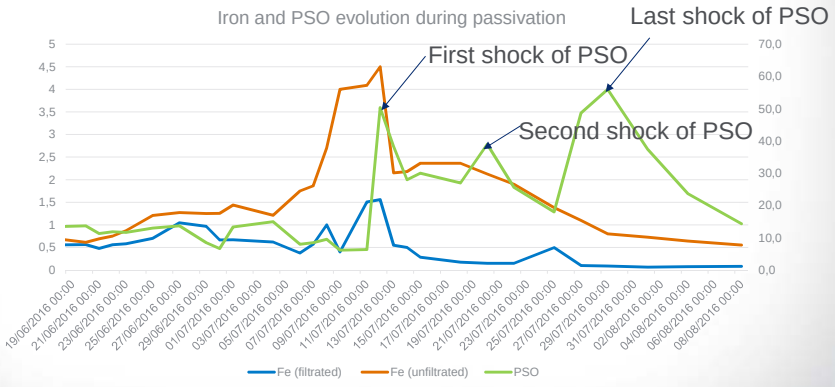
Effect of PSO during iron contamination



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Appendix 5

Cefracor Working group “corrosion in heat exchangers”

(Valerie Bour Beucler)

Working group “corrosion in heat exchangers”

- *7 avril 2016 first meeting (one per quarter)*
- *Around 35 attendees*
  - *Goals is to write a best practices manual on heat exchangers from manufacturing to cooling water operation*
- *Meeting agenda*
  - *Best Practices manual ,*
  - *Discussion and presentation,*
- *Working team*
  - *On different part (manufacturing, metallurgy, pre commissioning, passivation, operation …..*
- *Présentation during meeting 2 (around 1 hour).*

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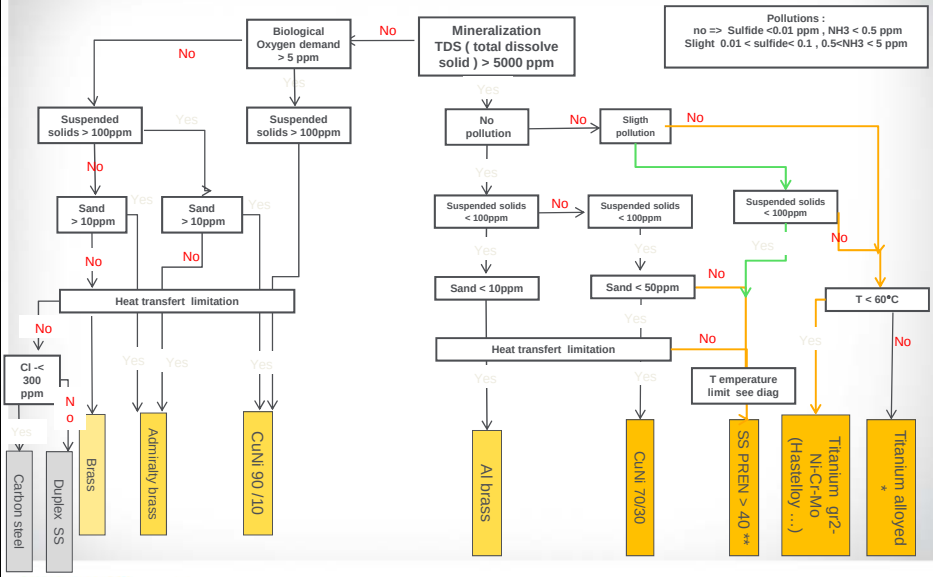
Cooling Water System Open and semi closed – selection of tubes materials for cooling water application – T° C max 60° C – biocide # 1 ppm residual chlorine



