Appendix 1

List of participants and excused persons

Participants EFC WP15 meeting 15th April 2008 Leiden

Name	Surname	Company	Country
Beucler	Valerie	Nalco Energy Services	FRANCE
Claesen	Chris J	Nalco	BELGIUM
de Bruyn	Hennie	Borealis AS	NORWAY
Deves	Jean Marie	Axens - IFP Technology Group	FRANCE
Gonzalez-Barba	Maria Luisa	Baker Petrolite	SPAIN
Kiiski	Arto	Neste Jacobs Oy	FINLAND
Lorenz	Maarten	Shell Global Solutions International B.V.	NETHERLANDS
Loukachenko	Natalia	Arcelor Mittal	FRANCE
MeLampy	Michael	Hi-Temp Coatings Technology	USA
Munier	Michel	Axens - IFP Technology Group	FRANCE
Nordstrom	Sofi	Nynas AB	SWEDEN
Parr	Dennis	iicorr Limited	UK
Pugh	John	BP	UK
Reynolds	Steve	PPLEU	UK
Richez	Martin	Total	FRANCE
Ropital	François	IFP	FRANCE
Tabaud	Frederic	BP Rafinaderij Rotterdam B.V.	NETHERLANDS
van Roij	Johan	Shell Global Solutions International B.V.	NETHERLANDS
Vanacore	Mario	Nalco	ITALY
Verstijnen	Wim	Shell Nederland Raffinaderij B.V.	NETHERLANDS
Wännman	Lennart	Nynas AB	SWEDEN
Wilms	Dimphy	Applus RTD Benelux	NETHERLANDS

Excuses received for the EFC WP15 meeting 15th April 2008 Leiden

Name	Surname	Company	Country
Authier	Sylvain	Exxon Mobil	FRANCE
Carroll	Richard	BG Group	UK
Davies	Michael	CARIAD Consultants	GREECE
Dean	Frank	Ion Science Ltd	UK
Farina	Carlo	CEFIT Corrosion Consultant	ITALY
Farina	Carlo	CEFIT Corrosion Consultant	ITALY
Fevrier	Philippe	Total	FRANCE
Floquet	Jean Pierre	Honeywell	BELGIUM
Groysman	Alec	Oil Refineries Ltd	ISRAEL
Hofmeister	Martin	Bayernoil Raffineriegesellschaft mbH	GERMANY
Holmquist	Martin	Sandvik Materials Technology	NETHERLANDS
Hucinska	Joanna	Gdansk Technical University	POLAND
Isaak	György	Env. & Corr. Manager	HUNGARY
Lunarska	Ellina	Institute of Physical Chemistry	POLAND
Maffert	Joerg	Dillinger Huttenwerke	GERMANY
Michvocik	Miroslav	SLOVNAFT	SLOVAKIA
Nielsen	Anni Visgaard	Statoil Refinery, Kalundborg,	DENMARK
Nolan	Peter	Advantica	UK
Pedersen	Iver Espen	StatoilHydro Research Center Rotvoll	NORWAY
Peultier	Jerome	Arcelor Mittal	FRANCE
Pritchard	Andrew	Corrosion & Fouling Consultancy	UK
Roberto Riva	Roberto	Eni R&M	ITALY
Rommerskirchen	Iris	Butting Edelstahlwerke GmbH&Co KG	GERMANY
Roumeau	Xavier	Total	FRANCE
Saarinen	Kari	Zerust Oy	FINLAND
Sargent	Margaret	Shell Global Solutions International B.V.	NETHERLANDS
Scanlan	Rob	Conoco	UK
Siegmund	Gerit	ExxonMobil Germany GfKorr	GERMANY
Smart	Smart	Serco Assurance F	UK
Trasatti	Stefano	University of Milan	ITALY
Zetlmeisl	Mike	Baker Petrolite	USA

Appendix 2

EFC WP15 Activities

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

EFC Working Parties

http://www.efcweb.org

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

EFC

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

EFC

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

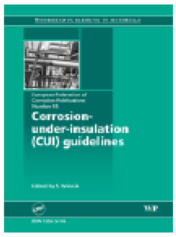
•Future publications

- suggestions ?

WP

WOODHEAD PUBLISHING LIMITED
Woodhead Publishing Limited, Abington Hall, Abington, Cambridge, CB1 6AH, England
Tel: +44 (0)1223 891 358 Fax: +44 (0)1223 893 694 Email: wp@woodheadpublishing.com

Corrosion under insulation (CUI) guidelines: (EFC 55)



Edited by S Winnik, ExxonMobil, UK

- guidelines cover inspection methodology for CUI, inspection techniques, including non-destructive evaluation methods and recommended best practice
- case studies are included illustrating key points in the book

Corrosion under insulation (CUI) refers to the external corrosion of piping and vessels that occurs underneath externally clad/jacketed insulation as a result of the penetration of water. By its very nature CUI tends to remain undetected until the insulation and cladding/jacketing is removed to allow inspection or when leaks occur. CUI is a common problem shared by the refining, petrochemical, power, industrial, onshore and offshore industries.

The European Federation of Corrosion (EFC) Working Parties WP13 and WP15 have worked to provide guidelines on managing CUI together with a number of major European refining, petrochemical and offshore companies including BP, Chevron-Texaco, Conoco-Phillips, ENI, Exxon-Mobil, IFP, MOL, Scanraff, Statoil, Shell, Total and Borealis. The guidelines within this document are intended for use on all plants and installations that contain insulated vessels, piping and equipment. The guidelines cover a risk-based inspection methodology for CUI, inspection techniques (including non-destructive evaluation methods) and recommended best practice for mitigating CUI, including design of plant and equipment, coatings and the use of thermal spray techniques, types of insulation, cladding/jacketing materials and protection guards. The guidelines also include case studies.

ISBN 1 84569 423 6
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March 2008
176 pages 234 x 156mm hardback
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Usually dispatched within 24 hours

EFC

http://www.eurocorr.org

Edinburgh 8-11 September 2008

Monday 8 September

Monday, 8 September 2008		
	09:00 - 09:15	**Opening Session: S. Lyon, M. Schütze**
	09:15 - 09:30	**Welcome Address: Member of the Scottish Parliament**
	09:30 - 09:45	**Cavallaro Medal Award Presentation**
	09:45 - 10:30	**Invited Plenary Lecture: Infrastructure Maintenance - 100 Years of Painting the Forth Bridge, N.N.**
	10:30 - 11:00	**Coffee Break**
		Working Party 15 Business Meeting
	11:00 - 11:25	WP15 Meeting
	11:25 - 11:50	WP15 Meeting
	11:50 - 12:15	WP15 Meeting
	12:15 - 12:40	WP15 Meeting
	12:40 - 14:00	**Lunchtime**
		Workshop Corrosion under Insulation
	14:00 - 14:25	1197 **Winnik**/UK A corrosion under insulation prevention strategy - Experience with an approach aligned wiht the EFC WP 13 and WP 15 corrosion under insulation guideline
	14:25 - 14:50	1045 **Scanlan**/UK A refinery approach to address corrosion under insulation & external corrosion
	14:50 - 15:15	1416 **MeLampy** MA/USA Comparison of cost, application characteristics, service life, reliability and repairability of systems for preventing corrosion under insulation
	15:15 - 15:40	**de Bruyn**/N Risk-Based Approach to CUI Protection of Austenitic Stainless Steel
	15:40 - 16:15	**Coffee Break**
	16:15 - 16:40	Discussion
	16:40 - 17:05	Discussion
	17:05 - 19:30	**Poster Discussion / Poster Party with Beer and Pretzel**

http://www.eurocorr.org

Edinburgh 8-11 September 2008

Wednesday 10 September

Wednesday, 10 September 2008

09.00 - 09:45	**Invited Plenary Lecture: R.C. Newman/CDN**
09:45 - 09:55	**Break for Changing Lecture Hall**
	Refinery Process Corrosion
09:55 - 10:20	1331 **Eaton** TX/USA Refinery corrosion by salt hydrolysis in opportunity crudes
10:20 - 10:45	1284 **Matsuo** /UK Properties of sumitomo 347AP steel tube for use in desulfurizing plants in the petroleum refinery industry
10:45 - 11:20	**Coffee Break**
	Refinery Process Corrosion
11:20 - 11:45	1370 **Bhattacharya** GA/USA Corrosion and stress corrosion cracking of heat treated 2205 duplex stainless steel in caustic solution
11:45 - 12:10	1071 **Haug** /D Reuse of water: Maintaining reliability by avoiding corrosion effects
12:10 - 12:35	1394 **de Freitas** /BR Study of alternative systems for corrosion control in water cooling system operating in high concentration cycle
12:35 - 14:00	**Lunchtime**
	Refinery Process Corrosion
14:00 - 14:25	1121 **Lyblinski** OH/USA Corrosion protection of oil storage tank tops
14:25 - 14:50	1252 **Fleury** /F Corrosion in amine solvents used for the removal of acid gases
	Ethanol Biofuel Corrosion
14:50 - 15:15	1216 **Albistur-Goni** /E Stress corrosion cracking of carbon steel in ethanol-gasoline blends
15:15 - 15:40	1367 **Troßmann** /D Corrosion of metals for automotive applications in ethanol blended biofuels
15:40 - 16:15	**Coffee Break**
	Refinery Inspection - Monitoring
16:15 - 16:40	1133 **de Bruyn** /N Training & Certification of operating inspectors: A review of Norwegian standards NS 415-1 & NS 415-2
16:40 - 17:05	1372 **Dean** /UK The utility of hydrogen flux measurement in refineries
17:05 - 17:30	1145 **Holdefer** /D Reducing the effects of process corrosion "corrosion as a process variable"
20.00 - 24:00	**Conference Dinner at "The Hub"**

