Appendix 1

Welcome and

Presentation of Shell Technology Centre

EFC WP 15 Spring Meeting - 26 April 2012

Welcome to Shell Technology Centre Amsterdam

Introduction

Shell Technology Centre Amsterdam

&

Shell

Introduction

- Safety
- Welcome to Shell Technology Center Amsterdam
  - History
  - Today
- Shell
  - "Project and Engineering services"
- Mechanical, Materials and Integrity (MMI)

Safety is our first priority

General rules

- Wear your badge visibly
- Smoking is allowed in designated areas only
- Taking pictures and filming is only allowed in the Atrium, BDR and the lounge
- Note the location of escape routes, (emergency) exits

Emergency phone Number
(+31 20 630) 3333

In case of an emergency

- Follow the instructions given by your host or members of the Emergency Response Team
- Leave the building by the nearest (emergency) exit, follow the escape route signs
- In case of fire on no account use the elevators

Welcome to Shell Technology Centre Amsterdam

History – Shell laboratorium in Amsterdam

- Koninklijke Shell Laboratorium Amsterdam was founded in 1914
- Growth until ~1990

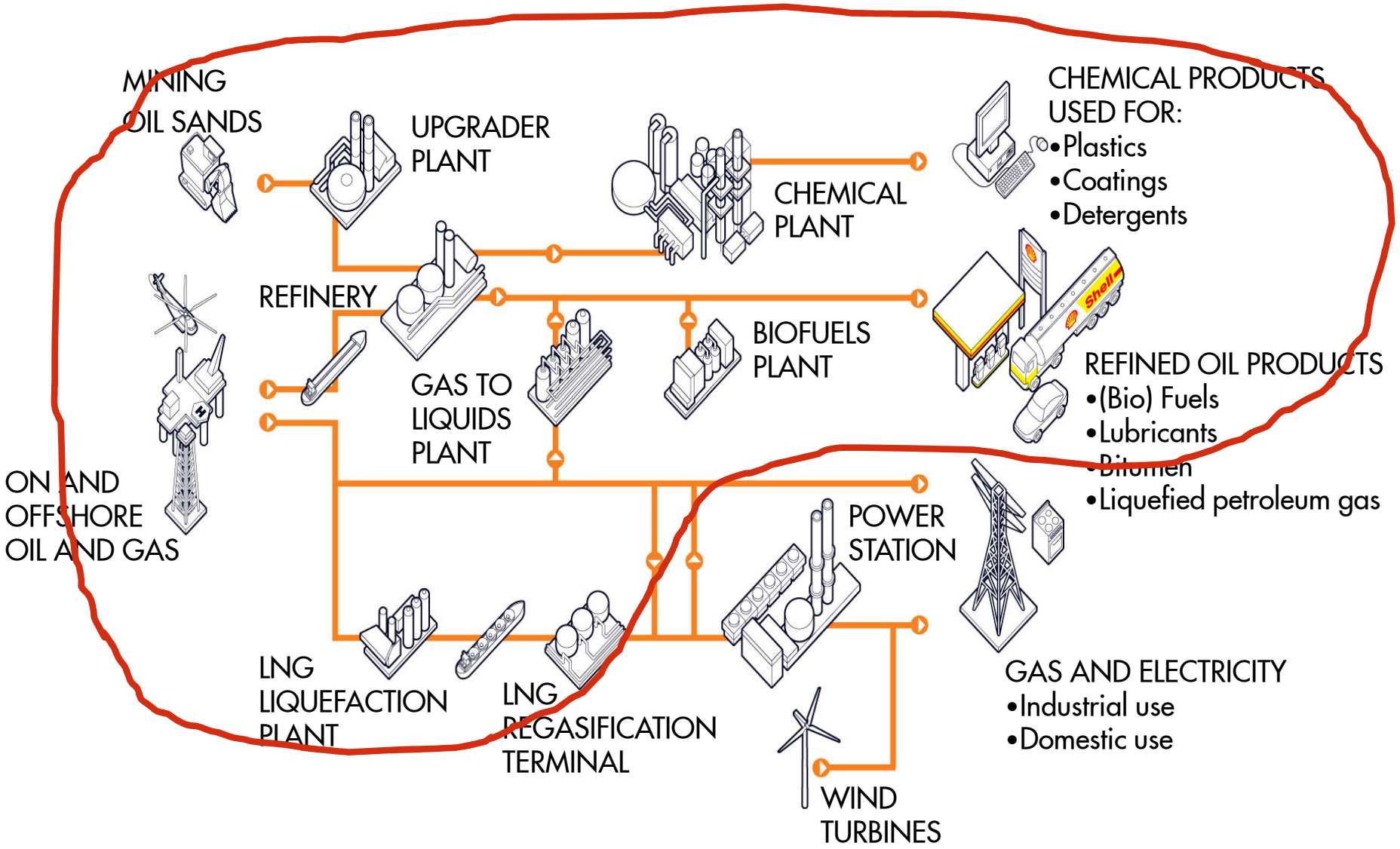
Het KSLA in de jaren zeventig. (Foto Bart Hofmeester).

- - 2009 Opening Shell Technology Centre Amsterdam
  The new building is virtually CO_2 neutral. It uses almost no natural gas and temperatures are regulated by a subsurface thermal energy storage system combined with heat pumps.

Shell Technology Centre Amsterdam – What we do

- Laboratory / pilot plants for Chemicals, Refinery and Gas Processes - including a Materials & Corrosion laboratory
- Creating clean, affordable fuel products based on the gasification technology developed in Amsterdam
- Speeding up processes by improving catalysts
- Gas-to-Liquid (GTL), high-quality, liquid fuels made from gas which is cleaner than regular oil distillates.
- Engineering groups

Our business activities: at STCA



Shell Technology Centre Amsterdam

Technology

Increasingly crucial

Energy solutions

Support to refineries, chemical plants

Products & Processes

R&D

(Alternative) fuels:
- Clean
- Affordable
- Available

Step changing inventions

Advanced analytical support

1.300 people

Technologists
Researchers
Lab assistants
Consultants
Support

International culture

Inspiring environment

Sustainability & Innovation

Transparent & Collaborative

CO_2 neutral building

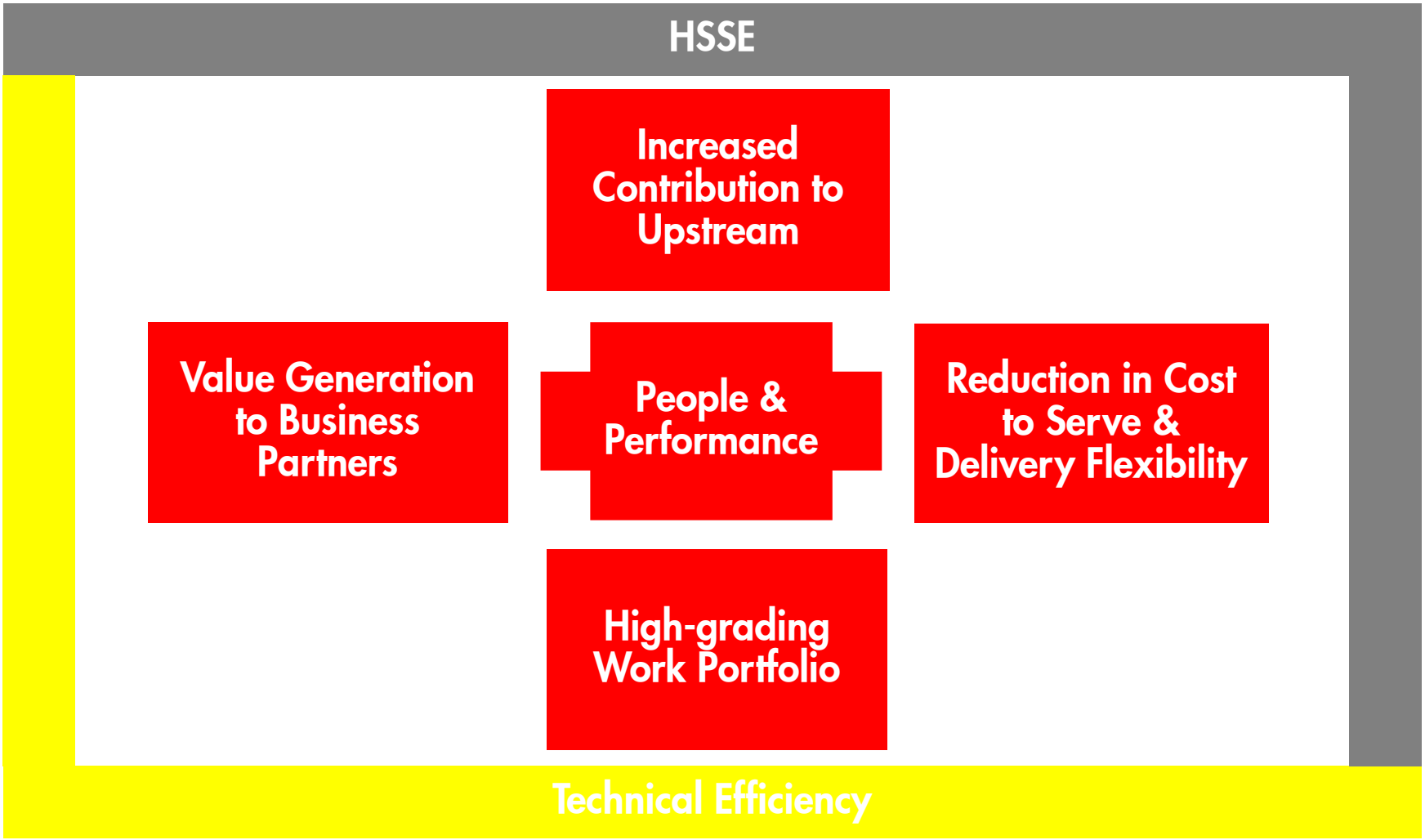
Project and Engineering Services (P&ES) –

To be THE sought after source of engineering advice in Shell

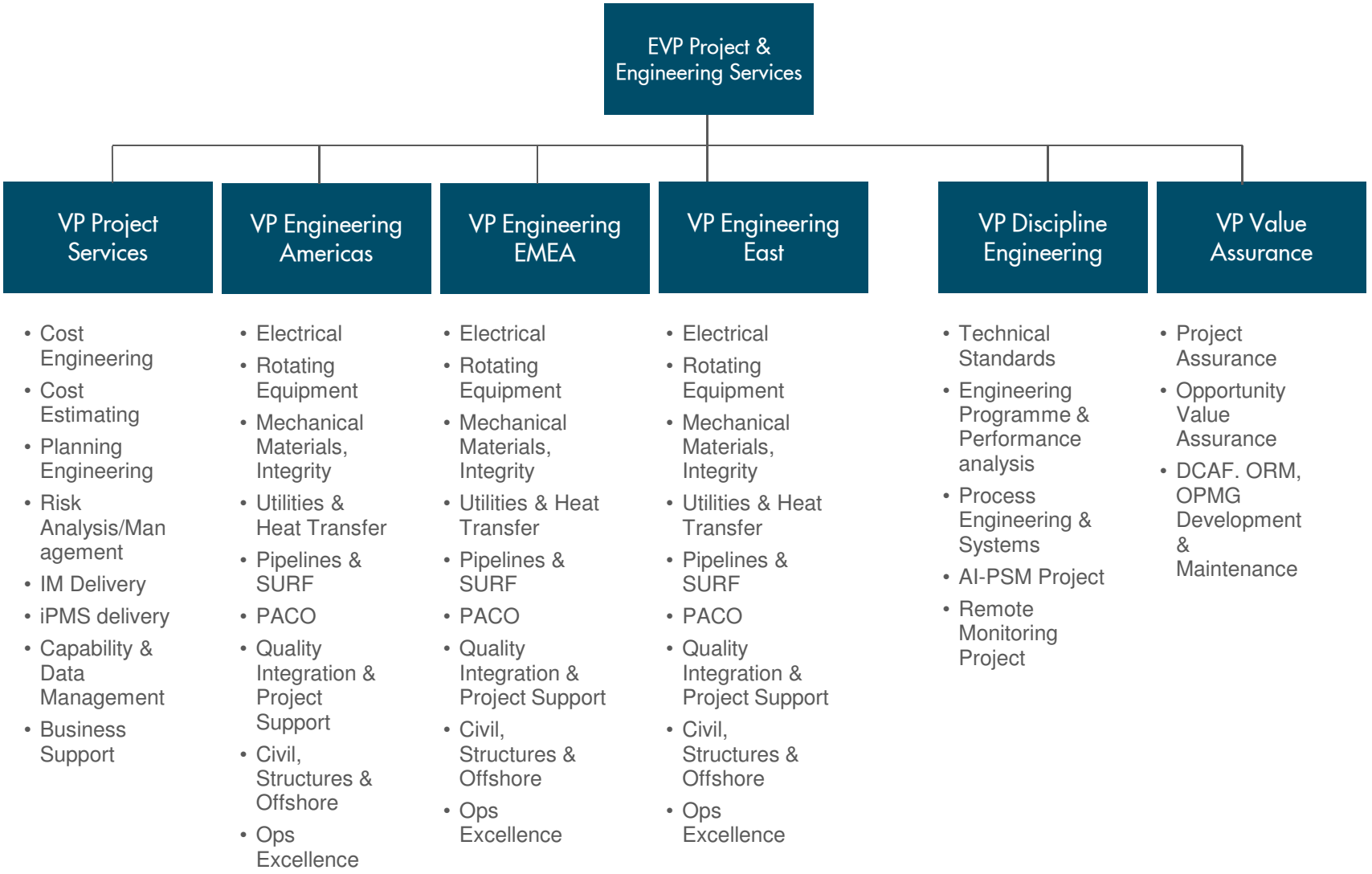
Providing engineering services, expert advice and solutions to both projects and operating assets:

- Assisting operations to achieve process safety, production, and cost goals through application of 'engineering and technology know how'
- Working with project teams toward faster technology development, deployment, and dissemination, in support of Top Quartile project delivery
- Increasing engineering capability by developing people, driving global policy, practices, and tools

PTE - OUR PRIORITIES



What the team does



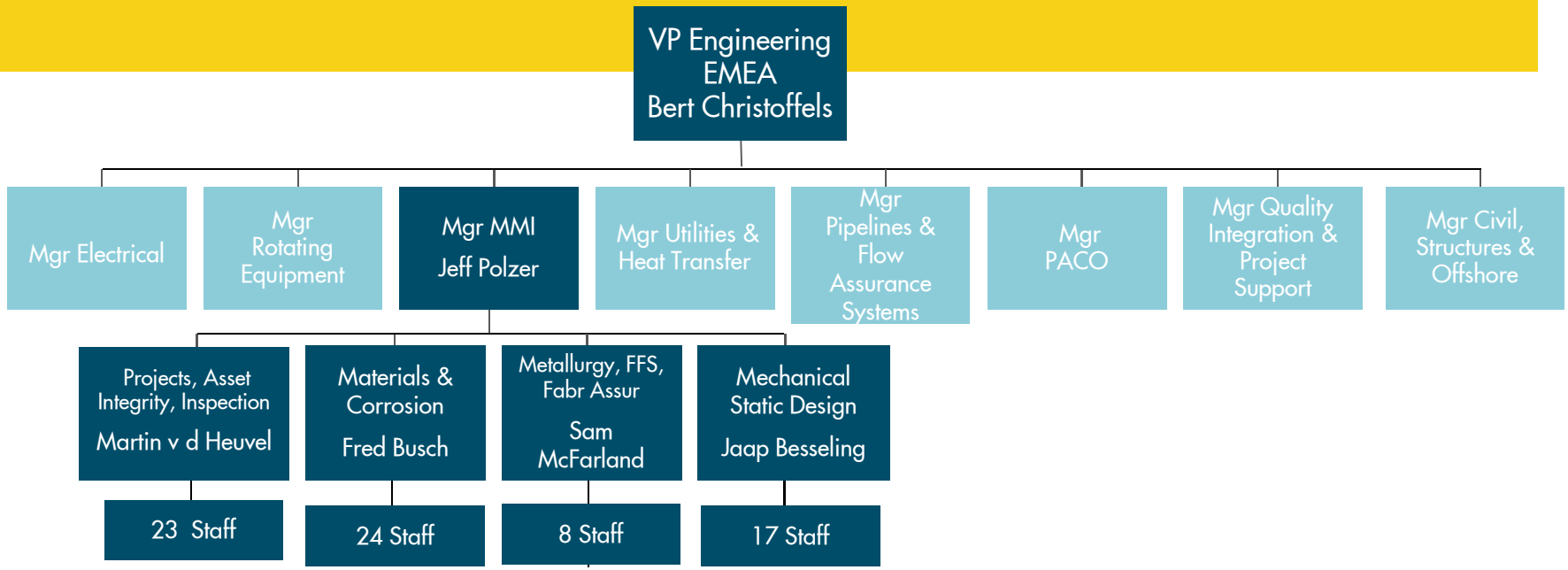
Mechanical, Materials and Integrity

- Technology Centres in Amsterdam, Rijswijk, Houston and Bangalore

- **Mechanical, Materials and Integrity (MMI)**

  "Delivering fit for purpose solutions to mechanical, materials, corrosion, inspection and integrity challenges for projects and assets."

- Overview:
  - Mechanical Equipment and Components / Mechanical design
  - Construction
  - Inspection and Testing
  - Integrity Management
  - Materials and Corrosion Engineering



PROJECTS, ASSET INTEGRITY, AND INSPECTION

- Lead Mech Engrs for Project delivery
- Management System Reviews (FAIR^{+MS})
- Equipment Condition Reviews (FAIR^{+ER})
- Risk assessment / risk management
- Non Intrusive Inspection (incl PEC)
- Integrity Management Systems
- Integrity Operating Windows
- IDMS (inspection data management)
- Turnaround work scope development
- Benchmarking
- PipeRBA (Pipeline risk assessment)
- Risk Based Inspection (RBI)

MATERIALS & CORROSION

- Material testing / qualification
- Materials selection
- Metals/non-metallics
- Failure Analysis
- Corrosion modelling
- Corrosion Management Systems
- Corrosion Control Documents
- Inhibitor testing & selection
- Cathodic Protection

Tools:

- MCI Infobase (refining and gas/LNG materials, corrosion & inspection information)
- MatHelp (EP materials and corrosion information)
- Corrosion Models via CWW HYDROCOR (EP corrosion prediction) SULTAN (HT acid corrosion prediction) Many others (Refining and EP models)

METALLURGY, FITNESS FOR SERVICE, FABR. ASSURANCE

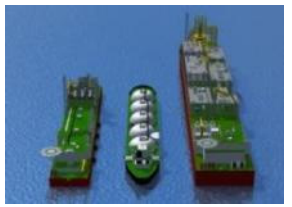
- Fitness for Purpose assessment
- Failure Analysis
- Stress engineering
- FFP Guides (Fitness for Purpose)
- Welding Engineering
- Standards review and improvement

MECHANICAL STATIC DESIGN ENGINEERING

- Static equipment design & specifications
- Piping design & specifications
- Flare and Relief systems
- Valves and sealing design & specifications
- Storage Tanks
- Plot Layout

Mechanical, Materials and Integrity

- Materials and corrosion engineering
  - For "Downstream" and "Upstream"
- Material selection and design
- Metallic materials
- Polymers and composites
- Well materials
- Refractory
- Insulation
- Protective coatings



MMI - Continued

- Integrity management
  - Failure analyses and prevention
  - Pipeline integrity management
  - Integrity Operating Windows
  - Asset Integrity
  - Fitness for Service

- Corrosion engineering
  - Process engineering
  - Corrosion – environments & industries
  - Inhibition &FCT
  - Corrosion prediction tools
  - Corrosion prevention and control

Trends

- Further drive towards standardisation and replication of materials design

- QA/QC is an ongoing concern with
  - Huge project scopes
  - Big contracts with limited amount of suppliers

- Materials & Corrosion discipline is highly in demand!

http://www.shell.com/home/content/careers/professionals/job_search/app_xp_find_a_job.html

Appendix 2

List of participants

Participants EFC WP15 meeting 26th April 2012 Amsterdam (The Netherlands)

Name	Company	Country
Klaus Bormuth	BASF	GERMANY
Johan Bossers	GE Water and Process Technologies	BELGIUM
Valerie Bour-Beucler	Nalco Energy Services	FRANCE
Stephen Brennom	Sulzer Chemtech USA	USA
Chris J Claesen	Nalco	BELGIUM
Hennie de Bruyn	Johnson Matthey Catalysts	UK
Alessandro Demma	Guided Ultrasonics Ltd	UK
François Dupoiron	Total Petrochemical	FRANCE
Meriem El Kamel	V&M France	FRANCE
Steve Fenton	Hi-Temp Coatings Technology	
Marcus Franz	SLG Carbon	GERMANY
Eugen Goudsmith	Nalco	NETHERLANDS
Martin Hofmeister	Bayernoil Raffineriegesellschaft mbH	GERMANY
John Houben	ExxonMobil Chemical Holland BV	NETHERLANDS
Sheila Ismail	Petroplus Refining & Marketing Limited	UK
Claudia Lavarde	GE S&I	FRANCE
Jan Links	Dow Benelux B.V.	NETHERLANDS
Graham R. Lobley	Davy Process Technology	UK
Michael MeLampy	Hi-Temp Coatings Technology	USA
John Pugh	BP	UK
Steve Reynolds	Performance Polymers b.v	NETHERLANDS
Martin Richez	Total	FRANCE
Andres Rivero	Statoil ASA	NORWAY
Francois Ropital	IFP Energies nouvelles	FRANCE
Renate Ruitenberg	Nalco	NETHERLANDS
Adrien Trillon	V&M France	FRANCE
Fred van Rodijnene	Sulzer Metco Europe GmbH	GERMANY
Johan van Roij	Shell Global Solutions International B.V.	NETHERLANDS
Peter Vermont	Consultant	NETHERLANDS
Stine Hals Verstraelen	CB&I Lummus B.V.	NETHERLANDS
Jim Weber	Sulzer Chemtech USA	USA
Francois Weisang-Hoinard	Outokumpu	FRANCE
Stefan Winnik	Exxon Mobil Chemical	SINGAPORE

Appendix 3

EFC WP15 Activities

(F. Ropital)

Presentation of the activities of WP15

European Federation of Corrosion (EFC)

- Federation of 31 National Associations
- 20 Working Parties (WP)
- 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 Party 15 « Corrosion in Refinery » Activities

Who is an EFC member

To be an EFC member you (individually or your company, university) has to be member of one of 31 national EFC "member societies". Your company or university can now also an affiliate member.

For example:
in Norway: Norsk Korrojonstekniske Forening
in France: Cefracor or Federation Française de Chimie
in Germany: Dechema or GfKORR
in UK: Institute of Corrosion or IOM or NACE Europe
in Israel: CAMPI or Israel Corrosion Forum
in Poland: Polish Corrosion Society
.....
You will find all these information on www.efcweb.org or in the EFC Newsletter

Benefits to be an EFC member:
- 20% discount on EFC Publications and NACE Publications
-reduction at the Eurocorr conference
-access the new EFC web restricted pages (papers of the previous Eurocorr Conference) via your national corrosion society web pages

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
- WP 21: Corrosion of archaeological and historical artefacts

- A task force on CO2 Capture and Sequestration (CCS) is launched

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 2011-2013

. Collaboration with Nace : exchange of minutes of meetings
"NACE TEG 205X information exchange -corrosion in refineries "

. Sessions with other EFC WP at Eurocorr (2013 Estoril-Portugal, 2014 Pisa-Italy, 2015 Graz-Austria) on which topics?
Polymer and composite equipments in refineries ?

- Update of publications
  - CUI guideline
  - Amine acid gas treatment plants

- New Publications: best practice guideline to avoid and characterize stress relaxation cracking ?

- Education – qualification – certification
  List of "corrosion refinery" related courses on EFC website ?
  Proposal of courses within Eurocorr ?

