Appendix 1

List of participants and excused persons

Participants EFC WP15 meeting 17-18th March 2005 Trondheim

NAME	ADDRESS 1	ADDRESS 2	ADDRESS 4	ADDRESS 5
Hennie de Bruyn	Statoil ASA	Arkitekt Ebbellsvei 10, Rotvoll	Trondheim	NORWAY
Anni Visgaard Nielsen	Statoil Refinery, Kalundborg,	Melbyvej 17	4400 Kalundborg	DENMARK
Stein Brendyen	Statoil R&D	Arkitekt Ebbellsvei 10, Rotvoll	Trondheim	NORWAY
Tor Harry Fauske	Statoil Troll Gas Processing		Kolsnes	NORWAY
Hildzgunn Urke	Statoil Mongstad		Mongstad	NORWAY
Jan Magne Sjøasæther	Statoil Methanol		Tjeldbergodden	NORWAY
Knut Sjølstad	Statoil LNG		Hammerfest	NORWAY
François Ropital	Institut Français du Pétrole	1-4 Avenue Bois Préau	92852 Rueil-Malmaison Cedex	FRANCE
Maarten Lorenz	Shell Global Solutions Inetrnational B.V.	Badhuiweg 3, PO Box 38000	1030 BN Amsterdam	NETHERLANDS
Andrew Kettle	Chevron Texaco Ltd	Pembroke Plant	Wales SA71 5SJ	UK
Nicholas Dowling	Shell Global Solutions International B.V.	Badhuiweg 3, PO Box 38000	1030BN Amsterdam	NETHERLANDS
Charles Droz	Exxon Mobil	BP No 1	76330 N.D.Gravenchon	FRANCE
Nick Smart	Serco Assurance	5 Culham Science Centre	ABDINGDON OX14 3ED	UK
Morten Langøy	Bodycote Materials Testing AS	PO Box 1084 Luramyrv. 69	4391 Sandnes	NORWAY

Excuses received for the EFC WP15 meeting 17 -18-th March 2005 Trondheim

NAME	ADDRESS 1	ADDRESS 2	ADDRESS 4	ADDRESS 5
André Claus	GE Betz	Toekomstlaan 54	B2200 Herental	BEGIUM
Iris Rommerskirchen	Butting Edelstahlwerke GmbH&Co KG	Sifnomer str. 59	29379 Wittingen-Knesebeck	GERMANY
Dr Liane Smith	Intetech Ltd	37, Mount Way	Chester CH3 7QF	UK
Sebastien Duval	Saipem			FRANCE
Dr Alan Turnbull	National Physical Laboratory	Teddington, Middlesex		UK
Dr Stefan Winnik	Exxon Mobil Chemical	Fawley Refinery	SO45 1TX	UK
Dipl.Ing. Gerit Siegmund	ExxonMobil Germany GfKorr	Riethorst 12		GERMANY
Martin Richez	Total	Technical Assisiatnce Division	76700 Harfleur	FRANCE
Ms Kirsi Rintamaki	FORTUM Oil & Gas Oy	P.O. Box 310	Porvoo	FINLAND
Mr Curt Christensen	Force Institutes	The Danish Corrosion Centre	DK-2605 Brøndby	DENMARK
Joanna Hucinska	Gdansk Technical University	G Narutowicza St No 11		POLAND
William C. Fort	Downstream Materials Engineering Ser.		1030BN Amsterdam	NETHERLANDS
Dr Istvan Lukovits	Chemical Research Center	Hungarian Academy of Sciences	1525 Budapest	HUNGARY
Danilo Baldassarre	Total	Technical Assistance Division	76700 Harfleur	FRANCE
Dr Christoph Beyer	Lurgi Ol Gas Chemie GmbH	Abt. A-GLSW	D-60295 Frankfurt	GERMANY
Carlo Farina	Corrosion Consultant	via G. Fara 11	28100 Novara	ITALY
Carmelo Aiello	Eni	Raffineria di Gela S.p.A	93012 GELA (CL)	ITALY
Ellina Lunarska	Institute of Physical Chemistry	Polish Academny of Sciences	ul. Kasprzska 44/52	POLAND
Bernard Roncin	Total	CERT, BP 27	76700 Harfleur	FRANCE
David Owen	GE Betz	Foundry Lane	Cheshire WA8 8UD	UK
Martin Holmquist	AB Sandvik Steel	SE-81181		SWEDEN
Stefano Trasatti	University of Milan	Dept. of Electrochemistry	20133 Milan	ITALY
Rob Scanlan	Conoco	Eastfield Road	North Linconshire DN40 3DW	UK
Stuart Bond	TWI	Metallurgy, Corrosion,	Great Abington, Cambridge,	UK
Richard Carroll	Foster Wheeler Energy	Shinfield Park	Berkshire, RG2 9FW	UK
Frank Dean	Ion Science Ltd	The Way, Fowlmere	SG8 7UJ	UK
Chris M Chis	Bechtel Ltd	245 Hammersmith	Road, London W6 8DP	UK
Martin Hofmeister	Bayernoil Raffineriegesellschaft mbH	Postfach 100858	85008 Ingolstadt	GERMANY
Chris J Claesen	Nalco		2550 Kontich	BELGIUM
Dr Alec Groysman	Oil Refineries Ltd	PO Box 4	31000	ISRAEL
Betrand Szymkowiak	IFP Technology Group - AXENS	89, bd Franklin Roosevelt	92508 Rueil-Malmaison cedex	FRANCE
Wim Verstijnen	Shell Nederland Raffinaderij B.V.		3190 GA Hoogvliet	NETHERLANDS
Guenter Luxenburger	Dillinger Huttenwerke	PO Box 1580		GERMANY
Eric Chauveau	UGITECH	Avenue Paul Girod	73403 Ugine Cedex	France
Dr Andrew M Pritchard	Corrosion & Fouling Consultancy	33 Laburnum Road	Oxford OX2 9EL	UK
John Thirkettle	Thor Corrosion			UK

