Appendix 1

List of participants and excused persons

Participants EFC WP15 meeting 22th June 2010 Budapest (Hungary)

Name	**Company**	**Country**
Hennie de Bruyn	Johnson Matthey Catalysts	UK
Andreas Glaser	OMV	AUSTRIA
Jonas Höwing	Sandvik	SWEDEN
György Isaak	MOL Hungarian Oil & Gas Co	HUNGARY
Miklos Kantor	Sandvik Hungary	HUNGARY
Davor Kesner	GE Betz	CZECH REPUBLIC
Claudia Lavarde	GE S&I	FRANCE
Francesco Locati	Saipem	ITALY
Rudolf Madarasz	Outokumpu	HUNGARY
Miroslav Michvocik	MOL Group, SLOVNAFT	SLOVAKIA
Tibor Nagy	MOL Hungarian Oil & Gas Co	HUNGARY
Tibor Puskas	GE Betz	HUNGARY
Martin Richez	Total	FRANCE
Johan van Roij	Shell Global Solutions	NETHERLANDS
Francois Ropital	IFP	FRANCE
Grzegorz Sielski	Sandvik Poland	POLAND
Anny Szabone	MOL Hungarian Oil & Gas Co	HUNGARY
Pascale Sotto-Vangeli	Outokumpu	SWEDEN
Francois Weisang-Hoinard	Outokumpu	FRANCE
Gerard Zima	MOL Group, SLOVNAFT	SLOVAKIA

Excuses received for the EFC WP15 meeting 22th June 2010 Budapest

Sylvain Authier	Exxon Mobil	FRANCE
Peter Nolan	Advantica	UK
Michael Davies	CARIAD Consultants	UK
Kari Saarinen	Zerust Oy	FINLAND
Anni Visgaard Nielsen	Statoil Refinery, Kalundborg,	DENMARK
Rob Scanlan	Conoco	UK
Dipl.Ing. Gerit Siegmund	ExxonMobil Germany GfKorr	GERMANY
Larry Lambert	Nynas AB	UK
Maarten Lorenz	Shell Global Solutions International B.V.	NETHERLANDS
Ksenija Babic	Baker Petrolite	USA
Brian Chambers	Honeywell	USA
Alec Groysman	Oil Refineries Ltd	ISRAEL
Joerg Maffert	Dillinger Huttenwerke	GERMANY
Tiina Hakonen	Neste Oil Corporation	FINLAND
Melitza Lobaton	Couronnaise de Raffinage	FRANCE
Carmelo Aiello	Consultant	ITALY
Martin Hofmeister	Bayernoil Raffineriegesellschaft mbH	GERMANY
Ariella Perez	Saipem	FRANCE
Johan van Roij	Shell Global Solutions International B.V.	NETHERLANDS
Madeleine Brown	Conoco	UK
Pieter Blauvelt	Shell Global Solutions International B.V.	NETHERLANDS
Frederic Tabaud	BP Rafinaderij Rotterdam B.V.	NETHERLANDS
Arto Kiiski	Neste Jacobs Oy	FINLAND

Excuses received for the EFC WP15 meeting 22th June 2010 Budapest

Antoine Surbled	Shell Global Solutions International B.V.	NETHERLANDS
Xavier Roumeau	Total	FRANCE
Stephane Cornali	Heurtey Petrochem SA	FRANCE
Marjolein van Loenhout	Fluor BV	NETHERLANDS
Carlo Farina	CEFIT Corrosion Consultant	ITALY
Iris Rommerskirchen	Butting Edelstahlwerke GmbH&Co KG	GERMANY
Joanna Hucinska	Gdansk University of Technology	POLAND
Dr Richard Pargeter	TWI	UK
Hildegunn Urke	Statoil ASA	NORWAY
Jerome Peultier	Arcelor Mittal	FRANCE
Nick Smart	Serco Assurance F	UK
Stefano Trasatti	University of Milan	ITALY
Mario Vanacore	Nalco	ITALY
Natalia Loukachenko	Arcelor Mittal	FRANCE
Chris J Claesen	Nalco	BELGIUM
Dagmar Blendin-Fuelz	Bayernoil Raffineriegesellschaft mbH	GERMANY
Roberto Riva	Eni R&M	ITALY
Dimphy Wilms	Applus RTD Benelux	NETHERLANDS
Chris Baartman	Borealis AS	NORWAY

Appendix 2

Welcome

Anti corrosion management in MOL refining

György Isaak

Anti – Corrosion Management in MOL Refining

György Isaák (MOL DS Development)

EFC WP 15 meeting Budapest, 22.06.2010

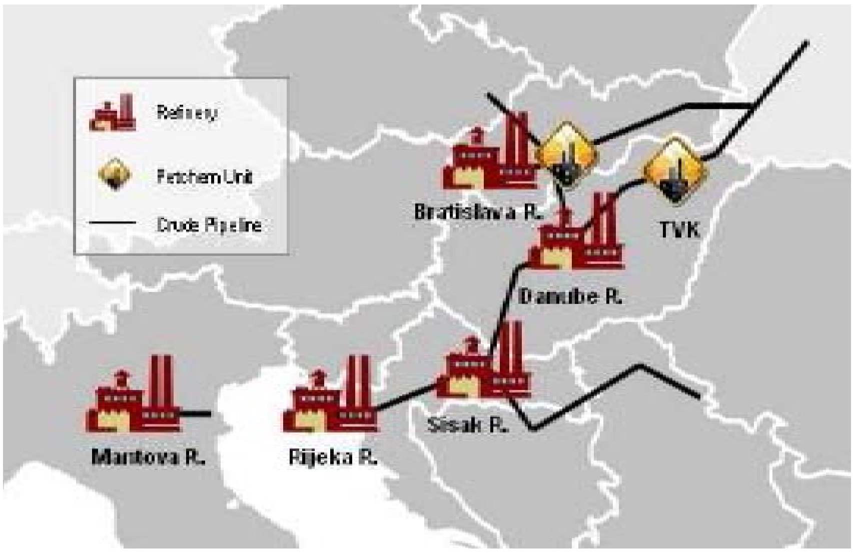
MOL GROUP

Content

- About MOL Group Downstream
- Driving forces of change
- Current status of CM
- Launch of the 3A initiative
- Organizational changes
- How could EFC help

MOL GROUP

About MOL Group Downstream



▶ MOL GROUP

About MOL Group Downstream

REFINERIES of MOL GROUP

DUNA
CAPACITY: 8.1 Mtpa
NCI: 10.6

BRATISLAVA
CAPACITY: 6.1 Mtpa
NCI:11.5

MANTOVA IES
CAPACITY: 2.6 Mtpa
NCI: 8.4

RIJEKA
CAPACITY: 4.5 Mtpa
NCI: 5.8

SISAK
CAPACITY: 2.2 Mtpa
NCI: 6.1

▶ MOL GROUP

About MOL Group Downstream

Net Cash Margin (USD/bbl) in Europe by refineries, 2007*

Ranking	Refinery	NCM in 2007 in USD/bbl	Country	Owner
1	**Duna**	**11.2**	**Hungary**	**MOL**
2	**Bratislava**	**10.8**	**Slovak Republic**	**MOL**
3	Schwedt	10.5	Germany	BP/ENI/Shell/Total/PV
4	Leuna (Mider)	10.3	Germany	Total
5	Porvoo	10.2	Finland	Neste Oil
6	Puertollano	10.0	Spain	Repsol YPF
7	Plock	9.8	Poland	PKN Orlen S.A.
8	Omsk	9.6	Russia	Gazprom
9	Pernis Shell	9.4	Netherlands	Shell/Statoil
10	La Coruna	9.0	Spain	Repsol YPF
...46	**Frassino, Mantova**	**5.2**	**Italy**	**MOL**

**Source: WoodMackenzie – European and Russian refiners, Net Cash Margin in 2007*

MOL GROUP

About MOL Group Downstream

HIGHEST PROFITABILITY OF DR AND BR IN EUROPE (2006)

KEY FACTORS IN ACHIEVING HIGH REFINERY MARGINS:

✓HIGH COMPLEXITY AND FLEXIBILITY TO FOLLOW MARKET DEMANDS

✓SUCCESSFUL APPLICATION OF SUPPLY CHAIN MANAGEMENT

✓UNRIVALLED RETAIL NETWORK IN THE REGION

✓HIGH AVAILABILITY OF PRODUCING ASSETS (>97%)

In the recent years we realized that for maintaining these high level of asset availability more and more efforts and resources are needed.
In order to prevent frequent unexpected corrosion failures and unit shutdowns we had to change paradigm in maintenance philosophy.
Finally we had to completely restructure anti-corrosion management in MOL Group Refining.

MOL GROUP

Driving Forces of Change

✓Increased frequency of corrosion failures and unscheduled unit shutdowns
✓Increasing maintenance costs
✓Increasing risk of HSE type accidents

The reasons for the above are the following:

✓Long operational life of equipments (some base units are over 40 years)
✓More challenging crude feed (higher salt, sulfur and nitrogen content)
✓Increased depth of processing, more destructive technologies
✓More frequent unit shutdowns due to economic considerations (reduction of product storage costs, supply chain management responses to product demand fluctuations)
✓Low effectiveness of anti-corrosion management in Refining

▸ MOL GROUP

Current Status of Corrosion Management

In 4Q 2009 a comprehensive survey was made to assess efficiency of the anti-corrosion activities in main 5 refineries of MOL Group.
It was concluded that the efficiency of the current system is very low, and further allocation of resources and complete renewal of the organization is needed.

The main conclusion of the survey were the following:
✓There is no dedicated organization or person who would be responsible for the management of anti-corrosion activities, neither at refinery nor at Group level
✓There are few corrosion experts working isolated in Maintenance or Single Service Company providing inspection, coating, maintenance, services but their influence to corrosion management is insignificant
✓While the refineries process almost the same crude, their anti-corrosion remedies (material selection, chemicals) are very different
✓Practically there is no information flow, we do not learn from each other's failures, best practices are not introduced into MOL specifications
✓Corrosion costs are not separated from maintenance costs, no LCA calculations are made for anti-corrosion solutions
✓No regular corrosion education or training, no easily accessible central database are available in MOL Group

▸ MOL GROUP

Launch of the 3A initiative

Based on the serious conclusions of the mentioned survey, leadership of Refining launched the 3A (Anti-Corrosion Applications and Actions) initiative in October 2009 with the following strategic targets:

:

Long term goals of the 3A (Anticorrosion Applications and Actions) process:

- Providing theoretical and practical support for considerable improvement of Corrosion Control in refinery operations by means of raising level of corrosion associated information.
- Support efforts of operational and maintenance staff to maintain high level of asset availability by upgrading corrosion monitoring system, adopting new inspection methods and creating an electronic, database from corrosion monitoring information and regular corrosion failure investigations.
- Support optimal decisions for corrosion protection investments by creating unified calculation method of corrosion related costs and evaluation method for justification of corrosion protection investments based on life cycle calculations.
- Include acquired experiences, knowledge and analysis results into MOL Technical Specifications for process equipment.

MOL GROUP

Organizational Changes

Structure of the new organization:

Corrosion Control Team - from delegates of HSE, Production, Maintenance and Production Excellence departments of Refining (3 - 5 part time members from each refinery of the MOL Group).

Corrosion Control Committee - composed of few experienced corrosion experts, invited from several segments of Refining, supporting the work of Corrosion Teams members in order to solve corrosion problems and raise level and quality of corrosion associated information of MOL employees.

The 3A activity is managed by Group level Corrosion manager under the supervision of the Steering Committee of concerned leaders of Refining, Maintenance, Production Excellence, DS Development, HSE and SSC.

MOL GROUP

How could EFC help?

Raising level of corrosion related knowledge can not be made without collaboration with concerned partners.

The main areas of of the activity of EFC WP15 is in line with our primary improvement targets, mainly:

- increase operational safety of of hydrotreaters,
- prevent corrosion failures in amine units,
- extend operational cycle of crude distillation units,
- find optimal solutions against CUI

Participate in the activity of EFC working parties can also be a good tool for our young corrosion engineers to get first hand information.

So, MOL want to be more active in this cooperation in the future.

MOL GROUP

Appendix 3

EFC WP15 Activities

Francois Ropital

Welcome to the EFC Working Party Meeting

"Corrosion in Refinery" WP15

Budapest 22 June 2010

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

AGENDA EFC Working Party 15

Corrosion Refinery Industry Meeting

9h00-9h15 Welcome by Mol

9h15-9h45 WP15 Activities (F. Ropital)
Eurocorr 2010 (Moscow) and 2011 (Stockholm) sessions and workshops, publications,
collaborations with NACE
other points

9h45-10h00 Stress Relaxation Craking

10h00-11h00 Corrosion failures
-Case history about the damage of MDEA regenerator column in Duna Refinery (György Isaak MOL)
-Two failure cases with duplex tubing in heat exchangers (Jonas Höwing - Swerea KIMAB)
-Corrosion case from Total (M. Richez - Total)
-Corrosion case from the audience

10h45-11h00 Coffee break

AGENDA EFC Working Party 15
Corrosion Refinery Industry Meeting

11h15-11h30	Stainless steels from Otokumpo
11h30-12h30	Duplex -Application of duplex stainless steels to prevent corrosion in refineries (M. Kantor and Mr. Sielski -Sandvick) -Discussion on NACE MR0103 and duplex stainless steel (Sandvick) -Are there experiences in application of lean duplex steels in refinery service ?(György Isaak MOL)
12h30-14h00	Lunch break

AGENDA EFC Working Party 15
Corrosion Refinery Industry Meeting

14h00-14h15	Metallurgical defects -Metallurgical problems with valves (M. Richez Total)
14h15-15h15	Monitoring -Corrosion and erosion monitoring using permanently installed sensortechnology for continuous wall thickness monitoring of your asset (Claudia Lavarde -GE) - Microbiologically influenced corrosion – association with biofilm, monitoring and removal (D. Kesner -GE)
15h15-16h00	Inspection - Inspection tools for prevention of corrosion failures (Miroslav Michvocík MOL-SLOVNAFT)
16h00	Other points of discussion End of the meeting

Participants :

György Isaak	MOL Hungarian Oil & Gas Co Env. & Corr. Manager
François Ropital	IFP
Hennie de Bruyn	Johnson Matthey Catalysts
Martin Richez	Total
Roy Holliday	GE Betz
Davor Kesner	GE Betz
Tibor Puskas	GE Betz
Claudia Lavarde	GE S&I
Jonas Höwing	Swerea KIMAB
Miroslav Michvocik	MOL Group, SLOVNAFT
Francesco Locati	Snamprogetti
Miklos Kantor	Sandvik Hungary
Grzegorz Sielski	Sandvik Poland
Jean Marie Deves	AXENS - IFP Technology Group
Johan van Roij	Shell Global Solutions International B.V.
Jorun Zahl Albertsen	Statoil ASA
Andreas Glaser	OMV
Pascale Vangeli	Outokumpu
Francois Weisang-Hoinard	Outokumpu

Excuses from :

Sylvain Authier	Exxon Mobil
Peter Nolan	Advantica
Dr Michael Davies	CARIAD Consultants
Kari Saarinen	Zerust Oy
Anni Visgaard Nielsen	Statoil Refinery, Kalundborg,
Rob Scanlan	Conoco
Dipl.Ing. Gerit Siegmund	ExxonMobil Germany GfKorr
Larry Lambert	Nynas AB
Maarten Lorenz	Shell Global Solutions International B.V.
Ksenija Babic	Baker Petrolite
Brian Chambers	Honeywell
Dr Alec Groysman	Oil Refineries Ltd
Joerg Maffert	Dillinger Huttenwerke
Tiina Hakonen	Neste Oil Corporation
Melitza Lobaton	Couronnaise de Raffinage
Carmelo Aiello	Consultant
Martin Hofmeister	Bayernoil Raffineriegesellschaft mbH
Ariella Perez	Saipem
Madeleine Brown	Conoco
Pieter Blauvelt	Shell Global Solutions International B.V.
Frederic Tabaud	BP Rafinaderij Rotterdam B.V.

Arto Kiiski	Neste Jacobs Oy
Antoine Surbled	Shell Global Solutions International B.V
Xavier Roumeau	Total
Stephane Cornali	Heurtey Petrochem SA
Marjolein van Loenhout	Fluor BV
Carlo Farina	CEFIT Corrosion Consultant
I. Rommerskirchen	Butting Edelstahlwerke GmbH&Co KG
Joanna Hucinska	Gdansk University of Technology
Dr Richard Pargeter	TWI
Hildegunn Urke	Statoil ASA
Jerome Peultier	Arcelor Mittal
Nick Smart	Serco Assurance F
Stefano Trasatti	University of Milan
Mario Vanacore	Nalco
N. Loukachenko	Arcelor Mittal
Chris J Claesen	Nalco
D. Blendin-Fuelz	Bayernoil Raffineriegesellschaft mbH
Roberto Riva	Eni R&M
Dimphy Wilms	Applus RTD Benelux
Chris Baartman	Borealis AS

Presentation of the activities of WP15

European Federation of Corrosion (EFC)

- Federation of 31 National Associations
- 18 Working Parties (WP) + 1 Task Force
- Annual Corrosion congress « Eurocorr »
- Thematic workshops and symposiums
- Working Party meetings (for WP15 twice a year)
- Publications
- EFC - NACE agreement (20% discount on books price)
- 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 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

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: Hennie de Bruyn

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

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

Publications - Guidelines

Publications from WP15

• EFC Guideline n°40 « Prevention of corrosion by cooling waters » available from http://www.woodheadpublishing.com/en/book.aspx?bookID=1193

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
http://www.woodheadpublishing.com/en/book.aspx?bookID=1299

•EFC Guideline n° 42 Collection of selected papers
http://www.woodheadpublishing.com/en/book.aspx?bookID=1295

•EFC Guideline n° 55 Corrosion Under Insulation
http://www.woodheadpublishing.com/en/book.aspx?bookID=1486

•Future publications : suggestions ?
- best practice guideline to avoid and characterize stress relaxation cracking ?

EFC Working Party 15 plan work 2008-2010

. Web seminar with Nace

"NACE TEG 205X information exchange -corrosion in refineries " has been recorded during San Antonio Corrosion Confrence and will be soon available on the Web with the possibility of sending question.