http://www.eurocorr.org

Edinburgh 8-11 September 2008

Thursday 11 September

09.00-9.45	**Invited Plenary Lecture: Gerald S. Frankel OH/USA**
9:45 - 9:55	**Break for Changing Lecture Hall**
	Refinery - Naphthenic Acid Corrosion
09:55 - 10:20	1437 **Kane** TX/USA Refining high acid crudes: When is an opportunity not an opportunity?
10:20 - 10:45	1199 **Invernizzi** /I The effect of molecular structure on the Naphthenic acid corrosion occurrence
10:45 - 11:10	1128 **Groysman** /IL New inhibitors for preventing naphthenic acid corrosion
11:10 - 11:45	
11:45 - 12:10	1248 **Claesen** /B 25 years experience of successful naphthenic acid corrosion inhibition
12:10 - 12:35	1118 **Sandu** TX/USA Surface study of naphthenic acid corrosion inhibitors on carbon steel
12:35 - 13:00	
13:00 - 13:25	
13:25 - 13:35	**Break for Changing Lecture Hall**
13:35 - 13:50	**Closing Remarks**
ca. 13:50	**End of Scientific Programme**

8

EFC Working Party 15 plan work 2006-2009

- Task force an Corrosion Under Insulation - achieved
- Failure cases atlas : creation of a task force and a web page
- Cooling water treatment:
  Creation of a task group of WP15 members to cooperate with EFC WP1 and NACE on publication of update or new documents
- . Session with NACE at Eurocorr 2009 in Nice on which topic ?
- . Sessions with other EFC WP at Eurocorr 2009 in Nice on which topic?

EFC Working Party 15: Future objectives of the group

How to manage our working party meetings / Eurocorr sessions

- Eurocorr Sessions

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

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

. Working Party Meetings

✓Future topics of task forces

✓Facilitating student trainings outside their countries in our companies

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

✓Collaboration on Standard

Increase the collaboration with NACE

exchange of information on our activities - joint Eurocorr sessions

Appendix 3

Case histories and 5 year track history of a liquid applied CUI coating

Michael MeLampy

(High-Temp Coatings Technology)

EFC Working Party 15

Corrosion Refinery Industry Meeting

Oegstgeest/Leiden

15th April 2008   9h30 - 16h

Corrosion Under Insulation and Case Histories

Michael MeLampy
Hi-Temp Coatings Technology
+1 978 635 1110
mmelampy@hitempcoatings.com
Steve Reynolds
Performance Polymers Ltd
+44 1367 242 732
steve@ppleu.net

Agenda

- A bit of history
- Insulation?
- Boiling water
- Coatings for Insulated Service
- Maintenance
- Case Histories
- Conclusions

"CUI occurs when the conditions …
…meet with unprotected steel.

The second critical point is that the REASON the steel was not adequately protected in the first place is because when our plants were built, industry did not understand that the environment under the insulation was going to be almost like immersion conditions (or worse)….

…So the correct type of coatings were not used. As a result, almost NONE of the surfaces under insulation in every single facility which are older than 15 years, are NOT adequately protected from CUI. CUI is a phenomena because of our ignorance."

➔ Monica Chauviere,

Non-metallic Materials. ExxonMobil Research and Engineering AAEO/Materials, Inspection, & Support

Insulation Leaks
…. Eventually

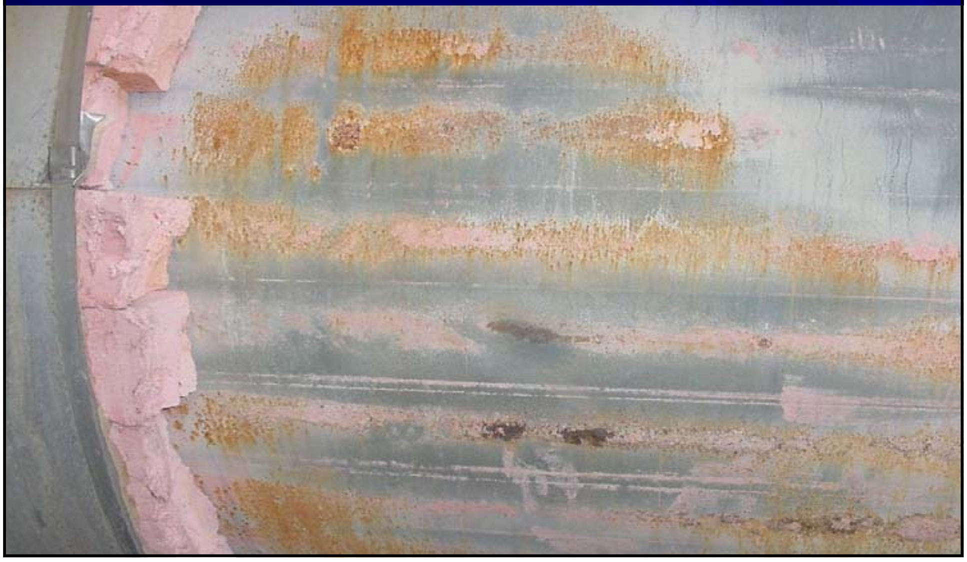

08 19 2001


Novalac Epoxy
After 3 months service
Originally White
Cracking
Excessive DFT in places.

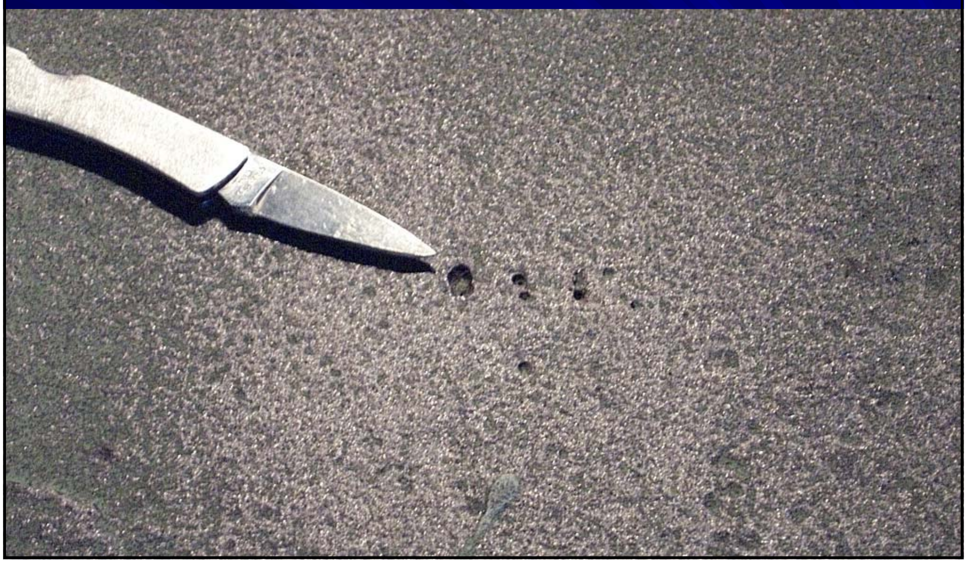

Overheated Epox

Corrosion under insulation

- Zinc Rich Systems – Galvanic Protection



What are the Consequences of Leaking Insulation?



Boiling Water

- For a coating to last a long time in needs to survive boiling water or close to boiling water.