Appendix 2

EFC WP15 Activities

Agenda EFC WP15 Spring meeting 17-18 March 2005

17 March

10h Welcome by Statoil

10h15 Report on EFC and WP15 activites

Finalisation of the agenda

11h Preparation of the CUI guideline

All together dinner

18 March

9h Open subjects of discussion from the particpants

Continuation of the CUI guideline

14h Closing of the meeting

Presentation of the activities of WP15

European Federation of Corrosion (EFC)

- Federation of 32 National Associations
- 19 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
- for more information http://www.efcweb.org

European Federation of Corrosion (EFC)
http://www.efcweb.org

EFC Working Parties

- 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
- WP 16: Cathodic protection
- WP 17: Automotive
- WP 18: Tribocorrosion
- WP 19: Corrosion of polymer materials
- Task Force 2: Corrosion and Protection of steel structures

WP 15 was created in sept. 96 with J. Harston as first chairman

EFC Working Party 15 « Corrosion in Refinery » Activities

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

Publications

EFC Working Party 15 « Corrosion in Refinery » Activities

WP Meetings
·One WP 15 working party meeting in Spring,
(this one on 17-18 March 2005 in Trondheim)

·One meeting at Eurocorr in conjunction with the conference,
(next one during Eurocorr 2005 4-8 September in Lisbon)

Eurocorr Conference sessions (September)
Refinery Corrosion Session
+ Workshops or Joint Session with other EFC WP parties
(as decided in 2003 spring meeting)
WP 3: High-Temperature Corrosion
WP 1: Corrosion Inhibition
WP 13: Corrosion in Oil and Gas Production

WP15 page in EFC Web site
http://www.efcweb.org/WP_on_Corrosion_in_the_Refinery_Industry.html

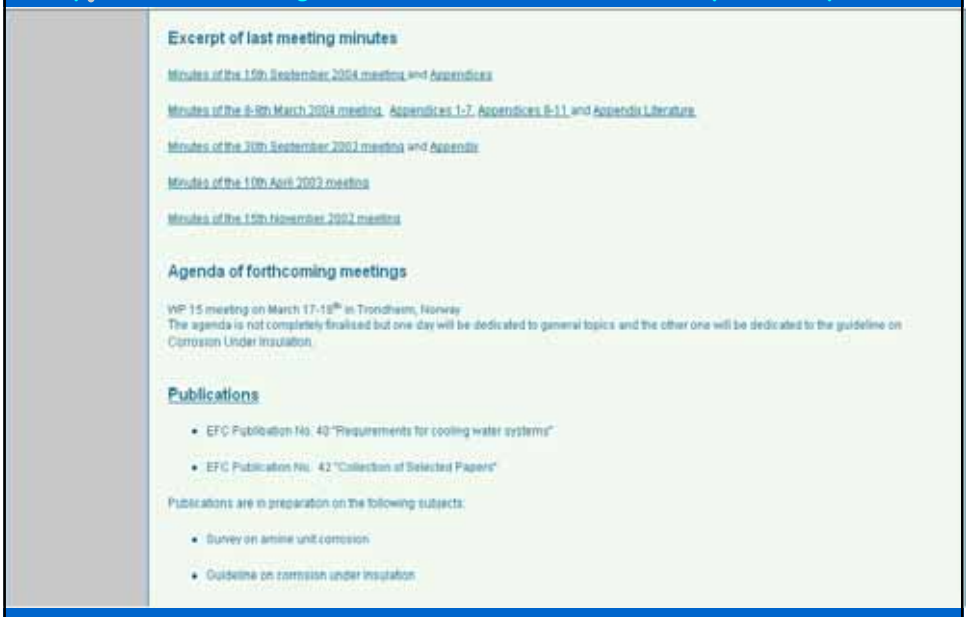
EFC Working Party 15 « Corrosion in Refinery » Activities

http://www.efcweb.org/WP_on_Corrosion_in_the_Refinery_Industry.html

WP 15 meeting March 17-18th 2005

EFC Working Party 15 « Corrosion in Refinery » Activities

http://www.efcweb.org/WP_on_Corrosion_in_the_Refinery_Industry.html



WP 15 meeting March 17-18th 2005

First Announcement

EUROCORR 2005

European Corrosion Congress

European Federation of Corrosion
Event n.° 273

EFC

Corrosion Control
for Sustainable Development

4 - 8 September 2005
Lisbon, Portugal

SPM
Sociedade Portuguesa de Materiais

INTRODUCTION

EUROCORR is probably the most important event in Europe and a reference around the world on the subjects of corrosion and protection.
Covering a large number of topics on the areas of corrosion science and corrosion protection technology, EUROCORR 2005 will focus on "Corrosion Control for Sustainable Development" and will have a hot topic on "Corrosion Control in the Aeronautical Industry". Meetings of the EFC Working Parties will take place in parallel with the sessions of oral and poster presentations.
We invite you to come to Portugal and participate both in the congress and in the technical exhibition.

SCIENTIFIC TOPICS:

A. Corrosion and Scale Inhibition
B. Corrosion and Protection of Steel Structures
C. Corrosion by Hot Gases and Combustion Products
D. Nuclear Corrosion
E. Environment Sensitive Fracture
F. Surface Science and Mechanisms of Corrosion and Protection
G. Corrosion Education and Computer Applications
H. Corrosion Testing
I. Marine Corrosion
J. Microbial Corrosion
K. Corrosion in Concrete
L. Corrosion in Oil and Gas Production
M. Coatings
N. Corrosion in the Refinery Industry
O. Cathodic Protection
P. Automotive Corrosion
Q. Tribo-Corrosion
R. Corrosion Control in the Aeronautical Industry

LANGUAGE

English will be the official language of the conference.