. Sessions with other EFC WP at Eurocorr (2011 in Stockholm, 2012 in Istanbul) on which topics?

- Typical corrosion failure cases atlas
- Publications
- Education – qualification - certification

http://www.eurocorr.org

Moscow 13-17 September 2010

Monday, 13 September 2010

16:30 - 19:00	Registration and Welcome Reception	Foyer and Exhibition Hall

Tuesday, 14 September 2010

	Room 1	Room 2	Room 3	Room 4	Room 5
09:00 - 09:15	Opening Session				
09:15 - 09:30	Welcome Address				
09:30 - 09:45	Cavallaro Medal Award Presentation				
09:45 - 10:30	Invited Plenary Lecture: Y. Kuznetsov/RUS				
10:30 - 11:00	Coffee Break				
	Coatings (Inorganic)	Corrosion Mechanisms & Methods	Joint EFC/NACE Session: Corrosion in Oil & Gas Production	Corrosion by Hot Gases and Combustion Products	Corrosion in the Refinery Industry
11:00 - 11:25	9611 Vagramyan/RUS	9541 Persson/S	9526 Fassina/I	4734 Franz/D	Keynote 9242 Tomin/RUS
11:25 - 11:50	4723 Eyraud/F	9468 Renner/D	9350 Moderer/A	9638 Kasatkin/RUS	
11:50 - 12:15	9559 Matykina/E	9358 Prohaska/A	4672 Marchebois/F	4735 Knittel/F	9216 Medaber Jambo/BR
12:15 - 12:40	9170 Kuznetsov/RUS	9322 Williams/UK	9274 Askari/IR	9658 Terentieva/RUS	9475 Candido/BR
12:40 - 14:00	Lunch Break				
	Coatings (Inorganic)	Corrosion Mechanisms & Methods	Joint EFC/NACE Session: Corrosion in Oil & Gas Production	Corrosion by Hot Gases and Combustion Products	Corrosion in the Refinery Industry
14:00 - 14:25	9345 Fürbeth/D	9351 Greenfiled/UK	9184 Skjellerudsveen/N	Keynote: 9623 Zhabrev/RUS	9243 Belyaeva/RUS
14:25 - 14:50	9435 Bestetti/I	9399 Andreatta/I	9394 Bosch/F		4673 Latyshev/RUS
14:50 - 15:15	9550 Pedeferri/I	9387 Nazarov/F	9205 Caldwell TX/USA	9653 Lours/F	9278 Hörstemeier/D
15:15 - 15:40	9155 Yabuki/J	9678 Anufriev/RUS	9474 Smirnova/N	9237 Raja/IND	9539 Eaton TX/USA
15:40 - 16:15	Coffee Break				
16:15 - 16:40	9337 Fell/D	9573 Eliseeva/NL	4697 Timonin/RUS	9637 Belousov/RUS	9615 Meck IN/USA
16:40 - 17:05	9563 Rosero Navarro/E	9505 Jellesen/DK	9236 Gao/PRC	9647 Castañeda/E	9542 Morton/UK
17:05 - 17:30	9449 Rossi/I	9516 Minzari/DK		9499 Agüero/E	9442 De Marco/I
18:00 - 19:00	General Assembly	Press Hall			
17:30 - 19:30	Poster Discussion / Poster Party				

Wednesday, 15 September 2010

09.00 - 09:45	Invited Plenary Lecture: Y. Zuo				
09:45 - 09:55	Break for Changing Lecture Hall				
	Room 1	Room 2	Room 3	Room 4	Room 5
	Coatings (Organic)	Corrosion Mechanisms & Methods	Corrosion in Oil & Gas Production	Corrosion by Hot Gases and Combustion Products	Corrosion in the Refinery Industry
09:55 - 10:20	4668 Nenakhow/RUS	9372 Zhang/NL	9486 Johansson/S	9556 Fedorova/RUS	9323 Chambers TX/USA
10:20 - 10:45	9273 Polastri/I	9151 Luo/UK	9265 Case OK/USA	9321 Chyrkin/D	9167 Groysman/IL
10:45 - 11:20	Coffee Break				
11:20 - 11:45	9233 Sykes/UK	9434 Bousquet/F	9446 Haruna/J	9549 Lasslaz/F	4768 René de Cotret/D
11:45 - 12:10	9466 Ozkanat/NL	4692 Tarantseva/RUS	9294 Sunaba/J	9613 Sanchez Pasten/MEX	9668 da Silva/BR
12:10 - 12:35	9481 Jimenez-Morales/E	4714 Marcus/F	9547 Clements/UK	9601 Stewart/UK	9125 Lyublinski OH/USA
12:35 - 14:00	Lunch Break				
	Coatings (Organic)	Corrosion Mechanisms & Methods	Corrosion in Oil & Gas Production	Corrosion by Hot Gases and Combustion Products	Corrosion in the Refinery Industry
14:00 - 14:25	9393 Gelling ND/USA	4706 Yakovleva/RUS	9334 Ohe/J	9135 Al-Meshari/SAR	9377 El Kamel/F
14:25 - 14:50	9532 Toews/D	9586 Ferreira/P	9381 Badrak TX/USA	9371 Montgomery/DK	9595 Claesen/B
14:50 - 15:15	9604 Trueba/I	9307 De Rooij/NL	4737 Rebak NY/USA	WP Business Meeting	WP 15 Business Meeting
15:15 - 15:40	9639 Agustynski/PL	9376 Grushevskaya/RUS	9203 Winning/UK	WP Business Meeting	WP 15 Business Meeting
15:40 - 16:15	Coffee Break				
	Coatings (Sol-gel)	Corrosion Mechanisms & Methods	Corrosion in Oil & Gas Production		Corrosion in the Refinery Industry
16:15 - 16:40	9244 Gonzales-Garcia/NL	9330 Angelini/I	9333 Takabe/J		WP 15 Business Meeting
16:40 - 17:05	9202 Garcia/NL	4748 Li/F	9524 Joosten OK/USA		WP 15 Business Meeting
17:05 - 17:30	9445 Fedel/I	9448 Lekbir/F	4726 Kichenko/RUS		WP 15 Business Meeting
17:30 - 17:55	9283 Taheri/NL	9580 Frappart/F	9300 Johnsen/N		WP 15 Business Meeting
17:55 - 18:20	9223 Kharsan MN/USA				WP 15 Business Meeting

EFC Working Party 15: Future objectives of the group

How to manage our working party meetings / Eurocorr sessions

· Eurocorr Sessions

✓Implements of Eurocorr sessions or workshops with other WP and NACE (a workshop can be on a topic without formal presentation)

✓Implication of young corrosion students, PhD at Eurocorr session with a dedicated poster session

. Working Party Meetings

✓Future topics of task forces

✓Facilitating student trainings outside their countries in our companies

✓Presentation of UE funding projects in our area (if they are)

✓Collaboration on Standard

Increase the collaboration with NACE

exchange of information on our activities - joint Eurocorr sessions

Appendix 4

Stress Relaxation Cracking

Advancement of the Cefracor group work

CEFRACOR
French corrosion Society

Corrosion in Oil and Gas Industries
High temperature working group

Members :

CETIM , EPA, Haynes Intl , IFP , Industeel , Heurtey Petrochem, Technip, Total

---

Oil and gas High temperature group GT9 :

Specific CEFRACOR Comittee

Main goals :

- Return of experience exchanges
- « Forum « between users (Petrochemical, Refinery , Chemical industries) , Research center , producers , fabricatior, engineering .
- Works on specific topics : Stress relaxation cracking

2

Stress Relaxation Cracking :

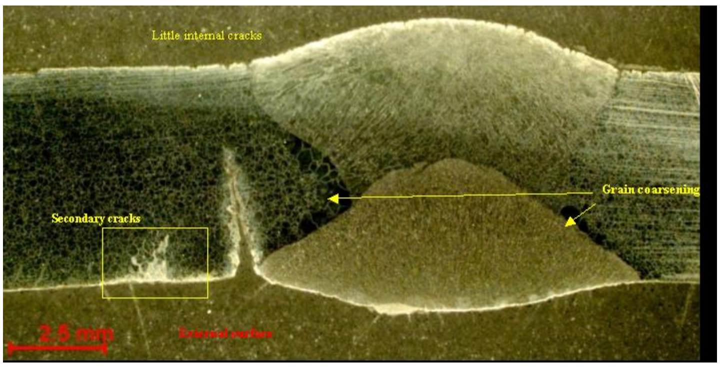
Location : primarily in heat affected zone but not only !

3

Stress Relaxation Cracking :

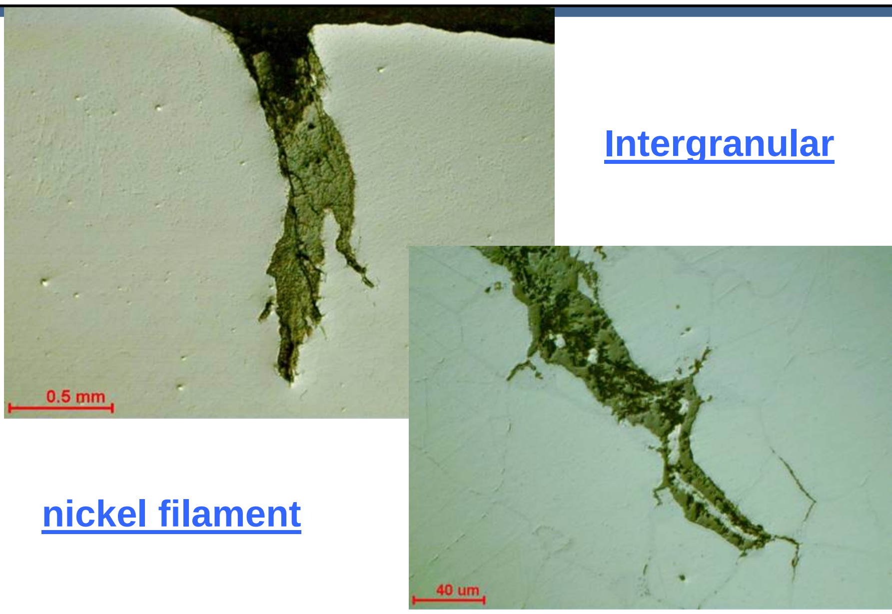
Cracking phenomenon of the austenitic grades working at high temperatures 450 à 800°C and particularly in case of high stress and strain.

Location : primarily in heat affected zone but not only !



4

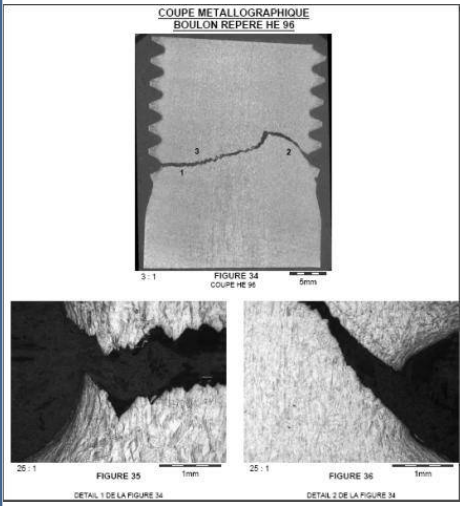
Intergranular

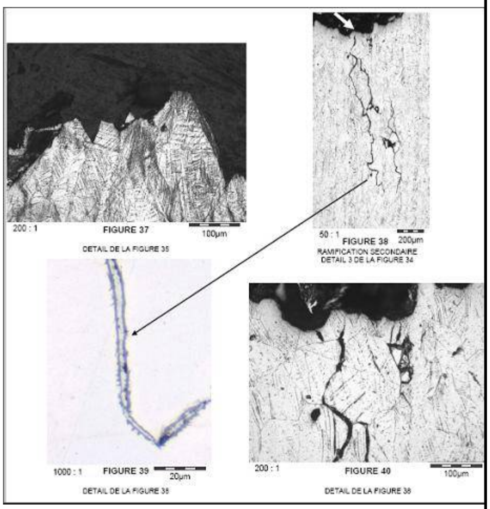


nickel filament

5

Location : primarily in heat affected zone but not only !
Cold work 304 Cu – 550°C





Grain size 2-3 , hardness 250-290Hv –Intergranular rupture – Metalic filament

6

Stress Relaxation Cracking 450-850°C

- **Thicker walls (>1”) more susceptible for cracking during fabrication; all thicknesses can crack in-service**
- **Location – primarily HAZ and highly stressed zone (stresses , cold worked)**
- **High sensitivity to grain size particularly coarser than 3**
- **Sensitivity to (?):**
  - Heat input and residual stresses
  - Cold work
  - Thermal expansion differences between filler material and base material
  - Filler metal contraction level

7

Stress Relaxation Cracking :

- **Caracterisation :**
  - Short term and high stresses:cracking can occur during heat treatment... => high heat rate in the sensitive zone and low cooling rate
  - Long term : cracks observed in the first 18 months
  - Expertise Intergranular:crack in the highly stressed zones, Ni filament

8

Stress Relaxation Cracking :

- **Caracterisation :**
  - Expertise Intergranular:crack in the highly stressed zones, Ni filament

JIP in preparation

A- Correlation determination from data banks: correlation from "plant results" and main parameters in order to affect severity factors

B-Experimental validations of the correlations :
From the correlations , run an experimental to validate 2 sensitive steels (800H and 347H) to study:

Variations of the composition and microstructure.
Variation of residual stresses ,
Variation of welding parameters.
Hardening to simulate hot forming
Validation of the effect of thermal treatments

C-Modelization :
From the previous steps
establishment of a risk evaluation matrix
definition of a methodology to evaluate the sensitivity for new steel grade or a new elaboration process.

JIP in preparation

Alloy manufactures: Industeel, Outokumpu , Special metals , Haynes , VDM Krupp , Sumitomo, Sandvik , DMV , Metrode Boehler Thyssen …

- Boiler makers: Verolmes , ATC , ACM …

- Engineering : Technip , Fluor , Shaw (Badger) , Heurtey , Hude , Areva…

- End users : Total , BASF , Bayer , Dow Chemicals , Exxon Mobil, Shell , EDF, RWE ,

- Notified bodies on RBI : DNV , Bureau Veritas , TUV , AFIAP ,

- Independent research centers: TNO , BIL (Institut de soudure Belge) , EWI , DECHEMA …

For further information contact: francois.dupoiron@total.com

11

Open for collaborations and exchanges

Thank you for your attention

12

Appendix 5

Case Study: Amine unit failure

György Isaak (Mol)

Case Study – Amine Unit Failure

György Isaák (MOL DS Development)

EFC WP 15 meeting Budapest, 22.06.2010

MOL GROUP

Content

- Technology, corrosive environment
- Regenerator column features
- Description of the failure
- Forms of corrosion
- Potential causes of corrosion
- Options for materials selection
- Remedial actions

MOL GROUP

Technology, Corrosive Environment

▪ Role of Delayed Coker Unit in Duna Refinery

Delayed Coker Unit thermally cracks heavy vacuum residues high in sulfur and metals at 450 – 500 ºC producing coker gasoil and FCC feed which are further processed to valuable motor fuels. Petroleum coke is sold for coal fired power plants and cement factories as high calorific value fuel.

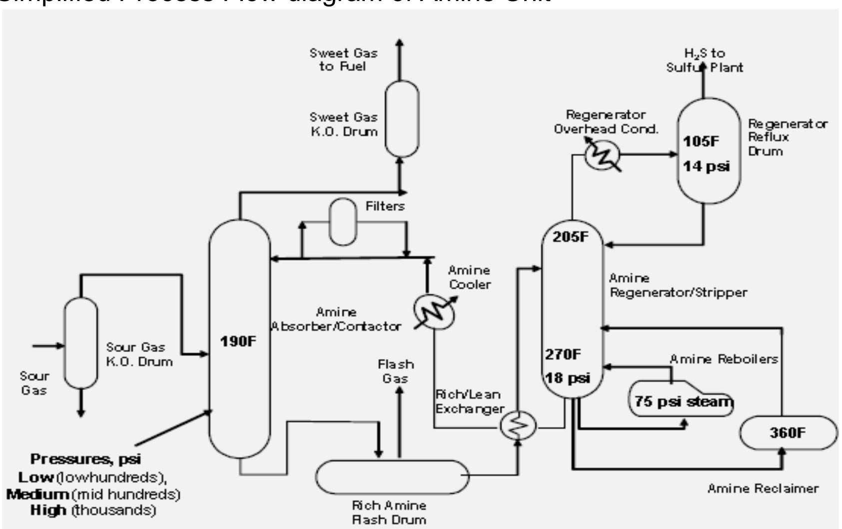
▪ Role of Amine Unit in Delayed Coker Plant

Amine unit removes the corrosive and environmentally hazardous components (H2S, CO2, light mercaptanes, etc.) from acid gases generated as by-products in Delayed Coker unit. Contaminants are removed by specialty amines (MDEA) in the amine absorber. The clean gases are utilized as flue gases for heating refinery furnaces. Reach amine is thermally regenerated by freeing acidic contaminants and recirculated back to the system.
At higher temperature and long residence time, in presence of catalytic metals and oxygen amine decomposes to non-regenerable heat stable salts . These salts can aggravate foaming, corrosion and scaling and have to be removed .