Eurocorr 2012

Istanbul 9-13 September 2012

Authors have been informed by mid April and the program is on Eurocorr Website

Tuesday 11 September: Refinery corrosion session

Wednesday 12 September: Annual WP15 working party meeting

http://www.eurocorr.org

nds

7

Tuesday 11 September morning

Day, time	Session	Lecture
11.09.2012 10:00	Corrosion in the Refinery Industry (WP 15)	**Introduction to experimental methodology for evaluation of crude corrosivity - naphthenic acid and sulfidic corrosion** B. Chambers, S. Srinivasan, Honeywell Corrosion Solutions, Houston, TX/USA; R. Kane, iCorrosion, LLC, Houston, TX/USA; M. Blades, Honeywell Corrosion Solutions, Houston, TX/USA
11.09.2012 10:20	Corrosion in the Refinery Industry (WP 15)	**Naphthenic acid corrosion of sulfided carbon steel at high temperature: a combined AFM and ToF-SIMS approach** M. Millet, A. Galtayries, A. Seyeux, L. Klein, Chimie ParisTech - CNRS/F; X. Roumeau, G. Morel, Total, Le Havre/F; P. Marcus, Chimie ParisTech - CNRS/F
11.09.2012 10:40	Corrosion in the Refinery Industry (WP 15)	**Critical issues in refinery crude corrosivity assessment** S. Srinivasan, B. Chambers, KM. Yap, Honeywell International, Inc, Houston, TX/USA
11.09.2012 11:30	Corrosion in the Refinery Industry (WP 15)	**On stream analysers improve crude unit corrosion control** C. Claesen, Nalco, Antwerpen/B; N. Hilton, Nalco, Sugarland/USA
11.09.2012 11:50	Corrosion in the Refinery Industry (WP 15)	**Application of near infrared spectroscopy, NIR and chemometric methods for prediction of corrosion in crude oil refining units** C.A Mejía, D. Laverde, Industrial University of Santander, Bucaramanga/CO
11.09.2012 12:10	Corrosion in the Refinery Industry (WP 15)	**Corrosion protection of oil storage tank tops application experience** E. Lyublinski, Y. Vaks, Northern Technologies International Corporation, Beachwood/USA; M. Schultz, Petrobras, Rio de Janeiro/BR; R. Singh, Zerust, Rio de Janeiro/BR
11.09.2012 12:30	Corrosion in the Refinery Industry (WP 15)	**Examination of "green" corrosion inhibitors and corrosion resistant alloys for the overhead of the crude oil distillation unit** A. Groysman, Oil refineries Ltd. and ORT Braude, Karmiel/IL; J. Penner, Oil refineries Ltd., Haifa/IL; L. Mizrahi, ORT Braude, Karmiel/IL; N. Brodsky, Oil refineries Ltd., Haifa/IL

Tuesday 11 September afternoon

11.09.2012 14:00	Corrosion in the Refinery Industry (WP 15)	**Guided wave testing for the detection of corrosion under insulation (CUI) in pipes and pipelines** A. Demma, D. Alleyne, Guided Ultrasonics Limited, Brentford/UK
11.09.2012 14:20	Corrosion in the Refinery Industry (WP 15)	**Selection of coatings for use in preventing corrosion under insulation** M. MeLampy, Hi-Temp Coatings Technology, Acton, MA/USA; P. Bock, Hi-Temp Coatings Technology, Inc., Acton, MA/USA
11.09.2012 14:40	Corrosion in the Refinery Industry (WP 15)	**Risk based insepction - Jeddah refinery conduted RBI ofr many plants as first time and it was an ezxcellent one** M. Bokhari, King AbdulAziz University, Jeddah/SAR
11.09.2012 15:00	Corrosion in the Refinery Industry (WP 15)	**Corrosion investigation of gas sweetening plant /case studies** Sh. Azadi, South Zagros Oil&Gas Company, Shiraz/IR; N. Deris, South Pars Gas Complex, Assaluyeh/IR
11.09.2012 15:50	Corrosion in the Refinery Industry (WP 15)	**Evaluation of an electrochemical method to determine critical crevice corrosion temperatures** J. Flyg, M. Sparr, Swerea KIMAB, Stockholm/S; S. Hägg Mameng, R. Pettersson, Outokumpu Stainless AB, Avesta/S
11.09.2012 16:10	Corrosion in the Refinery Industry (WP 15)	**Corrosion behaviour of 617 and 625 alloys in $PbCl_2$ - KCl** M. Golozar, A. Alfantazi, University of British Columbia, Vancouver/CDN
11.09.2012 16:30	Corrosion in the Refinery Industry (WP 15)	**Case studies of caustic gauging of boiler tubes** J. Zhang, Sabic, Redcar/UK
11.09.2012 16:50	Corrosion in the Refinery Industry (WP 15)	**Failure analysis of tubes of a heat exchanger in Abadan oil refinery** E. Rafiee, M. Farzam, M.H. Maddahi, Petroleum University of Technology, Abadan/IR

Information : Future conferences related to refinery corrosion

•9-13 September 2012
EUROCORR 2012 Istanbul Turkey Website: www.efcweb.org/Events

•17-21 March 2013
Nace Conference 2013 Orlando USA

•1-5 September 2013
EUROCORR 2013 Estoril Portugal

•8-10 October 2013
ESOPE Paris France
(construction technologies, Codes, Standards and European Directives for stationary and transportable Pressure Equipment)

Appendix 4

Stress relaxation cracking

(H. de Bruyn)

Stress Relaxation Cracking
Feedback from Kick-Off Meeting

Hennie de Bruyn

Johnson Matthey

Kick-Off Meeting - 25 April 2012

- Representatives
- BASF
- Davy Process Tech.
- Böhler Welding Group
- Borsig
- CB&I
- DuPont
- Fluor (not present)
- Haldor Topsøe
- Johnson Matthey
- Linde Engineering
- MTI
- NEM BV
- Sabic
- Schmidt + Clemens
- Shell
- Sumitomo Metal Industr.
- Technip
- ThyssenKrupp VDM
- Total Petrochemicals
- UHDE
- Laborelec

Status (2000)

- Susceptibility test available for base metals and welds
- Remediation strategy available based on stabilising heat treatment
- Many examples of new and aged materials and welds in the recommended practice
- For each alloy: temperature window of susceptibiliy and preferred temperature for stabilising heat treatment
- No distincition between thin/thick walled components, welds, deformation, …

New SRC Program

- WP1 Improved Recommended Practice
- WP2 Modelling & Characterisation
- WP3 Alternatives to PWHT
- WP4 Creep Life Time
- WP5 New Alloys
- WP6 Dissimilar Welds
- WP7 Dissemination

WP1 Improved Recommended Practice

- Current recommended practice has yes/no assessment for each material
- No correction for stress intensity factor (welds, wall thickness, deformation, …)

- Goal: to refine the recommended practice to take into account the effect of the stress intenstity factor on the susceptibility towards SRC

Johnson Matthey

WP2 Modelling & Characterisation

- Modelling
  - Coupled FEM / PFM model: coupling of macroscopic stresses to microscopic changes in microsctructure (deformation along grain boundaries, cavities, cracks)
  - Carbide precipitation and chromium diffusion
  - More insight in the determining parameters

- Characterisation and varying the microstructure:
  - H, L and LN grades
  - Grain sizes (anneal)
  - Aging

WP3 Alternatives to PWHT

- Large or thick walled components are difficult to heat treat, homogeneous temperature and significant heating rate are difficult to achieve
- Thin-walled components can suffer deformation due to the heat treatment
- In existing equipment, high temperatures cannot be achieved, even though longer treatments are possible
- SRC prevention heat treatments are not identical to ASME / ASTM preferred values
- Heat treatment causes scale formation, which has to be removed before commissioning the equipment

WP4 Creep Life Time

- Creep life time may change due to stabilising heat treatment
- Creep reduction factor may have to be used (can be required by notified body)
- Effect will be quantified based on previous tests, discussed with steering committee
- Focus on alloy 800H

WP7 Dissemination

- Preparation of an EFC document on SRC, containing the results of the previous JIP
- Contents to be decided by the consortium

- How to recognise SRC
- Susceptibility test procedure
- Susceptible materials
- Stabilising heat treatment temperatures
- Metallography

Johnson Matthey

Appendix 5

HTHA

Gasoil Hydrotreater Heat-exchanger

Degradation

(M. Richez, Total)

HTHA
Gasoil Hydrotreater Heat-exchanger Degradation

API alert sent in september 2011

- Numerous case of HTHA reported by Exxon, then by other companies, Shell, Valero etc..
- Cases reported on welded carbon steel equipment non stress relieved and operating below API RP 941 curve for CS
- Serious accident on TESORO Anacortes refinery in

energy API
AMERICAN PETROLEUM INSTITUTE

Carbon Steel Degradation in High Temperature Hydrogen Service

Industry Alert

The purpose of this alert is to inform you that there have been several reports of cracking-related issues with carbon steel piping and equipment in high temperature, high pressure hydroprocessing service at operating conditions where carbon steel was previously thought to be resistant to high temperature hydrogen attack (HTHA). One published report of such incidents can be found in the paper PVP2010-25455, Proceedings of the 2010 ASME Pressure Vessels and Piping Conference, July 18-22, 2010, Bellevue, WA.

API RP 941, *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants*, 7th Edition, 2008, Figure 1, shows the operating limits for steels in hydrogen service to avoid decarburization and fissuring from HTHA. One curve on that graph is for carbon steel. At temperatures and hydrogen partial pressures below the curve, HTHA is not expected to occur in carbon steel.

Prior to these recent reports, the only reported failures of carbon steel below the API RP 941, Figure 1 curve were in cases of exceptionally high stress, as discussed in Sections 5.2 and 5.3 of API RP 941. All of the new reports of HTHA involve carbon steel equipment that was not postweld heat treated. Past research summarized in API TR 941, *The Technical Basis Document for API RP 941*, states that non-postweld heat treated welds not only retain high residual welding stresses but also have lower carbide stability in the weld heat affected zone that further increases HTHA susceptibility. The API RP 941 Task Group of the API Subcommittee on Corrosion and Materials is now in the early stages of collecting and verifying data and information to determine if the recommended practice might need to be altered as a result of this new information.

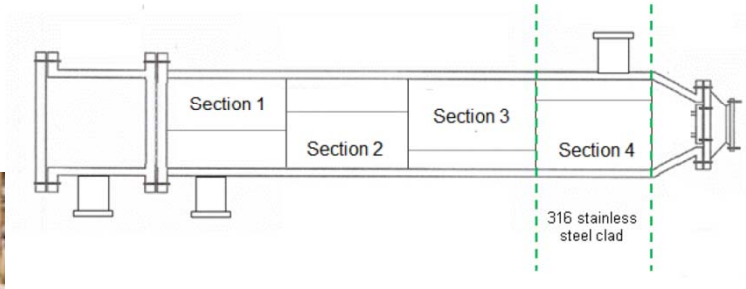
API is notifying all refining operating companies of this new issue should owner-operators decide to alter their inspection plans or risk assessments for carbon steel piping and equipment, especially if not postweld heat treated and/or highly stressed, and particularly in hydroprocessing services. Section 6 of API RP 941 provides recommended practices for inspection of equipment that may be susceptible to HTHA.

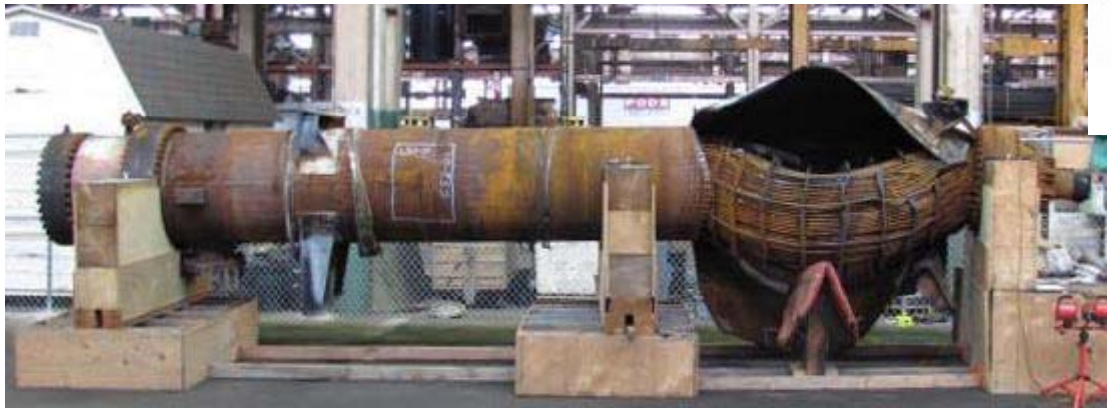
If any of your operating sites have experienced unexpected cracking issues associated with carbon steel equipment that may be due to HTHA, please bring those to the attention of API by participating in the Corrosion and Materials Subcommittee and the RP 941 Task Group. The form found in Annex F of API RP 941, *Datasheet for Reporting High Temperature Hydrogen Attack (HTHA) of Carbon and Low-alloy Steels*, provides a recommended format for internal company data collection.

For information on API's Refining Standards and the API RP 941 Task Group please contact David Soffrin, Manager, Downstream Standards, at soffrind@api.org.

TOTAL

TESORO Anacortes





- Naphta hydrotreater
- Feed effluent heat exchanger (failure on the shell side – effluent)
- Seems to operate below the API curve (but lack of TC to know the temperature accurately)
- Equipment made of A 515 Gr 70 – No PWHT – put in service in 1971
- Accident happens the 2 April 2010 – 7 fatalties

Equipment and main findings

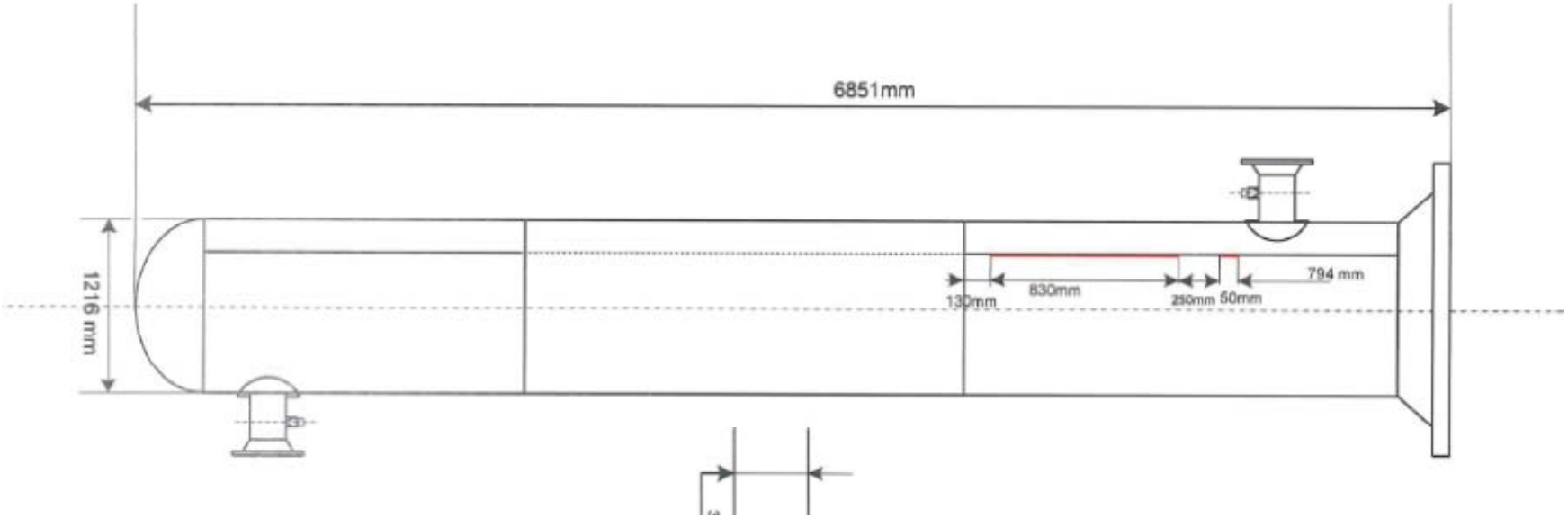
- Unit : HDS built in 1979
- Feed effluent heat exchanger
- The feed is on the shell side
- Design : 800 PSI (54.8 bars), 500°F
- Seam coefficient 0.8 – design stress 123 MPa (17.8 KSI)
- External diameter : Ø 1216 mm Shell nominal thickness 36mm.
- Shell material A 48 CP (A 516 Gr 70), no PWHT
- Built in 1979 (origin of the unit)
- In 2008 during turnaround, inspection of the equipment : control of the main weld by UT TOFD and MT.
  - Cracks found in the longitudinal weld : length ≈ 4 feet,
  - Close to the hotter nozzle
- In April 2011during a catalyst change, UT control of the weld. New cracks found
- The equipment has been removed from service.

Illustration - 2008

Cracks found

Cracks after grinding
Before repair

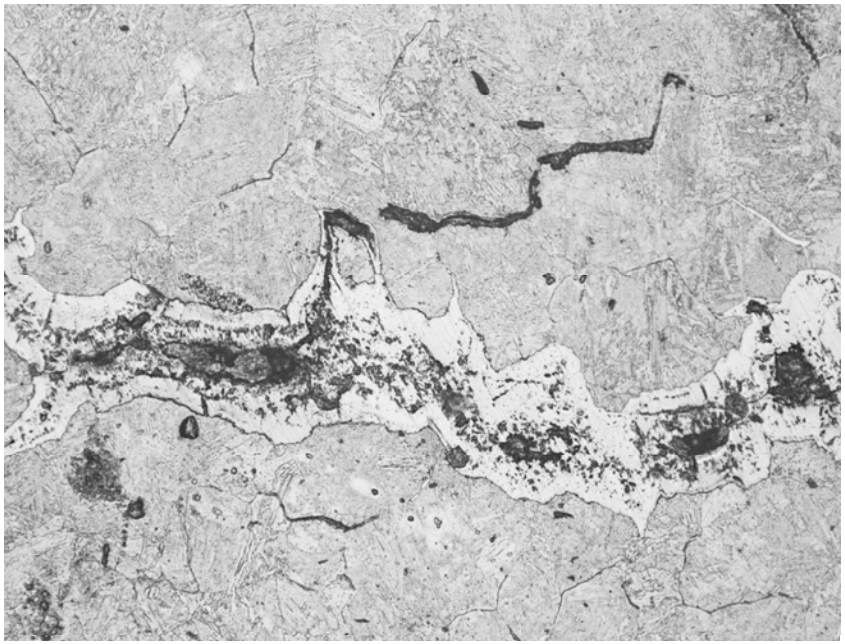
Cracks location and extension

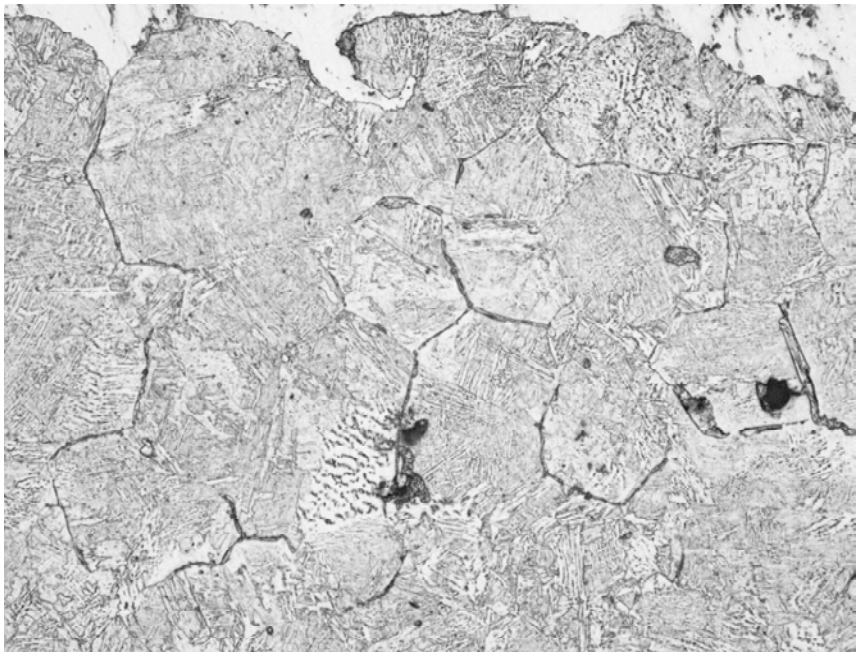


Cracks found in 2011

Crack assesment

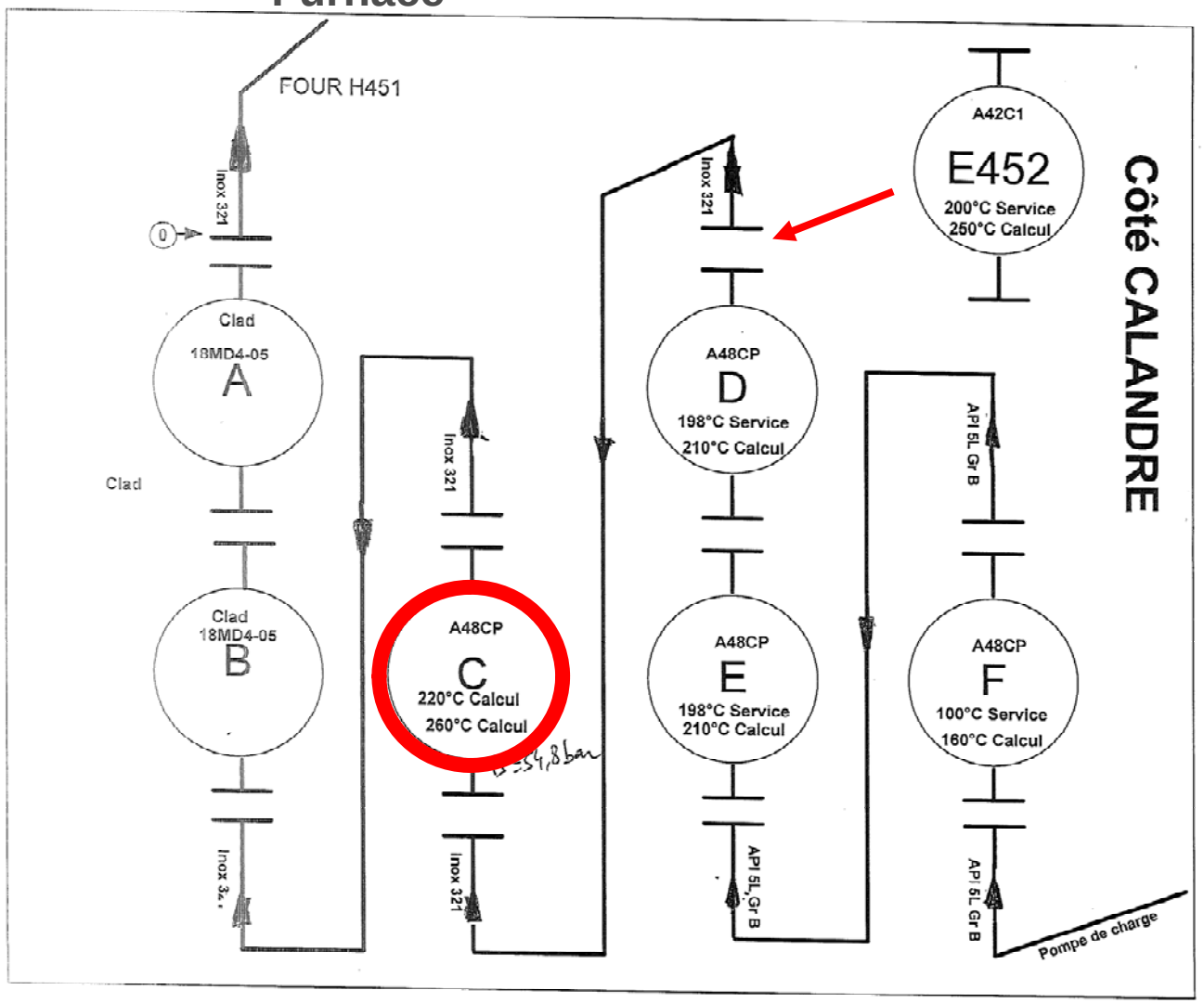
- Main crack located just below the weld metal in the HAZ
- The main crack is strongly oxydized
- The main crack is intergranular
- Micro cracks are detected around the main crack in HAZ or the weld metal, without preferential orientation
- Localized decarburation is observed
- Micro cracks have been observed in area far from the main crack