PUBLICATIONS

A book of abstracts as well as the proceedings on CD-ROM will be provided on-site.

EXHIBITION

A Technical Exhibition will be organized, allowing manufacturers and users of materials, instruments, software and publications to contact and exchange information. Potential exhibitors should contact the Congress Secretariat for specific information.

DEADLINES

15 November 2004	Submission of Abstracts
15 February 2005	Notification of acceptance to authors
15 May 2005	Submission of full manuscripts

LOCATION

Lisbon, capital of Portugal for more than 700 years, stands by the estuary of the Tagus River and the Atlantic Ocean, on the westernmost limit of Europe. The city is favoured by a mild climate, with temperatures typically in the range 20-25°C during daytime in the beginning of September.

SOCIAL PROGRAMME

A social programme will be organized for the registered participants and accompanying persons, including a welcome reception and a congress dinner.
A large variety of sightseeing tours for accompanying persons will also be available.

CONGRESS SECRETARIAT

EUROCORR 2005
c/o Top Atlântico Operated by TopTours
Congress Department
Att. Mr. Vitor Alves
Av. D. João II, Lote 1.16.1
1990-083 Lisboa, Portugal
Ph.: (+351) 218 925 405
Fax: (+351) 218 925 406
e-mail: lisboa.congress@topatlantico.com
Congress Website: http://congress.topatlantico.com/eurocorr2005

http://www.eurocorr2005.org
http://www.efcweb.org/

Eurocorr 2005 Sessions

Scientific Sessions

A. Corrosion and Scale Inhibition
B. Corrosion and Protection of Steel Structures
C. High Temperature Corrosion in Energy Conversion
D. Nuclear Corrosion
E. Environment Sensitive Fracture
F. Surface Science and Mechanisms of Corrosion and Protection
G. Corrosion Education and Computer Applications
H. Corrosion Testing
I. Control of Marine Corrosion for Sustainable Development
J. Control and Causes of Microbiological Influenced Corrosion
K. Corrosion in Concrete
L. Corrosion in Oil and Gas Production
M. Coatings
N. Failure Cases and Corrosion under Insulation in the Refinery Industry
O. Cathodic Protection of Buried Structures
P. Automotive Corrosion
Q. Corrosion and tribo-corrosion phenomena in the automotive industry

Workshops

In addition to the Congress Sessions, workshops are planned, focussing on specific subjects:

1. Corrosion Control in the Aeronautical Industry
2. Atmospheric Corrosion
3. Biomaterials: Corrosion and Wear
4. Heritage Preservation
5. Alternative Reinforcing Materials for Corrosion Control in Concrete Structures
6. Corrosion Control in Water Systems
7. Corrosion Inhibitors to Fight Naphtenic Acid Corrosion
8. Corrosion Issues in Future Nuclear Systems
9. Pre-Treatments
10. Reliability of Polymer Piping Installations and Cracking of Polymer Materials
11. Corrosion Monitoring and Standards
12. Trends in Electrochemical Techniques

NACE A special workshop will be sponsored by NACE:
"ISO 15156/MR0175 - Evolution, Application, Implications and Experience"

WP 15 meeting March 17-18th 2005

Eurocorr 2005 Refinery sessions

Workshop 7 " Corrosion and remedies to fight naphtenic acid corrosion (with WP1 "inhibitors")

Session N " Refinery corrosion and failure cases"

Key note lecture due to the EFC 50th Anniversery (by the WP Chairman)
50 years of progress in the management of corrosion in the refinery industry
Volonteers to review my paper and to give comments …. ???

Eurocorr 2006 Refinery sessions topics ?

http://www.corrosiecentrum.nl/eurocorr2006/

Workshops and thematics for refinery corrosion dealing sessions ?

Publications EFC Guideline n°40

« Prevention of corrosion by cooling waters » available from Maney Editor

http://www.maney.co.uk/search?fwaction=show&fwid=623

Publications

- EFC Guideline n°40 « Prevention of corrosion by cooling waters » available from Maney Editor http://www.maney.co.uk/search?fwaction=show&fwid=623
- EFC Guideline n° 42 Collection of selected papers (available spring 2005)
- EFC Guideline on corrosion in amine units (John Haston finalises the review)
- EFC Guideline on Corrosion Under insulation (we are working on it)
- Future publications
  - Collection of papers of Eurocorr 2004 joint session WP 3 + 15
  - Typical refinery failure cases booklet ?
  - other suggestions ?

Appendix 3

Proposal of future topic on FCCU

Nicholas Dowling Shell Global Solutions

Shell Global Solutions

PROPOSAL FOR EFC FCCU MATERIALS AND CORROSION REVIEW

WP 15: Refinery corrosion group

Outline

- Reason for review: Development of new resources
- Goals: Exchange of experience in European refining
- Distribution of work among oil companies & contractors
- Development of ideas and new technology
- Adoption of new methods, technology
- Become more competitive globally

Why the FCCU?

- Fluid catalytic cracking technology provides gasoline and diesel for Europe's transport needs
- The FCCU frequently has the highest margin
- FCCU technology is complex involving many materials
- Small improvements can produce big gains
- Exchange of experiences will improve Europe's technical position (less weak)
- Technical licensors are not impartial! (End users self help)

Shell Global Solutions

Proposal for EFC 15

- A general exchange of FCCU end-user information
- The exchange should begin by a series of presentations by the main end-users and their contractors
- The exchange should take the form of open presentations -Materials selection (replacement)

  -Welding, erosion, corrosion, hardfacing

  -Erosion-resistant refractory (methods)
- General units should be divided into segments with each segment adopted by an end-user.