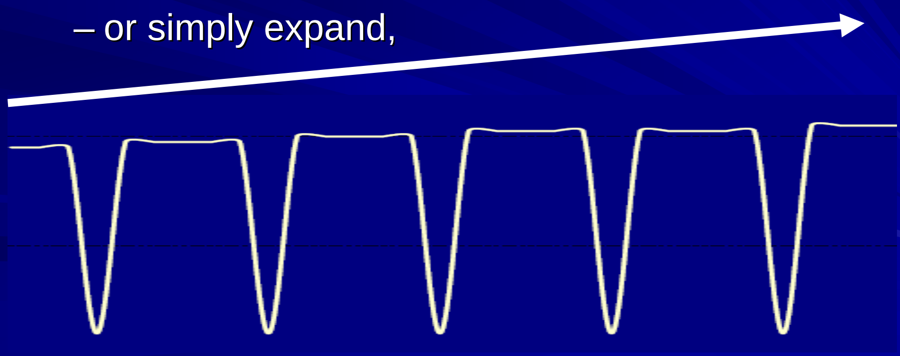
Surfaces at Elevated Temperatures

- Require specialized coating systems
  - appropriate levels of surface preparation
  - coating application
  - coating materials
    - Allow for future maintenance
  - inspection procedures

- In maintenance situations,
  - Some systems can be applied while units are in service, often near or at the unit’s peak temperature operation.
  - Some allow minimal surface preparation
  - Some have very long recoat window

New Interest In High Temperature Coating Systems

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



	Inert Multi-polymeric Matrix	Thermal Spray Aluminum	Traditional Elevated Temperature Silicones	Multi-polymer Primer	Inorganic Zinc	Novalac Elevated Temperature Epoxies
Max Operating Temp	750ºC	630ºC	540ºC	425ºC	400ºC	220ºC
Max DFT per Coat (in Microns)	150	200	37	150	75	100
Recoatable with self	Yes	No	Yes	Yes	No	Yes
Max DFT (in microns)	300 +		112	200		200 mils Max Recoat interval is critical
Single Component	Yes	n/a	Yes	No	No	No

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

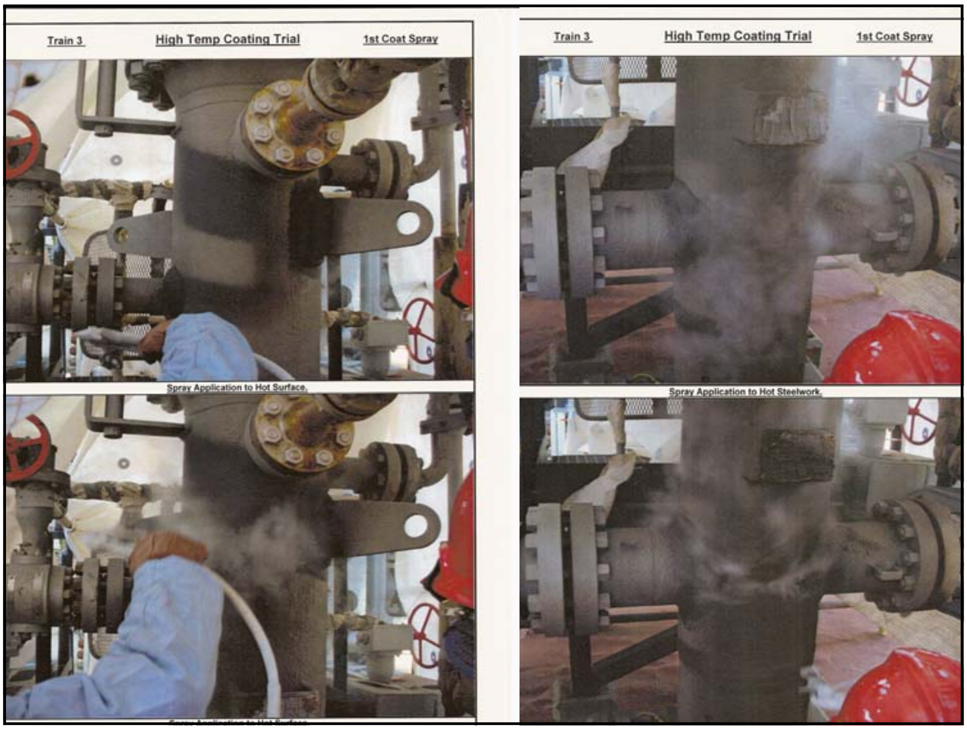
Surface Preparation

- Near White Metal Clean
- Power Tool Clean
- Hand Tool Clean

But really…

How clean can you get?

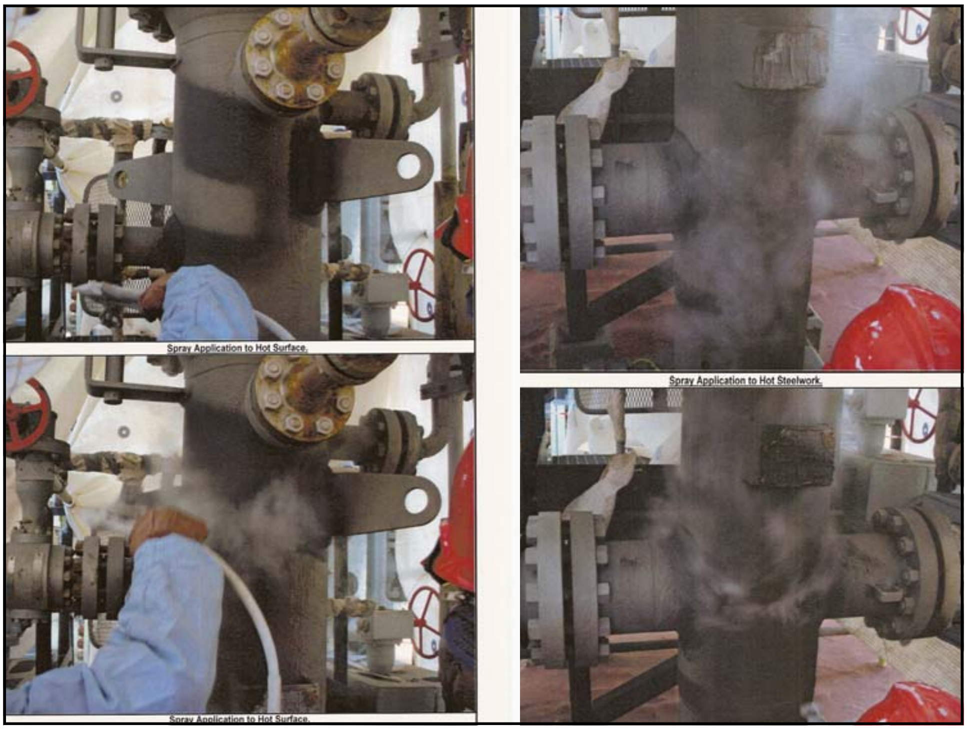
And at what cost?


Train 3
High Temp Coating Trial
1st Coat Spray
Spray Application to Hot Surface.
Train 3
High Temp Coating Trial
1st Coat Spray
Spray Application to Hot Steelwork.

Case Studies

1. Blast Cleaned – Off-Shore
2. Direct to rust
3. Other Examples

Coating applied to Regeneration heater that has cyclic temperatures ranging from -12ºC to 160ºC. Once the coatings were applied several tests were done along with two follow up visits.



Subsequent Visits

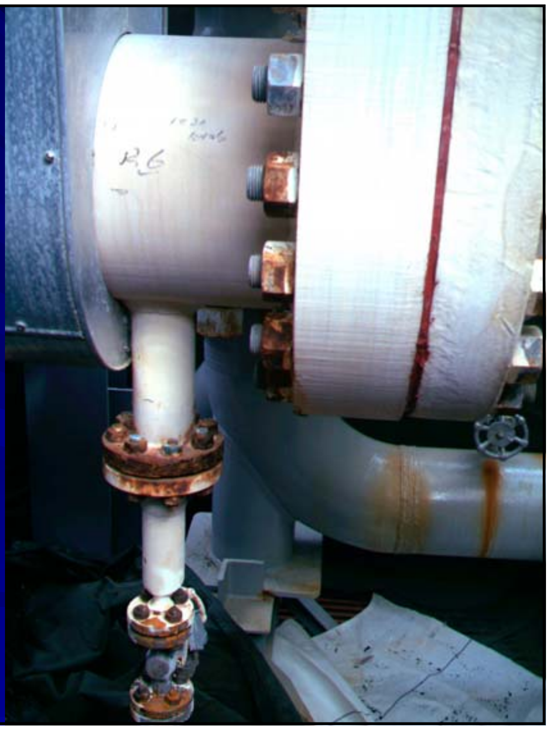
- 2cd Visit - Coating found acceptable after visual test for cracks, delaminations and other failure modes, Adhesion and Impact tests
- 3rd Visit Visual Inspection, insulated and put back into service.