MOL GROUP

Technology, Corrosive Environment

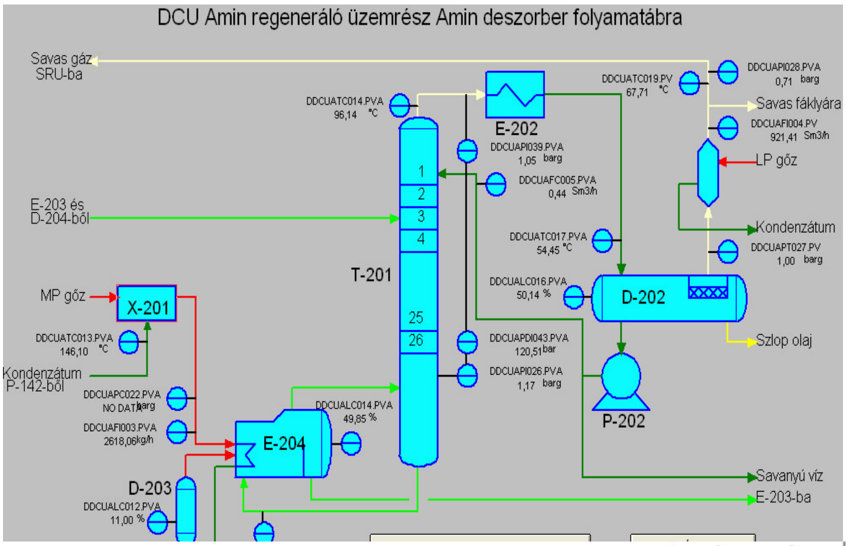
Simplified Process Flow diagram of Amine Unit



MOL GROUP

Technology, Corrosive Environment

The failed T 201 Amine regenerator column with connecting units



▶ MOL GROUP

Regenerator Column Features

Dimensions, metallurgy and operational parameters of the regenerator

Column height: ~ 20 m (including 7.5 m skirt)
Diameter: 1.1 m

Head temperature: 102 – 106 °C
Bottom temperature: 124 - 127°C
Bottom pressure: 0.95 – 1.05 barg

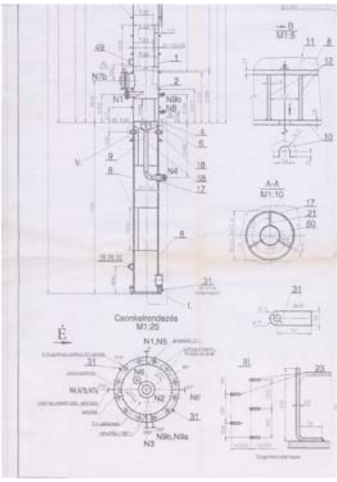
Composition of the acid gas feed:		Vol%
	H_2S	90.1
	H_2	6.7
	CO_2	4.1

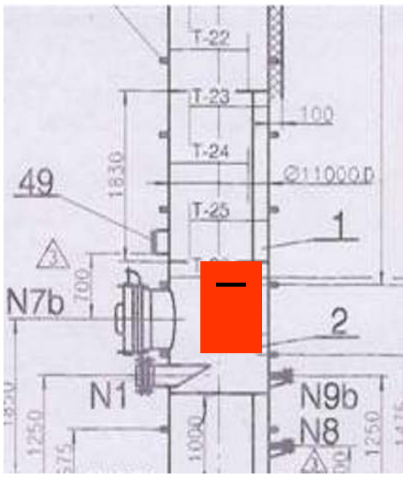
Metallurgy
Column corpus: killed Carbon Steel A516Gr70 (12 mm)
Upper section cladded with A240 TP410S (3 mm)
Tray holding rings: carbon steel
Tray holding beams: 410S
Valve trays: 410S (2 mm)

▶ MOL GROUP

Regenerator Column Features

Drawing of Amine regenerator column, corroded section enlarged





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Description of the Failure

During startup after turnaround a horizontal crack was observed on the regenerator column at the height of the evaporating zone. (20.10.2009)

After opening the column the inspection revealed multiple corrosion damages:

1) Severe general local thinning around the crack (~ ¾ m^2)
2) Pitting corrosion in several places of column wall
3) Erosion corrosion in the evaporation zone and around tray overflows
4) Corrosion of tray holding rings
5) Corrosion damage of some welds

The upper clad section of the column and 410 SS trays were in good condition.
The column was fixed with two welded overlay (from inside and outside and was authorized to continue operation until the next turnaround (2Q 2011)

The unit was first put in operation in 2001. UT wall thickness and weld integrity inspection during the first turnaround and maintenance in 2005 did not reveal any corrosion damage.
During 2009 maintenance only the corrosion of tray holding rings in 17-25 tray section were identified.
The corrosion failure caused ~ 1M USD financial burden.

MOL GROUP

Forms of Corrosion Damage

View of corroded section from outside

MOL GROUP

Forms of Corrosion Damage

Thinning of tray holding ring and damaged weld

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Forms of Corrosion Damage

Corroded internal wall showing erosion-corrosion pattern

MOL GROUP

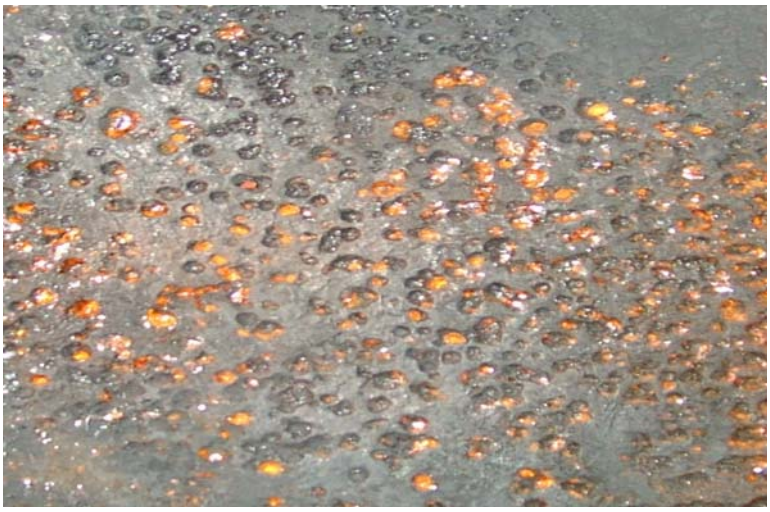
Forms of Corrosion Damage

Serious pitting caused by free carbon - dioxide

MOL GROUP

Forms of Corrosion Damage

Serious pitting caused by free carbon - dioxide



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Forms of Corrosion Damage

Heavy deposits of corrosion products and heat stable salts

MOL GROUP

Forms of Corrosion Damage

304SS valve trays in good condition

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Potential Causes of Corrosion

While the investigation is ongoing, it seems that the most likely root causes of the failure were the following:

- the unit operated with ~ 20 excess capacity compared to designed value leading to turbulent flows and erosion in the evaporation zone;
- the bottom temperature of the regenerator exceeded the recommended value and this led to faster decomposition of the amine and accumulation of HSS;
- the former practice (regular regeneration of amine by vacuum distillation ceased after installation a membrane amine purification unit (electro-dialysis);
- in 2005 -2208 period the regenerator failed to operate continuously and very high concentration of formiate, acetate and other acid salts was built up;
- the neutralization of acidic HSS precursors was made by batch addition of caustic which caused fluctuations in the pH, damaging the FeS protective layer;
- higher bottom temperatures and lower than designed pressure released more acid gases from the amine which could condense on the column wall. This corrosive effect was aggravated by turbulence causing erosion-corrosion.

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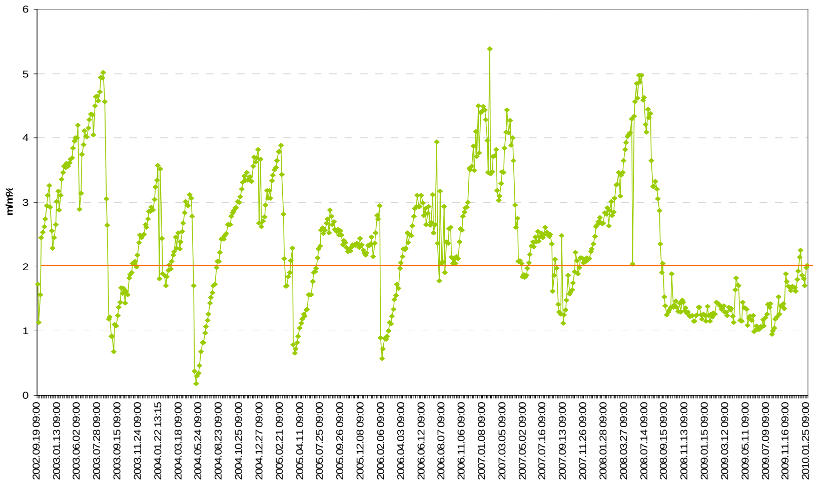
Potential Causes of Corrosion

Fluctuation of HSS concentration in regenerated amine (2002 – 2009)



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Options for Material Selection

Several options for construction materials have been tested:

	Options	Relative value of offers				
1.	Whole column redesign and fabrication: SA 516 Gr70 (Carbon steel)	1,479	1,572	1,842	3,262	
2.	Whole column redesign and fabrication: AISI 316L (Austenitic SS)	1,492	1,674	2,124	3,302	4,226
3.	Whole column redesign and fabrication: S 31803 (Duplex SS)	1,927	1,938	2,434	4,539	
4.	Partial redesign and fabrication SA 516 Gr70 (Carbon steel)	1,000	1,078	1,698		
5.	Partial redesign and fabrication : AISI 316L (Austenitic SS)	1,016	1,368	1,986		
6.	Partial redesign and fabrication : S 31803 (Duplex SS)	1,037	1,614	2,102		

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Remedial Actions

1) Redesign and fabrication of the amine regeneration column from Duplex SS

Until new column in place:
2) Frequent check of amine quality
3) Strict control of APU operation
3) Seeking opportunities to reduce temperatures
4) Controlled addition of caustic for neutralization
5) Regular inspection of column wall thickness

MOL GROUP

Appendix 6

Two failure cases in refineries

Jonas Höwing (Sandvick)

Two failure cases in refineries

Jonas Höwing
Sandvik Materials Technology
Budapest
2010-06-22

About me

- MSc and PhD in inorganic Chemistry, Uppsala University, Sweden
- Post doc. position 2 years, Institute for Energy Technology, IFE, Norway
- Working at Sandvik Materials Technology R&D since 2008

Hobby no. 1

Hobby no. 2

Agenda

- Failure case 1: Corrosion in an OHC
- Failure case 2: The result of too high temperature in a seawater cooled heat exchanger

SANDVIK

Failure case 1

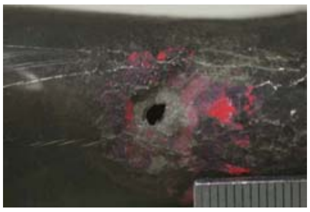
- Overhead condenser
  - ✓ 22% Cr duplex tubing installed
  - ✓ Tubes twisted in order to enhance heat transfer
- Parameters
  - ✓ Tube side
    - Diluted crude
      - Inlet temp. 44°C
      - Outlet temp. 77°C
  - ✓ Shell side
    - 93% naphtha diluents + water containing 80 ppm chlorides
      - Inlet temp. 130°C
      - Outlet temp. 78°C
  - ✓ Ammoniac used in order to neutralize pH
- Deposits found in the heat exchanger

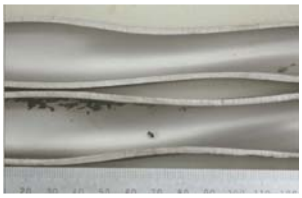
Sandvik Materials Technology

SANDVIK

Analysis

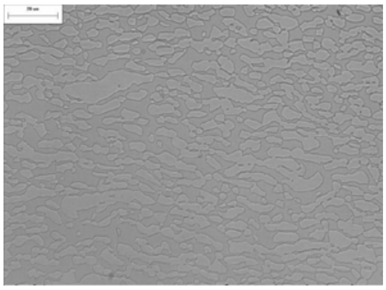
- **Corrosion damage on the tubes**
  - ✓ Hole in the tube wall
  - ✓ Corrosion isolated to shell side
  - ✓ Corrosion problems limited to the bottom row of tubes



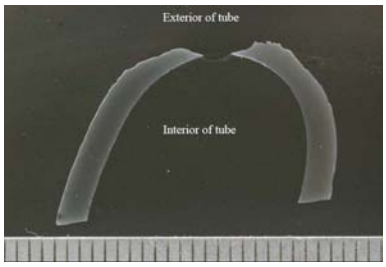


Analysis

- **Light optical microscopy showed a normal duplex microstructure**
  - ✓ Correct heat treatment



- **Corrosion clearly on the outside of the tube**



Analysis using X-Ray diffraction

- The deposits contained
  - ✓ Salmiac (NH_4Cl) ~70%
  - ✓ Sulfur ~20%
  - ✓ Quartz
- Corrosions products on tubes contained
  - ✓ Austenite
  - ✓ Ferrite
  - ✓ Fe_3S_4
  - ✓ Ni_3S_2
  - ✓ FeO(OH,Cl)
  - ✓ Fe_3O_4

Conclusions

- During uptime of the condenser, salmiac has accumulated in the bottom part of the condenser
- The build-up has resulted in deposits forming on top of the tubes
- The high temperature in combination with the high local chloride concentration under the deposits has lead to under deposit corrosion
- The corrosion products suggests that sulfur has taken part in the corrosion reactions
  - ✓ According to MTI sulfur can work as an oxidizing agent in the same way as oxygen*

*C.P. Dillon & S.W. Dean "Materials selection for the chemical process industries, Second edition", (2004), Chapter 28. (Materials Technology Institute)

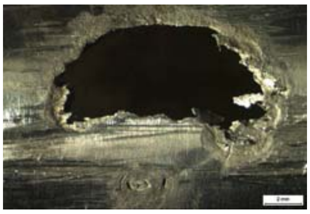
Suggestions

- Try to minimize the accumulation of salmiac
  - ✓ Desalting
  - ✓ Establish routines to remove the deposits
  - ✓ Alter the design of the condenser in order to inhibit pile-up of deposits
- Upgrade material
  - ✓ The environment is clearly too rough for 22% duplex
  - ✓ In the presented case the material specifications were altered to recommend hyper duplex UNS S32707 for the application

Failure case 2

- Seawater cooled heat exchanger
- Location
  - ✓ Middle east
- Material
  - ✓ Tube and tube sheet in Sandvik SAF 2507
    - Tube dimensions 25.4 x 2.11 mm
- Parameters
  - ✓ Tube side
    - Chlorinated seawater
    - 26°C
  - ✓ Shell side
    - Light petroleum
    - 148°C

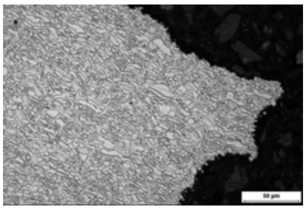
Analysis

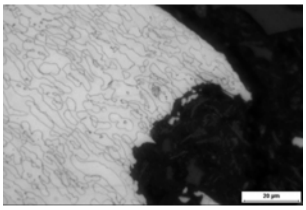


- Large hole in the tube: 1.2 x 0.5 cm
  - ✓ Several smaller corrosion attacks on inside of tube
- Thick brown scale inside the tube
  - ✓ Thickness up to 1.5 mm

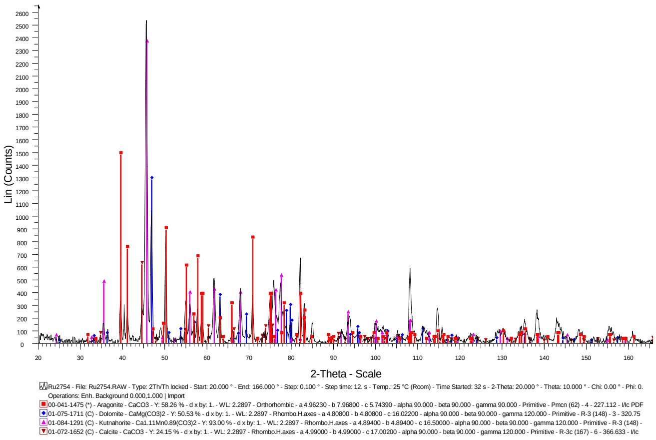
Analysis

- Chemical analysis consistent with Sandvik SAF 2507
- Normal microstructure
  - ✓ No precipitations of intermetallic phases or chromium nitrides





Results X-Ray diffraction of deposit



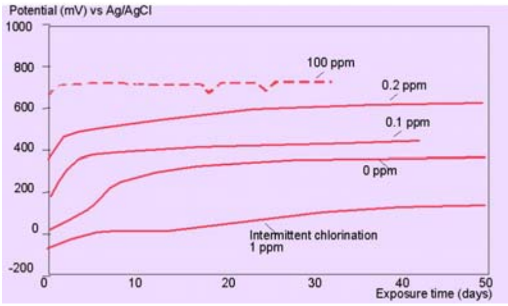
- ✓ Carbonates containing Ca, Mn, and Mg

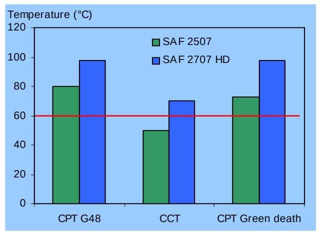
Conclusions

- **If seawater is heated above ~60°C carbonates starts to precipitate**
  - ✓ If the flow rate is too low deposits will form
  - ✓ Temperature depending on hardness
- **Chemical analysis and X-ray diffraction measurements**
  - ✓ The deposits consists mainly of $CaCO_3$ and $(Ca,Mg)CO_3$
- **The heat exchanger has been working at too high temperature with too low flow or poor maintenance procedures has been used**
  - ✓ With respect to the amount of deposits this has gone on for quite some time

Conclusions

- **Corrosion resistance of Sandvik SAF 2507 from ASTM G48 testing**
  - ✓ **CPT = 70°C**
  - ✓ **CCT = 50°C**
  - ✓ **Corrosion potential of 6% $FeCl_3$ = +700 mV**
    - Equivalent to continuously chlorinated seawater
    - If carbonates starts to precipitate, under deposit corrosion will be imminent!