Shell Global Solutions

FCCU Segments

SECTOR	POSSIBLE ADHERANTS*
Reactor	A
Regenerator	B
Light ends (fractionation)	C
Slurry lines and bellows	D
Y/V piece area (injectors)	E
Flue gas system (tertiary, CO boiler, precipitator etc.)	F
PRT Expanders and blowers	G
Slide valves	H

*SHELL, ESSO, BP, BAYERN OIL, FORTUM, BP, AGIP/ENI, CON
TOTAL, REPSOL

Reactor

- Reactor shell: 1.25Cr-0.5Mo
- Cladding?
- Cyclones (CS, 1.25Cr, 2.25Cr) coupled/non
- Diplegs
- Refractory (hexmesh, s-mesh, anchors)
- Steam strippers
- Riser
- Main issues: Creep embrittlement, cyclones replacement, operating temperature

Regenerator

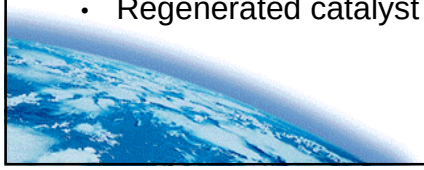
- Regenerator shell (CS)
- Plenum
- Cyclones 304H (welding)
- Refractory
- Air grid technology
- Torch oil lines
- Catalyst entry
- Mains issues: High temperature, erosion, thermal expansion, embrittlement

Light ends

- Main fractionator: Packed or not?
- Internal corrosion?
- Water wash?
- Packing metallurgy?
- Overhead temperature?
- Effect of Chlorides, cyanides, sulfides, water: Corrosion
- Carbonate cracking (low sulphur)

Catalyst systems

- Slide valves: Erosion (nitrogen flushed?)
- Catalyst lines (refractory), dissimilar welds
- Charge injectors
- Steam injectors
- Spent catalyst lines
- Risers (internal/external)
- Regenerated catalyst lines (dissimilar welds)

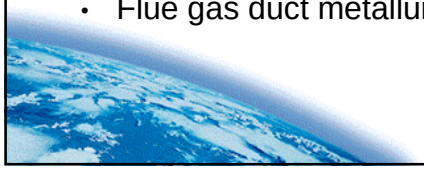


Specials cases

- Dynamic compensators (Bellows)
- Slurry lines
- Refractory installation (cast, gunite, RESCO and anchors)
- Flapper valves, Chinese hat valves, birds cage
- Column extensions (problems)
- Reactor extensions (problems)

Flue gas systems

- CO boilers
- Tertiary separation
- Electrostatic precipitators
- Wet slurry precipitators
- Lobster-backed Mitred bends
- Orifice chamber erosion
- Flue gas duct metallurgical problems



Rotating equipment

- Blowers
- Power recovery trains (expanders)
- Pumps

Summary/Conclusions

- Process conditions in a FCCU do encourage repetitive forms of material degradation
- Materials and corrosion problems have many potential solutions
- Experience of specific problems in end-users and contractors is very useful during unexpected shutdowns
- No one company is the source of all information
- Collaboration on degradation issues improves plant safety for all plants!

Shell Global Solutions

Appendix 4

Fin fan tube failure

Andrew Kettle Chevron Texaco

ChevronTexaco

FIN FAN TUBE FAILURE AT PEMBROKE REFINERY

Dave Hawkins – Inspection Engineer

March 2005

The Failure

On Monday 21st Feb 2005 a carbon steel fin fan tube failed on 1-E-22 diesel cooler. The tube was located on the top row 1m from the outlet end. Initially, it was thought that the tube failure was due to over pressure, the fins had split for a length of 200mm. After removal of the damaged fins it was evident that the failure had been caused by external corrosion that had developed underneath the L-fin type design.

Tube material: A214

Design Pressure: 5.3 KG

Design Temperature: 100 deg C

Operating Temperature: 45 Deg C

Service: Light diesel

Length of service: 24 yrs

The Failure

ChevronTexaco

3

Tube Fin Design

There are generally two different type of fin design and the way in which they are attached to the tube. The two types are used for different services. See below

L-FIN TUBE

Used for moderate temperature service, with a maximum design temperature of 150º C. The fin strip is formed into 'L' shape and tension wound onto the base tube. The feet of the fins cover the whole surface between fins.

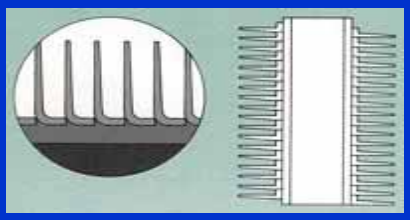
G-FIN TUBE

This type of tube is designed for a maximum design temperature of 450º C. A helical groove is cut into the tube, the fins are peened to push the displaced metal back into the fin to form a strong mechanical bond.

ChevronTexaco

4

Equipment Preservation



L-FIN TUBE

G-FIN TUBE

ChevronTexaco

5

Cause

The design of the L-Fin type is a cost effective way of providing the required contact between fin and tube that will produce the calculated heat transfer rate. However, in this particular case the L-fin design has caused tube failure by trapping rain water between and under the fin feet resulting in under fin corrosion.

Tubes with G type fins should not exhibit a similar corrosion problem as this design will not trap water and will drain freely.

ChevronTexaco

6

Inspection

After the failure, random top row tubes were subject to a radiographic survey. This indicated no material loss beneath the fins. It was decided to carry out a more comprehensive survey using IRIS (internal rotary inspection system). IRIS is an ultrasonic tube thickness measuring device, as apposed to Eddy current which measures volumetric loss. A 100% survey was carried out.