Location of the heat exchanger

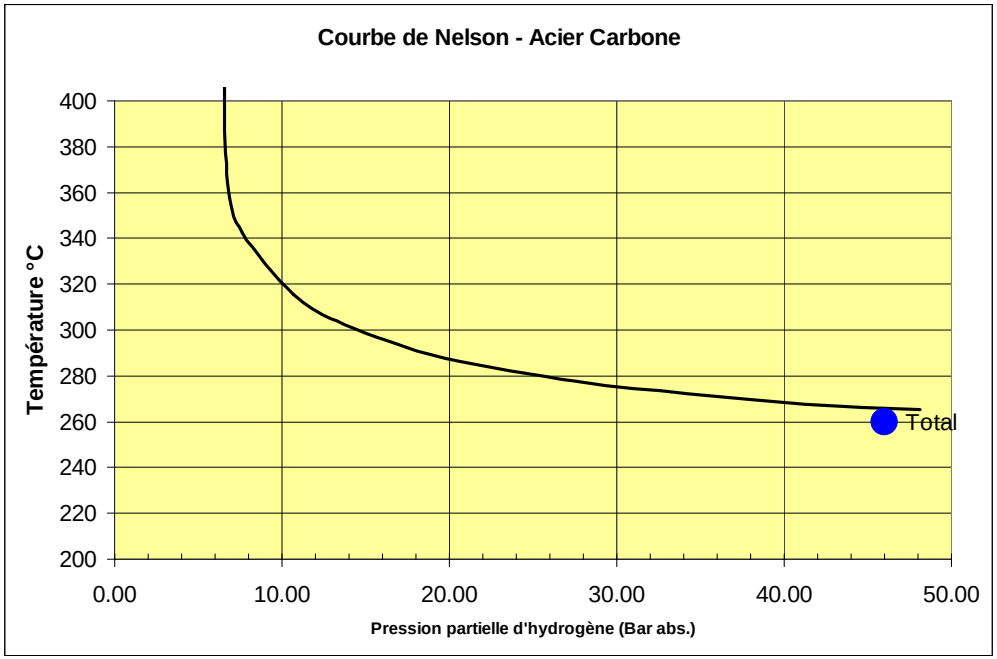
Furnace



Feed

Operating conditions

- Exact operating condition have still to be confirmed.
- Hydrogen is purified by membranes.
- Maximum operating (EOR) 500°F (260°C) and PPH2 (46 bars)



Appendix 6

Crack in FCC wye piece

(M. Hofmeister, Bayernoil)

Crack in FCC wye piece

Polythionic acid SCC

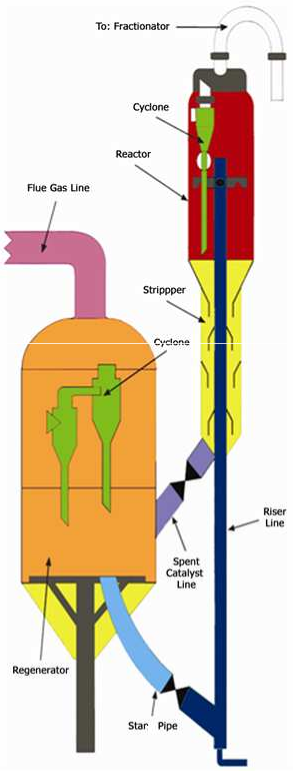
EFC WP15 Spring Meeting 2012

Martin Hofmeister, Bayernoil Raffineriegesellschaft mbH

26.04.2012

Wye Piece Data

- Design 3bar 730°C (Abnormal condition: 17.6bar 730° for 1h)
- Nicrofer 3220*, annealed to grain size 5 (similar Alloy 800H), pickled
- Technical rule for material: VdTÜV Entwurf 412 06/76
- Filler metals: Root pass - Fox NiCr70Nb, others Inconel 82
- 1977-82 Hot wall design with erosion resistant refractory and outer thermal insulation
- Since 1982 Cold wall design with thermal insulation (Fibrefrax) inside and erosion resistant refractory, wall temp. <350°C
- *alloying element limitations: C=0,08; Al+Ti=0,68;



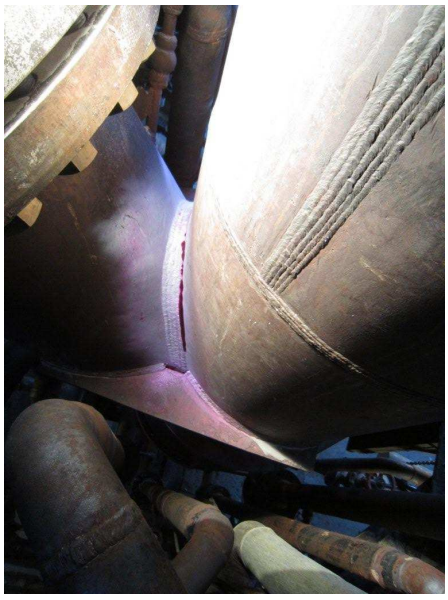
First visual and PT inspection results

- Crack in crotch (Leaking area)

- Spalled refractory (Hotspot)

Penetrant test

- Crack with leak – long crack without leak

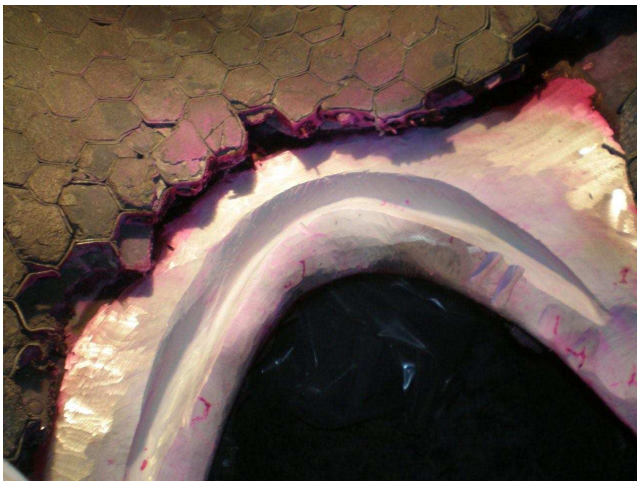


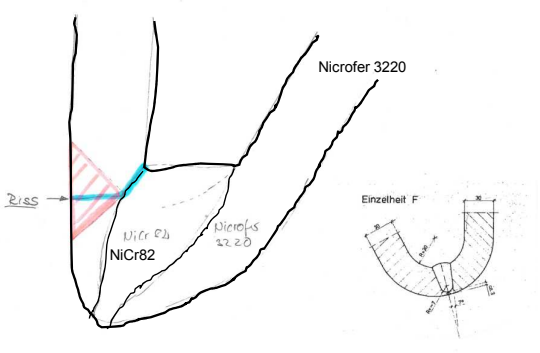
PT inside

- Main crack at crotch area, additional cracks at former stud welding areas

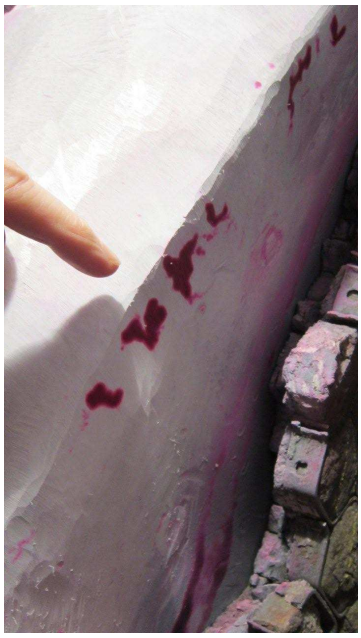
Grinding of main crack

- Crack opens in base material, welding not acc. to design





Sub cracks



Possible damage mechanisms to API 571

- Relaxation Cracking
  - Alloy 800, metallurgical notch (HAZ), coarse grain, temperature 500-750°
  - Intergranular cracks in HAZ
  - Ni filament, Cr-Carbide in grain (Hardening)
- Thermal fatigue
  - Hotspots
  - Design with stress concentration
  - Dissimilar weld (Austenitic-Nickel)
  - Crack extension following stress direction
  - Crack rest lines
- Polythionic acid SCC
  - Sensitazion
  - Sulfur spezies
  - Water

Sensitation Alloy 800

Table 1 – PTA-Induced SCC & IGA (ASTM A262C) Corrosion Testing of Alloys Used in Hydrocrackers & Hydrotreaters in Petroleum Refineries**

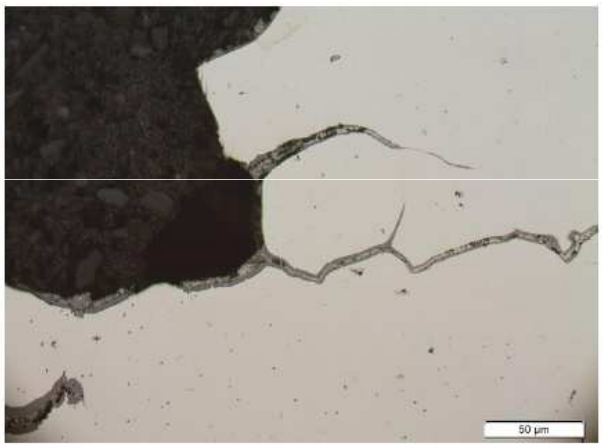
Material	PTA Results		IGA Results	
	Time to Initial Crack (Hours)	Time to Failure (Hours)	Corrosion Rate (mma)	Corrosion Rate (mpy)
304 Stainless Steel	<24	--	--	--
321 Stainless Steel	NC*	NF*	3.5	137
347 Stainless Steel	NC	NF	1.1	43
Alloy 800	5	30	42.4	1668
Alloy 800H	5	30	43	1692
Alloy 825	NC	NF	0.3	13
Alloy 625	NC	NF	1.4	55

* NC = No Cracking; NF = Did Not Fail during 72 hour test
** Test specimens were mill annealed, exposed at 670°C (1250°F) for one hour, and air cooled

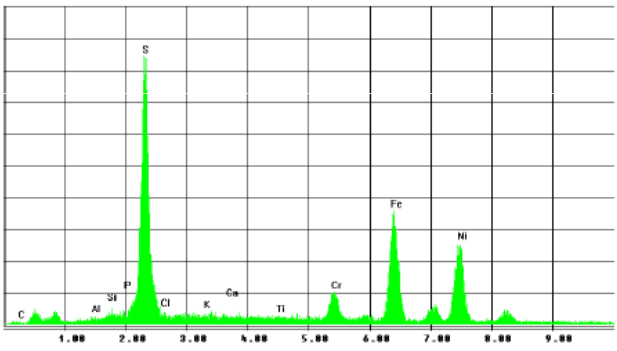
- From NACE Paper 08557: RESISTING PETROLEUM REFINERY CORROSION WITH NICKEL ALLOYS

- Chromiumcarbides concentrate at grain bounderies (400° bis 815°)
- Alloy 800/H susceptible (low Ti content)

Sulfur in sub-cracks

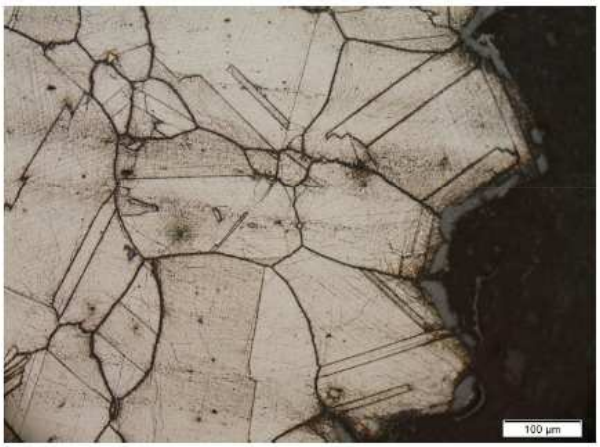


Präparativ ungeätzter Querschliff – Nebenriss mit Belegung

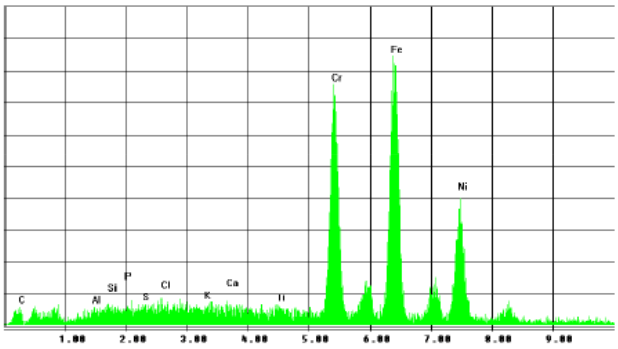


: Energiedispersive Analyse der Belegung im Nebenriss (Bild 10)

Chromiumcarbides at grain boundaries



Präparativ geätzter Querschliff – ausgeprägte Belegung der Korngrenzen



: Energiedispersive Analyse an Korngrenzen (beispielhaft) – der ausgeprägte Cr-Peak weist auf Chromcarbide hin.

Summary PTA SCC

- Sulfur content low in regenerator
- Sulfide layer on metal needed – verification only possible in cracks, cracked surface area was already grinded
- Temperature >370°C (> 450°C for stabilized steels) (hot wall design for 4 years, additional hot spots during life time)
- Desensitation at 600° and 100000h possible; operating time to short for this mechanism
- Mechanismus known for Incoloy 800
- No alkalisation treatment during turnarounds
- 2009 water jetting of riser because of safety reasons (coke built-up in vertical line above the wye piece)

Appendix 7

Metallurgical problems of cast steels

(F. Dupoiron, Total Petrochemical)

A TRAVERS LA PRESSE…

Ces "robinets" non
nformes ont été
t agréés par un
nuté.

La Provence

JEUDI 24 SEPTEMBRE 2009 | AIX-PAYS D'AIX | www.laprovence.com / 0,90€

POUR JOINDRE LA REDACTION : 04.42.38.74.4C

EXCLUSIF

Alerte rouge dans les usines chimiques

s présentent un risque d'explosion.
triels à les retirer

P. 2 ET 3

France-Soir

VOTRE GRAND QUOTIDIEN NATIONAL

Total – Des vannes chinoises inquiètent l'industrie française

USINENOUVELLE.com

Alerte aux vannes chinoises défectueuses : un problème de « traitement thermique »

Jeudi 24 Septembre 2009
www.laprovence.com

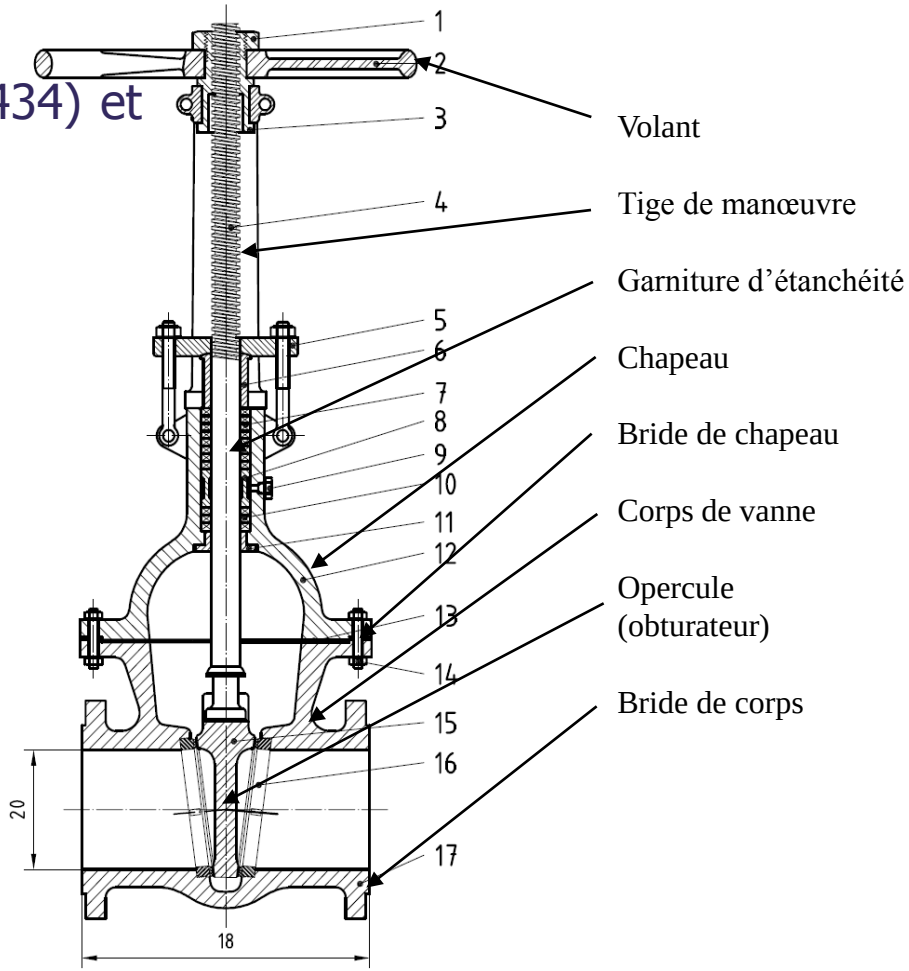
LE DOSSIER DU JOUR

ENVIRONNEMENT / Après les canapés, voici des robinets industriels dangereux fabriqués en Asie pour une entreprise

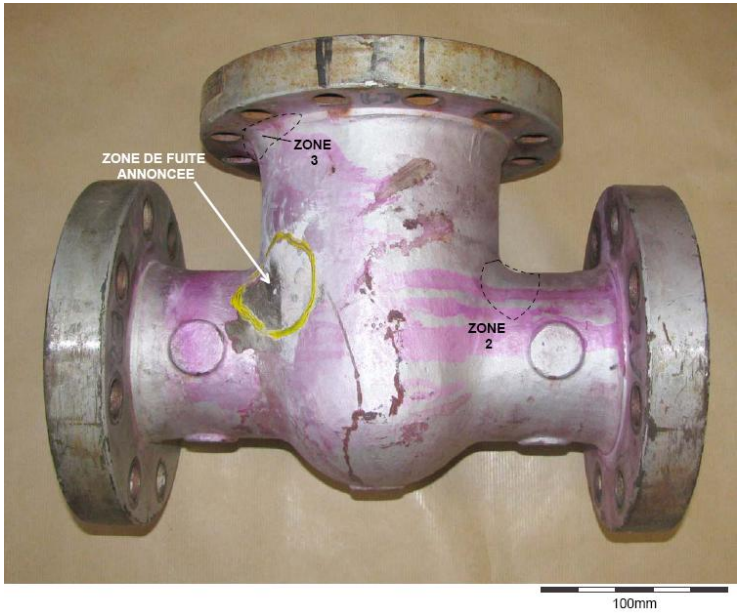
Alerte aux vannes chinoises

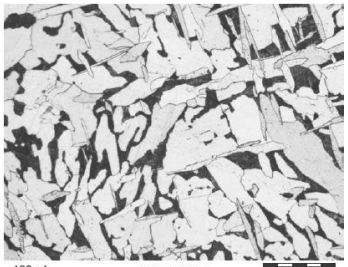
Vannes concernées – 2 ’’ à 24 ‘’

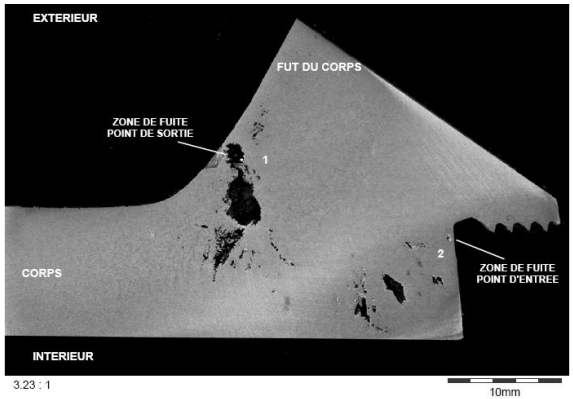
- Cast carbon steel valves
  - ↳ selon API 600 (NF EN ISO 10434) et ASTM A 216 GrWCB
  - ↳ selon DESP