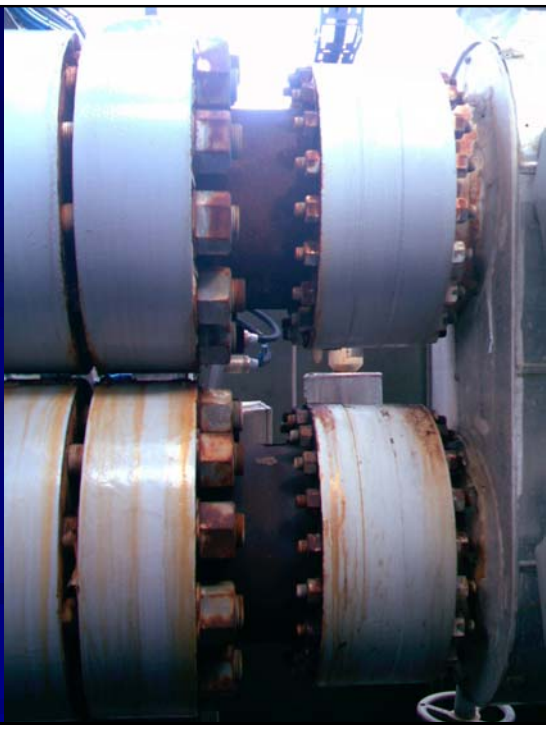
Off Shore Nigeria (Shell Bonga)

- Nozzles

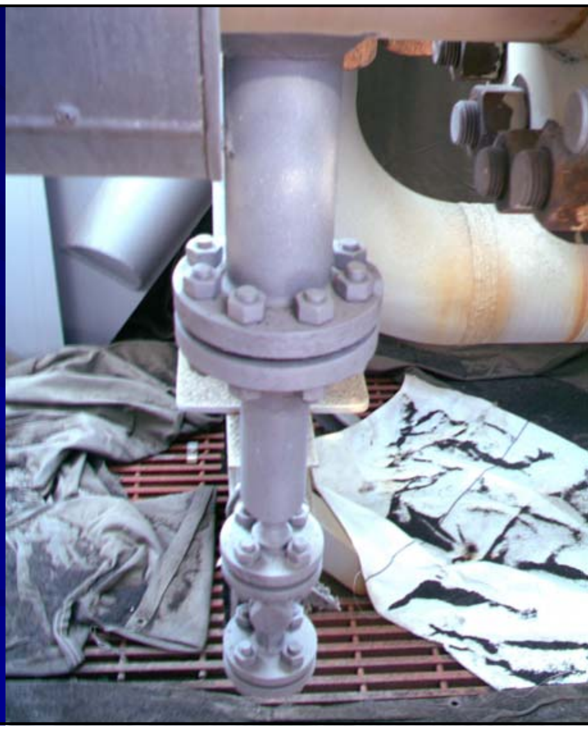
- Before
- Blast Cleaned
- Primer
- Topcoat

Before

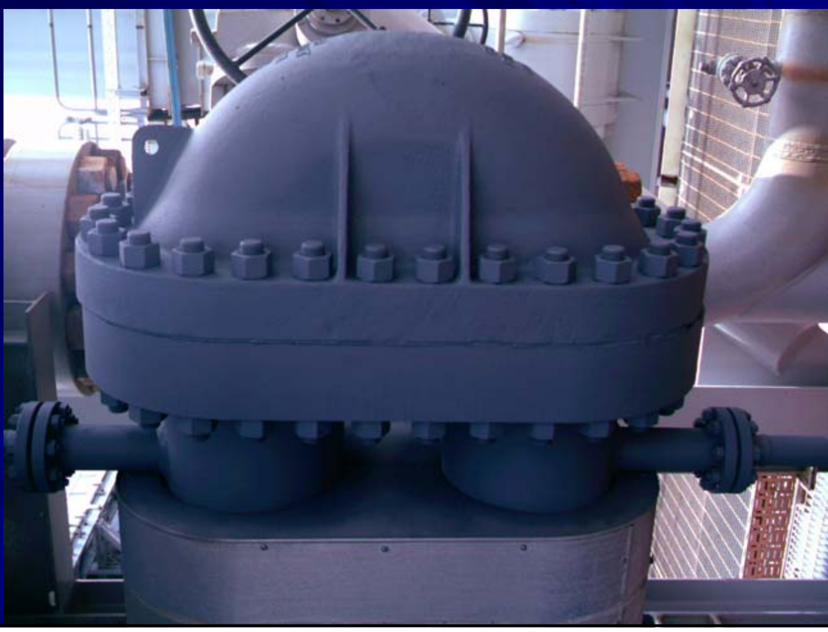




After Blast Cleaning



After 1027



After 1000VHA

Direct to Rust / Over Old Zinc

DOW CHEMICAL, PLAQUEMINE, LA.,

Project:	New Construction and Plant Maintenance
Location:	Plaquemine, Louisiana
Facility Type:	Chemical Plant
Start Date:	2003
Owner/contact:	Lynda Mink
Contractor:	Sipco/Protherm
Contact:	Johnny Thorning (B&H)
Engineering:	n/a
Coatings:	Hi-Temp 1027 10-15 mils DFT [250-375]Microns
Substrate;	Carbon Steel
Surface Prep:	Dry Abrasive Blast
Environment:	Chemical Plant
Project size:	

PROJECT DESCRIPTION

Multiple projects dating back to 2003. Hi-Temp Coatings products and systems are on the Dow Global Coatings specification.

VALERO REFINING, GOOD HOPE, LA.,

Project:	Field Maintenance
Location:	Good Hope, Louisiana
Facility Type:	Petroleum Refinery
Start Date:	2003 -- 2005
Contractor:	Mansfield / Brock
Contact:	Johnny Thorning (B&H)
Engineering:	n/a
Coatings:	Hi-Temp 1027 250-375 Microns
Substrate;	Carbon Steel
Surface Prep:	Dry Abrasive Blast
Environment:	Refinery / Chemical
Project size:	15,000 sq.ft. / 1500 sq. M

PROJECT DESCRIPTION

Valero Refining, Good Hope, Louisiana, was one of the earliest users of Hi-Temp Coatings Systems for CUI (Coating Under Insulation) projects and for exposed elevated temperature plant equipment as part of turnarounds and routine plant maintenance since early 2003. The facility continues using Hi-Temp products, with a series of small insulated vessel exteriors being the most recent project.

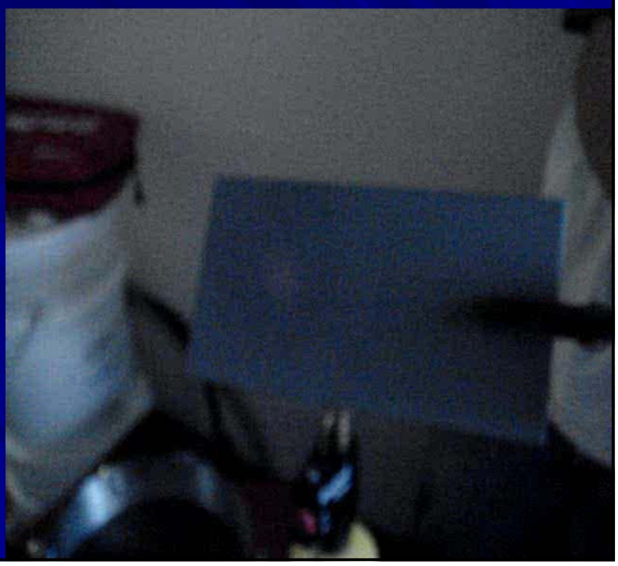
VULCAN CHEMICAL, GEISMAR, LA.,

Project:	New Construction and Plant Maintenance
Location:	Geismar, Louisiana
Facility Type:	Chemical Plant (now owned by Oxychem)
Start Date:	2003
Owner/contact:	
Contractor:	
Contact:	Johnny Thorning (B&H)
Engineering:	n/a
Coatings:	Hi-Temp 1027 10-15 mils DFT [250-375]Microns
Substrate;	Carbon Steel
Surface Prep:	Dry Abrasive Blast
Environment:	Chemical Plant
Project size:	

PROJECT DESCRIPTION
Multiple projects dating back to 2003.

-Conclusions- Surfaces at Elevated Temperatures

- Require specialized coating systems
  - appropriate levels of surface preparation
  - coating application
  - coating materials
  - inspection procedures.



Appendix 4

Unusual CUI failure

Hennie de Bruyn (Borealis Group)

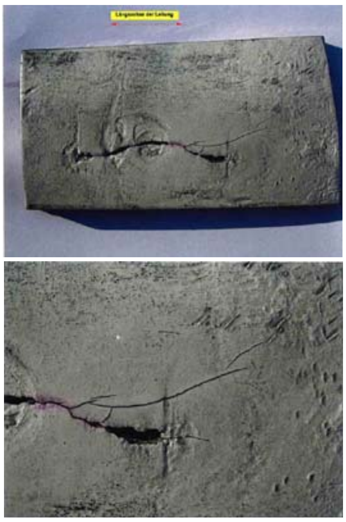
Unusual CUI Failure

Hennie de Bruyn – Chief Engineer Material Technology

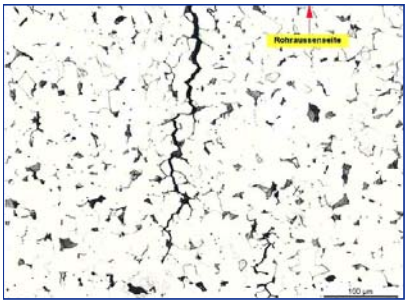
BOREALIS
SHAPING the FUTURE with PLASTICS

Nitrate SCC of Carbon Steel

- Benfield (CO_2 –removal) unit
  - Linz – Austria
  - Material: St35
  - Line: DN500 / 11mm WT
  - Operating at: 120ºC / 30 bar
  - Lean caustic potash solution
- Insulation system
  - Installed in 1974
  - Pb-based primer; no topcoat
  - Unspecified mineral wool insulation
  - No maintenance



Nitrate SCC of Carbon Steel



- Failure mode
  - Intergranular cracking that initiated from the external surface
  - Cracking occurred away from any welds or other structural discontinuities
  - Main crack direction is longitudinal to the pipe
  - Wet chemical analysis from surface debris indicate high nitrate levels

Nitrate SCC of Carbon Steel

- Investigation
  - Direct nitrate source not found
  - Old insulation material contains high levels of leachable nitrate
  - Possible atmospheric contamination from nearby nitric acid plant
- Mitigation
  - Extensive insulation removal program + inspection
  - Considering painting program / alternatively TSA
- Key questions
  - Has anyone else experienced similar failures?
  - Main reason: nitrate containing insulation or external contamination?
  - Experienced TSA applicators in Austria?
  - What about Al-foil wrapping? Sufficient electrochemical potential shift?