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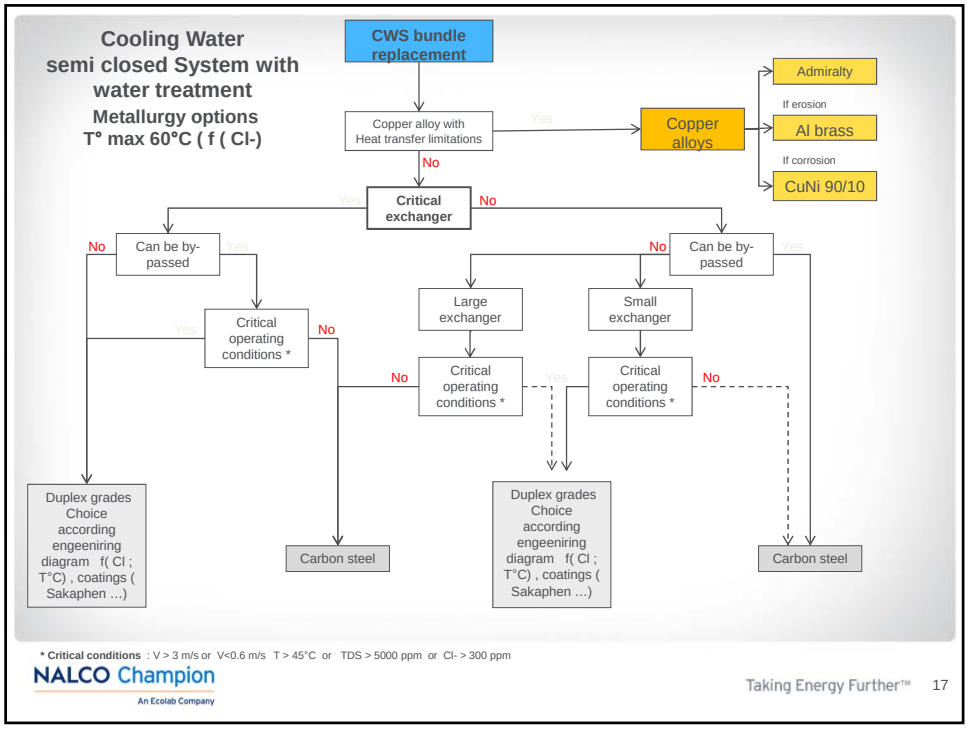
Cooling Water
semi closed System with
water treatment
Metallurgy options
T° max 60°C (f (Cl-)
CWS bundle replacement
Copper alloy with Heat transfer limitations
Yes
Copper alloys
Admiralty
If erosion
Al brass
If corrosion
CuNi 90/10
No
Critical exchanger
Yes
No
No
Can be by-passed
Yes
Critical operating conditions *
Yes
No
Large exchanger
Small exchanger
No
Can be by-passed
Yes
No
Critical operating conditions *
Yes
Critical operating conditions *
No
Duplex grades Choice according engeeniring diagram f(Cl ; T°C) , coatings (Sakaphen …)
Carbon steel
Duplex grades Choice according engeeniring diagram f(Cl ; T°C) , coatings (Sakaphen …)
Carbon steel
* Critical conditions : V > 3 m/s or V<0.6 m/s T > 45°C or TDS > 5000 ppm or Cl- > 300 ppm
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Appendix 6

Report on the advancement of Task Force work on the revision of the EFC 46 guideline

(Johan van Roij)

EFC WP 13+15
Amine Corrosion Taskforce

Progress / status 2017

EFC WP 13+15, Sep 2017

EFC WP13+15 Amine Corrosion Taskforce

- Main objective: Update Publication 46

European Federation of Corrosion Publications
NUMBER 46

Amine unit corrosion in refineries

J. D. Harston and F. Ropital

- Taskforce amine corrosion (joined WP13, 15) founded in Sep 2015
- Main items to address in the update:
  - Update the experience overview with new experience and experience from gas plants
  - Include a literature survey
  - Restructure & format the corrosion descriptions into "Corrosion Loops"
  - Include Integrity Operating windows
  - Include more extensive process and corrosion descriptions / backgrounds

Current amine corrosion Taskforce members:

Michel Bonis (Total)
Jean Kittel (IFPEN)
Slawomir Kus (Honeywell)
Sophie Loyan (Total)
Mabruk Suleiman (Takreer)
Steve Fenton (Protective Polymers Ltd)
Chris Claesen (NALCO Champion)
Gauthier Perdu (Prosernat)
Johan van Roij (Shell)

General contact address: EFC46-taskforce@efcweb.org

Or contact person: Johan van Roij (johan.vanroij@shell.com)

Progress / status

- 2016: Questionnaire was developed (in form of Excel spreadsheet) to obtain amine corrosion experience.
- December 2016: the Questionnaire issued by email to a selection of the WP13 and WP15 members with request to return it within 6 months time.
- A few sites returned the questionnaire – THANK YOU!
- Expectation more sites can respond if we help them remember…
- End of July 2017 a gentle reminder and the questionnaire (by email) to WP13 and WP15 members.
- Information in the questionnaire can be provided **anonymously** (= without link to a company or site).
- Participants will be rewarded by receiving a summary of all the obtained experience (complete overview will be part of the updated publication 46).

- Literature survey carried out
- Taskforce is working on corrosion and process descriptions
- Time line on agenda Taskforce meeting (6 Sep., 15:15, Room 202)

If you have not received the questionnaire and are interested in participation:
please provide your email address and we send you the questionnaire