Results from the IRIS survey indicated that instances of external tube corrosion had occurred predominantly on the top row, as expected the lower 5 rows exhibited very little external loss. Of the top 48 tubes, 10 exhibited external loss in excess of 50% wall thickness, whilst 3 of these had lost as much as 70%. The areas of corrosion occurred randomly at the tube sheet ends or intermittently along the full length of the tubes.

Further radiographs were taken at the corroded locations identified by the IRIS inspection and it has been concluded that radiography is a suitable method to detect this type of corrosion. There are however limitations:

Access for placement of radiographic film is only possible on top and bottom row tubes adjacent to the header boxes.

Tube condition can be measured in one plane only.

Inspection

Recommended Actions

A full review of all Pembroke Refinery air cooled exchangers is to be carried out using fin design and design/operating temperature as conditions to assess integrity risk. An inspection strategy is yet to be developed but will probably consist of the following:

In-service

random radiography of top row tubes to assess the immediate risk

Visual inspection of the top row tubes – part fins and examine fin feet for evidence of corrosion products or mechanical distortion/damage.

Turnaround

Internal inspection of top row tubes using the IRIS system

<u>Recommendations</u>

Review all air coolers for susceptibility to top row atmospheric external corrosion

Stipulate G-Fin design for all new and replacement air cooler tubes

ChevronTexaco

Appendix 5

Direct fired heater integrity failure

Nicholas Dowling Shell Global Solutions

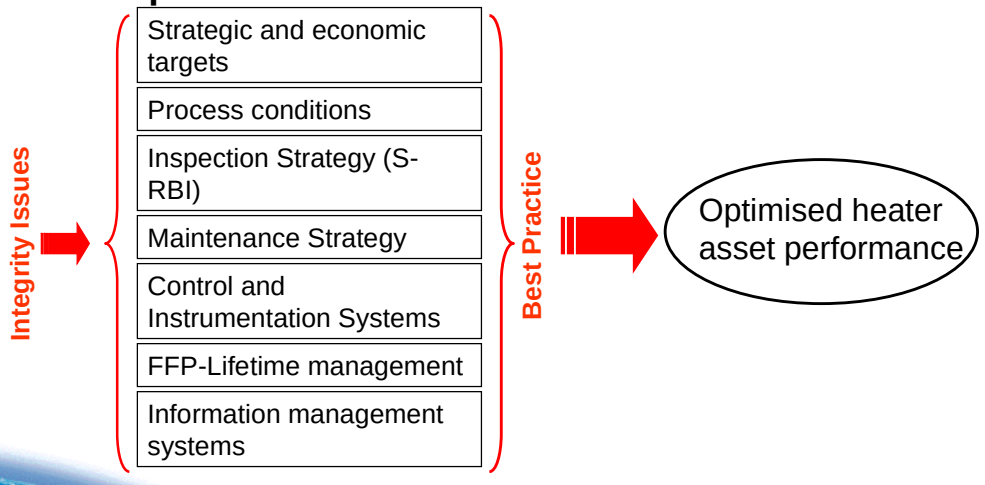
Introduction

- Heaters are an integral part of modern petrochemical plants. Reliability and availability is critical to ensure plant productivity targets are maintained
- Despite design differences, heater materials of construction and process fluids are often similar allowing integrity to be managed systematically and effectively.
- This presentation illustrates some of the common heater integrity issues that must be managed and/or mitigated and how this can be realised through the application of H-FAIR

Contents

- Introduction to the heater FAIR
- Main areas of concern
- Basic heater geometry
- Common heater integrity problems
  - Radiant section
  - Convection section
  - Hangers and guides
  - Refractory materials
- Inspection and maintenance
- Conclusions for the heater FAIR approach

HEATER-FAIR Allows best practice processes to be implemented



Heater equipment subsections

- Process fluid issues: Corrosion, erosion, coking, carburisation
- Process operation issues: Fuel/air ratio, volume flow, cycling operation (effect on materials)
- Radiant section: Tubes, hangers, piping, guides, refractory spalling, inspection, welding maintenance, corrosion, age related degradation .
- Burners, burner mounting and cones (proprietary technology)
- Convection section: Supports, hangers, piping, stubs/rings, soot blowers, ash removal, refractory integrity.
- Pipework and ducting: creep, dew point/acidic corrosion, weldment cracking
- Civil engineering: Concrete support pillars and apron, fire-proofing of I-beams,
- Electrical and control: Earthing, valve insulation, sight glasses, TI placement and monitoring

Common degradation issues per subsection

- Radiant and convection tubes

  Sulphidation, Naphthenic acid corrosion, Erosion, Creep, Carburization/metal dusting
- Refractory

  Cracking, spalling, ash/CO deterioration

  under refractory dew-point corrosion
- Hangers and guides

  Creep, cracking, thermal expansion problems, transformation, corrosion
- Civil works: Concrete

  Deadweight loading, fatigue, under-fireproofing corrosion, cracking, rebar corrosion
- Stacks

  Dew point corrosion

Main area of concern: Tube Metal Degradation

- Embrittlement
- Corrosion
- Metallurgical changes
  - creep
  - intermetallic phases
  - grain growth
  - sensitisation of SS and Ni alloys
  - Carburisation/decarburisation
  - graphitisation
- Deformation
  - creep
  - distortion
  - mechanical