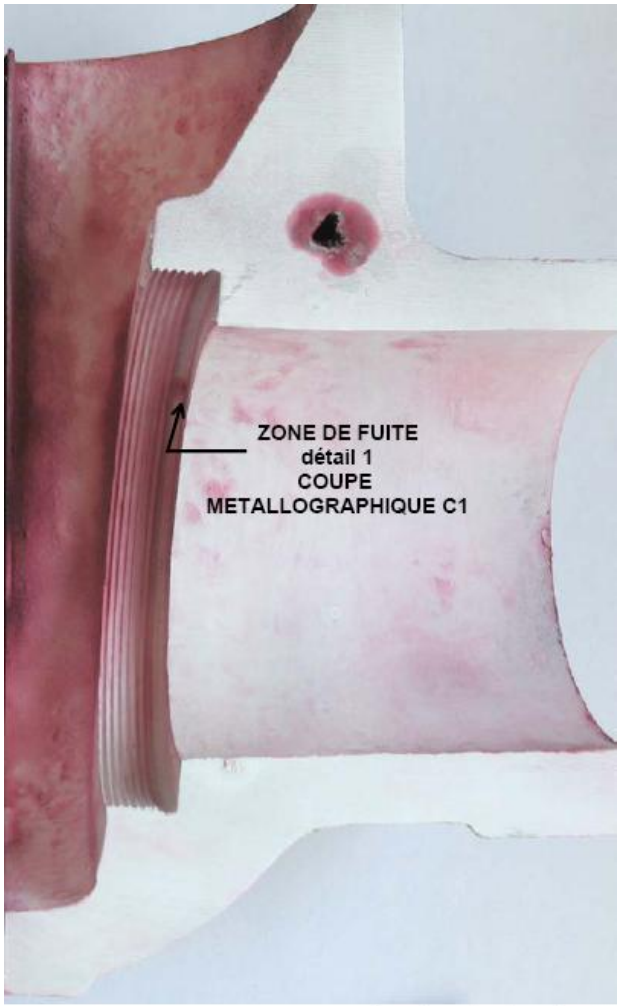


Detected following leak



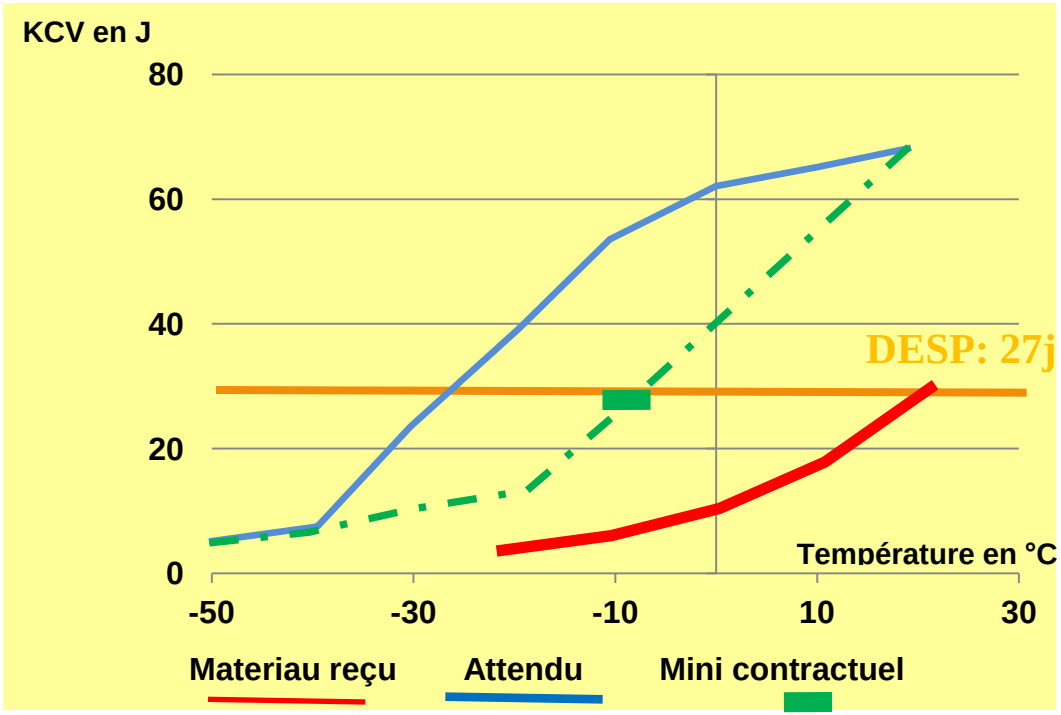


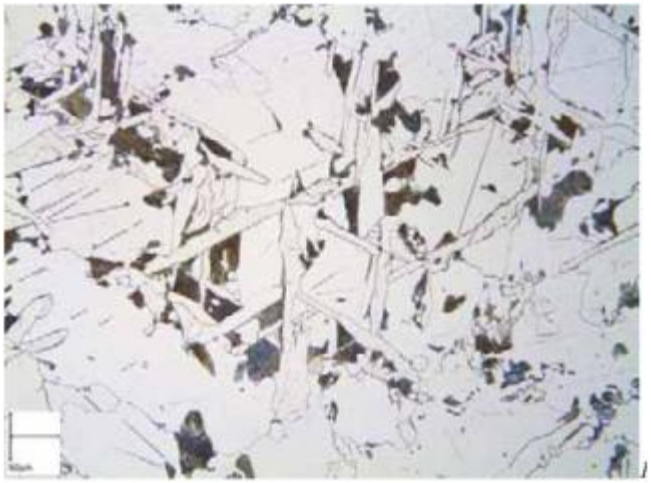




Material caracterisation

Very low toughness

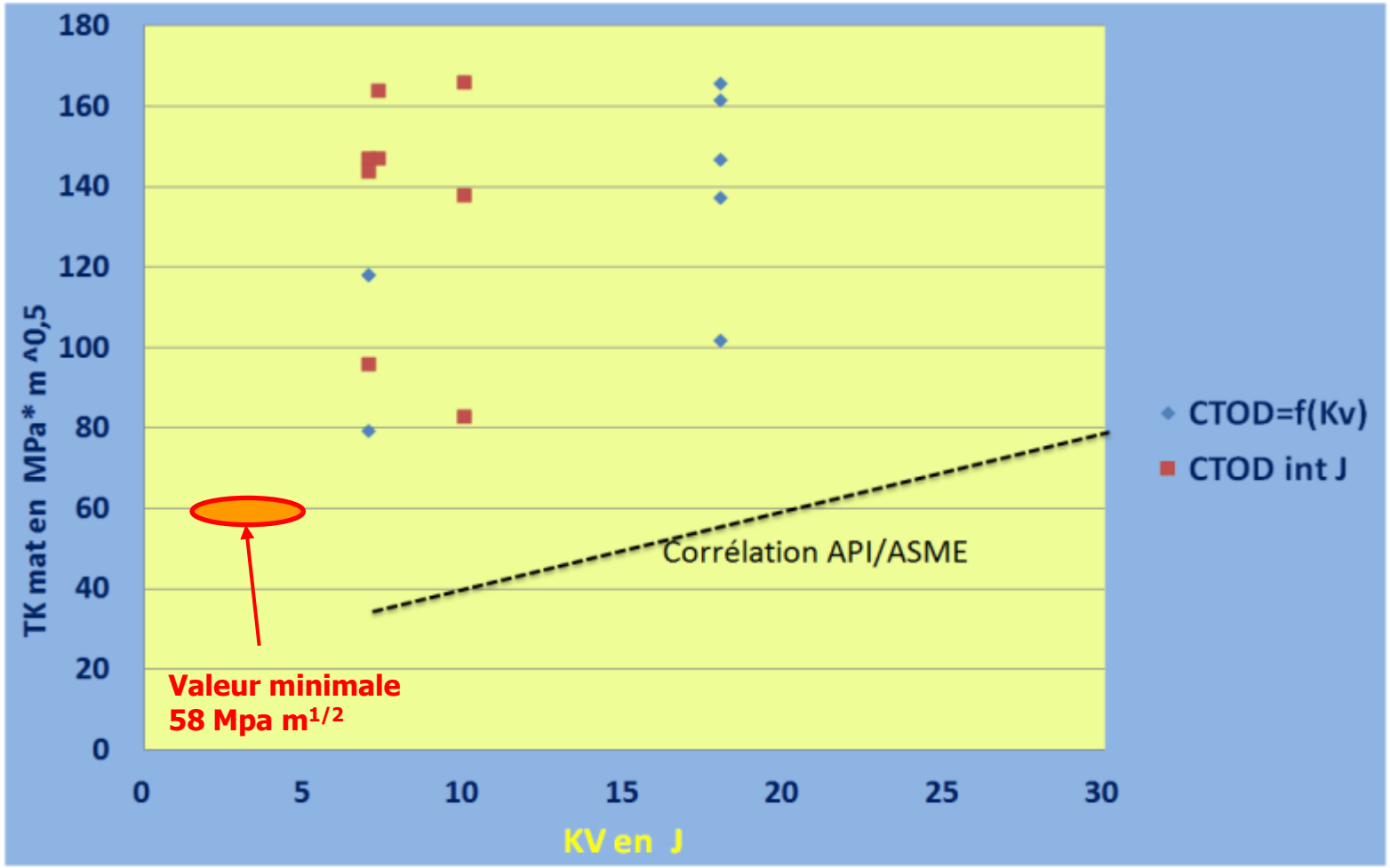




No or bad heat treatment

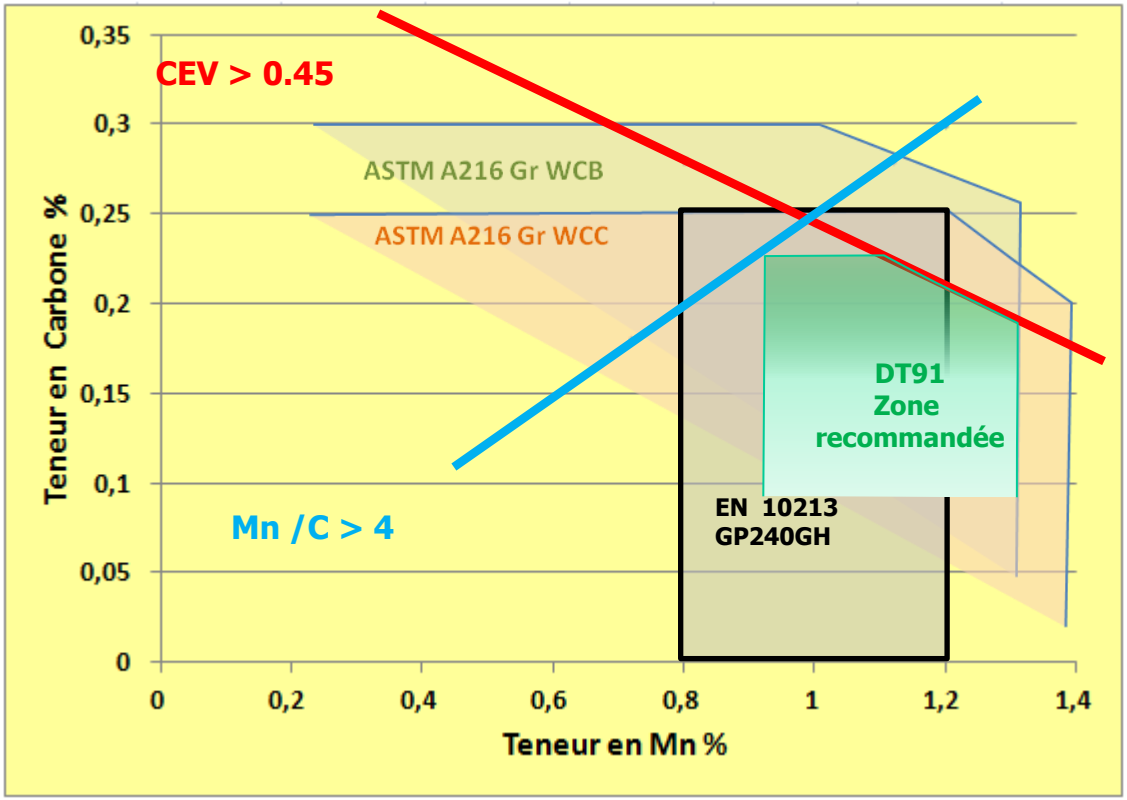
Same problem in Borealis in 1999 on forged materials : no heat treatment

CTOD and toughness correlations



Chemical composition improvement s

- In order to guarant the DESP spec for toughness :
- Low P and S
- High ratio Mn/C



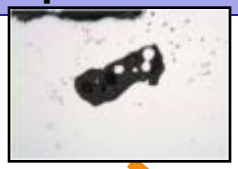
Toughness parameters

Composition

C% , Mn%, S%,P% , N%, Al, Ti …

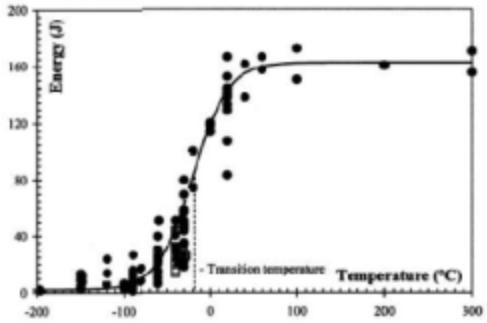
Propreté inclusionnaire

Compacité



Résilience / Ténacité

Temperature



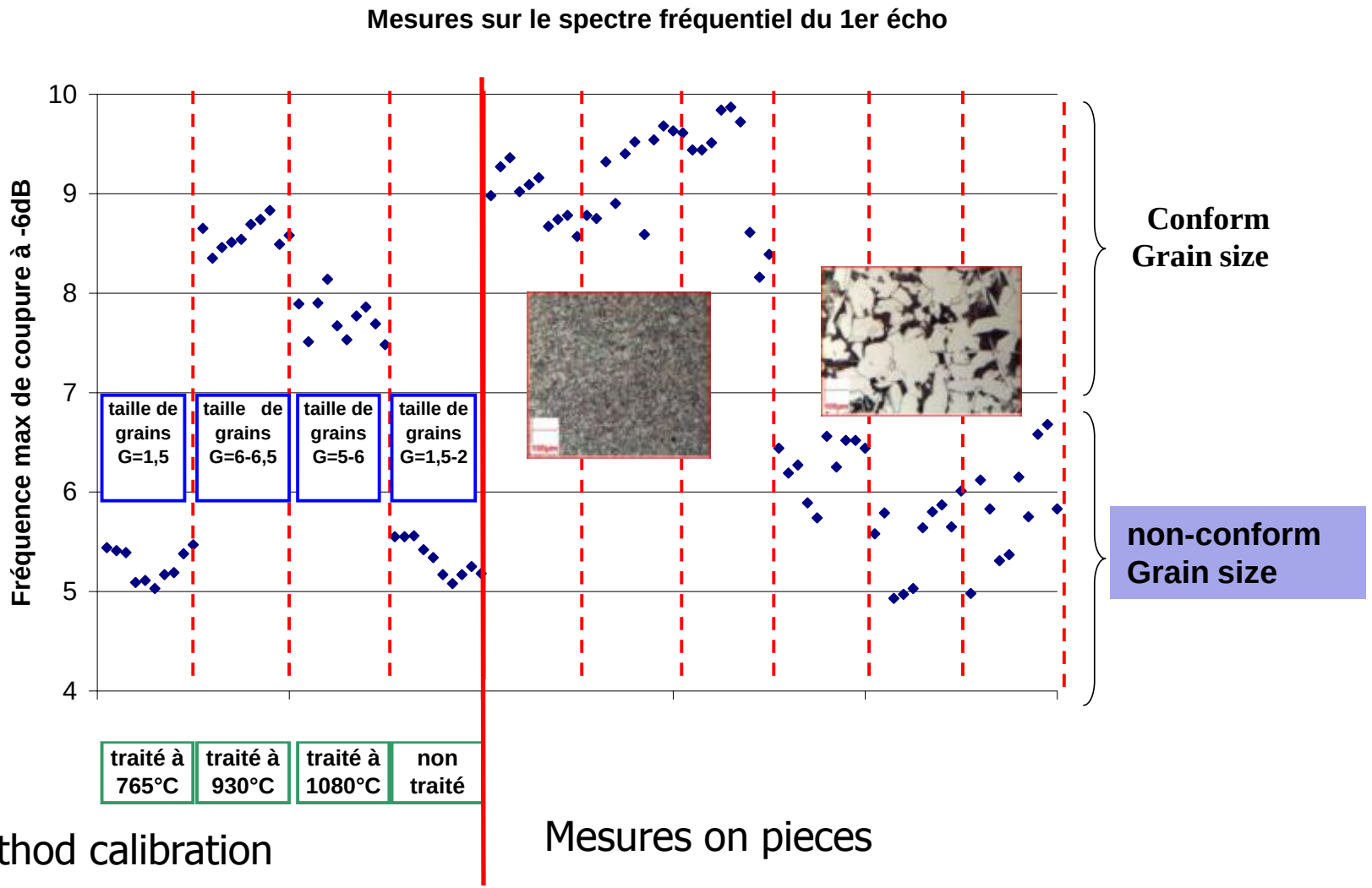
Microstructure

-Ferrite/ Perlite
- Martensite/

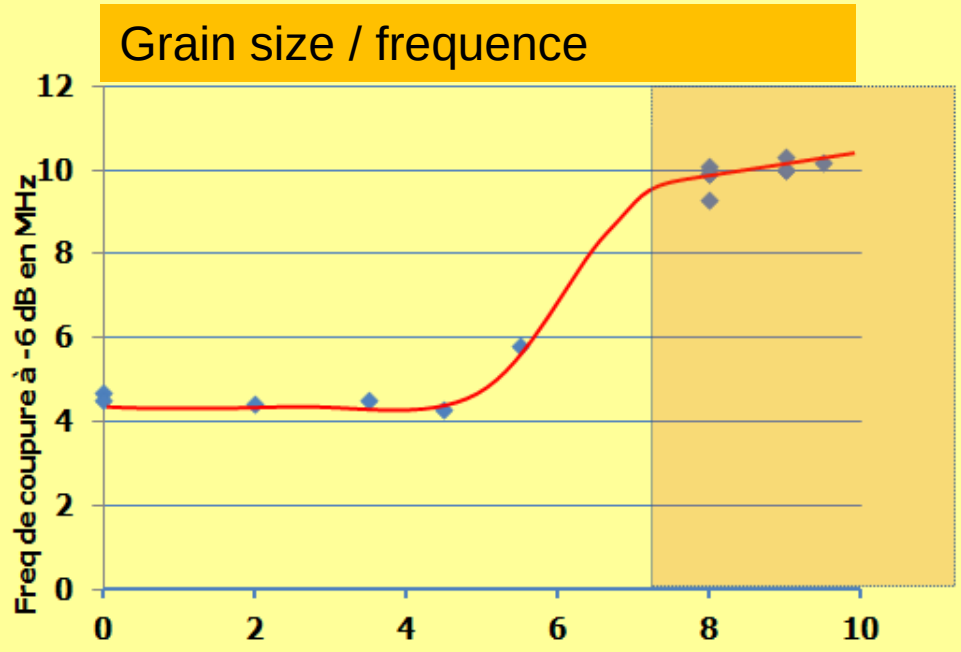
Importance de la taille du grain austénitique.(T, t)

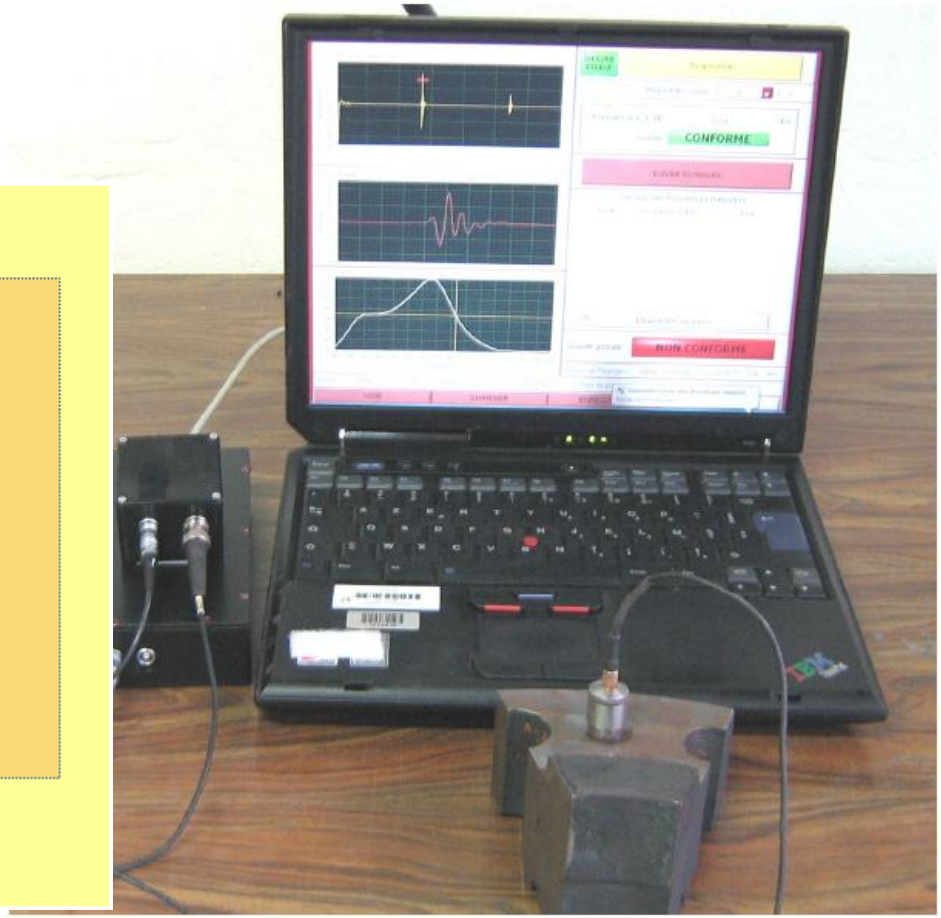
Traitement thermique

Normalized microstructure :Grain size checking
Replica (long and costly)- UT Method



Portable UT device used on site and as control



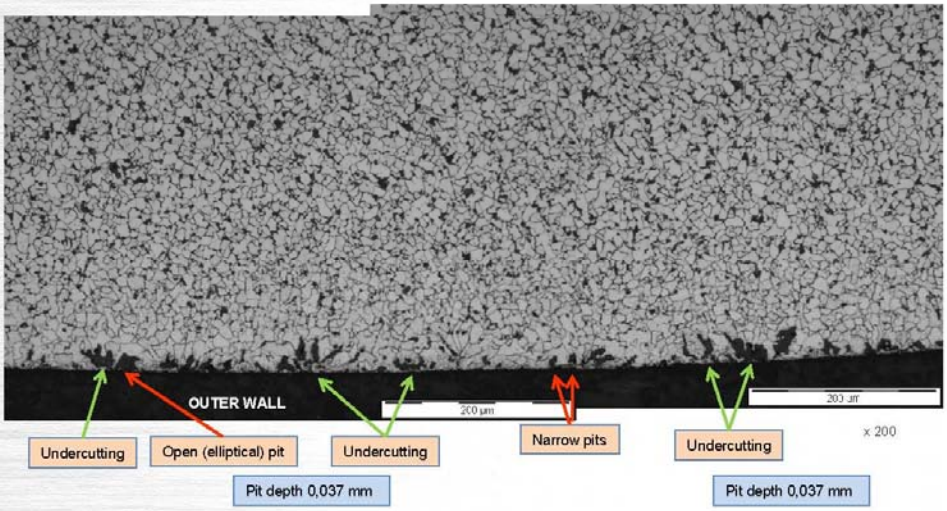


Appendix 8

Quality problems of heat exchanger tubes

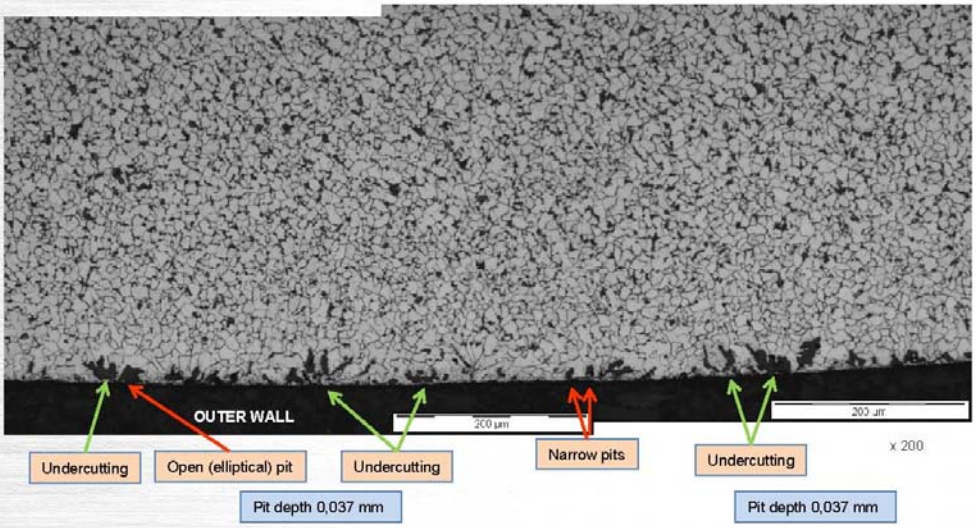
(F. Dupoiron, Total Petrochemical)

Pipe 22 (A210)



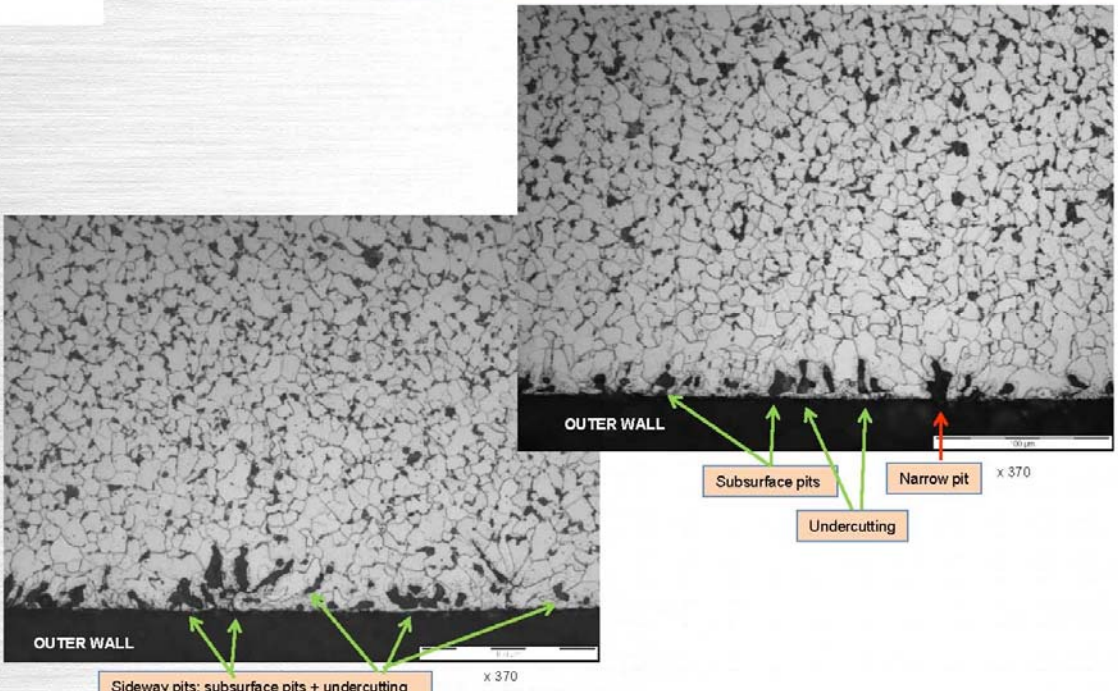
10-093 – 5 pipes 'as received'

Pipe 22 (A210)