Sandvik Materials Technology SANDVIK

Suggestions

- **Better procedures during maintenance**
- **If the temperature in the heat exchanger has been too high an inspection or cleaning procedure should be used**
- **A more corrosion resistant material gives a larger operating window**
  - ✓ **Hyper duplex UNS S32707 has CCT = 70°C (G 48 method F)**

Sandvik Materials Technology SANDVIK

Appendix 7

Crack on the effluent nozzle of a HDS reactor

Martin Richez (Total)

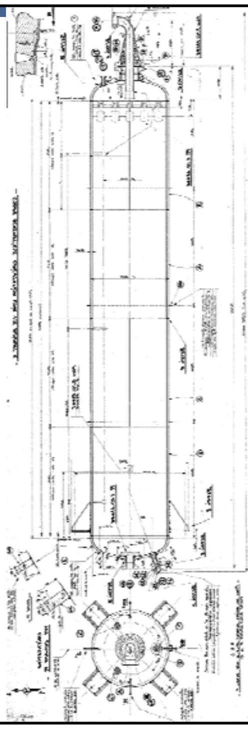
Crack on the effluent nozzle of a HDS Reactor

Martin RICHEZ

TOTAL

HDS Reactor

- Design pressure 56 bar
- Volume 65 m3
- Operating pressure 42 bar
- Design temperature 425 °C
- Operating temperature 385 °C
- Fluid gasoil .+ H2
- Built in 1966 according to ASME
- Matérial A204 Grade C (0.5 Mo) SS clad made of 321 and overlay in 347
- Bottom nozzle : 10''



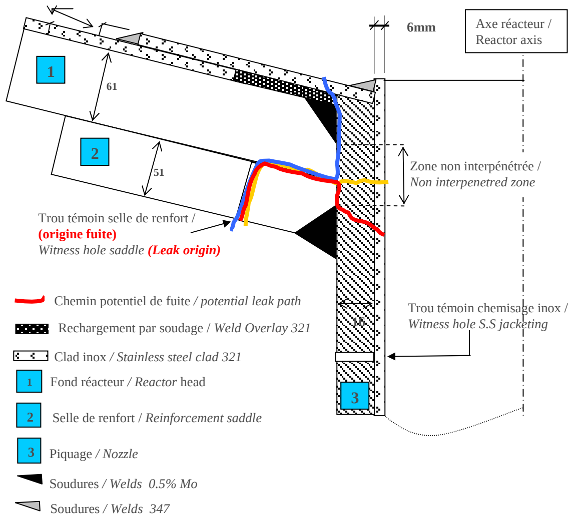
TOTAL

Observation: december 2009

- Product leak on the vent hole of the reinforcing pad.

- View from the inside

What could be the origin of the leak?

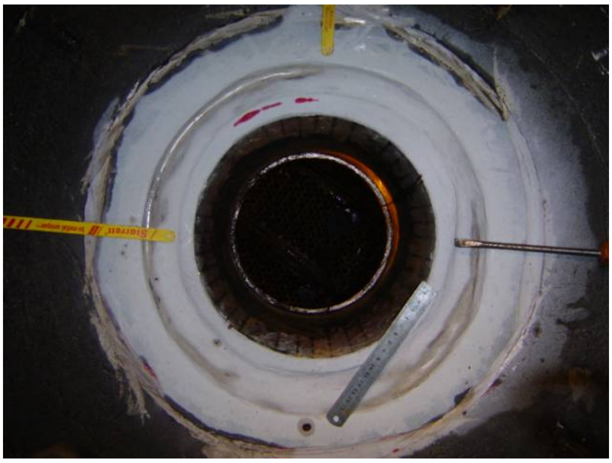


Search for leaks or other defects

OBJECTIVES	TEST	RESULT
Integrity of other nozzle and of the equipment.	AcousticeEmission then UT control of emmissive area.	Emissive area : supports, weld bottom:shell, no defect found
HTHA	AUBT and replica on base metal	None
Looking for cracks for the inner side	Removing : - Cracked collar and overlay - Dye penetrant	A crack is seen after removal of the collar and grinding of the overlay.
Looking for the initiation	Removing of the inner liner and looking by UT from the inside of the nozzle.	Bottom nozzle : The crack start at the toe of the Nothing on top nozzle.
Assement of the nozzle after removal		No degradation by HTHA

Inside, before and after collar removal.

Identification of the crack



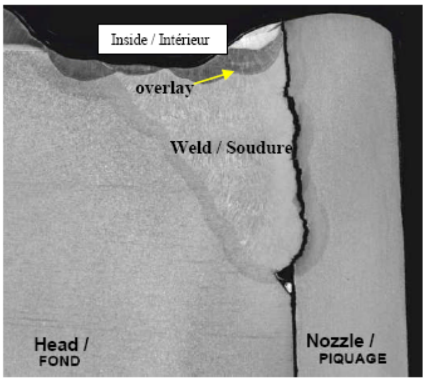
Inside view after removal of the collar and grinding.

7 - EFC WP 15 – 22 June 2010 – M. RICHEZ

TOTAL

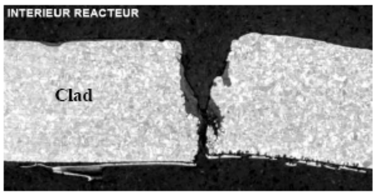
Analyse

Fissure dans soudure coté piquage
Crack in the weld on nozzle side



- The crack initiate at the root of the weld that was not fully fused.
- The weld is not a full penetration weld.

Fissure sur tôle de clad supérieure
Crack on upper clad sheet



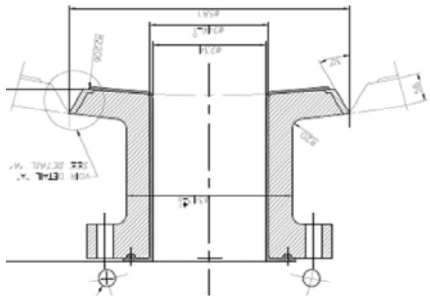
- Collar fully cracked
  - (thermal fatigue)

8 - EFC WP 15 – 22 June 2010 – M. RICHEZ

TOTAL

Recommandations

- This configuration is especially unfavorable (forbiden according to actual rules)
- It is strongly recommended to check for similar arrangement.
- Modification of the weld (full penetration) or change for a forged nozzle is strongly recommended.
- If changed the new nozzle shall be overlaid
- Do not plug the vent of the reinforcing pads.



TOTAL

Appendix 8

Outokumpu high performance stainless steels

Pascale Sotto Vangeli

Outokumpu, High Performance Stainless Steels

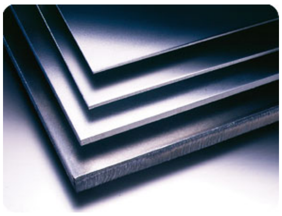
Pascale Sotto Vangeli - Budapest, 22 June 2010

www.outokumpu.com

- Main production sites in Sweden, Finland, the UK and the US
- Service centers and sales offices worldwide
- 7500 people employed

Broad range of products and grades of stainless steel

- Coil, sheet and plate
- Quarto plate
- Thin strip
- Tubular products
- Long products


From cutlery to bridges – endless possibilities






Austenitic Stainless Steel

Corrosion Resistance

EN	ASTM	Outo-kumpu	Typical Chemical Composition, %					
			Cr	Ni	Mo	C	N	Other
1.4372	201	4372	17	5	-	0,05	0,15	6,5Mn
1.4301	304	4301	18,1	8,3	-	0,04	-	
1.4307	304L	4307	18,1	8,3	-	0,02	-	
1.4401	316	4401	17,2	10,2	2,1	0,04	-	
1.4436	316	4436	16,9	10,7	2,6	0,04	-	
1.4539	904L	904L	20	25	4,3	0,01	-	1,5Cu
1.4547	S31254	254SMO	20	18	6,1	0,01	0,20	Cu
1.4565	S34565	4565	24	17	4,5	0,02	0,45	5,5Mn

Ferritic Stainless Steel

Corrosion Resistance ↓

EN	ASTM	Outo-kumpu	Cr	Ni	Mo	C	Other
			Typical Chemical Composition, %				
1.4003	410S	4003	10,5	0,3	-	0,03	
1.4512	409	4512	10,5	-	-	0,03	Ti
1.4016	430	4016	16	-	-	0,08	-
1.4113	434	4113	16	-	0,9	0,08	
1.4521	444	4521	17	-	1,8	0,025	Ti, Nb
1.4401	316	4401	17,2	10,2	2,1	0,04	

OUTOKUMPU

Duplex Stainless Steel

"Dual Phase" ~ 50-60 % austenite

Corrosion Resistance ↓

EN	ASTM	Outo-kumpu	Cr	Ni	Mo	C	N	Other
			Typical Chemical Composition, %					
1.4401	316	4401	17,2	10,2	2,1	0,04	-	
1.4162	S32101	LDX2101	21,5	1,5	0,3	0,03	0,22	5Mn
1.4362	S32304	2304	23	4,8	0,3	0,02	0,10	
1.4462	S32205	2205	22	5,7	3,1	0,02	0,17	
1.4410	S32750	SAF2507	25	7	4	0,02	0,27	

OUTOKUMPU

OUTOKUMPU

Heat resistant grades

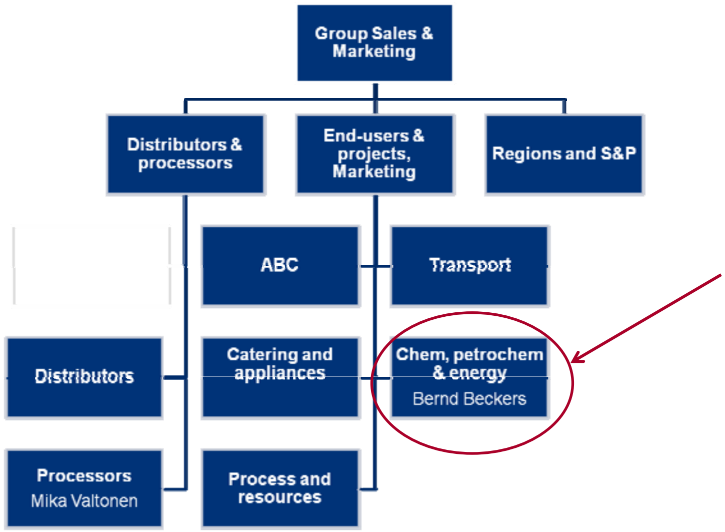
	Outokumpu	EN	ASTM	Typical composition, % C	N	Cr	Ni	Si	Others
Ferritics	4713	1.4713	-	0.08	-	6.5	-	0.8	Al, Mn
Ferritics	4724	1.4724	-	0.08	-	13.5	-	1.0	Al, Mn
Ferritics	4742	1.4742	-	0.08	-	18	-	1.3	Al, Mn
Ferritics	4762	1.4762	-	0.08	-	24	-	1.4	Al, Mn
Austenitics	4948	1.4948	(304H)	0.05	-	18.3	8.7	0.5	-
Austenitics	4878	1.4878	(321H)	0.05	-	17.5	9.5	0.5	Ti
Austenitics	153 MA™	1.4818	S30415	0.05	0.15	18.5	9.5	1.3	Ce
Austenitics	4833	1.4833	309S	0.06	-	22.5	12.5	0.5	-
Austenitics	4828	1.4828	-	0.04	-	20	12	2.0	-
Austenitics	253 MA®	1.4835	S30815	0.09	0.17	21	11	1.7	Ce
Austenitics	4845	1.4845	310S	0.05	-	25	20	1.0	-
Austenitics	4841	1.4841	314	0.05	-	25	20	2.0	2.0 Mn
Austenitics	353 MA®	1.4854	S35315	0.05	0.15	25	35	1.3	Ce

Micro alloying (MA) = Addition of small amounts of specific elements

Outokumpu Business Units

- Tornio Works
- Avesta Works
- Hot Rolled Plate
- Thin Strip
- Long Products
- Tubular Products

Group Sales & Marketing overview



Research centres

Avesta Research Centre, Sweden

- 70 employees
- Development and characterisation of stainless steel grades in terms of physical metallurgy, welding, corrosion and high temperature properties
- Development of new products, offer end-user process knowledge about forming, machining, mechanical properties etc.
- Training of customer and own staff, sales promotion, publications and customer support

Tornio Research Centre, Finland

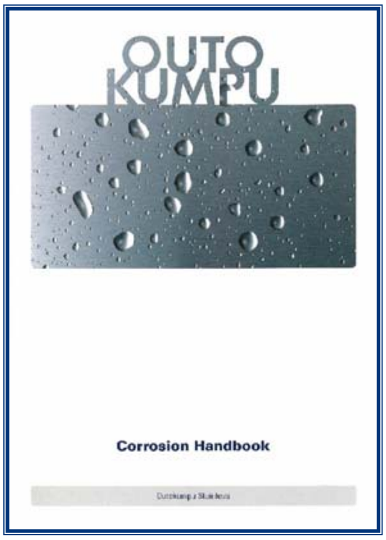
- 120 employees of which about 60 directly involved in R&D
- Focus on process development and ferritic grades

R&D helping our customers to be more competitive

- Technical support related to properties of stainless steels
- Technical support related to fabrication of stainless steels
- Advice in selection of best and most competitive steel
- Evaluation of steel performance in customer's applications
- Tailored development of even better steels to meet customer's needs

Corrosion handbook

- 10th edition, the first "Corrosion tables" were published in 1934
- Introduction to corrosion resistance of stainless steel and papers describing corrosion related issues within different industrial sectors



Stainless solutions to customers

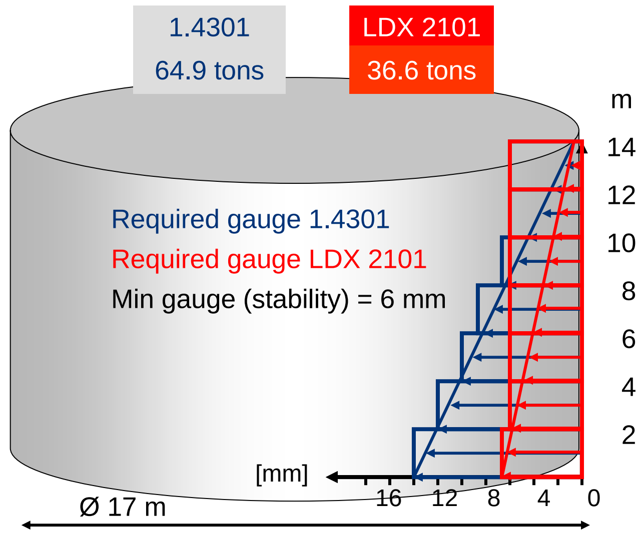
Tanks for storage and transportation

- Replacing standard stainless and mild steel
- Sufficient corrosion resistance
- Weight reduction

Road tanker LDX 2101

Liquor tank 2304

Tanks & towers, web calculation tool



Oil & Gas

Oil & gas

Pressure pipes in 4565 for offshore

Elbow in 4565

T-Pieces in 4565

Activating Your Ideas.

Appendix 9

Financial considerations of use of duplex/superduplex steels with two cases taken from refineries

Miklos Kantor (Sandvick)

Financial conciderations of use of duplex/super duplex steels with two cases taken from refinary applications

EFC – WP 15 Corrosion in Refinery Meeting

MOL, Hungary June 22nd 2010

Miklos Kantor
Sandvik Materials Technology in Hungary
Product Manager

General evaluation of material grade selection

- The raw material (crude oil which the refineries receive) changes from time to time as the exploitation in the oil fields goes ahead
- That might mean a bit different chemical composition from time to time
- That means change at the critical points of the process
- That means new challenges (Not sure if a problem was solved 10 years ago it is still 100% good even today)
- The laboratory tests and examinations can help a lot, but to create an exact model which reflects exactly the reality is practically in the majority of the cases impossible
- Result: Request for new materials which prooves a wider safety range

Oil refinery heat exchangers

Typical corrosions

General corrosion, under deposit corrosion
SCC – stress corrosion cracking
Hydrogen attack
Erosion corrosion- tube ends

Common Materials

Carbon and Low Alloy Steels - up to 12%Cr
Stabilised or ELC austenitic stainless steels
Ferritic stainless steels
Brasses, Bronzes
Duplex SAF 2205, SAF 2507, SAF2707HD
Titanium + Ni alloys

1. Sample No.1172-6 atmospheric column overhead condenser 6 identical units

Plant: AV-3 Crude distillation unit (capacity: 3 M tons/year)

Process: producing straight run hydrocarbon fractions for further processing from Russian export blend and internal slop oil by atmospheric and vacuum distillation

Loss in case of 1 day total production stop 421 040 USD

SERVICE CONDITIONS:

Tube side: treated cooling water
temp. inlet 26°C
temp. oulet 40°C
pressure: atm.

Shall side: condensing heavy gasoline and water vapours
tempr. inlet 175°C
tempr. oulet 50°C
pressure: atm.

Presently used tubes: mat grade:A35.29

1 unit 879 pcs 25x2,5-6000mm Unit weight of 1 equipment: 13,5 tons

Sandvik Materials Technology SANDVIK

Cost and maintenance review with the presently used C-steel tubes (A35.29)

(Based on the data from MOL Plc..)

Period: 2006.05.08- 2010.01.08.

44 months

Equipment Nr.: (operating paralelly)	Days causing proportional shut down	Maintenance costs total USD	Loss due to the shut downs USD	Total costs USD
F DAV3 172-1	37	135 870	2 596 413	2 732 283
F DAV3 172-2	24	42 138	1 684 160	1 726 298
F DAV3 172-3	19	129 061	1 333 293	1 462 354
F DAV3 172-4	17	111192	1 192 947	1 304 139
F DAV3 172-5	3	18 795	210 520	229 315
F DAV3 172-6	1	44 585	70 173	114 758
Total	101	481 641	7 087 507	7 569 148

Corrosion in CDU OH condensers

- **Corrosion in CDU OH condensing systems is a very common problem for most refineries worldwide using C- steel tubes**
- **Impurities present in many crudes can be highly corrosive for CDU service conditions due to presence or formation of:**
  - ✓ **chlorides (inorganic and organic)**
  - ✓ **hydrogen sulphide**
  - ✓ **strong acids**
  - ✓ **salts & deposits**

- Material choice of high importance to assure the CDU OH system integrity and reliability
- Corrosion rate influencing the overall system performance

Why Duplex, or superduplex Stainless Steels ?