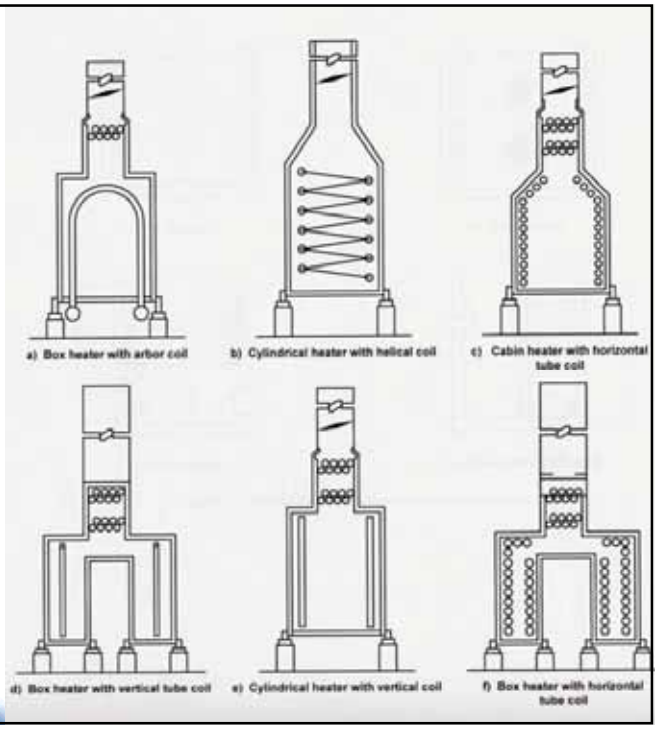
Basic designs: Cylindrical vs rectangular cabin

Scaffolding and access issues for inspection and maintenance

Designs:

Variation due to:

- Licensor (Foster Wheeler, Huertey etc..)
- Process (eg. CDU, CCR…)
- Heat-recovery needs
- Firing mode
- Environmental constraints



COMMON HEATER INTEGRITY ISSUES

Old heaters

Constructed in ‘60/’70s
Old technology
Still viable but not efficient
Optimization required

- Radiant section
- Convection section
- Burners
- Flue gas ducting

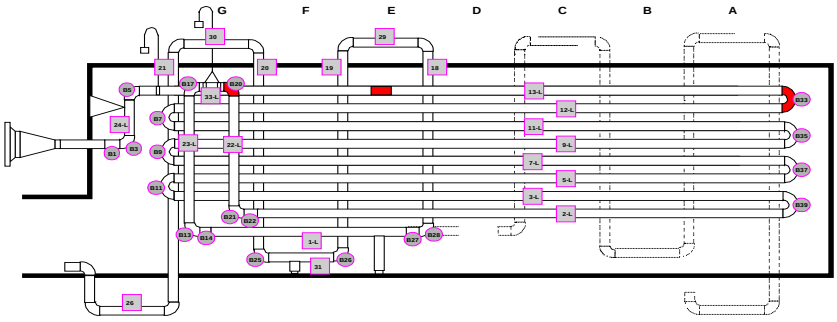
1) RADIANT SECTION

Fire box

- Flame impingement
- Flame shape
- Deposits on tubes
- Haze
- Rubble on floor
- Sagging tubes
- Broken hangers

Horizontal furnace layout

General layout for naptha cracker (ethylene) furnace



<u>Inspection areas:</u> Hardness, carburization, metal dusting, erosion depends on time in service (skin temperature)

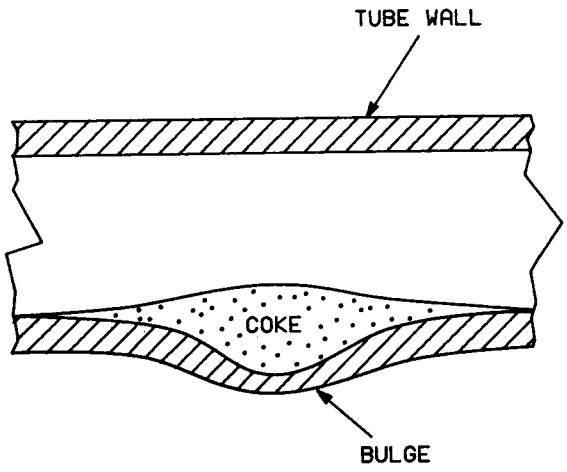
Vertical furnace: Creep

- **Long term – life exhaustion**
- **Short term rupture**
- **Catastrophic overheating**

- FFP methodologies can be employed to underwrite long term performance
- Operational procedures can be optimised to prevent upsets

Effect of coking on creep

- Temperature excursion
- Higher temperature produces coke
- The coke insulates the steel wall from the cooling effect of the process oil/gas
- The local temperatures exceeds the metallurgical limit:
  RUPTURE



Overheating – steam-air decoking of heater with zero flow

- Rapid plastic bulging of tubes
- Internal coking
- Rupture of bulged pipe
- Internal explosion (in radiant section)
- Flame impingement, Massive refractory spalling

  Mechanical shell failure(vertical loading with bending moment)

2) CONVECTION SECTION

Convection tubes (stubs) I

Sulphur and ash accumulation

- **Access easy for header boxes**
- **Access hard for tubes**
- **Inefficient air flow**
- **Safe drainage of cleaning agent**

Air Preheater – flue gas dew point corrosion

Flue gas side

Air side repair

Corrective action: Better process control and targeted inspection

3) HANGERS AND GUIDES

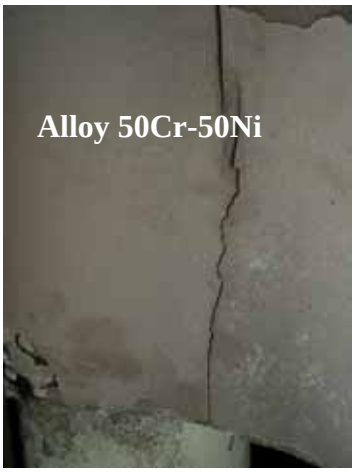
Elbow guide cracking

Vibration and debris build up
Inspection problems

Gas –fired gas heater versus oil-fired heater:

Considerable difference

Thermal expansion cracks in a CDU heater convection section hanger beam



Cracking and corrosion of heater supports

<u>Materials information:</u>

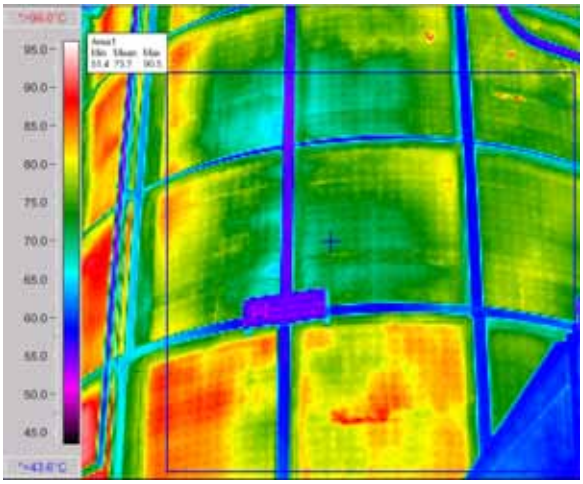
1) Support: Ni-based alloy (heated to flue gas temperature)
2) Materials options
3) Trade off: corrosion resistance against creep strength
4) *Problem of cost*

4) REFRACTORY MATERIALS

IR scan prior to shutdown

-Determine any falls in refractory

- Plan shell, anchor and refractory replacement



Refractory rubble

- Installation problems
- Operational problems
- Difficult geometry
- High bridge wall temperature
- Inspection?
- Periodicity?

Burner lining corrosion

Attack of burner lining by fuel ash

Top fired furnaces

Outside

Inside

Shrinkage of insulation packs

Burner block material failure

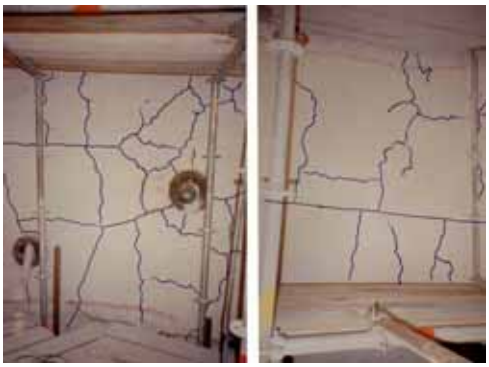
Internal loss of refractory material

Loss of internal refractory leads to burn though

Local burn-through of steel shell

Shrinkage and crack patterns

Excessive shrinkage in cold joint increased risk for hot spots

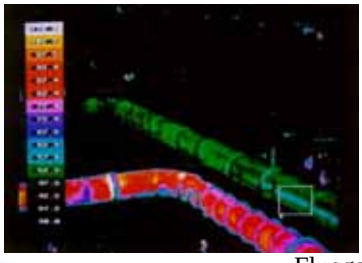


Normal crack pattern in gunnited medium weight concrete

Not every crack is detrimental

Flue gas ducting under dewpoint conditions

Accumulation of condensation debris in duct



Infrared measurements of piping external temperatures

Fluegas duct operated at too low temperatures (lining overdesigned)

Condensation and attack of steel work

Refractory lining inspection

- IR & visual inspection during operation
- Debris on heater floor and loss of material
- Excessive lining cracking
- Refractory spalling (falling off in clumps)
- Crack pattern in relation to material properties
- Glazing and or softening of the lining surface
- Loss of bonding in the lining material
- Lining corrosion (ash – CO damage)

INSPECTION AND MAINTENANCE STRATEGY

Metallurgical and refractory inspection

- Degradation mechanisms
  - Metal dusting
  - Sulphidation/naphth. acids/erosion/Oxid.
  - Thermal Fatigue
  - Deformations
  - Bad refractory installation
  - Ash/CO effects
  - Embrittlement
  - Sensitisation
  - Metall. Changes PASCC
- Morphology
  - Pitting
  - Metal loss/wide pitting
  - Cracks
  - Oval./Bending
  - (normally no problem, cracking if stressed cold during SD)
  - Intercrystalline cracking
  - Microstr. Changes
  - Fine intergranular cracking
- Inspection type
  - Numerous methods
  - Periodicity
  - Assessment of heater
  - Point system
  - Criticality assessment

Optimise Furnace Integrity and Performance

- Furnaces are a BIG potential source of extra revenue through limiting costs and increasing availability.
- The FAIR project benchmarks current heater asset management practice and policy
- The FAIR determines principal threats and opportunities for each furnace
- Provides a GAP analysis between actual individual practice /furnace availability with that of highest score equipment
- Output shall be used to develop and tune “best practice” policies and procedures for asset optimization

FAIR Deliverables: Heater optimisation

- Inspection of heater and its performance
  - Health check of existing equipment
  - Identifies areas of need and optimisation
- Tuning of process: Firing rate/fuel and hydrocarbon throughput
- Elimination of deleterious practices
- Rating of heater against others: Adopting better operational methods
- Efficient firing operation (hotter product for less gas/fuel burnt)
- Lowering of future inspection and maintenance costs
- Increase in availability

Conclusions for the heater FAIR approach

Division of unit into work zones: 1) Radiant, 2) Convection 3) Outlet manifold, 4) Stack, 5) Civil works, 6) Electrical and Control

- Reliable historical inspection data
- Access to good operating data for the past runs
- Accurate as-built and up to date modified engineering diagrams
- Comparison with a benchmarked data base to provide future reliability estimates and planned turnarounds
- What does your plant do?