Appendix 5

Assessment of the resistance to HTHA of a 5% Mo steel equipment

Martin Richez (Total)

Assessment of the resistance to HTHA of a 0.5 % Mo steel equipment

EFC – WP15

TOTAL

Presentation

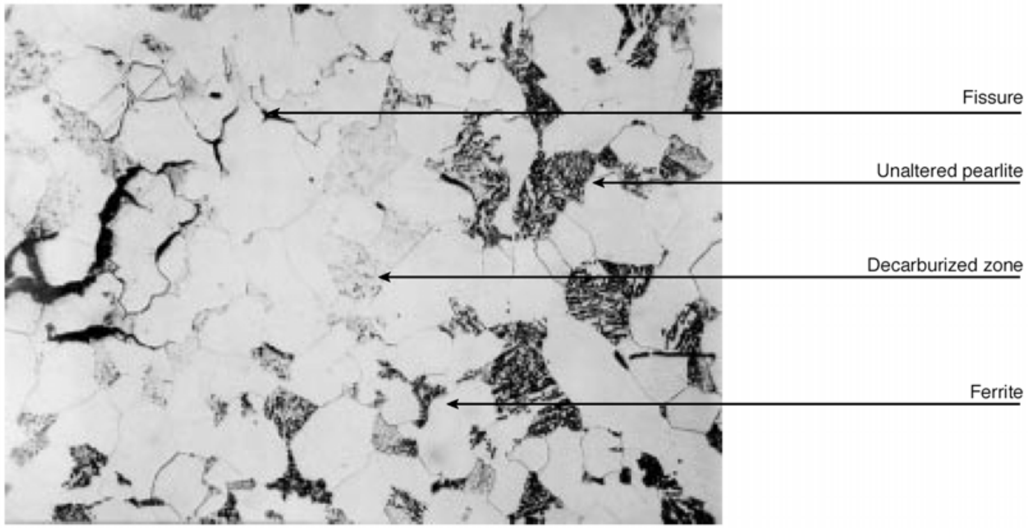
- HTHA mechanism
- Failure cases
- Resistance of 0.5 % Mo steel to HTHA (Hot Temperature Hydrogen Attack)
- Management of 0.5 % Mo equipments
- Assessment of an equipment by direct evaluation of metal resistance to HTHA

HTHA Mechanism

- **Hot Temperature (temp > 220°C)**
- **Concerned units in refining :**
  - **Hydrotreatments (HDT, HDS, Hydrocracker…) – Pressure from 30 to 170 bars, temp. from 350 to 430 °C**
  - **Les reforming – Pressure from 4 to 35 bars, temp. from 490 à 550 °C**
  - **Steam reforming (hydrogene production) 40 bars, 850 °C**
- **2 different types of attack :**
  - Surface decarburation
  - Internal decarburation

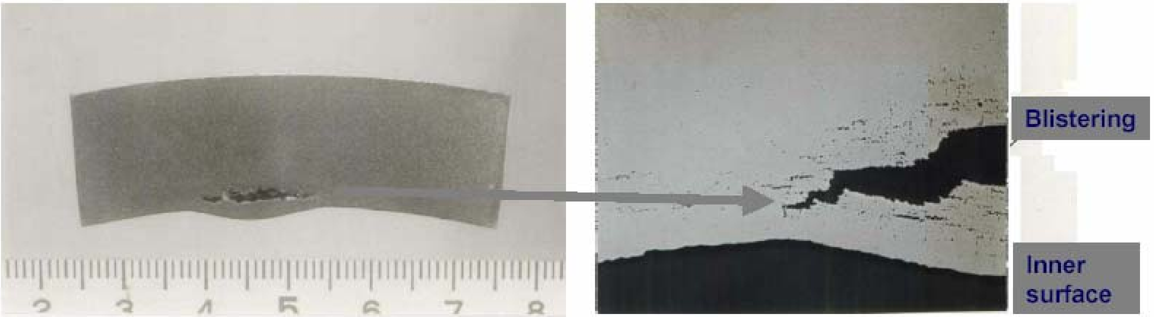
Décarburation interne

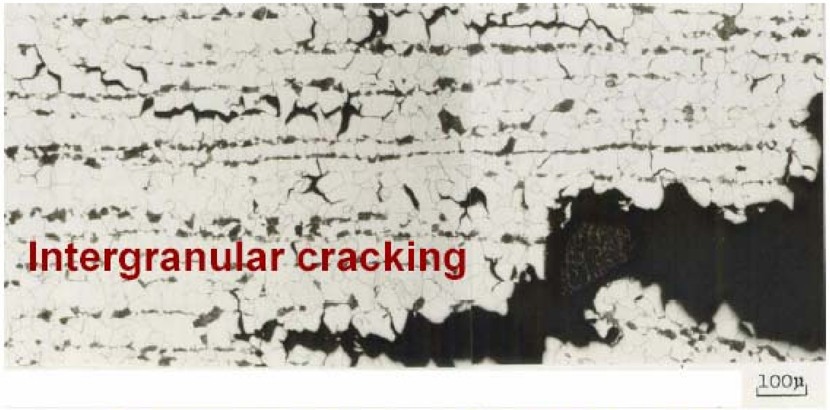
- Hydrogen ingress penetration in the metal
- Reaction with carbon to form methane CH4
- Trapping of methane dans les discontinuities and at grain boundaries
- Internal stresses leads progressively to micro void formation, then micro cracks ans cracks.
- Resistance to hydrogen attack is linked to carbide stability.



HTHA exemples

Exemples d'attaque à chaud





Cross section of HTHA elbow

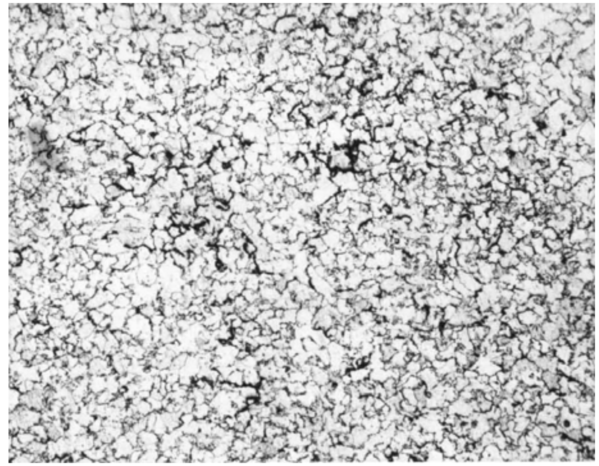
Figure 2 Blistering observed on C-0.5Mo nozzle flange used in Platformer unit