- Because so can be eliminated the
  - ✓ General corrosion of carbon steel
  - ✓ Localised corrosion and SCC of standard austenitic stainless steel
  - ✓ Erosion and special corrosion problems
  - ✓ High cost of Ni-based alloys and other special metals
- Excellent mechanical properties
- Fabrication compatibility with C-steel

✓Super duplex stainless steel SAF 2507 has demonstrated to be a cost- effective solution for retubing of old C-steel Crude Distillation Unit and Vacuum Distillation Unit OH condensers

Possible solution to save cost
Use of Sandvik superduplex SAF 2507 tube bundle

Other parts of the CDU OH condenser (e.g. tube-sheets) may be left with traditional selection

Suggested mat grade: SAF2507 / UNS S32750

We can reduce the WT due to use of duplex/superduplex steel with higher tensile strength and much higher corrosion resistance 25x2 instead of 25x2,5mm

This means 1318kgs less weight/ 1 unit Altogether at the 6 identical unit 6x1318 = **7908kgs weight saving**

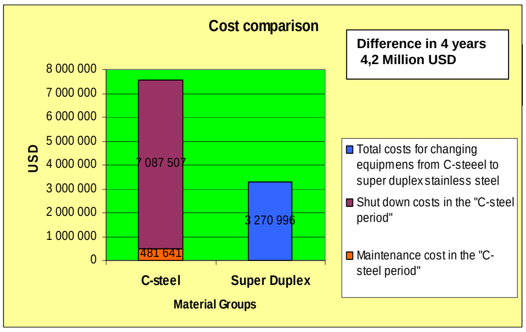
Calculated costs changing the tube bundle from C-steel to SAF2507 superduplex

(Calculation is made by well known expertized hungarian companies)

1 unit manufacturing cost	528.366 USD
Installing, assembling cost of 1 unit	16.800 USD
Total cost of 1 unit	545.166 USD
Total cost of change of the 6 units	**3.270.966 USD**

Comparison between the „C-steel” and the estimated „superduplex steel” period

	Installation cost USD	Maintenance cost USD	Shut down cost USD	Total USD
Traditional situation with C-steeel (period 44monts)	0	481 641	7 087 507	7 569 148
New situation with Superduplex steel (estim. 48 months)	3 270 996	0	0	3 270 996
Difference between the 2 periods				**4 298 152**



Here the amortization of the new installaion is not indicated, which should increase the difference

2. Sample No.W 104 1- 4 finned tube Reactor Effluent Air Cooler 4 identical units

Plant: HDS Hydrogen Desulphurization Unit

Process: producing low sulphur and nitrogen feed for Fluid Catalytic Cracking (FCC) Unit from broad hydrocarbon (HC) fraction by high pressure hydrogenation

Loss in case of 1 day total production stop 238 360 USD

SERVICE CONDITIONS:

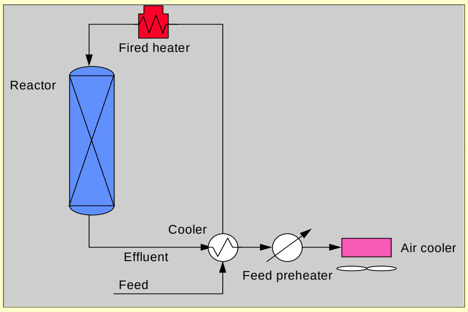
Tube side: Circulation gas (HC + hydrogen + H2S + ammonia + water vapour or steam)
temp. inlet 175°C
temp. outlet 65°C
pressure: 72 bars

Shall side: Ambient air

Presently used tubes: mat grade: EN 1.4462 / UNS 31803, aluminium outside finned

1 unit 148 pcs 25x2,5-6000mm (finned) Unit weight of 1 equipment: 5,8 tons

Hydrodesulphurisation (HDS)



Specific Problems

Chlorides
- SCC
- Ammonium bisulphide
- Erosion,
- Under-deposit
- Polythionic acid
- Intergranular corrosion

Feed/Effluent Exchanger
SAF 2205, TP 321, TP 347

Reactor Effluent Air Cooler (REAC)
SAF 2205, SAF 2507, Sanicro 28, Alloy 825,

Cost and maintenance review

(Based on the date from MOL RT.)

Cost and maintenace revue due to the failure of the earlier used C-steel tubes (St35.8)

Previous (C-steel) period 2004.01.-2006.05.08.
28 months period

Days (total unexpected production stop)	Loss in case of 1days total production stop (USD)	Maintenance costs USD	Loss due to the unplanned shut downs USD	Total costs USD
12	238 360	62 800	2 860 320	2 923 120

Cost and maintenace revue of the "present" priod with duplex tubes (1.4462)

Mainly cleaning and repair of ventillation units (failures are not caused by the tubes)

New (duplex) period: 2006.05.08- 2010.01.08.
44 months period

Equipment:	Maintenance costs total USD (did not cause shut down, or considerable production loss)	Enduser did not have problems with the tubes in the investigated 44 months period (2006.05.08-2010.01.08) Total costs (USD)
F DHDS W104-1	5 703	
F DHDS W104-2	711	
F DHDS W104-3	10 531	
F DHDS W104-4	3 318	
	20 263	20 263

Transition costs from C-steel to duplex

(Calculated values are from well known expertized companies in Hungary)

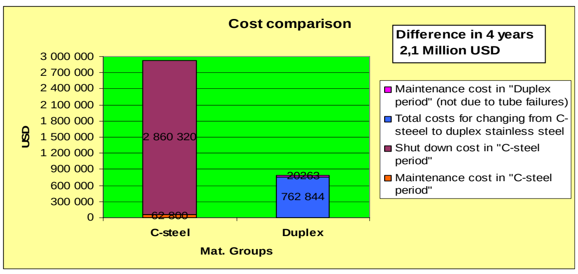
Manufacturing of 1 unit (mat. grade S31803 / EN1.4462)	**183.011 USD**
Installing, assembling cost of 1 unit	**7.700 USD**
Cost of total change of 1 unit	**190.711 USD**
Total cost of change at all the 4 units	**762.844 USD**

Comparison between the „C-steel" and the „Duplex steel" periods

Cost of changing equipments from C-steel to duplex steel	762.844 USD
Maintenance cost due tu tube failures in the 44 monts period with duplex	0 USD (NO FAILURE)
Maintenance costs due to the failure of ventillators	20.263 USD
Total costs for changing from C-steel to duplex stainless steel	783.107 USD

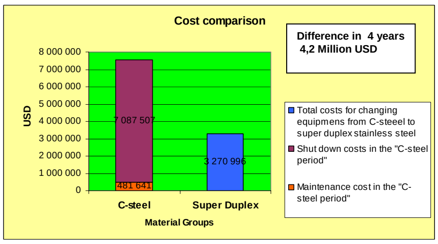
Maintenance cost in the past 28 months period with C-steel tubes	62.800 USD
Shut down cost in the past 28 months period with C-steel	2.860.320 USD
Total cost in 28 months period with C-steel	2.923.120 USD

Difference between the 2 periods **2.140.013 USD**



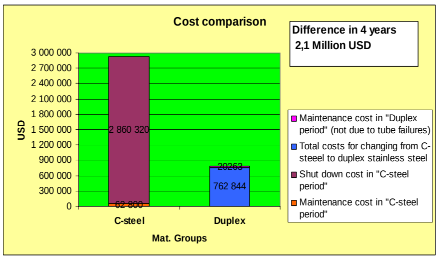
Here the amortization of the new installaion is not indicated, which should increase the difference

Summary



6 units overhead condenser		
Installation	3 270 996	USD
"Interest" in 4 years	4 298 152	USD
"Interest" for 1 year	23,30%	

Would you accept such interests from a bank ?



4 units air cooler		
Installation	783 107	USD
"Interest" in 4 years	2 140 013	USD
"Interest" for 1 year	39,70%	

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End

Thank you for your attention !

Sandvik Materials Technology

SANDVIK

Appendix 10

Material acceptance criteria for standard

NACE MR 01 03

Jonas Höwing (Sandvick)

Material acceptance criteria for standard NACE MR0103

Jonas Höwing

Sandvik Materials Technology

NACE MR0103

- **To qualify a material for NACE MR0103 it has to pass the acceptance criteria described in NACE TM0177**
  - ✓ **NACE TM0177 describes tests for down hole services**

- **Super duplex should be able to withstand**
    - 25% NaCl
    - pH = 3
    - 3 psi H_2S
    - 90°C (worst temperature for duplex) and/or 232°C (max temp.)
  - ✓ **…or**
    - 5% NaCl
    - 0.5% acetic acid (pH = 2.6 - 2.8)
    - Saturated with H_2S
    - 24°C

NACE MR0103

- The environment in refineries is much more controlled
  - Is testing according to NACE TM0177 relevant when qualifying material for NACE MR0103?
  - Alternative testing standard needed?

Appendix 11

Lean duplex stainless steels in refineries

György Isaak (Mol)

Lean Duplex Steels in Refineries?

György Isaák (MOL DS Development)

EFC WP 15 Meeting Budapest, 22. 06. 2010

MOL GROUP

- <u>Content</u>
- Drivers for material upgrading
- Lean duplex vs. Austenitic stainless
- Economic considerations

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Drivers for Material Upgrading

✓Processing more challenging feedstocks
✓Need for longer operational cycles
✓Need for increased operational safety
✓Need for cleaner products
✓Reduction of inspection and maintenance costs
✓Elimination of chemicals, coating and CP costs
✓Higher strengths allows lighter equipments

and last but not least

✓Reduction of price difference between CS and SS

What are the obstacles?
Not long enough experience – lack of information
No joint efforts to make field trials
Conservative design practices

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Lean duplex vs. Austenitic stainless

What steel producers claim:

✓The newest development of lean duplex steels are as corrosion resistant as 304SS
✓In some applications approaching 316SS performance
✓Their strength is about twice of 316SS
✓Their weldability and machining properties are superior
✓Due to their hardness they are more resistant to wear and erosion
✓Their prices are stable, not influenced by Ni and Mo price volatility
✓And so forth…..

Why don't we use them in the oil industry – except some sporadic Upstream applications ?

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Economic considerations

No.	Tube Material	Size	Min. Qty (pieces)	Price EUR/m
	Cold drawn pipes			
1	Carbon steel P235GH	20x2,0x3000	200	2,25
2	304L austenitic stainless 1.4306	20x2,0x3000	375	8,35
3	316L austenitic stainless 1.4435	20x2,0x3000	375	11,85
4	2205 duplex stainless 1.4462	20x2,0x3000	375	11,55
5	2507 duplex stainless 1.4410	20x2,0x3000	375	15,70
6	Lean duplex stainless: - 2202,- 2304 or - LDX 2101,- AL 2003	20x2,0x3000	375	9,85

No.	Tube Material	Size	Min. Qty (pieces)	Price EUR/m
	Cold drawn pipes			
1	Carbon steel P235GH	25x2,5x3000	200	3,25
2	304L austenitic stainless 1.4306	25x2,5x3000	375	11,90
3	316L austenitic stainless 1.4435	25x2,5x3000	300	16,65
4	2205 duplex stainless 1.4462	25x2,5x3000	245	16,10
5	2507 duplex stainless 1.4410	25x2,5x3000	245	22,25
6	Lean duplex stainless: - 2202,- 2304 or - LDX 2101,- AL 2003	25x2,5x3000	245	14,15

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Appendix 12

Cast valve quality

Martin Richez (Total)

Cast Valve Quality

Martin RICHEZ

EFC WP 15 – 22 June 2010 – M. RICHEZ

Facts

- **Beginning of 2009, during start up of a new Styrene unit of Gonfreville (TOTAL Petrochemicals) 6 valves are found leaking.**
- **Mecanical test made on defective valve bodies have shown :**
  - Low impact toughness results, despite MTR showing good values
  - Lack or incorrect thermal treatment
  - Weld repairs without heat treatment
  - Numerous metallurgical defects: cracks, porosities, shrinkage cavities
- **Valves are officially made by a European manufacturer with the CE conformity attestation. But they are really made in China.**
- **European Pressure Equipment Directive requires 27 J at minimum design temperature**
- **Equipment concerned : check valves, globe valves, and gate valves in A 216 WCB and A 352 LCB since 2006**
- **Main risk : sudden failure by brittle fracture and drainage of all the contained fluids ?**

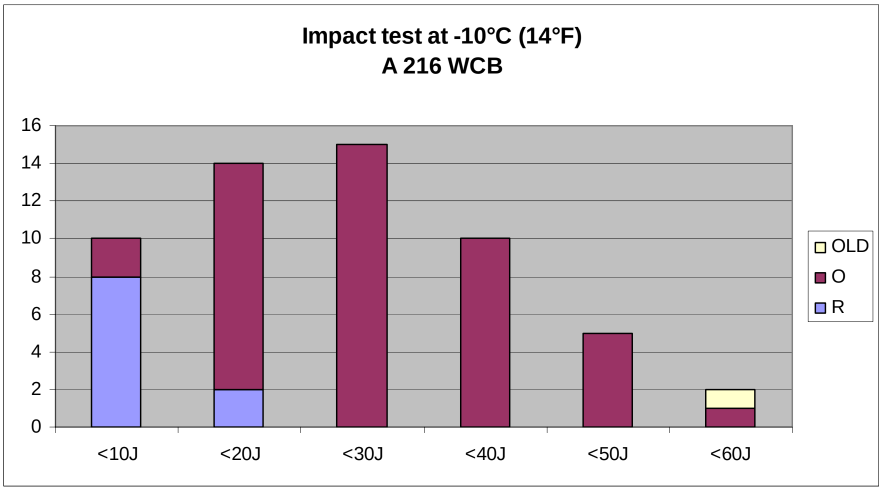
Type of defects found

Lot of article in news papers and action taken by the French administration

Situation in France

- ≈ 8000 valves have been installed in the French industry.
- French administration position depends of the region.
- Some requires the removal of all valves, some other the inventory on critical services and an action plan.
- Specific shut-down may be require.
- A specification for valves body has been written :
  - Restricted composition
  - Heat treatment limited to normalized or quench and tempered (A 216 WCB)
  - The ingot for testing shall be attached to the valve body or be a valve body
  - Clear definition of a lot.
  - Limits on repairs

- What about the quality of other valves ?
- According to ASTM A216 valves shall be annealed, normalized or quench and tempered.
- Should be good down to -29°C (-20°F°) but no requirement of impact testing…
- Impact testing required according to PED but
  - It can be done at 20°C (68°C)
  - The ingot for tests may not have the same heat treatment that the valves (not the same heat, not the same thermal inertia, simulated heat treatment)
  - A paper is only a paper…
- More than 50 valves tested from different manufacturers:
  - No major problem of composition or mechanical strength
  - Limited defects
  - But…



Conclusion

- Heat treatment is not made properly. That leads to high grain size, improper structure and low impact test (only one valve was recognized as being correctly heat treated)
- Nearly all manufacturers are affected
- PED and the intervention of notified body is not a effective barrier
- PED will be modified to define criteria for the nomination of notified body and to increase their supervision activity.

Appendix 13

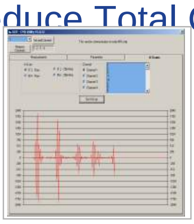
Rightrax corrosion monitoring

Claudia Lavarde (GE)

GE Energy- Sensing & Inspection Technologies

Rightrax Corrosion Monitoring

Reduce Total Corrosion Costs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You asked . . .

Industry Requirements

- ✓Automatic Temperature Correction
- ✓Provides data to be utilized with Risk Base Inspection database
- ✓Ability to trend; demonstrate corrosion rate over selectable periods of time
- ✓Remaining life calculations
- ✓Provides data to optimize chemical inhibitor use

We listened

Preferred Features

- ✓Reliably operates at temperatures ranging from
  - ✓-40 °C to 350 °C/500°C
- ✓A-Scan captured & digital measurements of thickness
- ✓Software provides warning, alarming, trending & remaining life calculations
- ✓Analyzed results can be used for life calculations of assets
- ✓Manual & Automated systems can be used as part of solution for optimizing chemical inhibitor use

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Upstream Solutions

Key Features

•Up to 120°C

•Non intrusive

•ATEX Certified Safe Systems/Solution Available

•Alarmed

•Accuracy= 0.05mm

•Repeatability= 0.1mm

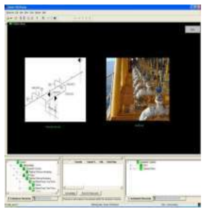
Applications

• Material Erosion + General Corrosion

•Erosion on Flow Lines

•Manned / Unmanned platforms / FPSO's

Manual



Automated

Mid Stream Solutions

Problem Addressed

•General Corrosion & Erosion

•Variable accuracy of manual inspections

•Low percentage of pipelines are "piggable"

•High cost of inspections

Applications

•Buried Pipelines -Tank Walls & Roofs - LNG Terminals-Ship to Shore Pipelines

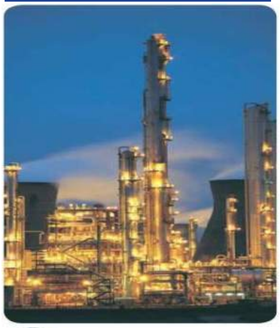
•Excellent Compliment to pig inspection runs, cathodic protection, and area inspection using Guided Wave techniques

Manual

Automated

Downstream Solutions

Key Features



- •Up to 350°C/500°C
- •Non intrusive
- •Various Pipe Diameters 3” up to 24” with standard clamping design , customization for larger diameters
- •Intrinsically Safe Systems/Solution
- •Accuracy = 0.0025mm
- •Repeatability = 0.01mm

Applications

- •General Corrosion in High Temperature Crude Lines
- •Critical Locations-High Temperatures
- •Enables fast detection of High Total Acid Number (TAN) corrosion
- •Response time and data points to control chemical corrosion inhibitors influencing production

Manual

Automated

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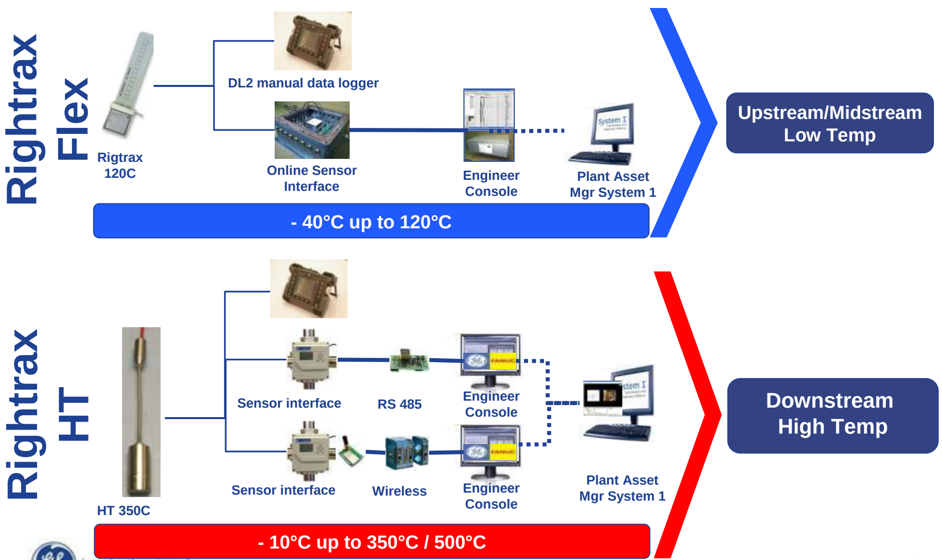
Online Corrosion Monitoring

Two product lines for corrosion and wall thickness monitoring available



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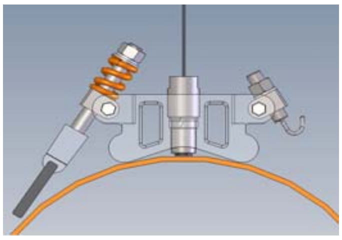
Non Intrusive sensors



Sensors simply bond or
are clamped onto the inspection area

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Remote access to corrosion data, eliminating, excavations, erect scaffolding, remove insulation or shut down plants.