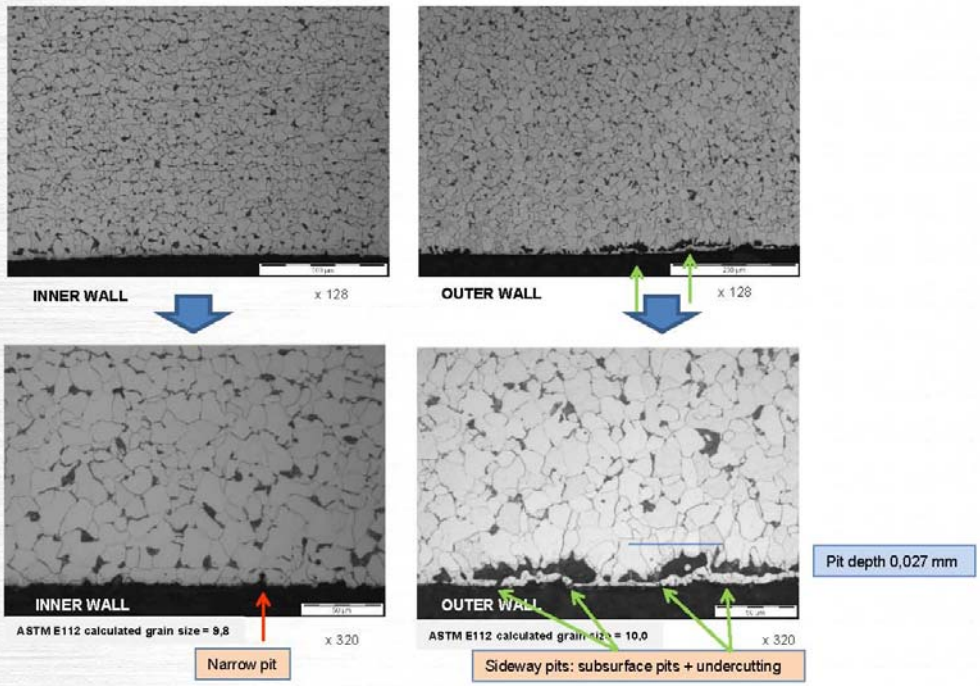
10-093 – 5 pipes 'as received'

Pipe 22 (A210)



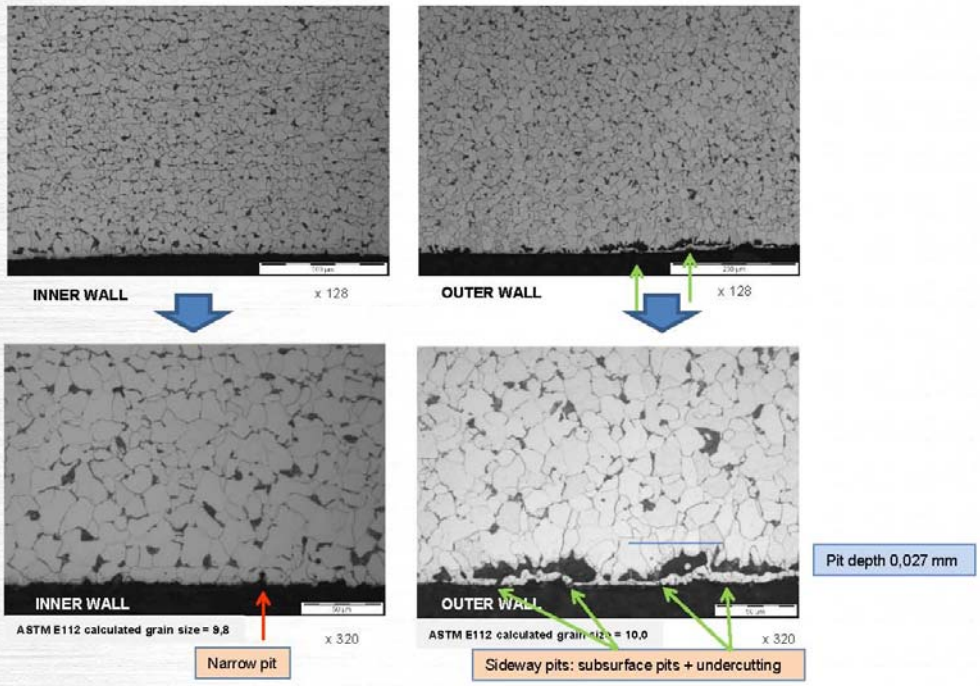
10-093 – 5 pipes 'as received'

Pipe 24 (A179)



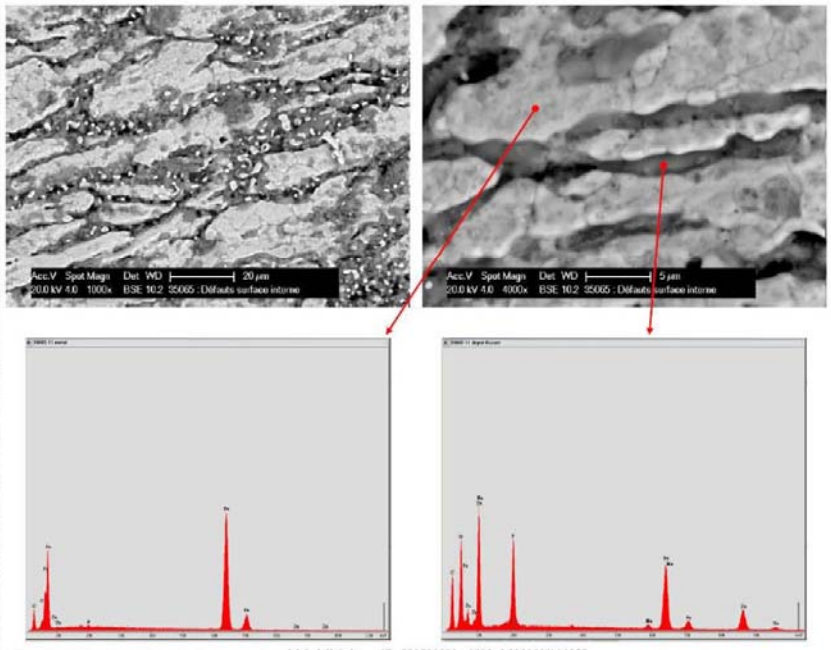
10-093 – 5 pipes 'as received'

Pipe 24 (A179)



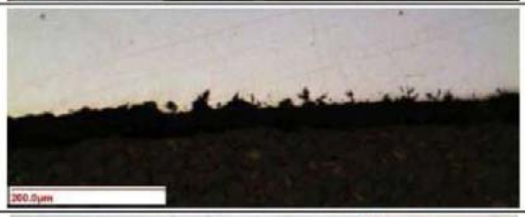
10-093 – 5 pipes 'as received'

Pipe (A179 –)



10-093 – 5 pipes 'as received'

Pipe (A179 –)

Coulée	*Défauts externes*	*Défauts internes*	*Micrographie des défauts en surface interne*
104 430	Cratères avec démarrage d'une fissure en fond de cratère Profondeur 57 µm	Cratères – Profondeur 32 µm	
104 942	Cratères – Profondeur 33 µm	Cratères - Profondeur 60 µm	
103 390	Cratères et fissure Longueur 81 µm	Cratères – Profondeur 26 µm	

Appendix 9

SiC and graphite equipments

(M. Franz, SLG Carbon)

SGL GROUP
THE CARBON COMPANY

Introduction

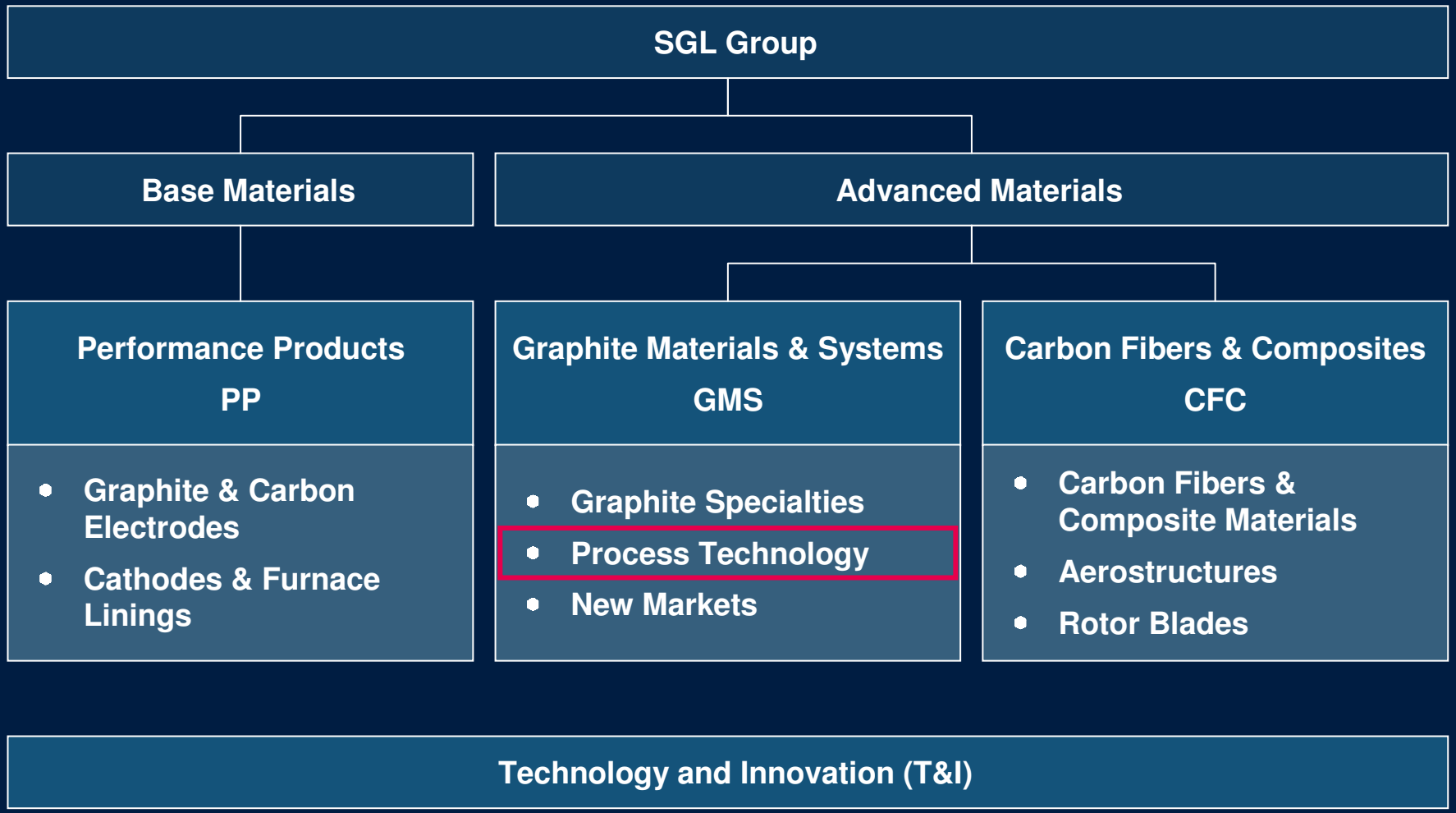
SGL Group – The Carbon Company

Company Profile

- One of the world's largest manufacturer of carbon-based products
- Comprehensive portfolio ranging from carbon and graphite products to carbon fibers and composites
- More than 40 production sites worldwide with
- Service network covering more than 100 countries
- **Sales of 1,54 billion EUR in 2011** (+12% yoy)
- > 6.000 employees worldwide
- Listed on MDAX

SGL Group – The Carbon Company

Organization



Broad Base. Best Solutions.

SGL GROUP
THE CARBON COMPANY

SGL Group – The Carbon Company

Broad Base

Core competencies

- High temperature technology
- Know-how in:
  - Materials
  - Engineering
  - Applications

Comprehensive portfolio

- Coarse-grain graphite
- Fine-grain graphite
- Expanded natural graphite
- Carbon fibers and composites

Global presence

- Global network
- Close to our customers

Broad Base. Best Solutions.

SGL GROUP THE CARBON COMPANY

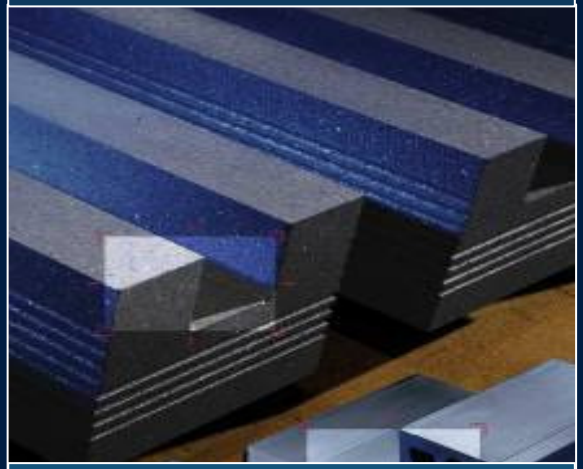
SGL Group – The Carbon Company

Best Solutions

Iron and steel

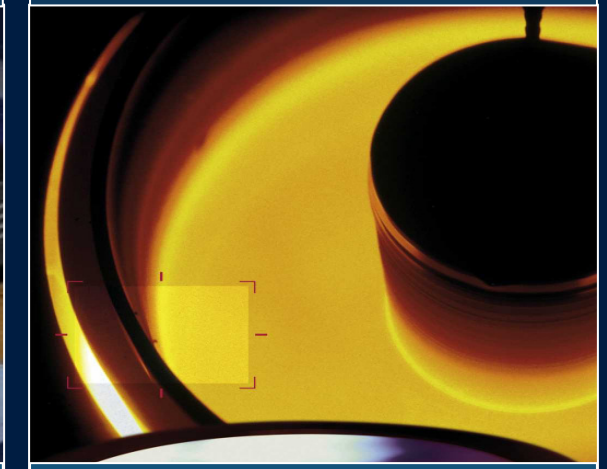
- High-performance graphite electrodes
- Carbon and graphite lining materials for blast furnaces

Non-ferrous metals (e.g. aluminum)



- Carbon and graphite cathodes in customized designs for primary aluminum
- Fine-grain graphite for continuous casting

Photovoltaic, Semiconductor, LED

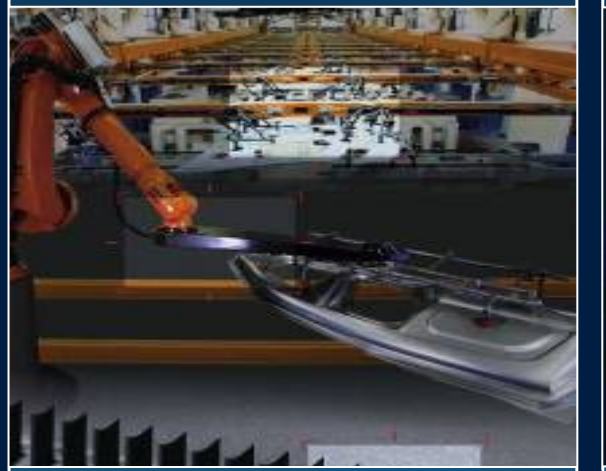


- High-purity fine-grain graphite for polysilicon and monocrystal growing
- Coated graphite susceptors

SGL Group – The Carbon Company

Best Solutions

Mechanical engineering



- CFRP light weight components
- Fine-grain graphite for electrical discharge machining

High temperature technology

- Graphite heaters and insulation material
- C/C charging systems

Chemicals

- Sealing material
- Thermal decomposition units
- Multi-tube heat exchangers

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SGL Group – The Carbon Company

Best Solutions

Aerospace

- Primary structural CFRP components
- Carbon fibers for aircraft brakes
- C/SiC for satellite mirror support

Automotive

- Carbon fiber materials
- Carbon ceramic brake discs
- Cylinder head gaskets
- Pump components

Energy and Environmental technology

- Carbon fibers for rotor blades
- Storage systems for truck air conditioning
- Graphite anode materials for batteries

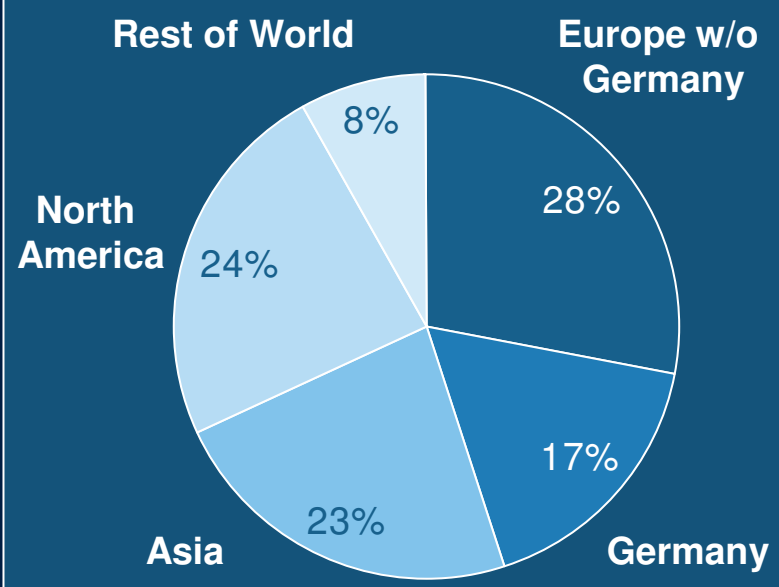
Broad Base. Best Solutions.

SGL GROUP THE CARBON COMPANY

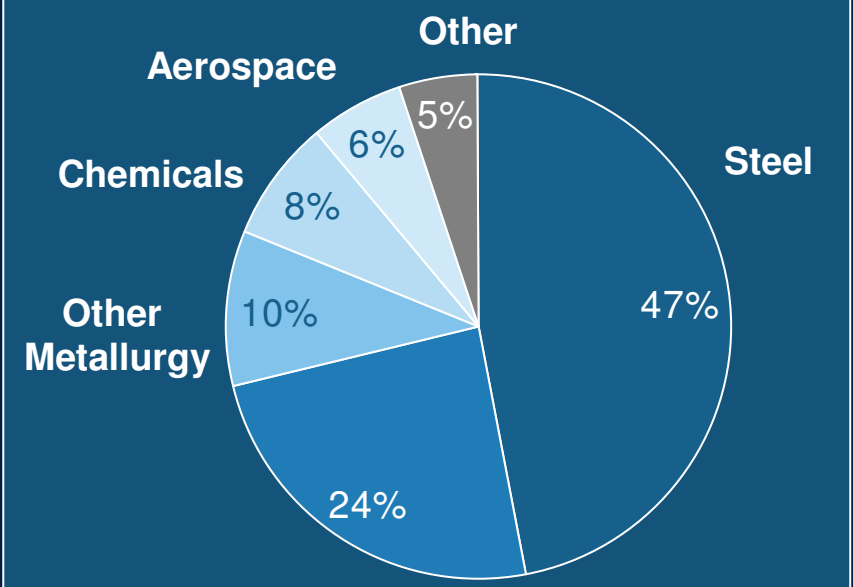
Sales distribution SGL Group

Sales revenue 2010 (total € 1.382 bn)

By region



By industry



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MORE
CARBON

FOR LESS
CARBON DIOXIDE

BROAD BASE. BEST SOLUTIONS.

SGL GROUP
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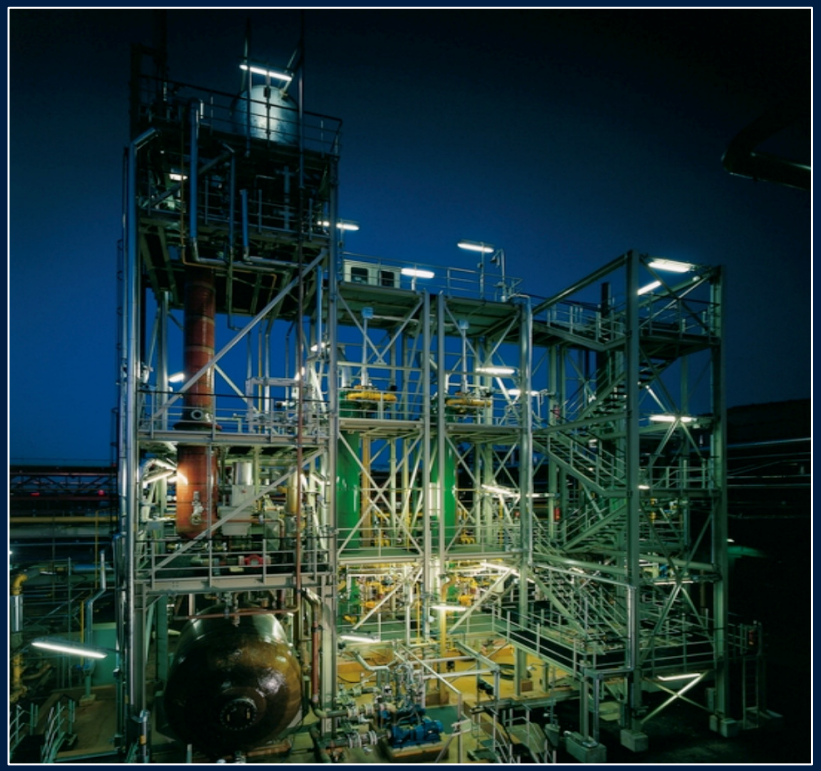
THE CARBON COMPANY

Business Unit

Process Technology

BU Process Technology

At a glance



- Equipment and process solution provide for chemical and related industries
- Broad material base
  Graphite, SiC, PTFE, exotic metals, steel
- Outstanding track record at many global industry leaders
- 9 manufacturing and service sites in 8 countries
- Global sales and service network
- Headquarter in Wiesbaden

Best Solution

Reliability	Efficiency	Sustainability	Innovation

Broad Base. Best Solutions.

SGL GROUP
THE CARBON COMPANY

BU Process Technology

Global business platform

- Headquarter
- **Manufacturing and service site**
- Regional sales center

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THE CARBON COMPANY

BU Process Technology

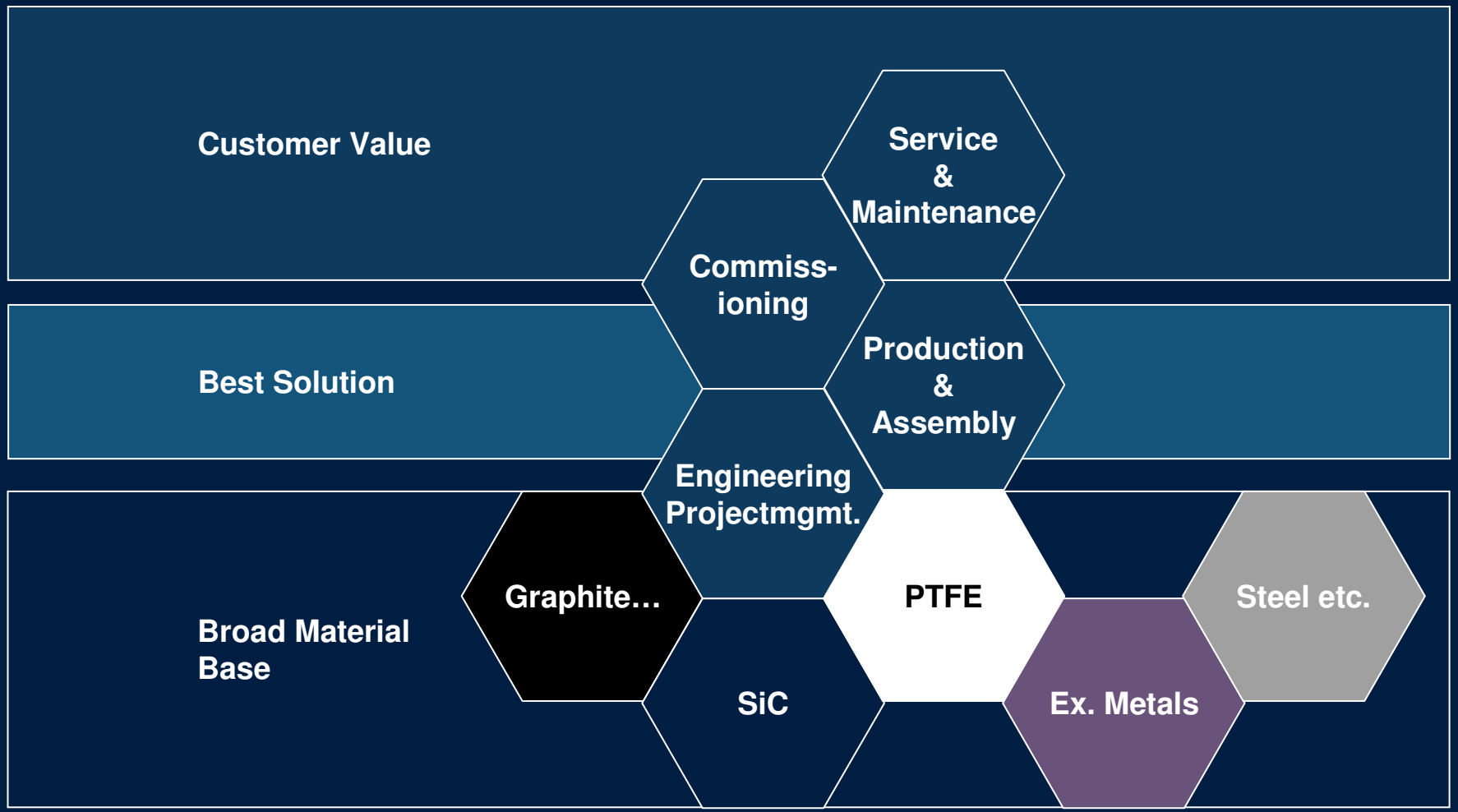
Global organization

BU PT Management Committee

S & M	Product Management	BD	Project Execution	Production	Controlling
▪ CE & CIS ▪ MED & MENA ▪ Americas ▪ Far East ▪ India	▪ Systems ▪ Equipment ▪ PTFE products	▪ Business Develop-ment	▪ Project mgmt. ▪ Project Engineering ▪ Process Design ▪ I&C ▪ CAD Design ▪ Docu-mentation	▪ STR ▪ GRE ▪ MEI ▪ LIM ▪ STY ▪ PUN ▪ SHA ▪ YAM ▪ KAR	▪ STR ▪ GRE ▪ MEI ▪ LIM ▪ STY ▪ PUN ▪ SHA ▪ YAM ▪ KAR
regional	global	global	global	local	local

BU Process Technology

Business model



Broad Base. Best Solutions.