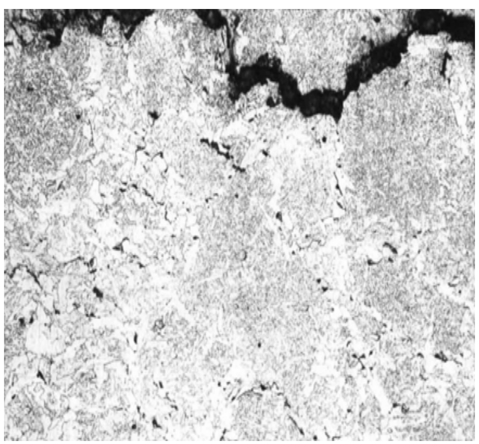
Défaillance du à l’attaque à chaud

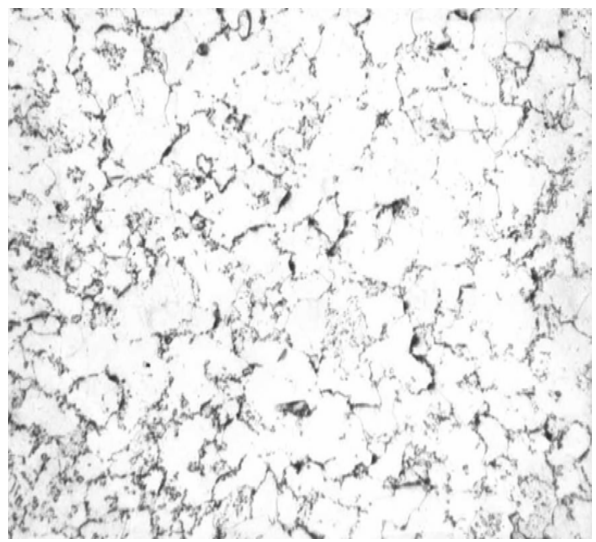
Réformeur 1989

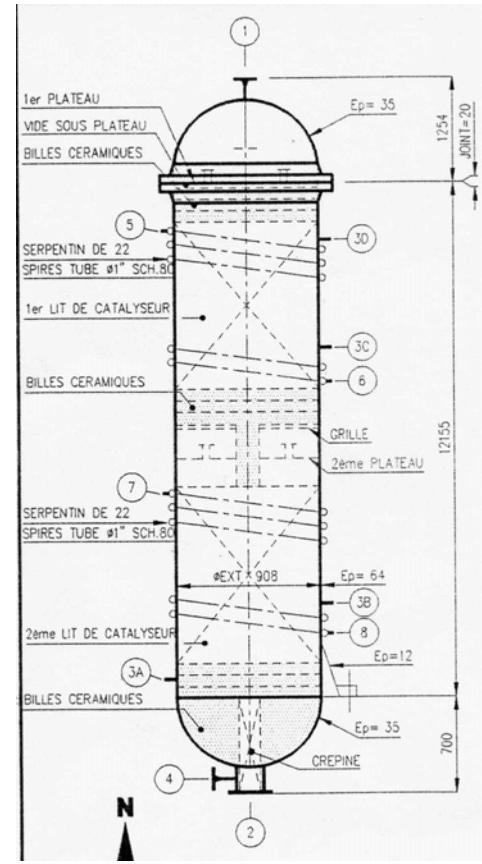
Exemple d’attaque dans le raffinage TOTAL (2004)

- Réacteur d’hydrofinissage d’huile
- A 204 Gr B (0,5 % Mo), ép. 64 mm
- 260 à 350 °C
- ppH2 78 à 136 bars





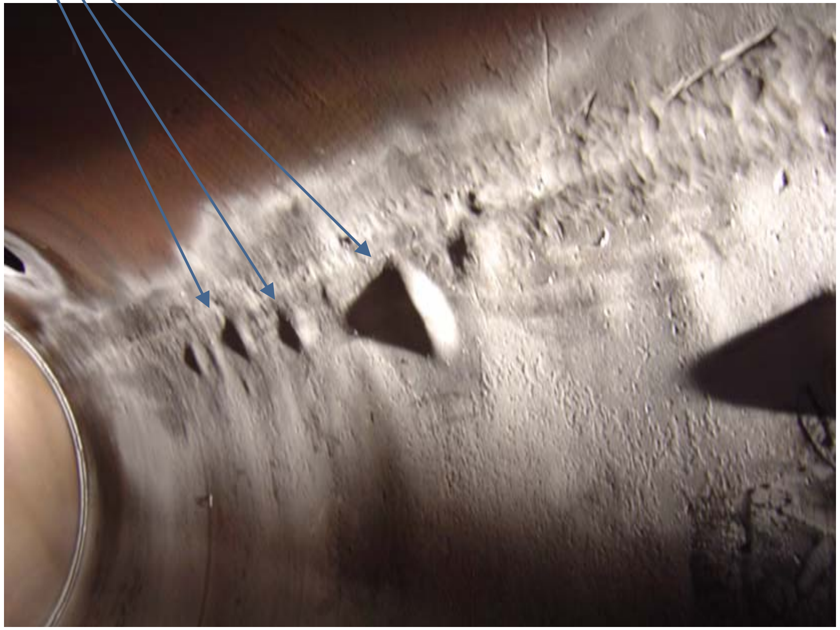




Exemple d'attaque dans le raffinage TOTAL (2005)

- Fabrication 1967 – les 4 plus chauds: calandre A204 Gr.B (0,5 Mo) – TTAS – épaisseur 28mm
- Conditions de service pour les 4 plus chauds:
  - Température de service sortie calandre 420 à 450°C
  - Pression partielle d'hydrogène 12 à 18 bars
  - Durée d'exploitation 330 000 heures

•Hernies ϕ 80/100 mm le long soudure L2 sur calandre E5E



•Fissures longitudinales le long soudure L2 sur calandre E5J

TOTAL

ATOCHEM Carling (2007)

- fuite d'un mélange d'hydrogène / hydrocarbures
- Une soudure circulaire de la tuyauterie 4’’ (DN100) ép 6 mm ASTM A53 Gr.A est fissurée sur ¾ de sa section (fissure débouchante sur toute sa longueur).
- Condition de fonctionnement : 40 bar – # 300°C– mélange H_2 + hydrocarbures(50% H_2 molaire pour P totale 40 bar)
- Mise en service de la tuyauterie: 1968

TOTAL

Décarburation interne

- **Elements like chromium, molybdenum, titanium, or niobium… are benefitial to resistance to HTHA by forming stable carbides.**

- **O.5 % Mo non sufficient to stabilize carbides**

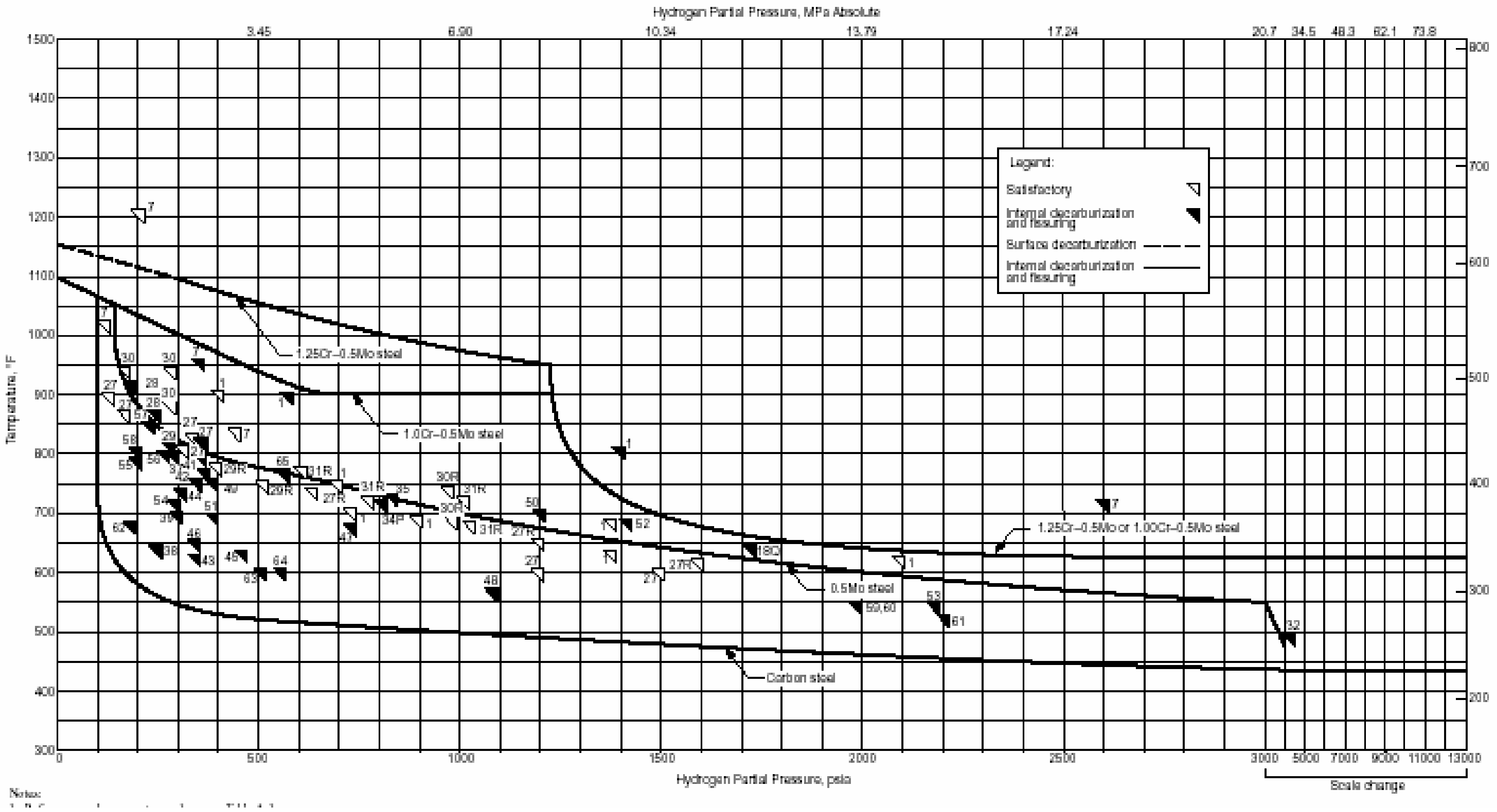
- **HTHA happen in 3 phases :**
  - Incubation time, during which metallurgical evolutions are not detectables
  - Degradation phase, during which mechanical properties are decreasing
  - Then properties reach their final value (depletion of carbon)