Excavations

Rope access

Remove Insulations

Scaffoldings

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HT System

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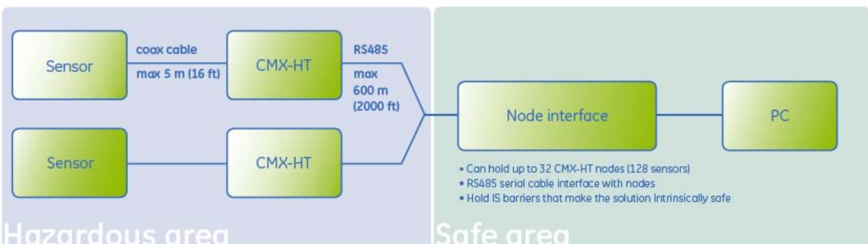
Rightrax HT – The System

Consists of four basic elements:

- The HT350x ultrasonic high temperature sensor
- The CMX-HT sensor node
- The Node Interface and IS Barriers
- Data acquisition and data analysis software



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Core element the HT-350x sensor

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GE Proprietary Information
For Internal Use Only

<350/500°C

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The HT350x Sensor, Key Features

- Single element sensor
- Intrinsically safe certification
- Thickness range 3 mm - 19 mm
- Temperature range -20°C - 350°C/500°C
- 5 m cable length to CMX-HT sensor interface
- Suitable for pipe diameters of 3” up to 24” with standard clamping design
    - Customization for larger diameters
- Nominal operating frequency of 5MHz
- Coupling is achieved through gold foil

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<350/500°C

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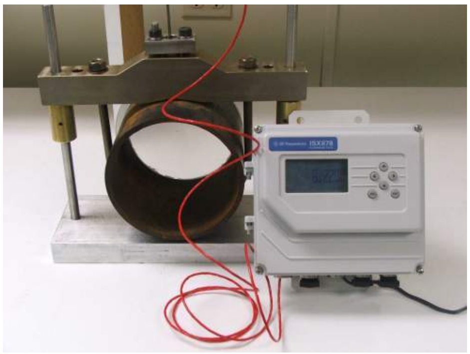
The CMX-HT node

- **Intrinsically safe sensor interface box**
- **Supports up to 4 HT350x sensors**
- Connect to the system node interface using a RS485 cable
- Each sensors returns
  - Time of flight interface echo
  - Time of flight back wall echo
  - Ascan
- Driven by the CMX data acquisition software
- Does not store data



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<350/500°C

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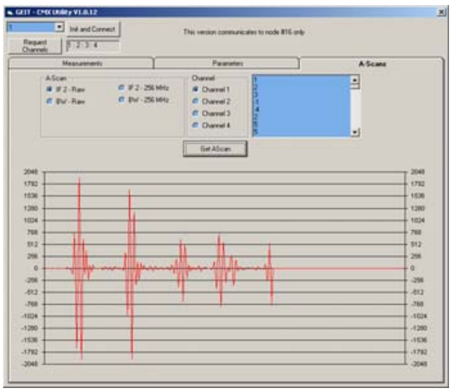
Data Acquisition & Data Analysis Software

Functionalities include:

- Temperature-corrected thickness
- Alarms for thickness levels and corrosion rates
- Minimum/Maximum/Average thickness
- Short term and long term corrosion rates
- Maximum corrosion rates
- A-scans to verify signal accuracy



All values can be exported to third party systems by industry standard OPC, Modbus, or in CSV data file format

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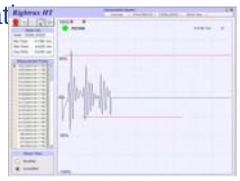
Data Acquisition & Data Analysis Software

Screen displays tailored to suit specific requirements.

- Global view, showing sensor locations
- Local view, showing site locat
- Node views
- A-scan
- Trend plot
- Alarm lists
- Tabulated data
- Diagnostics overview

Global View



AScan View

Local View Example

Node View Example

Integration to Plant Asset Management Systems

Interface with asset management systems such as

OC System 1, enables

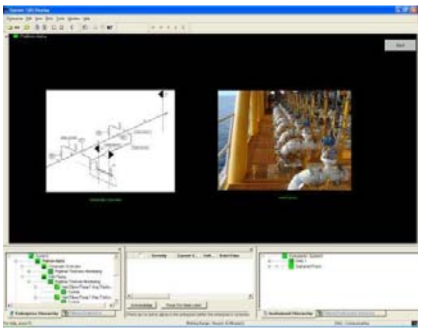
the **time stamped correlation**

of absolute wall **thickness**

and corrosion rates **to critical process variables**

such as temperature, pressure, flow,

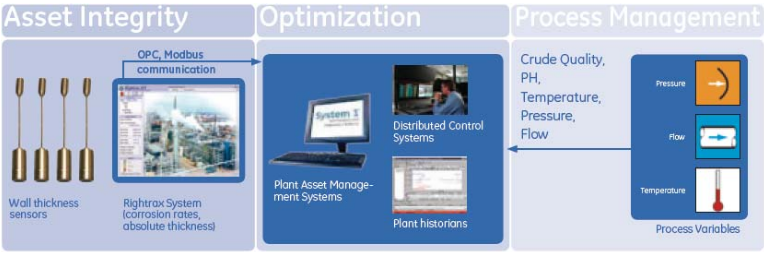
crude quality, and chemical injection.



Value Proposition– Online Corrosion reliable data

Improve Productivity :

•Can ensure that plant uptime is maximized
•Allow to process opportunity crude:
Wall-thickness data taken at selected critical points can help support chemical injection systems to effectively manage corrosion rates.



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Value Proposition– Online Corrosion reliable data

Decrease inspection cost

Provides wall-thickness data on-line without the need to erect scaffolding, remove insulation or excavations.
Reduce inspection cost

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Value Proposition– Online Corrosion reliable data

Improve plant safety

Prevent failure and unscheduled shutdowns

or accidents are very costly

- •Environmental damage
- •Loss of production
- •Large fines
- •Repair cost
- •Damage of reputation & image

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LT System

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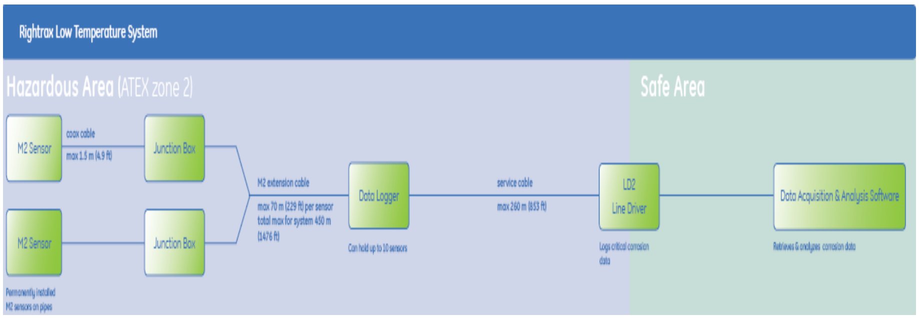
Rightrax LT – The System

Consists of four basic elements:

- The Multi element sensor: 14 sensors elements
- The ATMS Data Logger
- The LD2 Line driver
- Data acquisition and data analysis software



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The M2 Sensor, Key Features

- Multi element sensor: 14 sensors elements
- 12mm by 200mm inspection coverage
- Thickness **range <u>5 mm <> 100 mm</u>**
- Temperature range **<u>-40°C / 120°C</u>**
- Self Calibrating, programmable identification, Built in Temperature chip
- Suitable for pipe **<u>diameters of 6”</u>** and above

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GE Proprietary Information
For Internal Use Only

<120°C

imagination at work

Functionality DL2

- DL2Works with **M2** Rightrax sensors
- **Store up to 100 complete M2 measurements**
- **View M2 sensor elements in live mode**
- Ease of use, unskilled personnel
- **Connect to PC with RS232 to download measurements**
    - Using the complementary software packet WinHostp
- Carry case, battery charger and cables included

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<120°C

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GE Title or job number /
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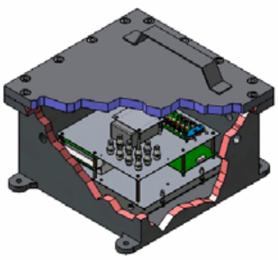
The ATMS Data Logger

(Automated Thickness Measurement System)

- Flaw detector with intelligent Decision making software
- **Makes direct measurements in millimeters**
    - Software converts to inches
- **Built-in 10 way multiplexer to connect 10 M2 sensors**
- **Connect to LD2 line driver with multi-core cable**
    - Providing Serial RS232 connectivity with the PC



GE Proprietary Information
For Internal Use Only

<120°C

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The LD2 Line driver

•Powers the data logger with **24 Volts DC**

•**Provides RS232 communication between the ATMS data logger and the PC**

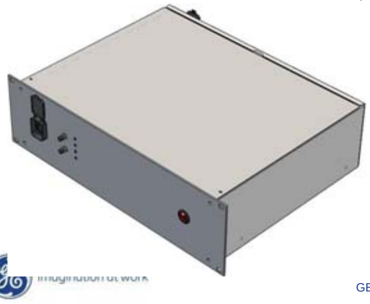
•Is placed within the control room or other nominated safe area

•Is fitted with a Single Board Computer (SBC) which is used to manage the operation of the system using proprietary software pre installed.

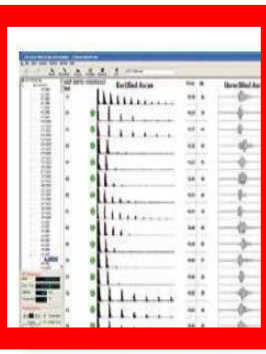
•Can be supplied in a 19” rack mount enclosure

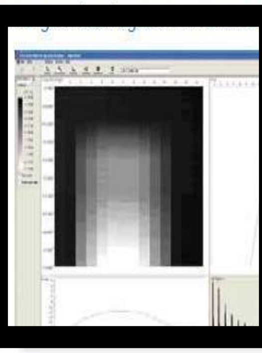
•Can be supplied in wall mounted cabinet for installation outside safe areas

•Provides MODBUS RTU and VFC outputs



Rightrax LT Reporting & Analysis Views





A-scan View

Showing individual measurements

Map View and B-scan View

Showing Overall

Trend View

Showing Overall Corrosion Rates

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Appendix Slides

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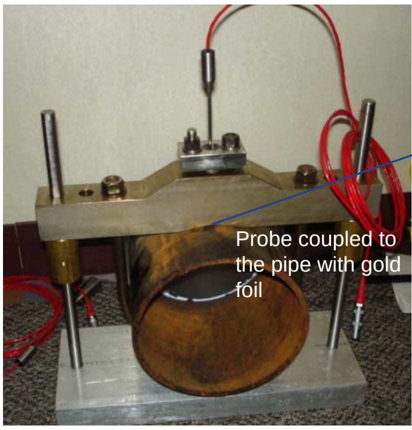
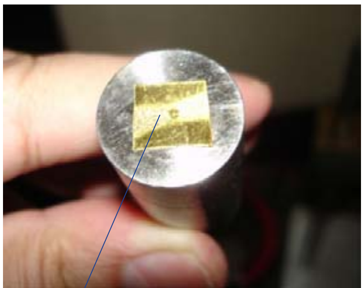
High Temperature Sensor

Probe Setup





2 mil Gold foil

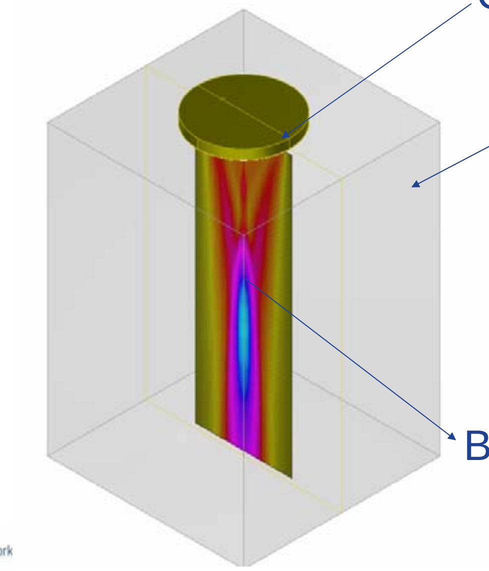
Coupling mark about 3mm wide

CIVA model

Crystal

Probe Delay

.7” thickness



Beam analysis

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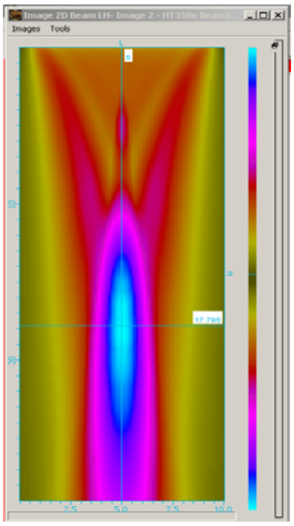
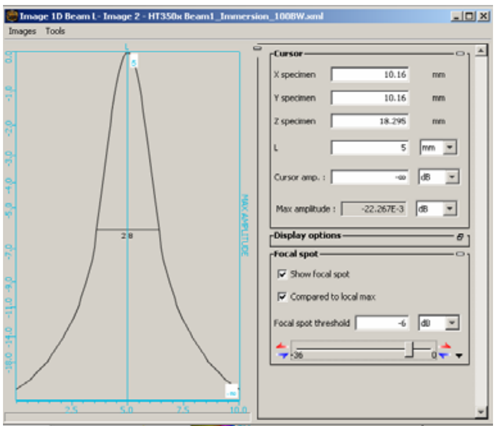
Acoustic beam in the delay





Beam profile at the delay tip or probe/pipe IF

3 dB width = 1.9 mm

6 dB width = 2.8 mm

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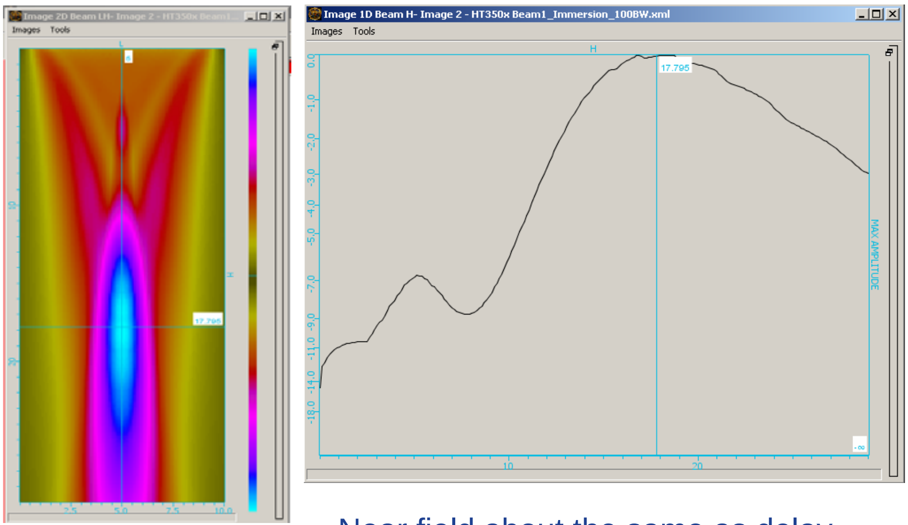
Axial Acoustic beam- Near field



Near field about the same as delay length .7”

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High Temperature Clamping Systems

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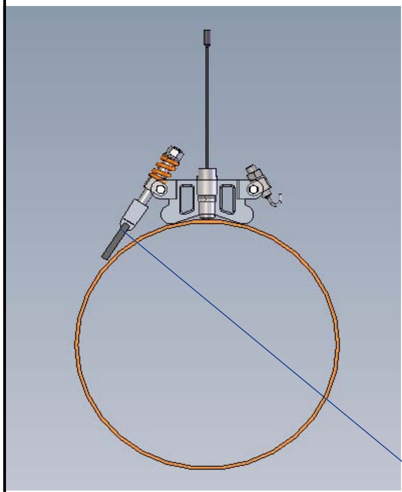
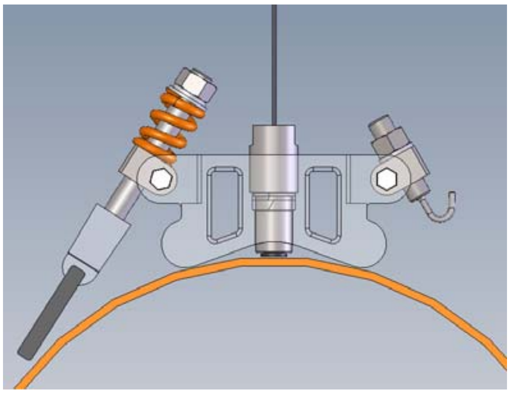
The HT Sensor Clamp

Large pipes: 8”-30”