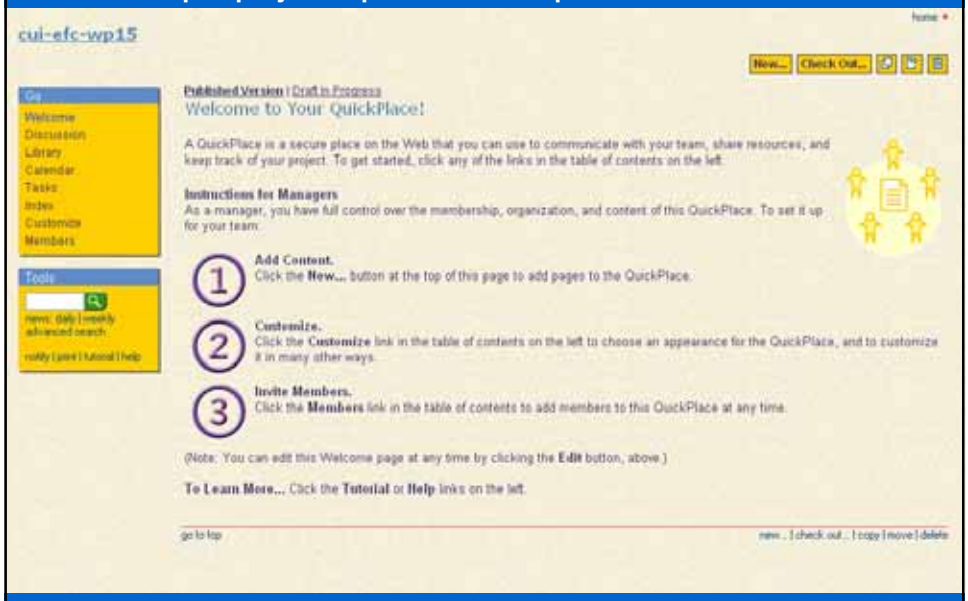
Appendix 6

Corrosion Under Insulation Guideline

Information on

http://project.ifp.fr/cui-efc-wp15

EFC WP15 Guideline
http://project.ifp.fr/cui-efc-wp15



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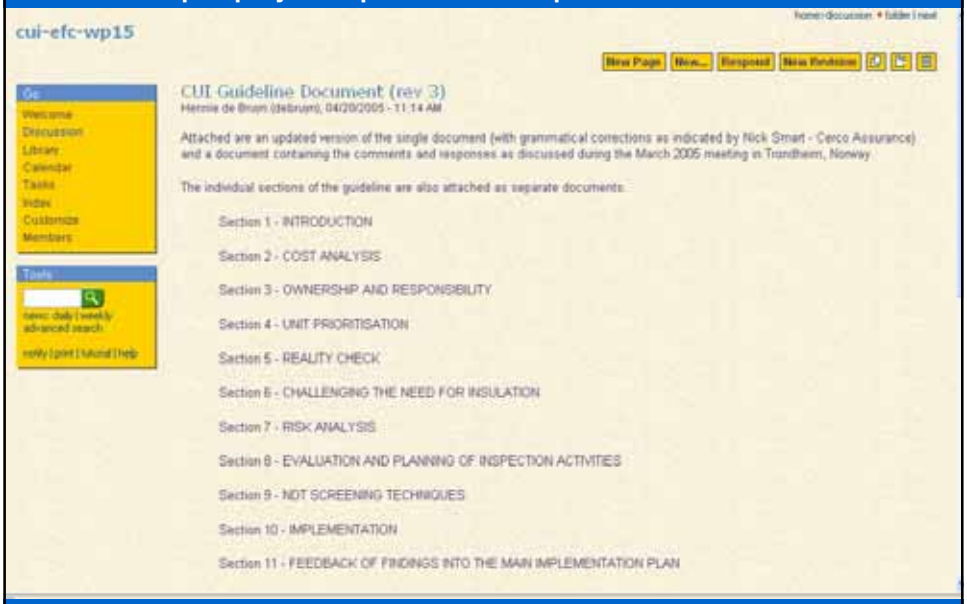
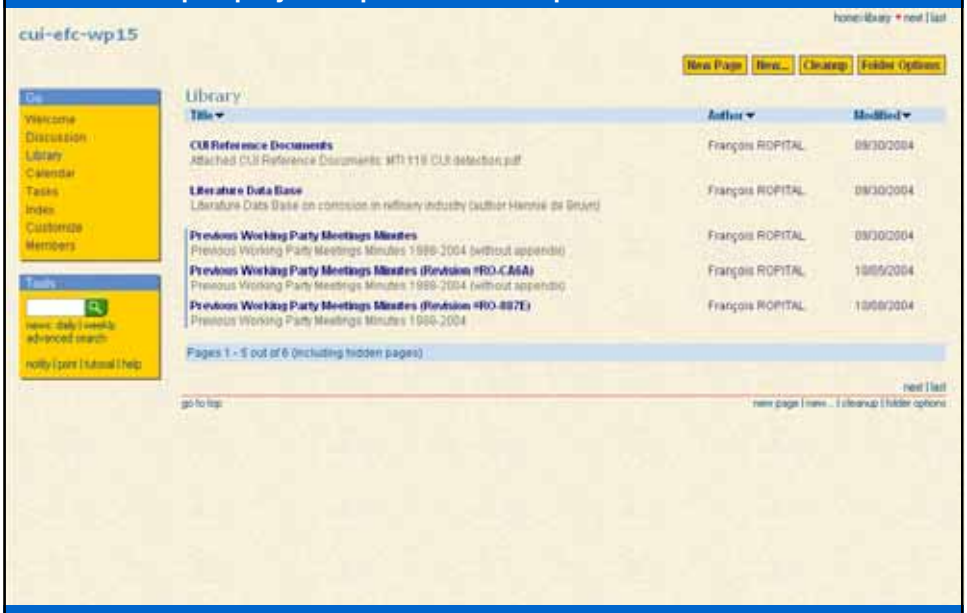


WP 15 meeting March 17-18th 2005

EFC WP15 Guideline
http://project.ifp.fr/cui-efc-wp15



WP 15 meeting March 17-18th 2005