Courbes de Nelson

Courbes de Nelson

- Ces courbes empiriques représentent l'expérience de l'industrie du raffinage
- Premières courbes publiées par George NELSON dans les années 40
- Première publication dans l'API 941 en 1969
- Les aciers à 0,5 % de Mo sont abaissés de 33°C en 1977 suite à des expériences défavorables
- Dans l'édition de 1983, une note particulière est émise concernant des cas de HTHA sur des réformeurs catalytiques.
- De nouveau cas d'attaque sur l'acier 0,5 % Mo sont observés jusqu'à 110 °C en dessous de la courbe publié en 1977
- En 1990 les courbes concernant l'acier à 0,5 % Mo sont retirées
- L'expérience semble montrer que l'acier à 0,5 % Mo a une résistance très variable

Courbes de Nelson publiées en 1977



TOTAL

Résistance des aciers contenant 0,5 % de Mo

Facteurs influençant la tenue à l'hydrogène

- Temps d'exposition
- Température et Pression (ppH2)
- Les méthodes de production (histoire thermique)
- La présence ou non d'une barrière à la diffusion de l'hydrogène
- Le niveau de contrainte

Incidence d'un revêtement métallique

- Les aciers ferritiques ont un fort coefficient de diffusion de H_2 mais une faible solubilité, comparés aux aciers austénitiques
- Les revêtements en aciers austénitiques sont un obstacle à la diffusion de l'hydrogène dans l'acier. L'efficacité de cette barrière dépend :
  - L'épaisseur relative d'acier austénitique et ferritique
  - Du bon état du revêtement
  - De la température

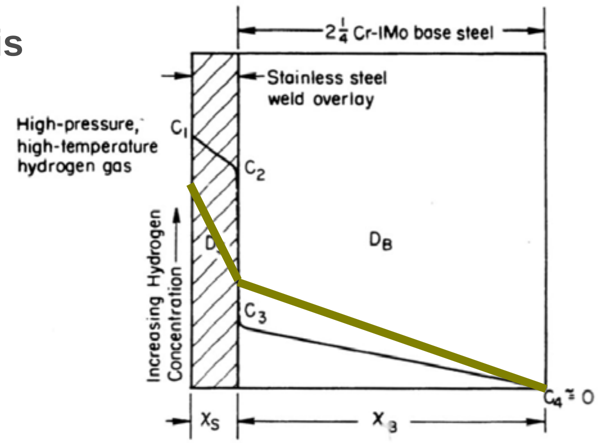


FIGURE 4. SKETCH SHOWING HYDROGEN DISTRIBUTION IN A STAINLESS STEEL-WELD-OVERLAYED 2-1/4Cr-1Mo STEEL VESSEL EXPOSED TO HIGH-PRESSURE, HIGH-TEMPERATURE HYDROGEN

- Les aciers ferritiques type 410, n'assurent aucune protection
- La pression effective sur la paroi peut être calculée par la formule suivante :

$$P_{Interface} = \frac{P_0}{\left[1 + 0.18 \frac{t_{Clad}}{t_{Base}} \exp\left(\frac{2984}{T}\right)\right]^2}$$

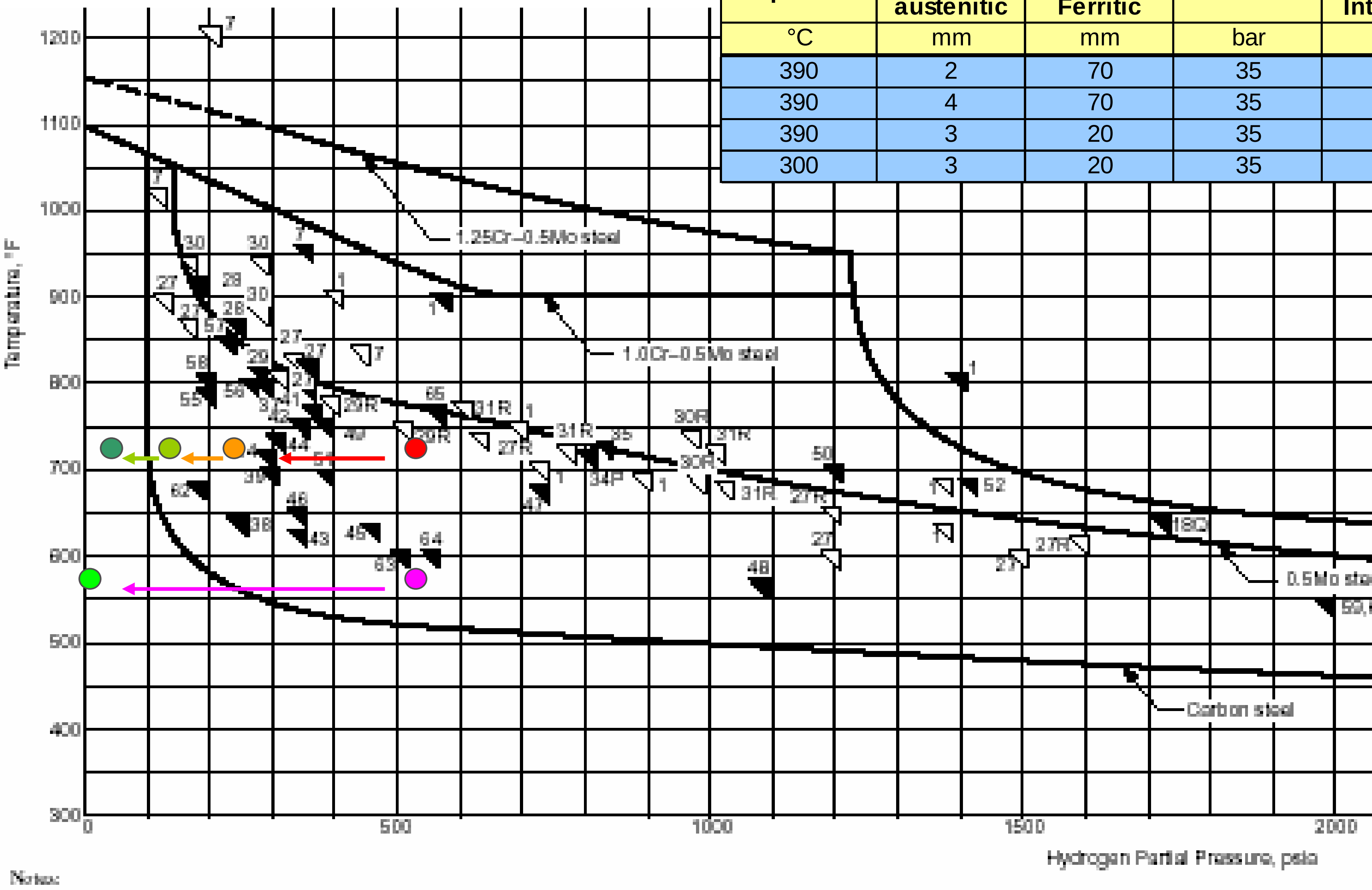
- Exemple :

temperature	Thickness		PPH2	PPH2 Interface
	austenitic	Ferritic		
°C	mm	mm	bar	bar
390	2	70	35	16.3
390	4	70	35	9.4
390	3	20	35	3.0
300	3	20	35	1.0

TOTAL

Incidence d'un revêtement métallique

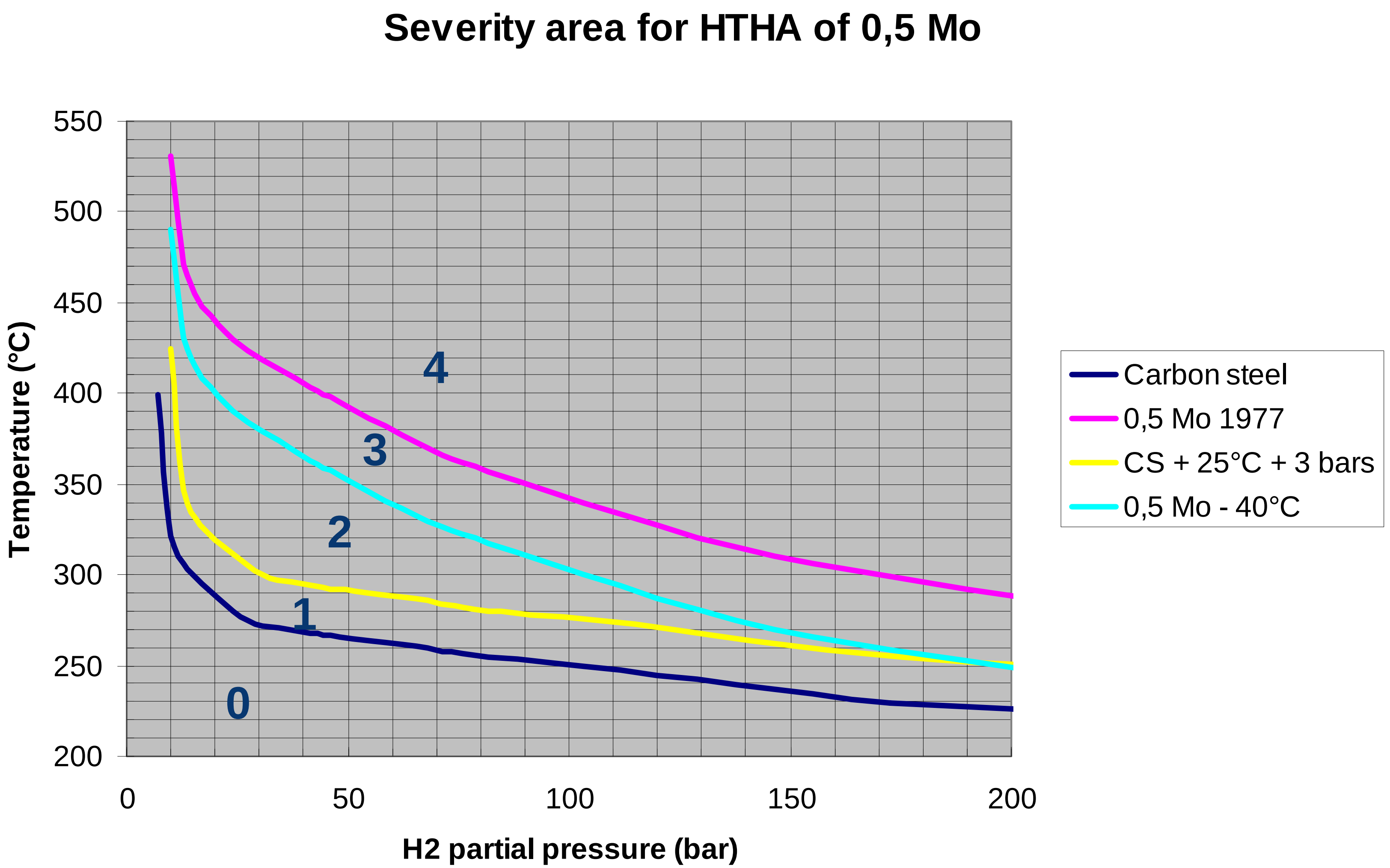
temperature	Thickness		PPH2	PPH2 Interface
	austenitic	Ferritic		
°C	mm	mm	bar	bar
390	2	70	35	16.3
390	4	70	35	9.4
390	3	20	35	3.0
300	3	20	35	1.0