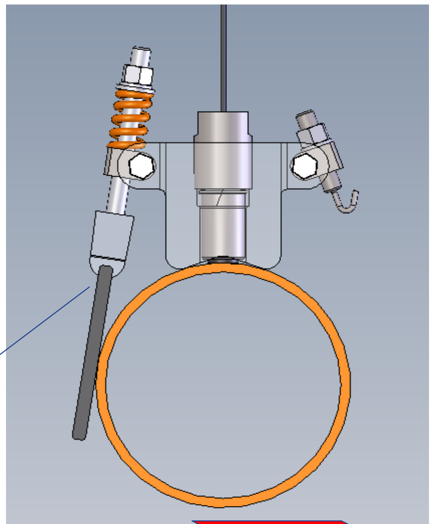


SS Chain

<660°F

The HT Sensor Clamp

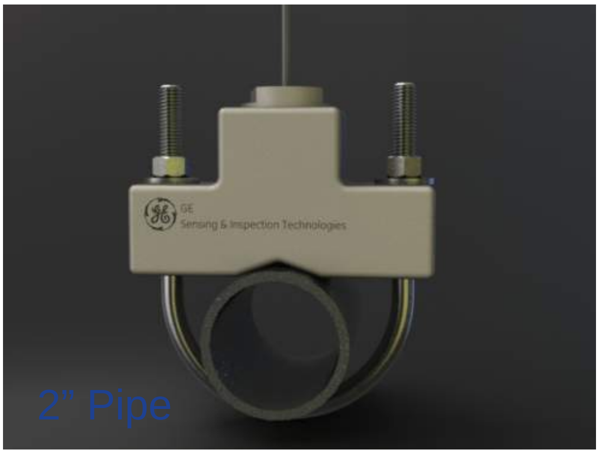
Small pipes: 3”-8”



SS Chain

<660°F

Small HT Piping Clamps



2" Pipe

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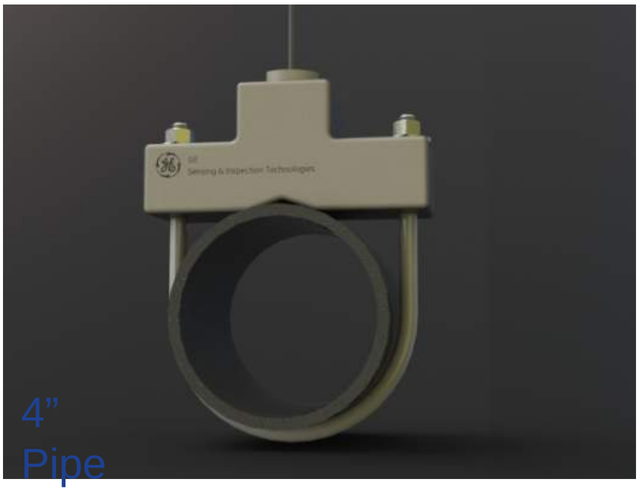
Small HT Piping Clamps



4" Pipe

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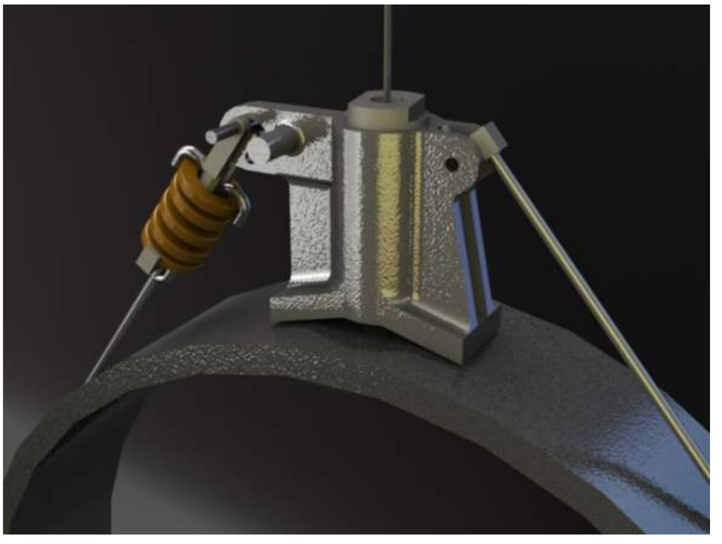
Adjustable HT Clamping Systems



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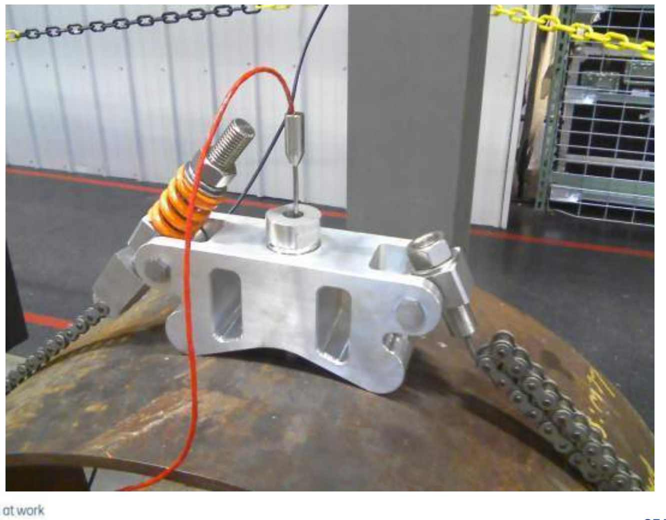
Chain Clamp system on actual 30” pipe



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Chain Clamp mounted on 24” crude line

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Four (4 ea.) Chain Clamps mounted on actual 24”crude line

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Low Temperature Sensor

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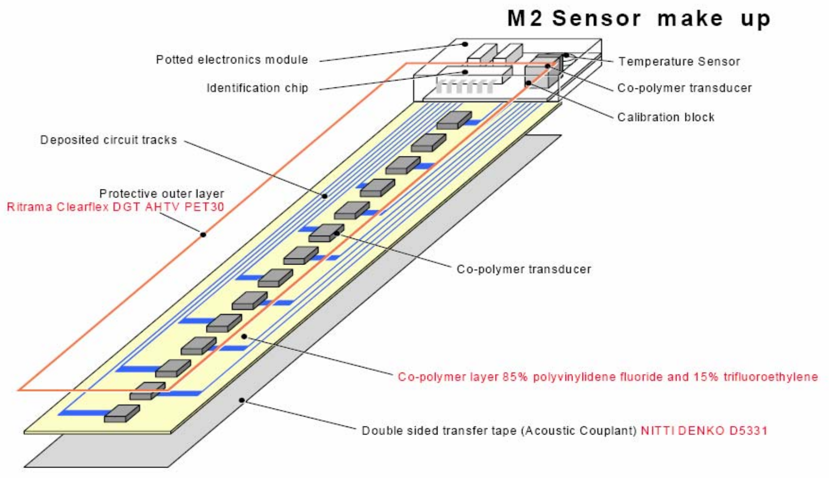
The M2 Sensor, Schematics



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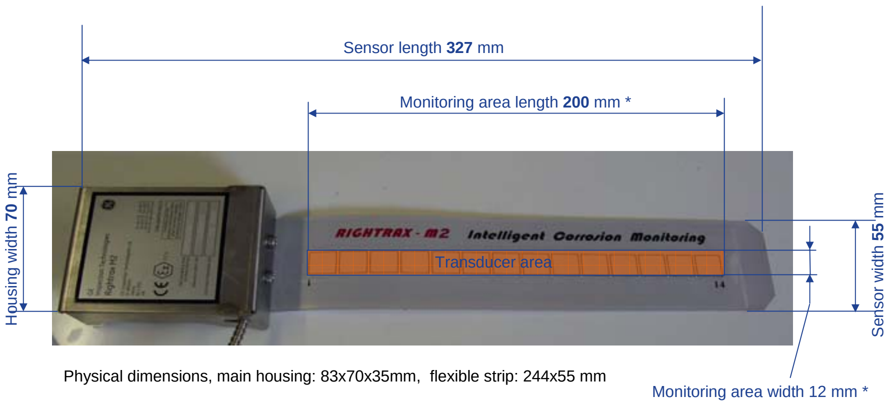
The M2 Sensor, Inspection Area



Physical dimensions, main housing: 83x70x35mm, flexible strip: 244x55 mm

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The Value Chain - Your Choice

The Transfer Function

Wall thickness Loss = Crude Quality +Chemical Inhibitors+ Operating Temp+ Ageing Assets+Fluid Dynamics

Improve Safety and Reduce Inspection Costs

Safety = less labor+less scaffolding+automation+ less risk+defined damage mechanisms

Improve Environmental Health & Safety & Revenue

EHS $

EHS & Revenue = reduce unscheduled shutdowns+loss of capital equipment+hazards to personnel+ pollution to the environment+increase revenue

Appendix 14

Microbiologically influenced corrosion: association with biofilm, monitoring and removal

Davor Kesner (GE)

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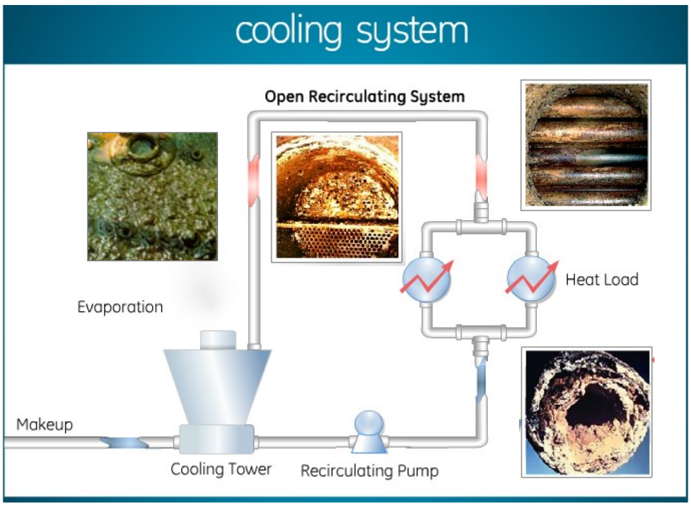
Microbiologically Influenced Corrosion - Association with Biofilm, Monitoring and Removal

GE Energy – Power & Water
Davor Kesner

Common problems



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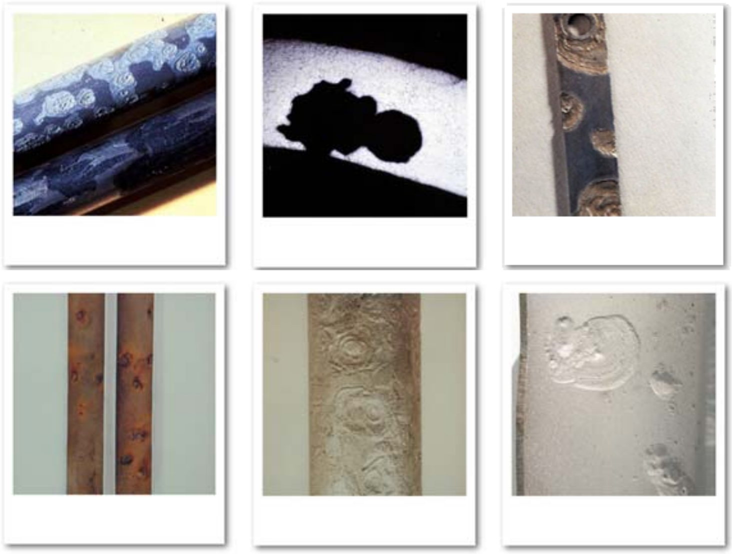
Does this problems looks familiar?



Microbiological Corrosion

Passive attack

- biological product accumulation
- large surface area involved
- concentration cell development
- underdeposit corrosion

Active attack

- local environment is altered, (lower pH, higher conductivity, etc…)
- accelerate or establish new electrochemical reactions
- production of corrosive products
  - Inorganic acids
  - Sulphides
  - Ferric chloride
  - Organic acids
- known as **MIC**

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Mechanism of MIC

Destabilisation of anodic and cathodic sites by reaction with corrosion products

Anode - Oxidation of ferrous to ferric ions, removal of ferrous ions by precipitation with sulphide ions

Depolarisation reactions accelerate corrosion rate

Cathode - Hydrogen removed by reduction of sulphate to form hydrogen sulphide

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Bad Bugs

Sulfate Reducers
- *Desulfomonas*
- *Desulfovibrio*

Metal Depositors
- *Gallionea*

Acid Producers
- *Thiobacillus thiooxidants*
- *Clostridium*

Slime Producers
- *Pseudomonas*

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Sulfate Reducing Bacteria

Anaerobic Bacteria that reduce SO_4 to H_2S

- Grow in low/no oxygen conditions
- Reduce sulfate to sulfide
- Often associated with MIC
- Cause cathodic depolarization

$$8H + SO_4^{2-} \xrightarrow[SRB]{} S^{2-} + 4\,H_2O$$

$$4\,Fe + SO_4^{2-} + 4\,H_2O \rightarrow 3\,Fe(OH)_2 + FeS + 2\,OH^-$$

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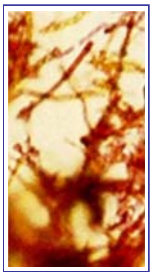
Metal Depositors

Iron and Manganese Oxidizing Bacteria

- Oxidize ferrous (Fe^{+2}) iron to ferric (Fe^{+3})
- Found in neutral pH environments
- Some bacteria oxidize manganese
- *Gallionella* bacteria



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Acid Producers

Thiobacillus thiooxidans

- Aerobic bacteria
- Oxidize sulfide or elementar sulfur to sulfate
- Some strains oxydize sulfur into sulfuric acid creating low pH environment (pH < 1)
- Symbiotic growth with SRB's

Clostridia

- Anerobic bacteria
- Produce short chain organic acids
- Found beneth deposit

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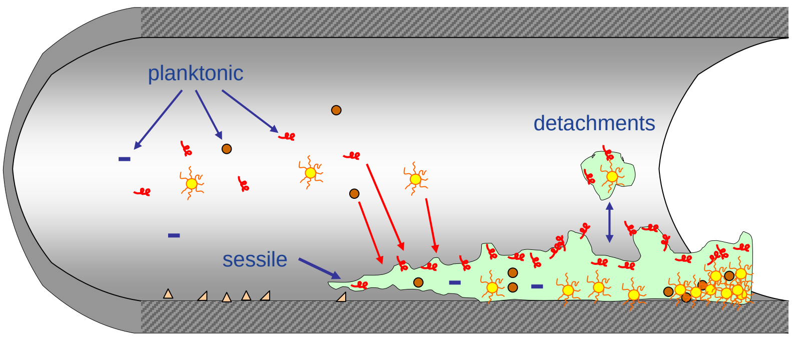
Planktonic and Sessile Organisms



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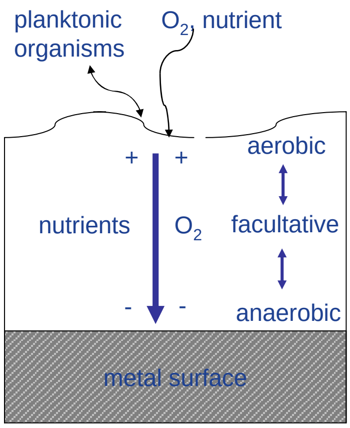
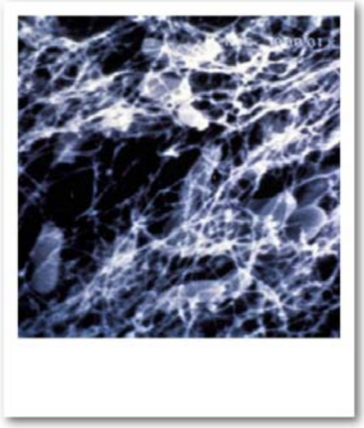
Biofilm Structure





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MB Monitoring - Planktonic

- Routine monitoring
  - The key to microbiological control
  - A trigger to take action
  - Take 2 days from sampling to result
  - Delay corrective action

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MB Monitoring - Planktonic

•Dipslides, Petrifilm, Pour Plates

– Total Aerobic Count – EasiCult

– compare density of growth to chart for interpretation

– results are expressed as estimated ranges of CFU/ml or qualitative

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MB Monitoring - Planktonic

Bioscan monitor

– Instant microbiological monitoring at the touch of a button

– Uses proven technology based on the measurement of ATP (Adenosine Tri-Phosphate), a substance found in all living cells

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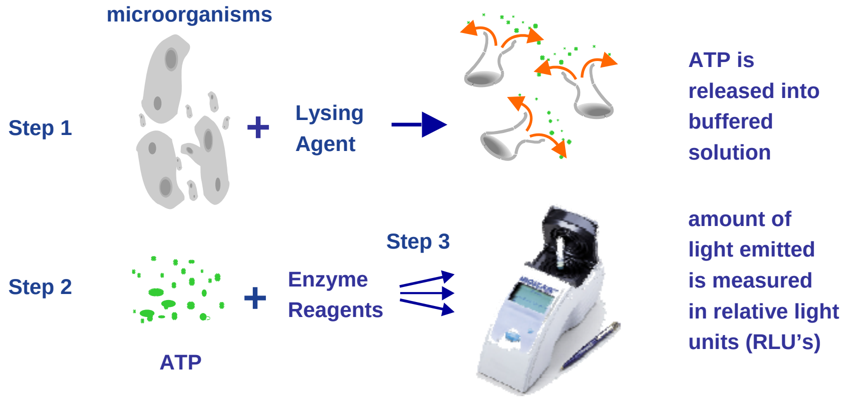
MB Monitoring - Planktonic

How ATP is detected?