SGL GROUP THE CARBON COMPANY

BU Process Technology

Products - Engineered solutions

System solutions

- Syntheses
- Concentration / dilution
- Absorption / desorption
- Reactors
- Steel pickling

Equipment solutions

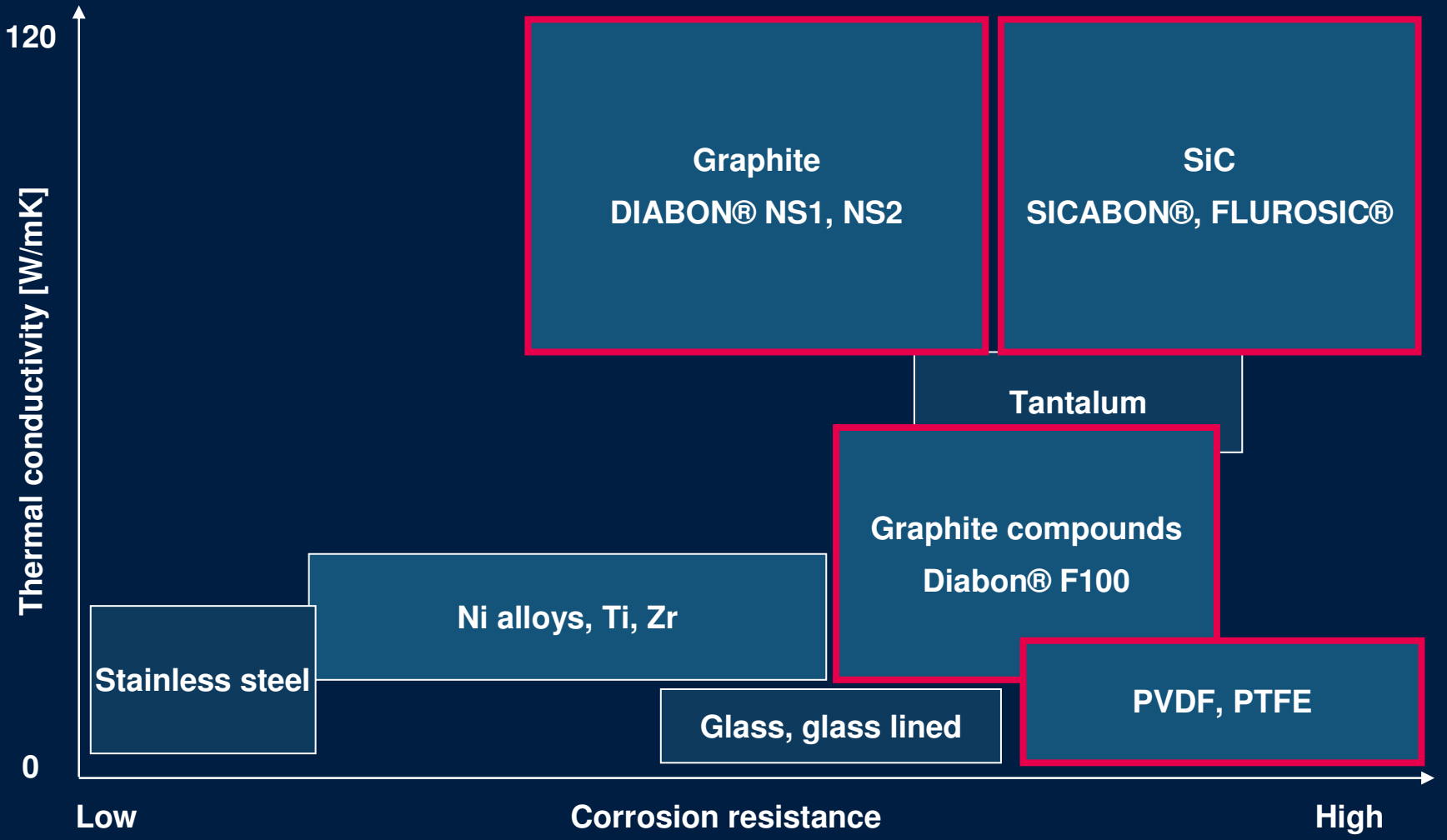
- Heat exchanger
- Reactors / Columns
- Quenchers
- Pumps
- Piping
- Accessories

After sales services

- Spare parts
- Maintenance
- Repairs
- Training

BU Process Technology

Materials



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Applications

- Polysilicon
- Hydrochloric acid HCl
- Hydrofluoric acid HF
- Phosphoric acid H_3PO_4
- Sulfuric acid H_2SO_4
- Vinyl chloride monomer VCM
- Epichlorohydrine EPC
- Isocyanates MDI / TDI
- Diammonium phosphate DAP
- … and many more

BU Process Technology

Industries

Chemicals

Pharma &
Fine Chemicals

Photovoltaic

Environmental

Energy

Food

Steel

Systems

Service

Equipment

Parts

Industries requirements:
Anti-corrosion, abrasion resistance,
heat transfer and heat storage,
high temperature processes, etc.

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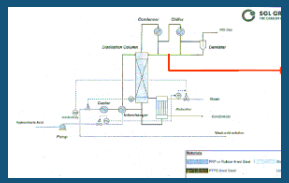
BU Process Technology

Innovation and sustainability

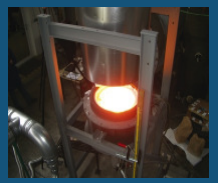
- >60% of PT's product sales already contribute to reduction of CO_2 emissions
- … and our R&D pipeline offers more

Grow green solutions examples

Existing



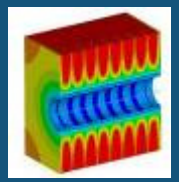
HCl synthesis with heat recovery



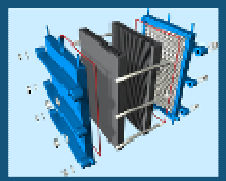
Porous burner for HCFC abatement

New

SiC BHX



PCM thermal battery



Economizer

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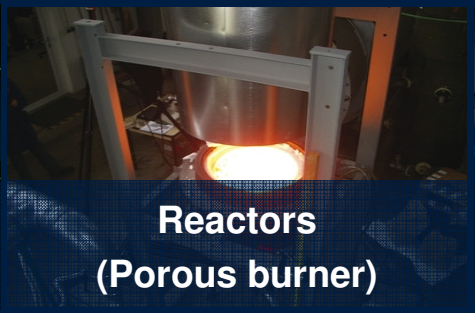
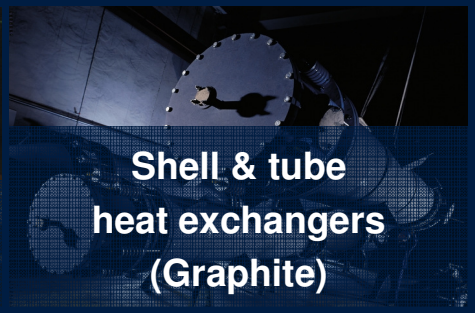
BU Process Technology

Product examples

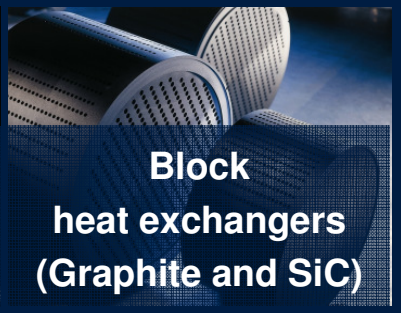
Systems
(HCl, H_2SO_4, etc.)



Reactors
(Porous burner)



Shell & tube
heat exchangers
(Graphite)



Block
heat exchangers
(Graphite and SiC)

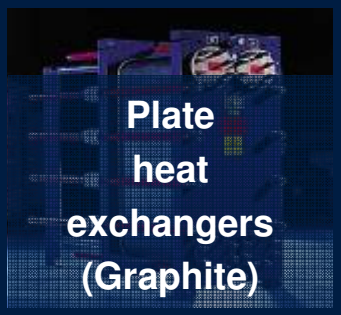
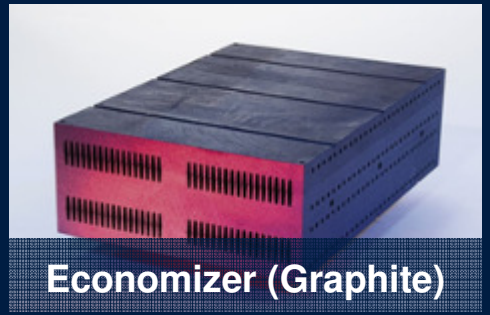


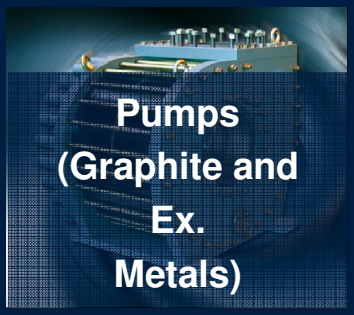
Plate
heat
exchangers
(Graphite)

Shell & tube
heat exchangers (SiC)



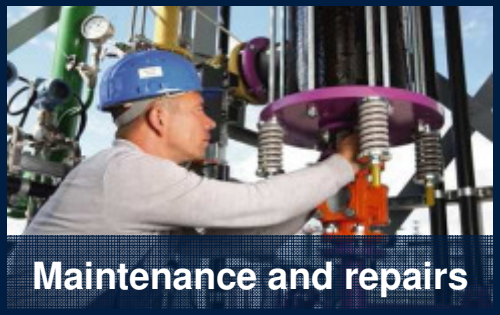
Economizer (Graphite)

Columns
(Graphite and PTFE)



Pumps
(Graphite and
Ex.
Metals)

Piping and bellows
(PTFE)



Maintenance and repairs

Customer training
workshops

BU Process Technology

References (extract)

Broad Base. Best Solutions.

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Appendix 10

Water treatment : 3D TRASAR for boiler technology

(V. Bour-Beucler, Nalco)

NALCO

An Ecolab Company

Essential Expertise
for Water, Energy and Air

3D Trasar for boiler systems

improves Sustainability Performance and Reliability
and reduce Total cost of operation at
a Major Gas Production Plant in Europe

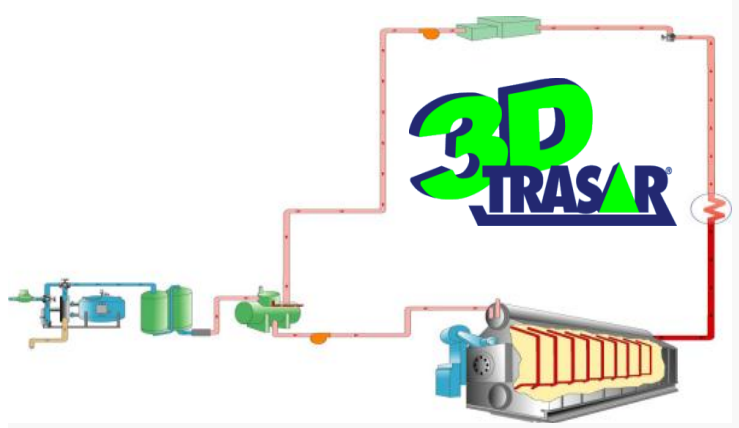
EFC WP 15 Spring Meeting Amsterdam 2012

2012 April 26th

NALCO

Overview

- Introduction
- Benefits
- 3DTrasar Boiler technology
- Background
- Customer goals
- Root cause analysis
- Action Plan
- Results
- Conclusion



DETECT DETERMINE DELIVER

NALCO

3D Trasar Boiler Technology

NALCO

BENEFITS

3D TRASAR

Major Gas Production Plant in Europe

BENEFITS

- **Reduction in Fresh water demand of 27 600 m^3 per year through water use efficiency**
  - Equivalent to annual water needs of 470 people
  - Savings of over €39 000 per year as water use reduction and sewer reception
- **Elimination of silica scale formation and associated maintenance operations and production downtime**
  - Increase in production value of €250 000 per year
  - Maintenance activity reduction of €40 000 per year
- **Energy use reduction eliminated emissions of CO_2 by 1020 tonnes per year**

NALCO

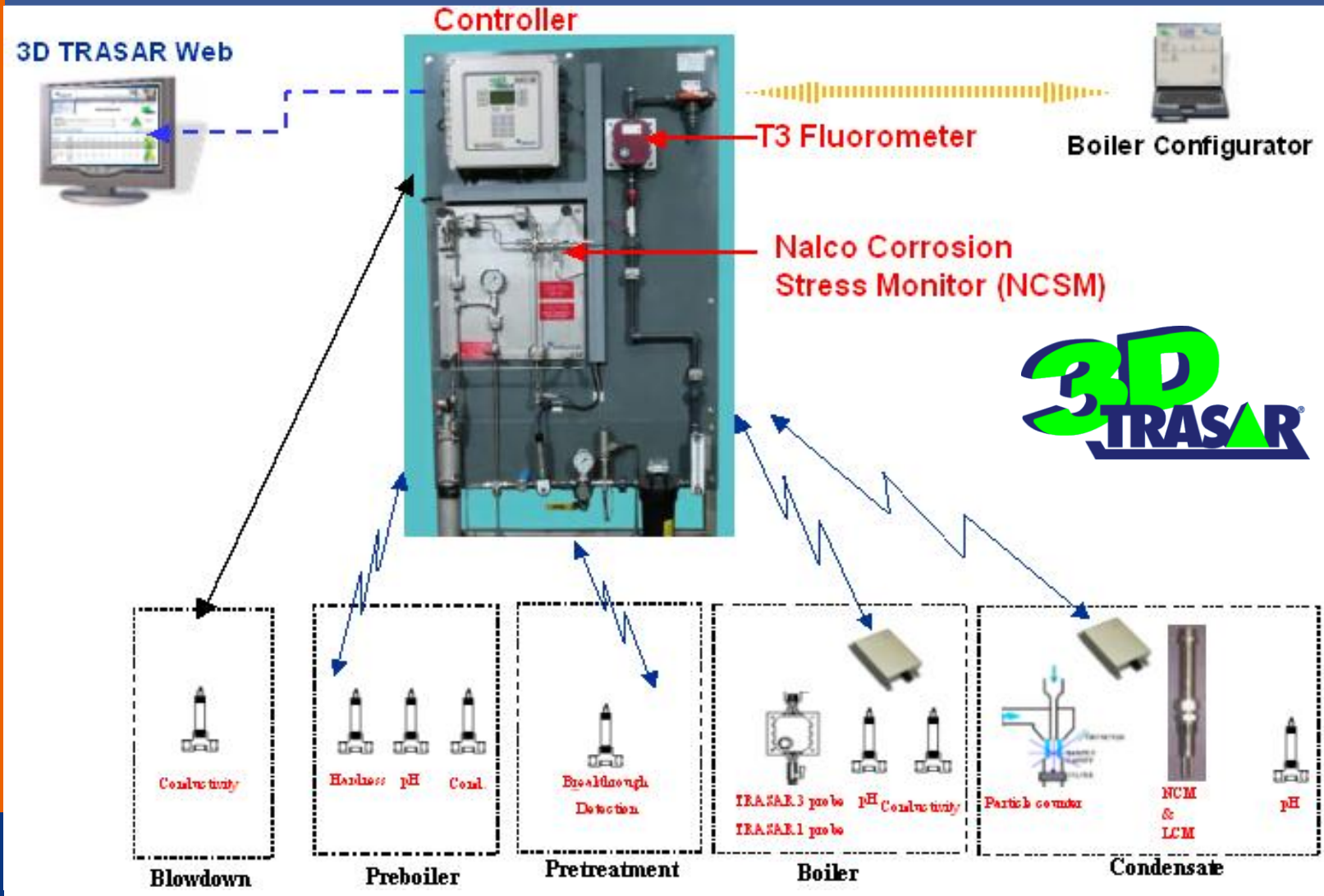
3D Trasar Boiler Technology

3D Trasar Boiler Technology

- Automatically ***Detects*** system variability
  - Nalco Corrosion Stress Monitor (NCSM)
  - TRASAR internal treatment control
  - Direct measurement assures appropriate response
- ***Determines*** appropriate response
  - Compares system condition to desired condition
  - Adjusts system control immediately before problems occur
- ***Delivers*** results through improved control
  - Equipment protection / capital preservation
  - Energy efficiency
  - Prevention of unplanned outages and labor efficiency

NALCO

3D Trasar Boiler Technology



NALCO

3D Trasar Boiler Technology

Nalco Corrosion Stress Monitoring

- It is a real time monitoring
- It a continuous ORP @ temp BFW measurement
- Oxygen scavenger control
- Proactiv tool
- Detect ⇨ Adjust ⇨ Deliver

NALCO

Major Gas Production Plant Case Study

Background

- **Gas production plant > 30 years**
- **2 boiler systems of 60 bars**
- **Steam and power production(turbine)**
- **Periodic upsets of colloidal silica**
  - Low pH and corrosive conditions
  - Significant water and energy losses
    - Manual blowdown,
- **4 deaerators connected together**

NALCO

Background

- **Try to prevent Silica Scale formation on turbine.**
  - One event of major silica ingress
    - Costs over €1M in cleaning,maintenance operation, lost of production during unplanned shutdown
  - Routine ongoing problems
    - Costs of €40 000 per year as maintenance operation and € 250 000 per year as lost of production

NALCO

Gas Plant Goals

- **Negatives impacts upon production, productivity, sustainability performance**
- **MOC audit request to provide recommendations and improvements**
- **Goals for new treatment :**
  - Fresh water savings
  - Energy use and emissions reduction
  - Decrease risk of silica scaling
  - Improve blowdown control
  - Optimize treatment to assure operational integrity and performance
  - Reduce TCO (maintenance and downtime costs

NALCO

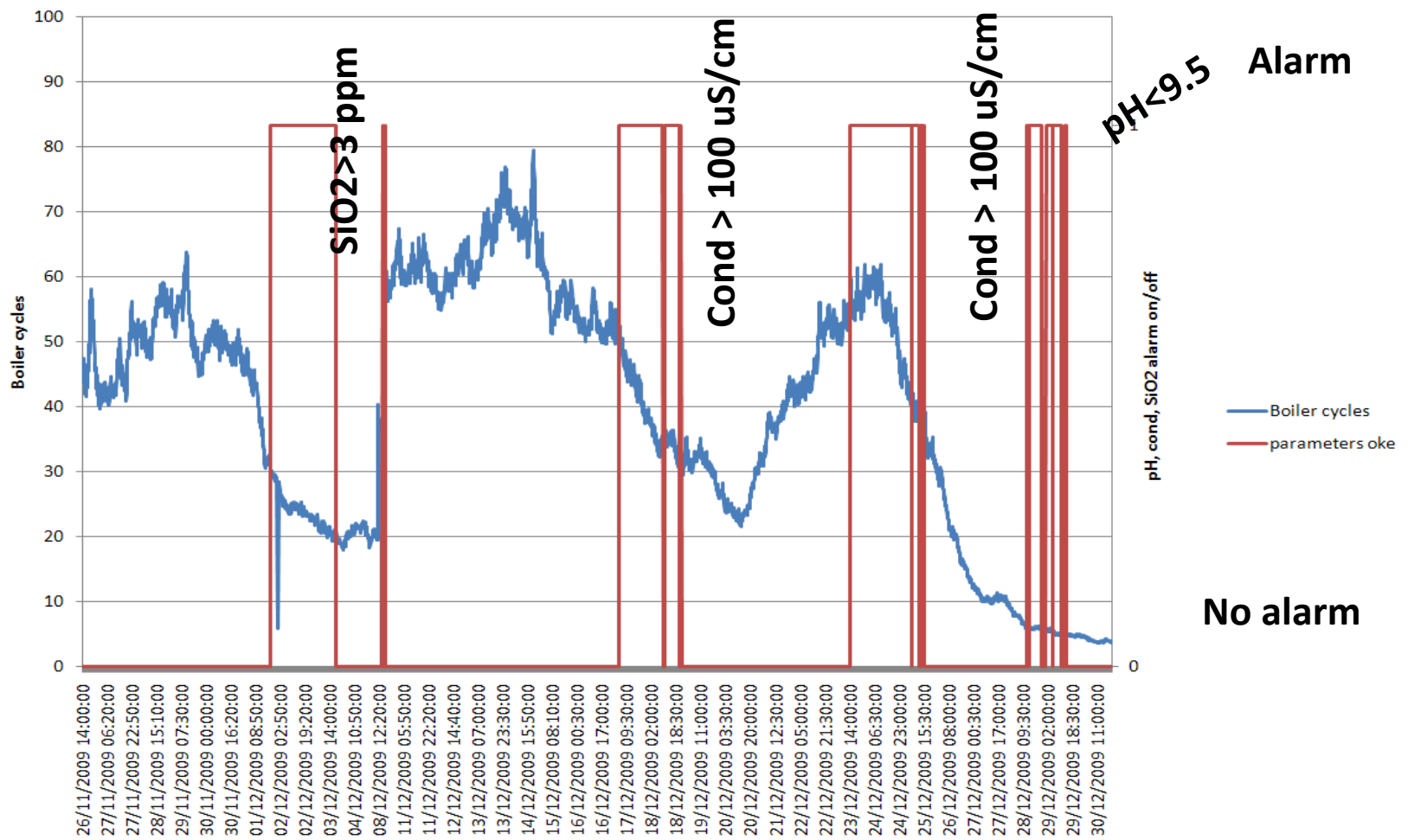
Root Cause Analysis

- **Colloidal silica can't be avoided**
  - Comes spot time from river mountain and goes through demin plant.
  - The colloidal silica breaks in silica and organic acids
    - pH decrease, silica upsets
    - Increases risk of volatile silica flashing-off with steam
      - Precipitation of silica deposits onto the turbines