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Bioscan

Monitoring technique / Micro organism			
Aerobic bacteria	☺	☺	☺
Anaerobic bacteria	☹	☹	☺
Sulfate reducing bacteria	☹	☹	☺
Nitrogen cycle bacteria	☹	☹	☺
Legionella	☹	☹	☺
Yeast & Fungi	☺	☹	☺
Algae	☹	☹	☺

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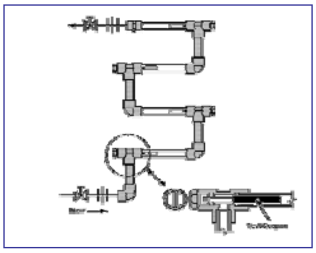
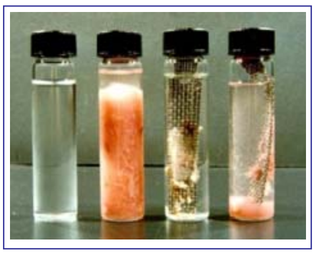
MB Monitoring - Sessile

- Collection of Biofilm
  - Remove deposit from accessible surfaces within the system
  - Install monitoring device that can be removed at frequent intervals/exposure times for examination and/or enumeration

MB Monitoring - Sessile





MB Monitoring - Sessile

- Examination
  - Microscopic
- Indirect Enumeration
  - Remove deposit (swabbing or sonification)
  - Suspend in sterilised water
  - Enumerate
  - Traditional counting (plating) techniques
    - ATP
    - Protein analysis
    - DNA analysis

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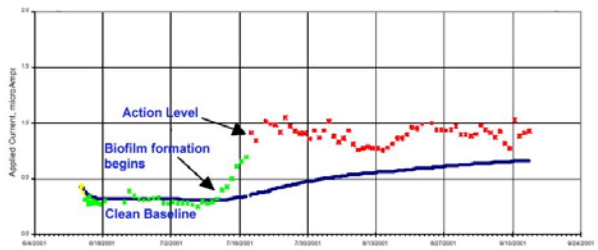
MB Monitoring - Sessile

BIoGEORGE™



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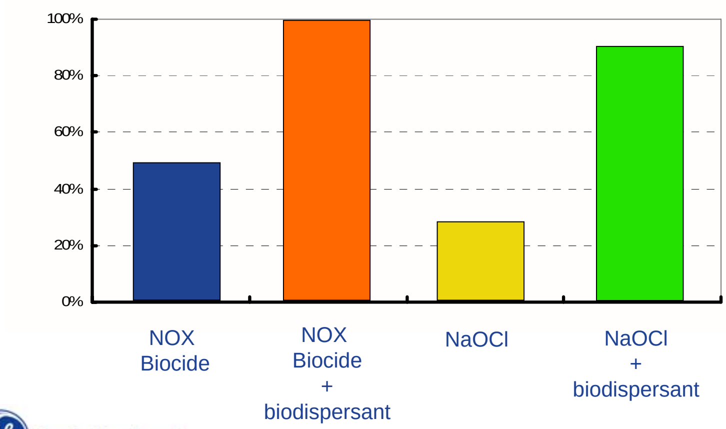
Biofilm Removal

Effectives on **BULK** Water Populations
% Decrease from Control



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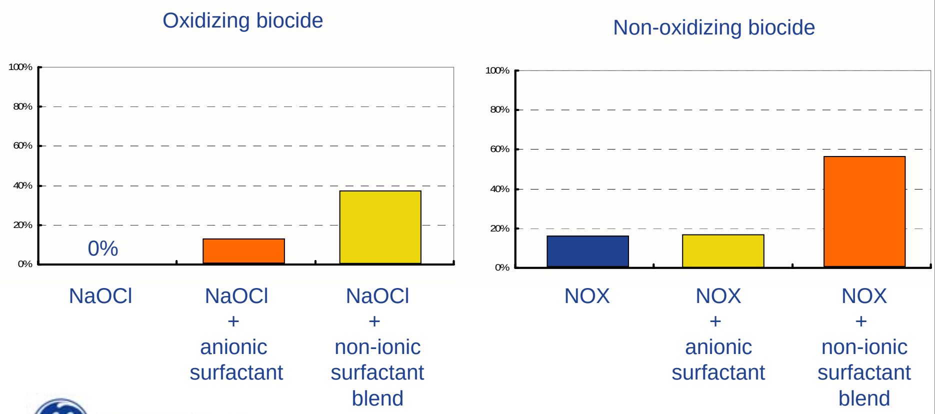
Biofilm Removal

Effectiveness on **Biofilm Removal**
% Biofilm Removal vs. Control



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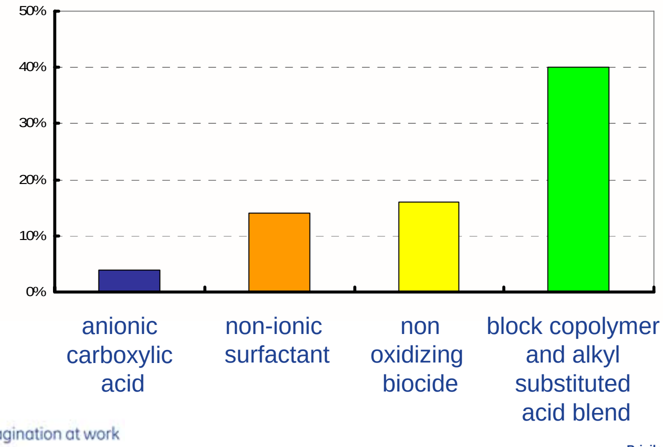
Biofilm Removal

Relative efficiency of biofilm removal from surface



Why Use Biodispersants?

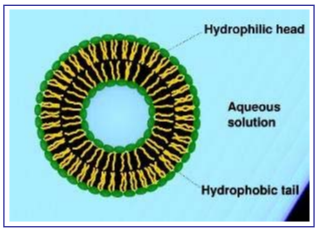
Improve bio-control achieved with biocides alone

- Increase penetration of biocides into biofilm
- Increase transport of biocides into cell
  - Expose microbes to higher levels of disinfectant
- Slow the rate at which clean surfaces foul
- Disrupt biofilms on fouled surfaces
  - Interfere with cell attachment mechanisms

Future Developments

Liposomes

- Target Biodelivery
- Type of organic nano technology
- New patented biocide



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Appendix 15

Effectiveness of NDT methods for corrosion/erosion monitoring and diagnostic

Miroslav Michvocik and Gerard Zima

(Slovnaft)

Effectiveness of NDT methods for corrosion/erosion monitoring and diagnostic
(Input for discussion)

Miroslav Michvocík, Gerard Zima
SLOVNAFT, a.s.
EFC Working Party 15, Budapest, 22nd June 2010

Slovnaft
MEMBER OF THE MOL GROUP

Content

- Idea definition
- Some Slovnaft experiences
- Questions

Idea

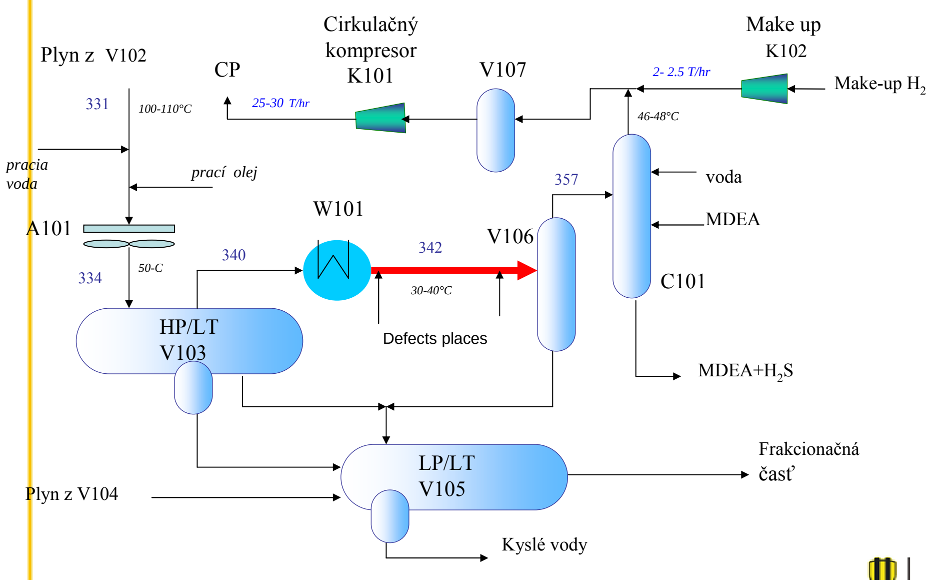
- Several arguments and motivations exist for analysis and discussion of NDT effectiveness for corrosion/erosion monitoring:
  – high number of UT measurements points for thinning monitoring (several ten thousands)
  – related high cost
  – low effectiveness of such monitoring
  – high cost of alternative methods

Slovnaft experiences

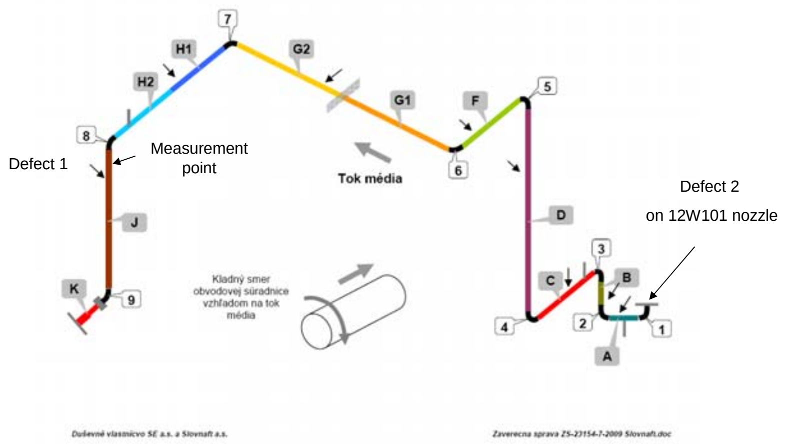
- About 40 000 measuring points were specified on the beginning of systematic UT monitoring in 1998 (problematic number for realization)
- Up to 15 000 Measuring points still leave after first RBI analysis (API 581) – still high number
- In spite of massive UT monitoring the leakages are occurred

  In the recent years several problems with unexpected damages of pipelines were occurred
  – Mainly localized thinning of pipes
  – Fact: used inspection methods (UT straight beam) did not indicate any problems in these cases

Example 1: Defects localization



Impacted pipe



Example 1: VGH piping defect 1

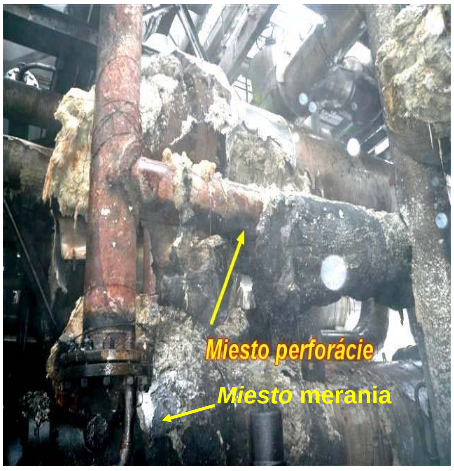
Example 1: VGH piping defect 2

Example 1 - summary

- The scope of defect 1 was local: approx 30 cm long damaged area
- UT thinning monitoring point was approx. 1 m from place of defect - measurements didn't indicate any thinning.
- The scope of defect 2 was local too, no UT monitoring specified before.

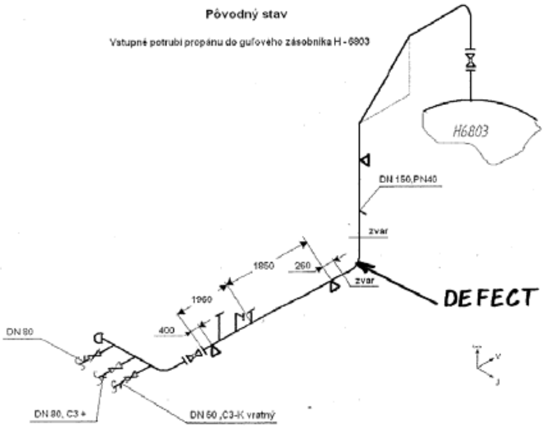
Example 2: AD5 piping damage

- Perforation of atmospheric residue bypass pipe results in fire
- UT monitoring point – approx. 1 m from the place of perforation
- Measurement of main pipe did not indicate any thinning of both main pipe and bypass pipe



Example 2: AD5 piping damage

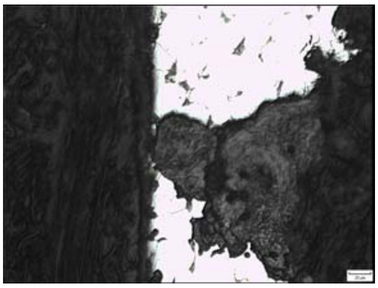
Example 3: Propane pipes leakage – LPG storage tanks



Example 3: Propane pipes leakage – LPG storage tanks

- Leakage on the propane pipes into spherical tank
- Localized thinning of elbow-pipe
- The pipes were not regularly checked in the past because no defect measuring was still indicated

Example 3: Propane pipes leakage – LPG storage tanks



Slovnaft at present praxis

Slovnaft was and is applying since the beginning the usual praxis: regular visual inspections, hammer test, regular preventive parts replacements, later on UT thinning measurement in line of method and instruments development

Since the beginning of 90-ies extension of overhaul cycles, increased effort to maintenance cost cutting and wishes of insurance companies caused start of massive regular UT thinning monitoring.

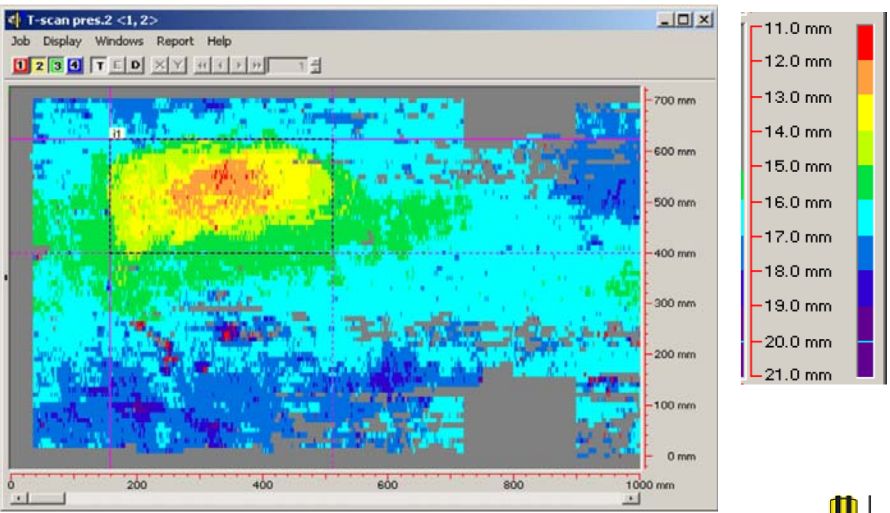
Result:

1. Specification of 40 000 measuring points – problematic for execution.
2. 15 000 measuring points after first RBI assessment – still problematic.
3. In-convincing results of monitoring – see presented examples

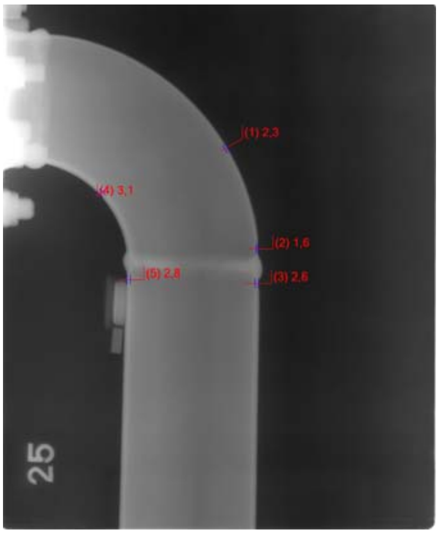
Slovnaft actual activities and goals

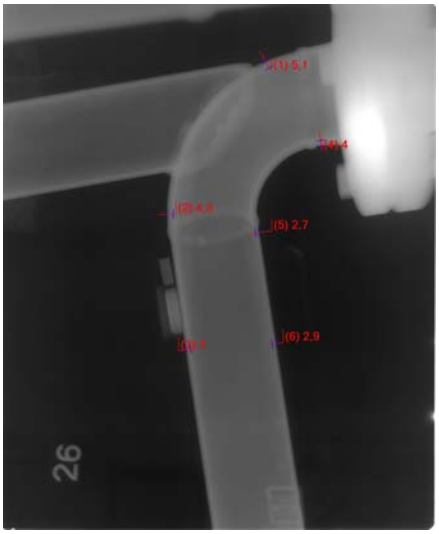
1. Effort to improve actual praxis of UT thinning monitoring:
    1. Improvement of data managed in CMMS
    2. Improvement of measuring quality and reliability
    3. Next Inspection plan optimization (technical and economical) via RBI step by step reassessment
2. Testing application of new progressive methods for thinning problem monitoring like: UT scanning, Digital radiography, etc.
3. Creation of new philosophy for thinning monitoring

UT scanning method

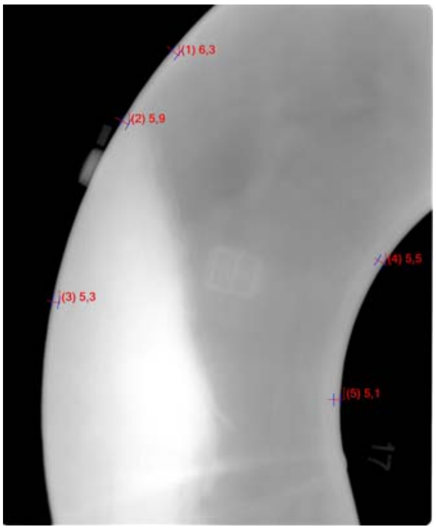


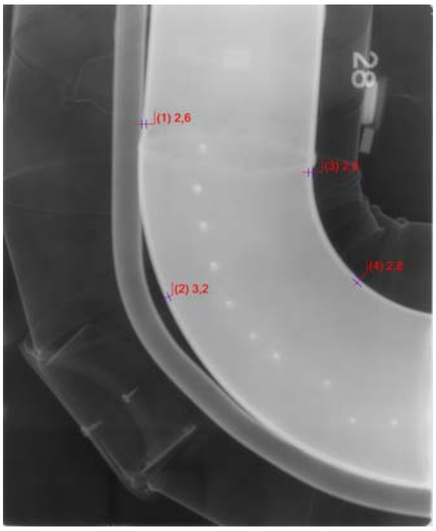
Digital Radiography 1





Digital Radiography 2





Note

Slovnaft is applying also other usual NDT like PT, MT, UT Shear Wave, RTG, AE in standard manner however these methods normally are not applicable for thinning.

Questions for discussion

- What is your experiences in this matter?
- What is your scope and philosophy of UT thinning monitoring?
- Which other methods are you using?
- What is your application philosophy of other methods like UT Scanning, Digital Radiography, Incotest and similar?
- Do you have some cost ratio analysis for the above methods in comparison with normal UT?

Thank you for your attention