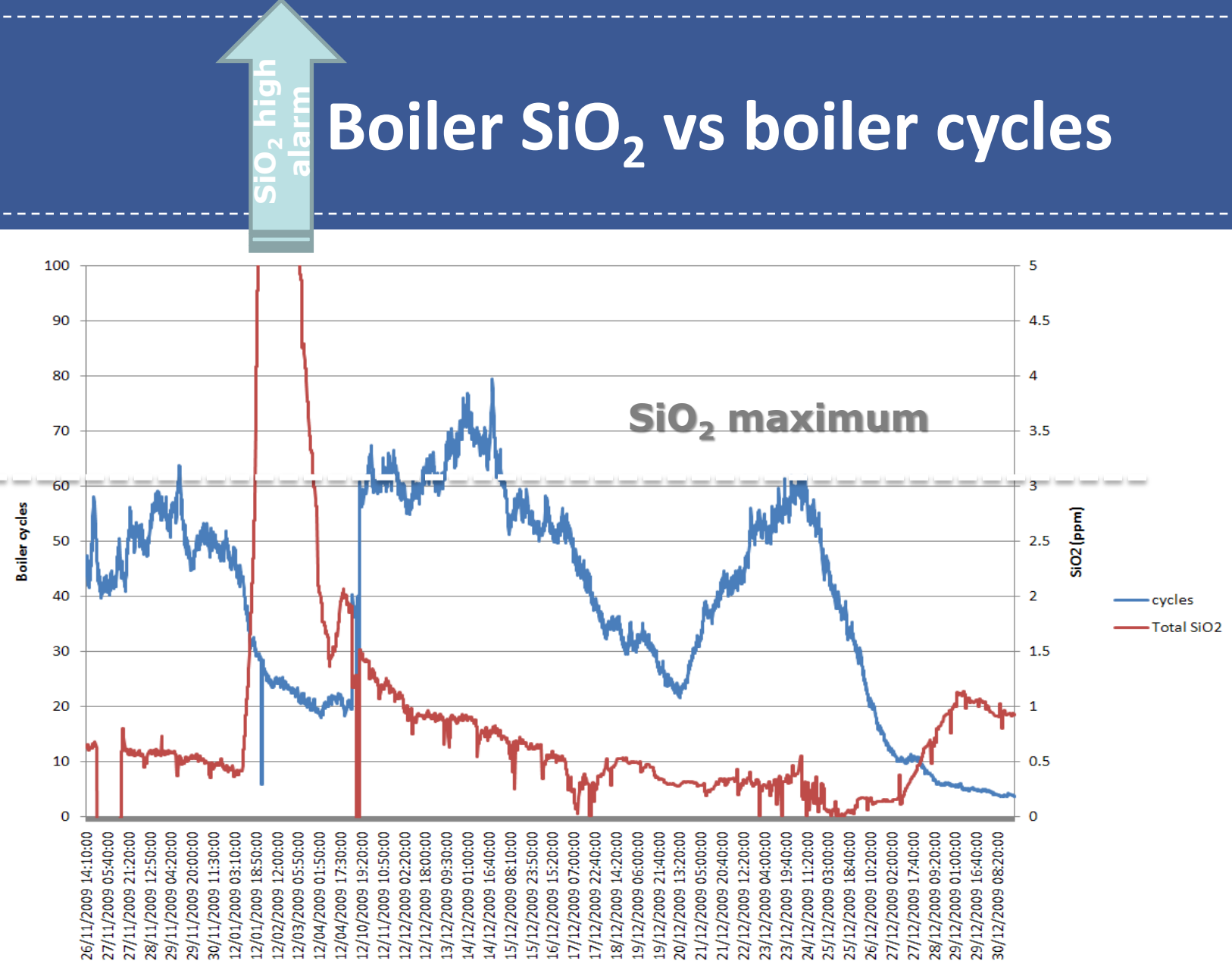
- **Manual blowdown control**
  - No cycle information
  - Limited opportunity to detect impacts and improvements
- **No deaeration performance information**

NALCO

Boiler cycles vs [pH>9.5; conductivity>100 µS/cm; SiO_2>3ppm] alarms



Boiler SiO_2 vs boiler cycles



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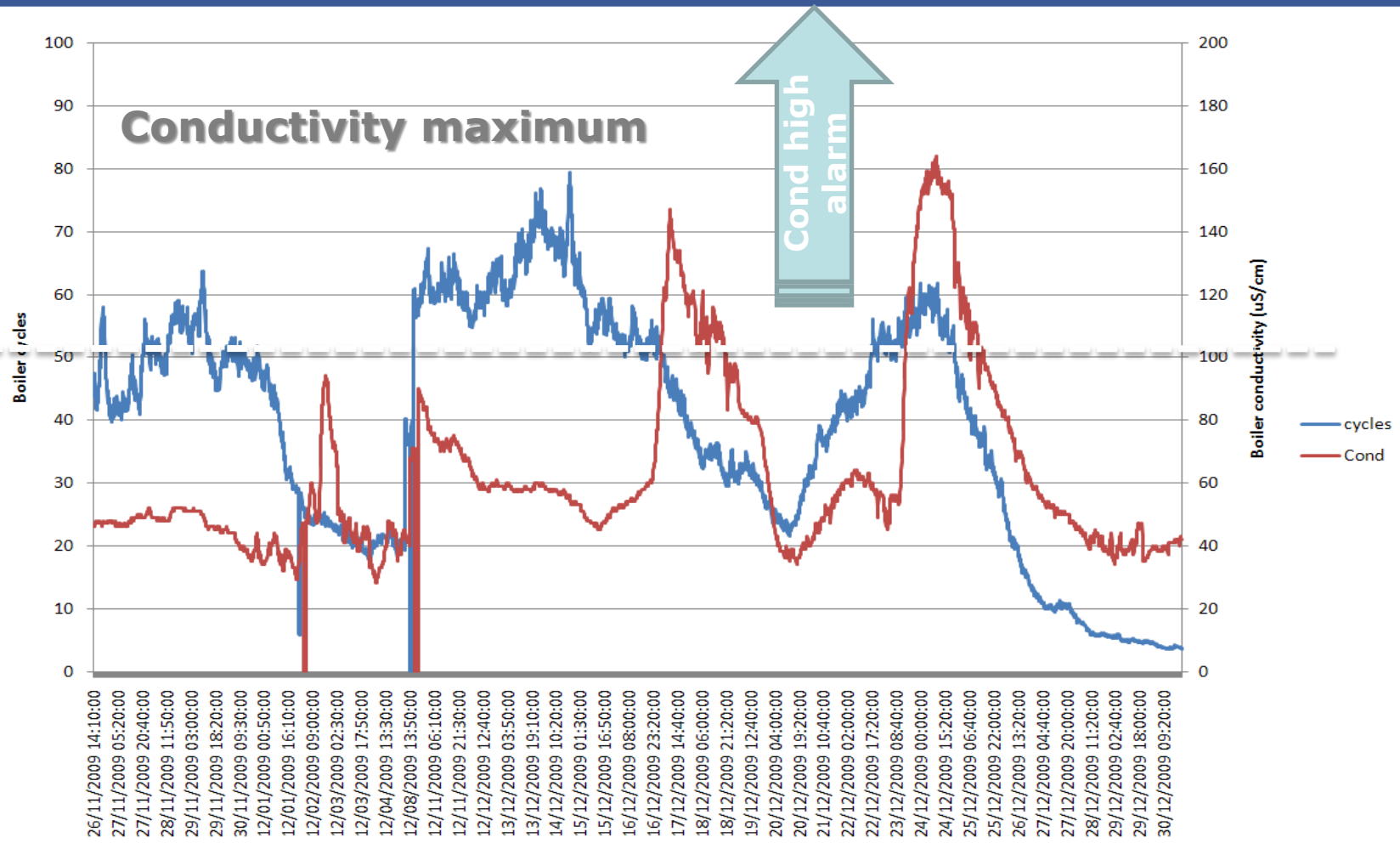
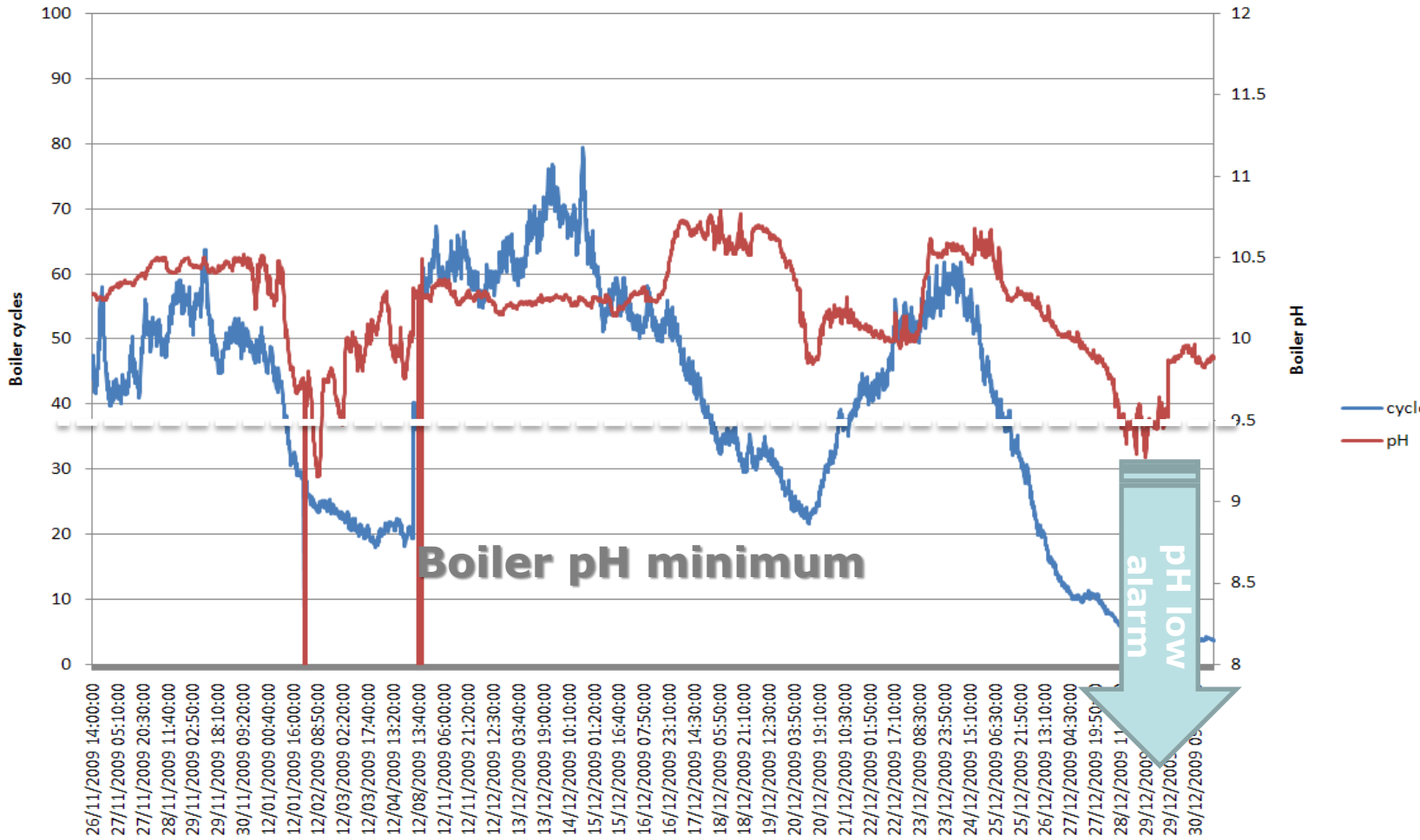
Boiler SiO_2 vs boiler cycles



NALCO

Boiler pH vs boiler cycles



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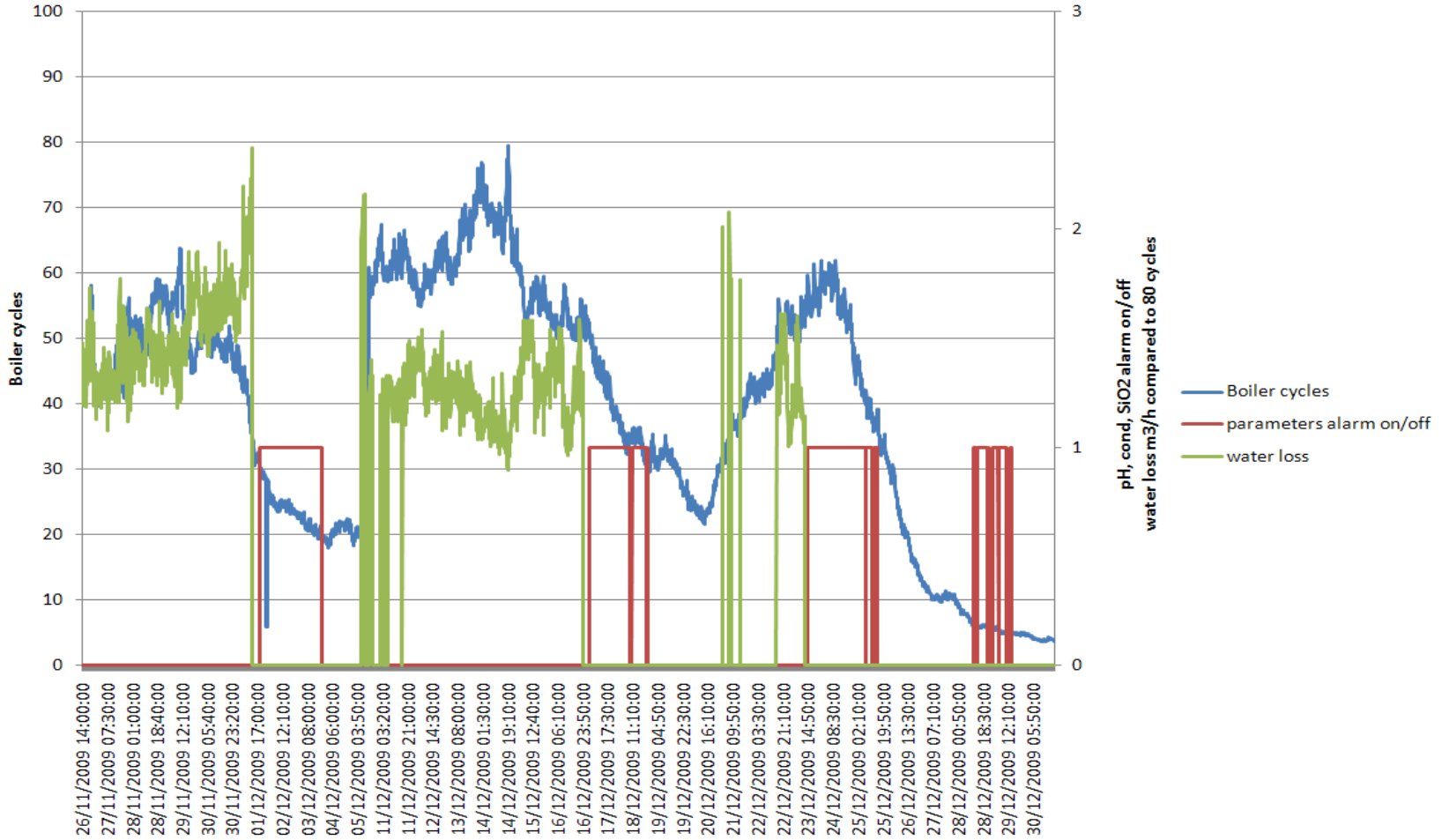
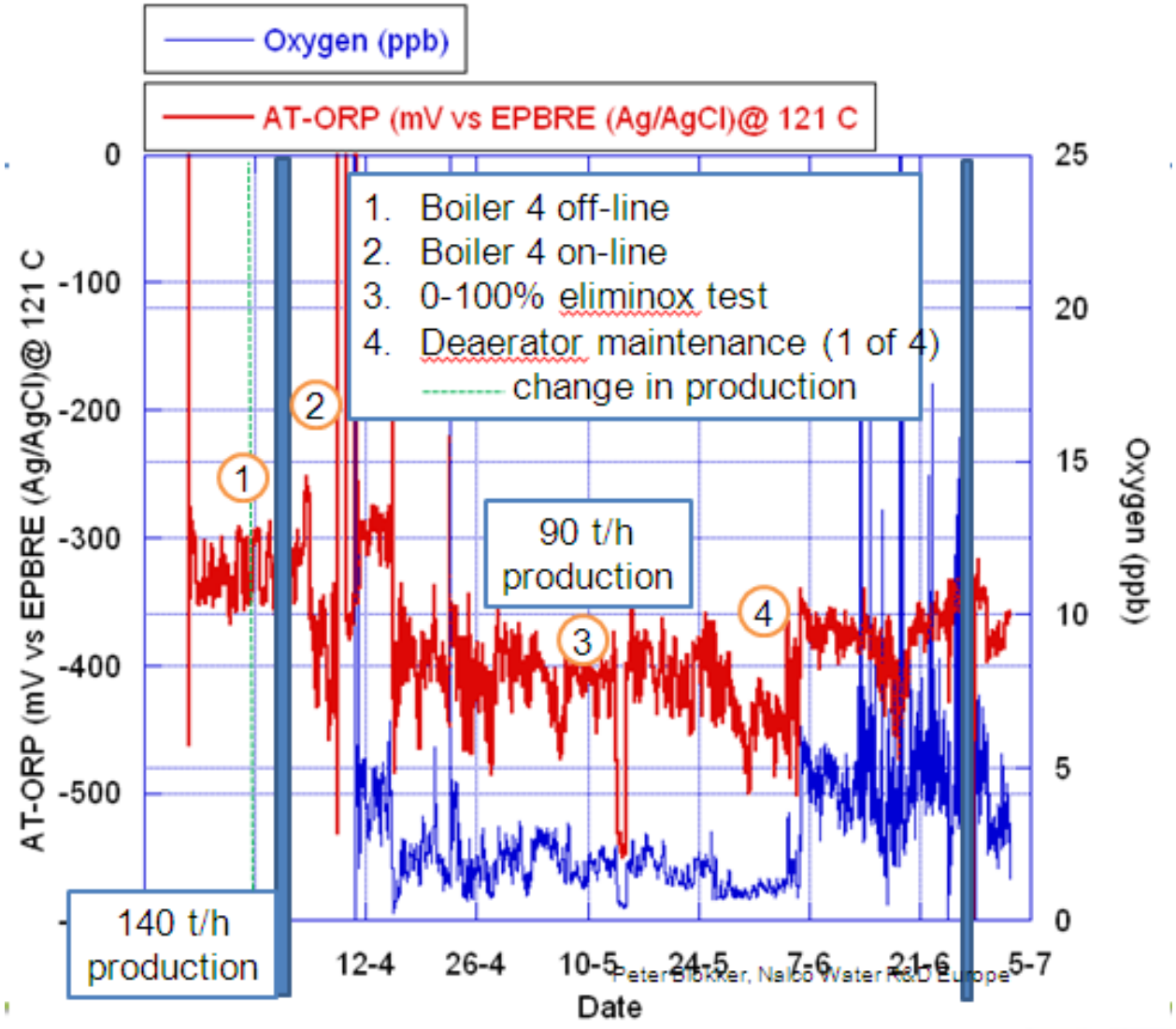
Water savings if main parameters optimized



NCSM Manages Corrosion
Despite Variable System Operation



ACTION PLAN

- **Implementation of NCSM on BFW**
  - Optimize oxygen scavenger injection
  - Real time and continuous information on deaerator performance

- **Implementation of 3D Trasar for boiler water**
  - Injection of traced chemistry to continuous cycle information
  - Treatment are injected at constant level even when the flow changes.
  - Blowdown control on silica level (<3 ppm) during upsets
  - When pH falls below the set point a second phosphate dosing pump is energised to maintain the pH is the recommended range.

ACTION PLAN

This part of 3D Trasar boiler technology is designed to:

- Deliver improve reliability
- Reduce maintenance costs
- Continuously respond to changes in boiler operation and BFW quality
- Minimising system corrosion
- Ensuring clean watersides surfaces
- Minimising water and energy resource use

Continuity of production, conservation of ressources, improve costs management and minimisation of emissions including Greenhouse Gases (GHG)

RESULTS

- **3D Trasar for boiler**
  - Plant goals succesfully met
  - Maintenance savings €40 000/yr (silica)
  - Production increased (€ 250 000/yr) (silica)
  - Cycle from 25 to 50 (80)
    - Savings of 27 600 m3 in fresh water
    - Energy demand reduction of € 40 000
    - Reduction of 1020 tonnes of CO2 per year
    - Savings in TCO of €29 000/yr (Maint. € 25 000)

NALCO

CONCLUSION

- **3D Trasar boiler technology implementation**

  - Improved boiler operations reliability
  - Improved sustainability performance through reduced water and energy usage
  - Optimised treatment giving max system protection, eliminating silica formation on turbine and the associated costs and downtime
  - Increased asset reliability and max production
  - Improve overall plant profitability

NALCO

Appendix 11

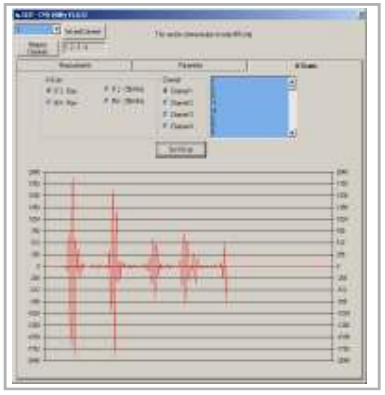
Corrosion Monitoring for sour water application

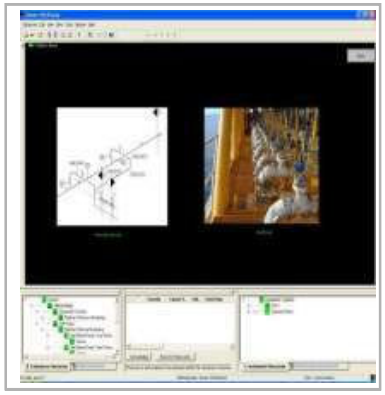
(C. Lavarde, GE)

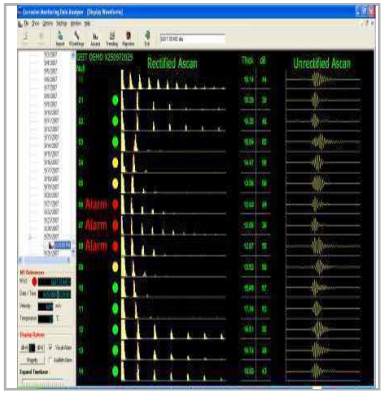
GE Energy- Sensing & Inspection Technologies

Rightrax Corrosion Monitoring

Reduce Total Corrosion Costs







imagination at work

Why Rightrax is used

Aging

- Most assets are old
- 60% of the worlds pipelines are more than 40y old
- these factors increase inspection requirements

Cost

- Inspections are expensive
- Corrosion abatement is expensive
- Loss of production is the biggest cost factor

Safety

- HSE is expensive
- Safety comes first
- Remote monitoring reduces access to dangerous sites

Image

- If accidents happen the company image is damaged
- Multi million dollar fines could be imposed

AND IMPROVED DATA QUALITY !

imagination at work

Where Rightrax is used

Access

- Build scaffolding
- Remove insulation
- Bury pipelines

Hazards

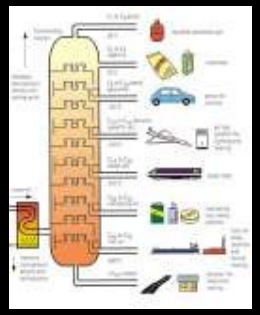
- Chemical areas
- High temperature areas
- Radiations
- High altitude installations
- Explosions

Remote

- Offshore facilities
- Desert facilities
- Jungle facilities
- Artic facilities

Process

- Corrosion
- Erosion



Product versions

Flexible array (LT)

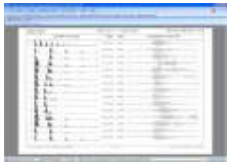
- Both manual and automatic version
- Flexible array with 14 individual transducer elements
- Bonded to the object
- Wall thickness 5mm to 100mm / 0.2" to 3.9"
- Pipe sizes of 6" and over, and flat surfaces
- Operational temperature –40°C up to 120°C / 248°F
- Certified for ATEX zone 2

Advantages:
- Non intrusive, easy installation
- Array coverage area = 12X200mm

Sensor

Controller

Display



Coax Max 70m

Serial Max 260m

High temperature (HT)

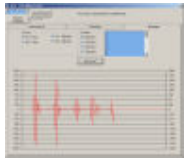
- Both manual and automatic version
- Single point transducer
- Clamped to the object
- Wall thickness 3mm to 16mm / 0.12" to 0.6"
- Pipe sizes of 3" and over
- Surface temperature -20°C up to 350°C and 500°C / 662°F and 932°F
- Certified for ATEX IS for use in zone 1

Advantages:
- Non intrusive, easy installation
- Process related events due to high resolution

Sensor

Controller

Display



Coax 5m

Serial Max 600m

imagination at work

Online Corrosion Monitoring

Two product lines for corrosion and wall thickness monitoring available

Rightrax Flex

Rigtrax 120C

DL2 manual data logger

Sensor Interface

Engineer Station

Plant Asset Mgr System 1

- 40°C up to 120°C

Upstream/Midstream Low Temp

Rightrax HT

DL2 manual data logger

HT 350C

Sensor interface

RS 485

Engineer Station

Plant Asset Mgr System 1

- 10°C up to 350°C / 500°C

Downstream High Temp

imagination at work

Downstream Showcase: Essar (formerly Shell Stanlow) Sour Water Stripper system

Concern:

This system required frequent inspections on a monthly basis due to the aggressive and sometimes irregular corrosion rates, in normal operation the system is insulated and has required constant removal and replacement of the insulation, therefore greatly increasing of the inspection costs.

Solution:

- Manual system for high temperature with 20 sensors on the critical 8" CS piping, Pipe Operating Temp is 90 °C
- Manual data logger

Configuration:

- Measurements are made manually as per customer's required time frames
- Data stored on DL2
- Data analysed via downloading DL2 to customer's PC w/ supplied software

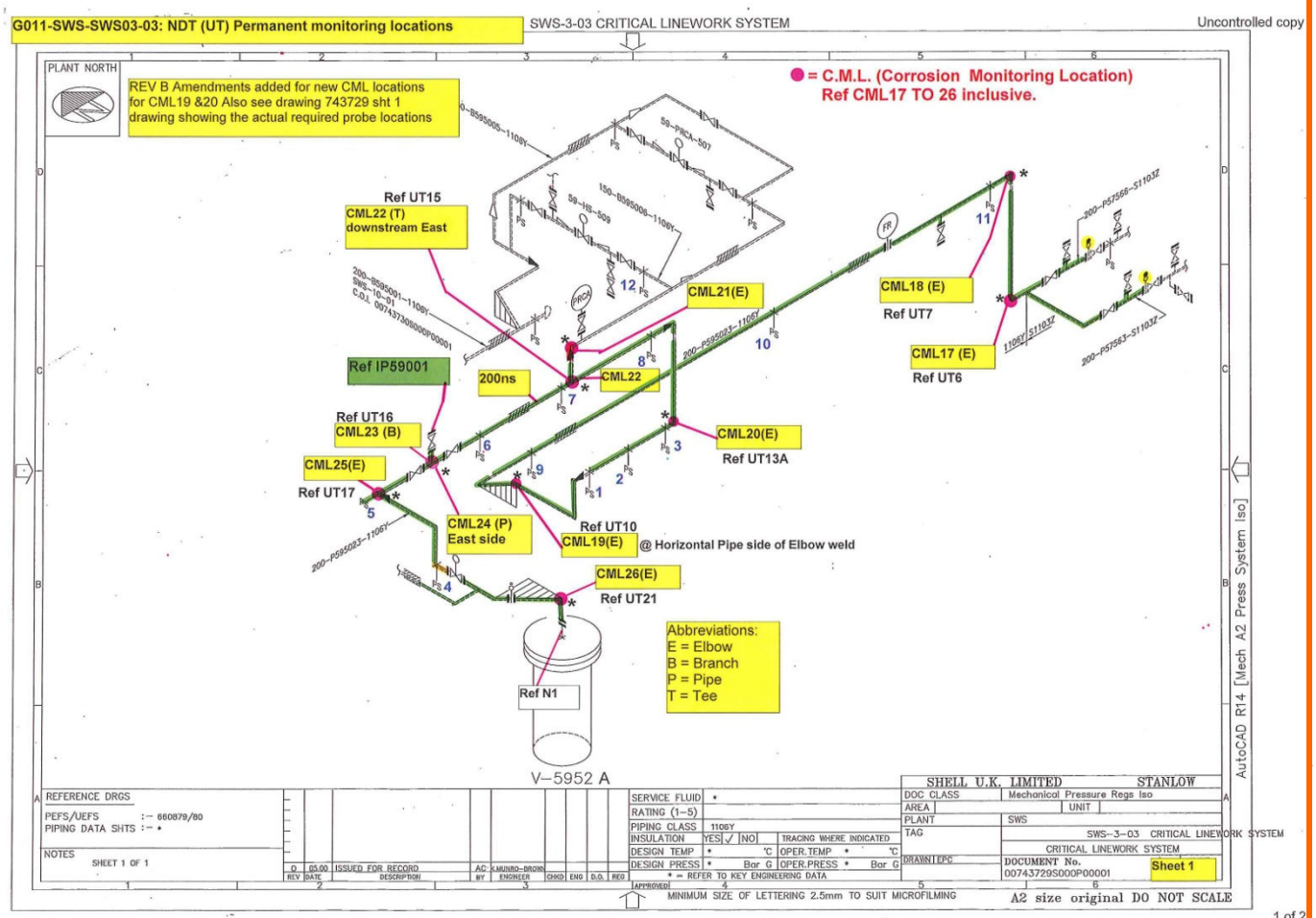
Value and cost saving:

- Reduced costs with thickness measurement services, insulation removal
- Regular inspections are now carried out 2 to 3 times a week with no extra preparation costs.
- Monitoring critical process and preventing incidents
- More operational control

Statement from Paul Wilcox:
"Working closely with Applus RTD and GE Inspection Technologies, the installation of a 20 point, High temperature Rightrax system at our facility at Stanlow, UK, is providing satisfactory information to confirm that the corrosion monitoring capabilities of this system.
It's cost effective, accurate and simple to to operate
Wilcox Chief Inspector
Essar Stanlow Refinery (formerly Shell)

imagination at work

Corrosion Monitoring Essar (Shell Stanlow) Sour Water Stripper system



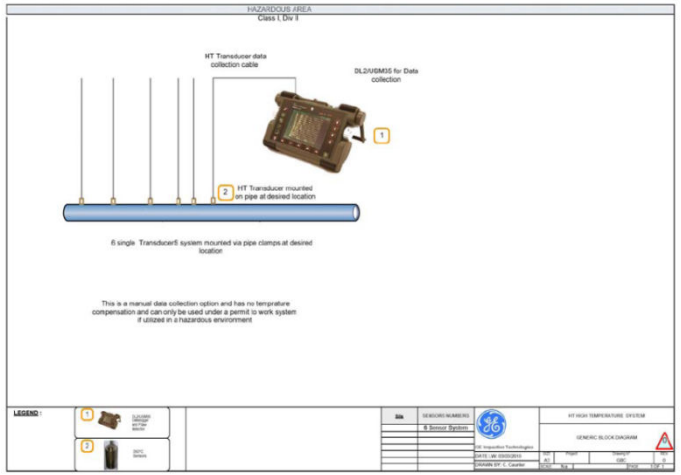
Permanent Monitoring Locations

CML17	Outer radius of bend
CML18	Outer radius of bend
CML19	Outer radius of bend
CML20	Outer radius of bend
CML21	Outer radius of bend
CML22a	130mm from weld
CML24	bottom of PUP piece
CML25	Outer radius of bend
CML26	Outer radius of bend
CML31	Top of pipe

imagination at work

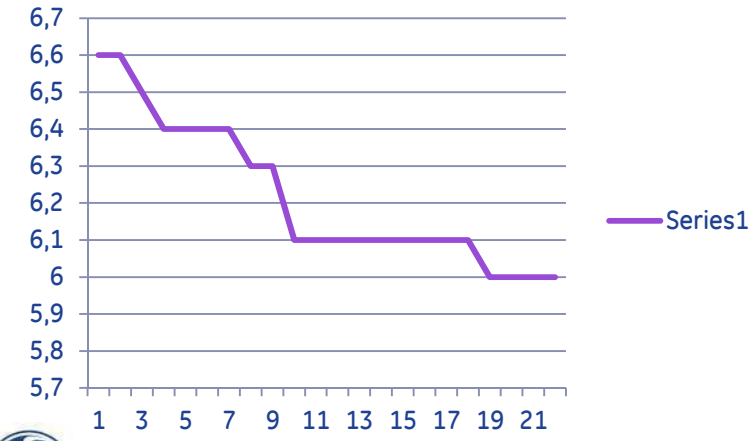
Downstream Showcase: Essar (Shell Stanlow)

Conceptual drawing

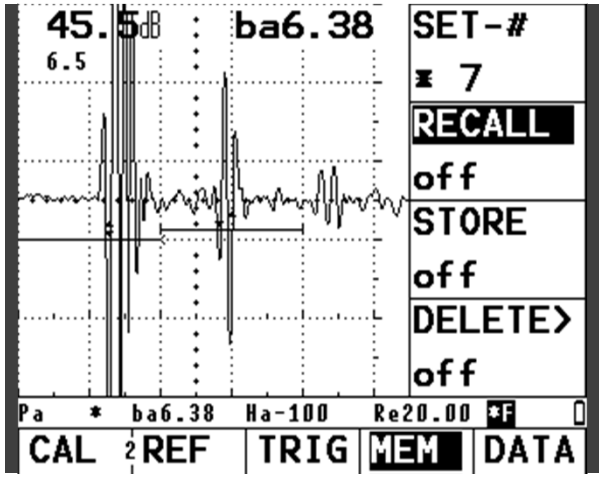


HT350 Transducer installed on an Elbow before Insulation re-instatement

Readings taking in mm



A Scan response from CML Point 20 on a corroded area showing the wall thickness at 6.38mm



imagination at work

Appendix 12

Monitoring of long lengths of pipes using permanent guided waves sensors

(A. Demma , Guided ultrasonics Ltd)

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

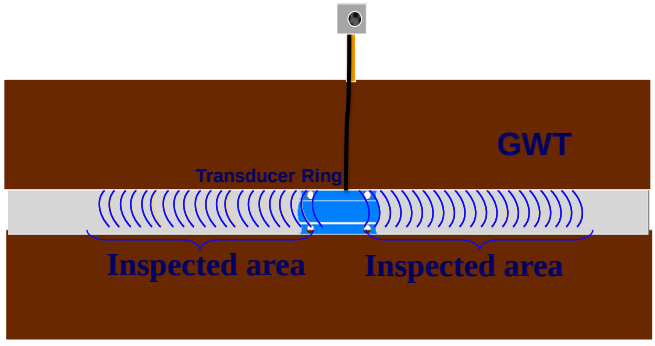
Monitoring of long lengths of pipes using permanent guided wave sensors

A. Demma

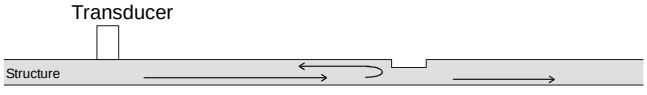
gPIMS monitoring

Guided Wave Permanently Installed Monitoring System

g-PIMS principle



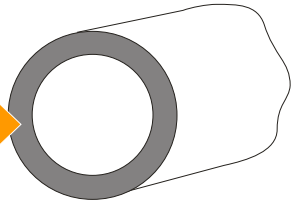
Reflection from a Feature
(such as corrosion)



When the guided wave hits a change in cross section (or impedance), it reflects back toward the transducer

Cross Section Change

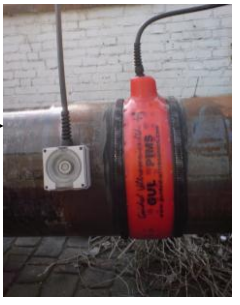
The dark grey Section represents the Cross-sectional area

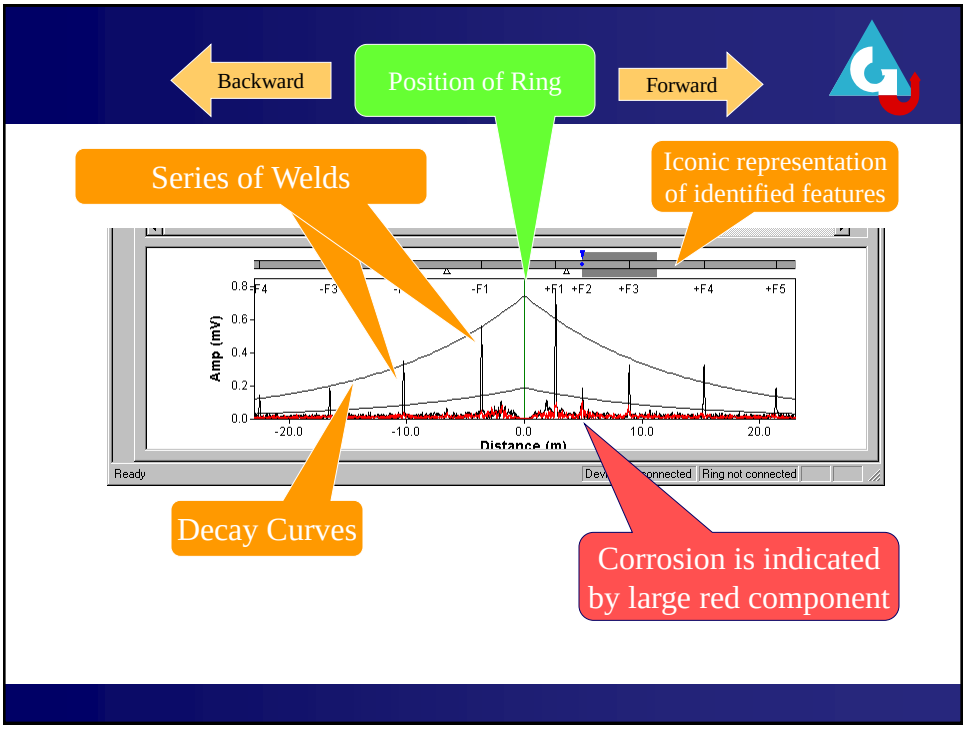


Typical targets are corrosion and erosion

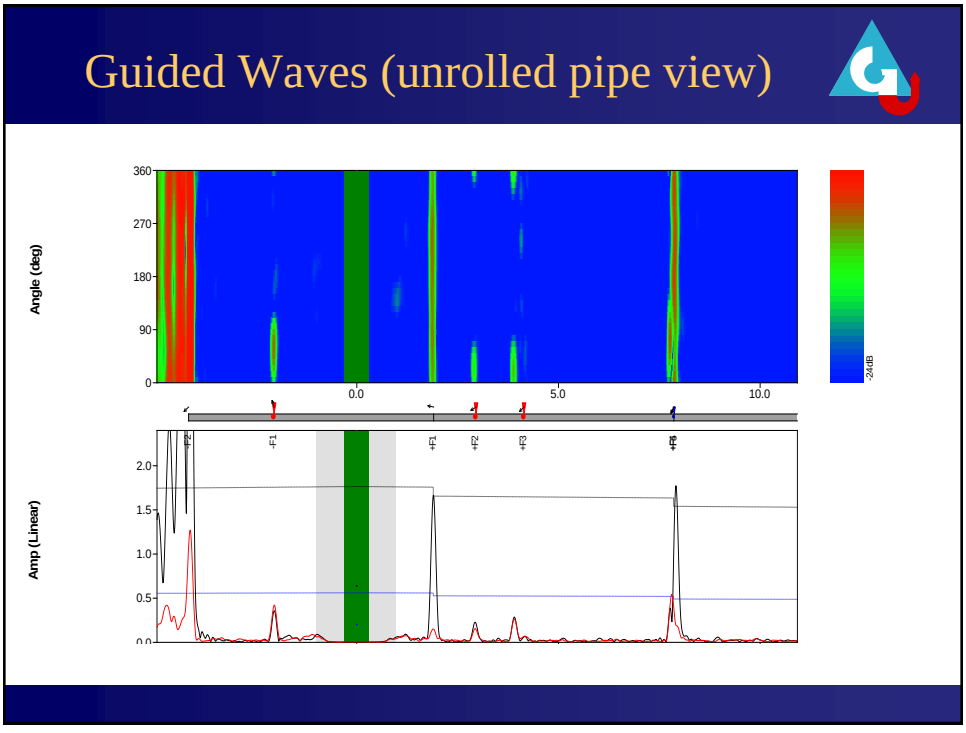
gPIMS unit

Wavemaker G3/G4 fully compatible with g-PIMS rings.





Guided Waves (unrolled pipe view)



gPIMS solution

- One time access
- High productivity
- Comparison of data allows for sensitive monitoring capability
- Carried out with pipe on-line

Example locations

- Bare pipes
- Buried pipes
- Road crossings
- Offshore risers
- Subsea lines
- Lines in contaminated or high risk areas

gPIMS transduction

gPIMS transduction

- Can be attached to a pipe and left in place (repeat GW inspection over an extended period of time)
- Sealed in polyurethane to give lifetime protection
- Connection can be made through a cable many meters long.

gPIMS experience

•First on-site installations in 2006

•3 stages of development to reach the current level of performance

•Several hundred gPIMS installed on site

Current Limitations

- Pipe operating temperature -40°C to +90 °C
- Install temperature -5°C to +60°C
- Pipe size 6-24” for standard install
- Almost any size out side this range by custom moulding
- Standard cable length up to 25m, up to 200m cable possible.

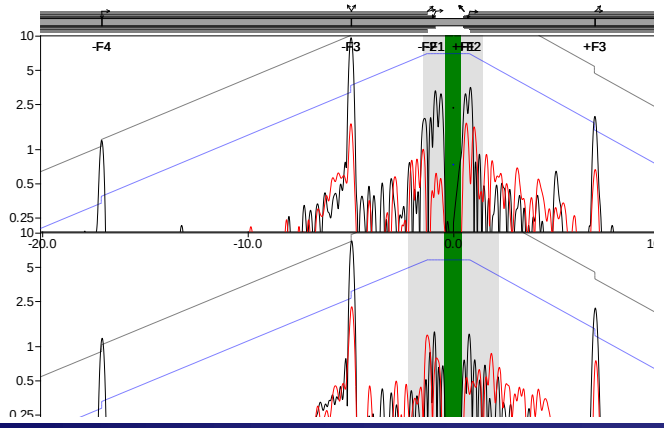
gPIMS
Performance

Results comparison with standard rings

Result from buried 8” line

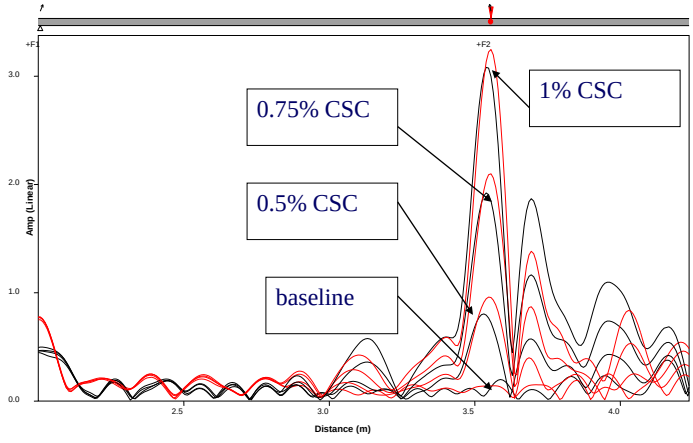
Result using G-PIMS collar (before back fill)

Result using standard collar



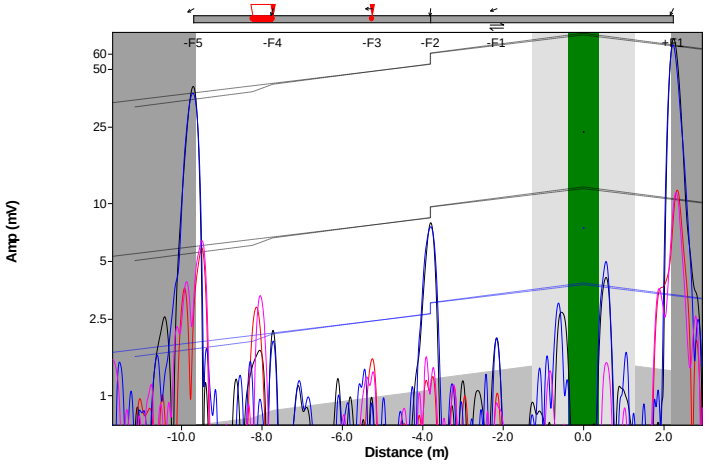
Test pipe for sensitivity to change demo

Sensitivity to change



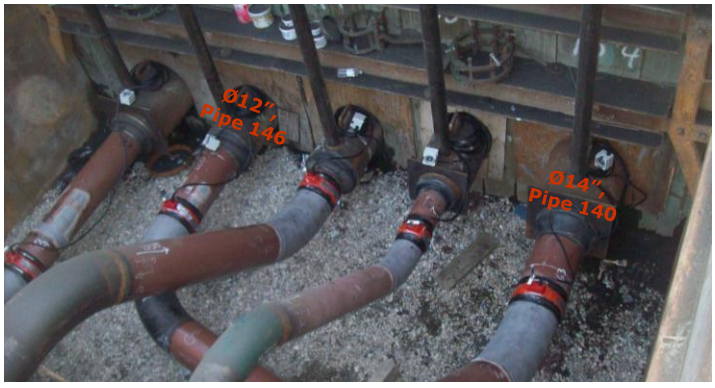
Stability of results

Exposed test sample, results 12 months apart



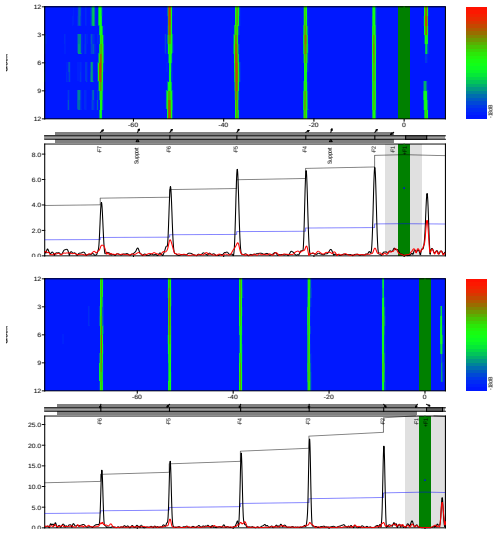
gPIMS
Case study

Case Study: Cased Crossing pipes



•**G-PIMS** installed on pipes at a cased road crossing position prior to back filling. Monitoring tests can be performed without expensive excavations in the future.

Results from cased section of previous slide

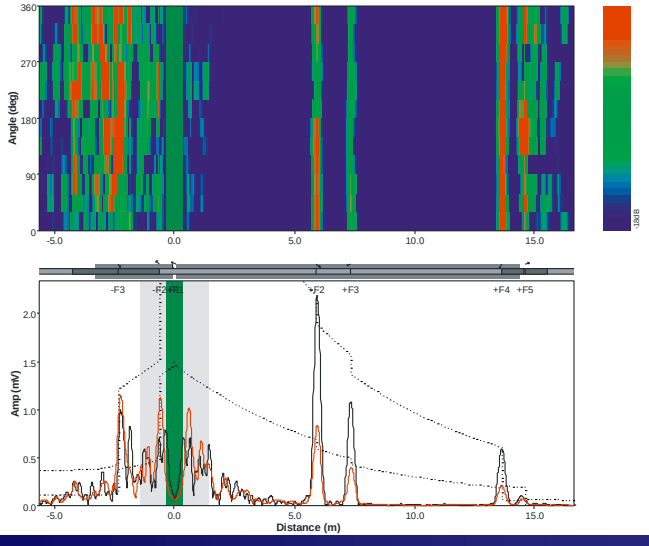


- Ø12", Pipe 146
- Ø14", Pipe 140

Case study: buried pipe

- 24” buried line in tank farm
- G-PIMS installed on buried section beneath instrument
- Connection box on yellow post

Result from buried section of previous slide



Conclusions

- Monitoring is providing new solution to old inspection problems
- This approach can reduce risk and increase inspection efficiency