TOTAL

Management of O.5 % Mo equipment

Zones de risque



TOTAL

Risk Area

- <u>Area 0</u> – Below carbon steel curve. Degradation probability is considered as null
- <u>Area 1</u> – Between carbon steel curve ans carbon steel + 3 bars and 25 °C. In this area no failure case on 0. 5 % Mo steel has been reported. HTHA risk is considered as very low.
- <u>Area 2</u> – It is an intermediate area where risk is considered as low for equipment made of normalized steel and PWHT.
- <u>Area 3</u> – Between 1977 0.5 % Mo steel curve and 40°C below. In this area degradation risk is considered as high on old.
- <u>Area 4</u> – Located above 0,5 % Mo curve of 1977. This is an area where degradation risks are very high and unacceptable.

TOTAL

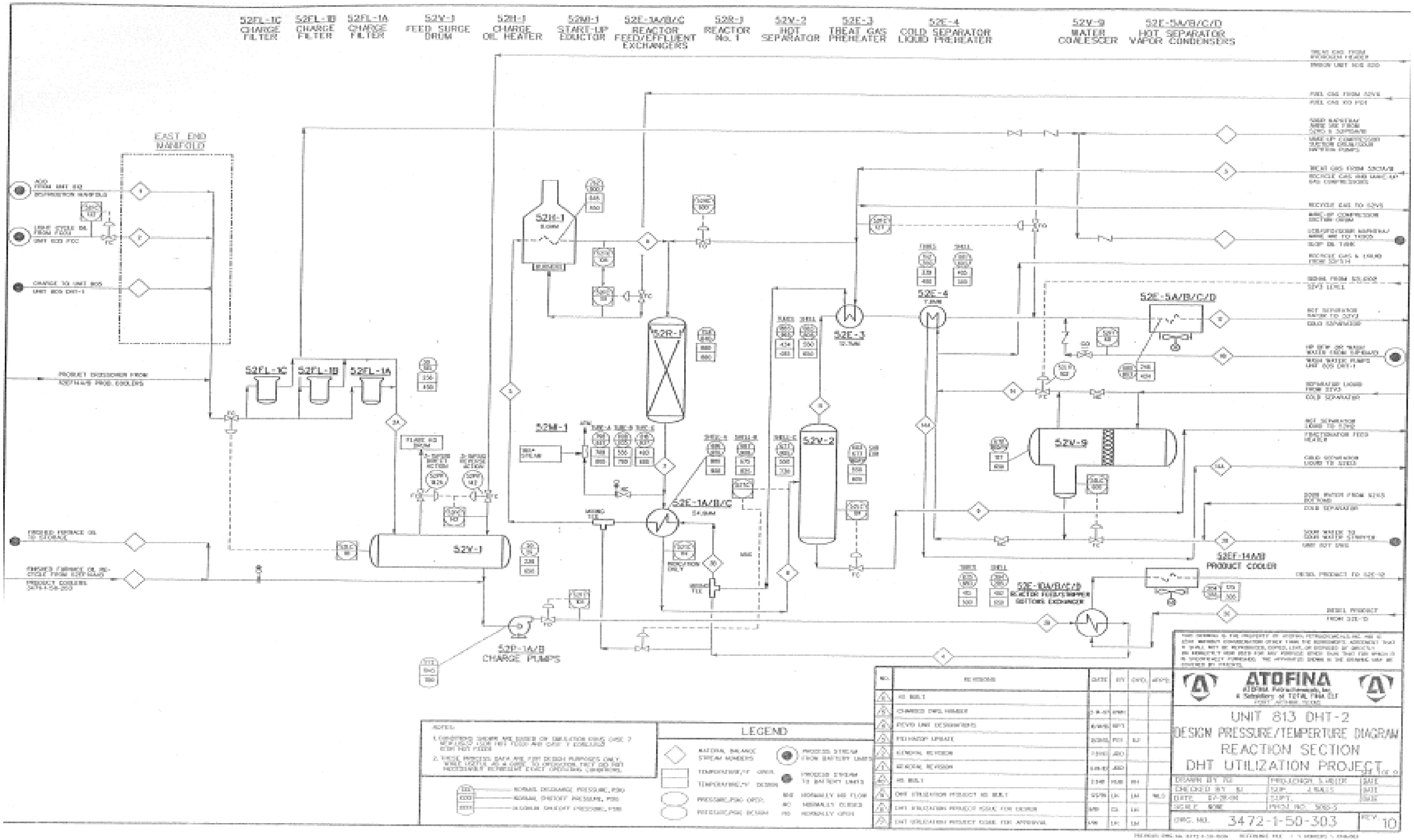
Secteur	Inspection HTHA	Remplacement	Sévèrisation des conditions procédé
Secteur 0	**Néant**	**Néant**	**Sévèrisation des conditions procédé autorisée si :** **- L'équipement est en zone 1 après prise en compte du clad.** **- Le clad est en bon état** **- L'appareil est traité thermiquement s'il se retrouve en zone 1.**
Secteur 1	**- Partielle si l'appareil est traité thermiquement.** **- Complète si l'appareil n'est pas traité thermiquement.**	**- En cas de détection d'HTHA et,** **- Systématique si tuyauteries**	**Sévèrisation des conditions procédé autorisée si :** **- L'équipement est en zone 1 après prise en compte du clad.** **- Le clad est en bon état** **- L'appareil est traité thermiquement**
Secteur 2	**Complète**	**- En cas de détection d'HTHA ou,** **- Si l'équipement n'est pas traité thermiquement ou,** **- Tuyauteries ou équipements peu inspectables**	**Sévèrisation des conditions procédé non autorisée sauf si :** **- L'équipement est en zone 1 après prise en compte du clad.** **- Le clad est en bon état.**
Secteur 3	**Complète**	**- En cas d'HTHA ou,** **- Si l'équipement n'est pas traité thermiquement ou,** **- Si le clad est détérioré ou,** **- En l'absence de clad protecteur ou,.** **- Tuyauteries ou peu inspectable**	**Sévèrisation des conditions procédé non autorisée.**
Secteur 4	**Néant (appareil à remplacer)**	**- A remplacer systématiquement et dans les délais les plus bref.**	**Sans objet (appareil à remplacer)**

Inspection for High Temperature Hydrogen Attack on a Carbon 0.5% Molybdenum Vessel

EFC WP 15 – 15 April – Leiden – Martin RICHEZ

TOTAL

Process Service



TOTAL

52V-2 Hot Separator

Vessel Specifics

- **Built in 1962 - 45 years in Hydrotreater Hot Separator Service**
- **Design Pressure 803 PSI**
- **Operating Hydrogen Partial Pressure 587 psia**
- **Design Temperature 600 degrees F**
- **Operating Temperature 595 degrees F**
- **Shell 6' Diameter Height 21'1"**
- **Shell Material A204 grade C with .078" TP 410 Clad**

TOTAL

Scope

- To evaluate the future performance of 52V-2 , Lloyd's Register Capstone performed HTHA exposure testing on Scoop Samples removed from the OD of the vessel. Two scoop samples were removed from 4 locations. These locations consisted of the top and bottom heads and each of the two shell courses. Two test coupons were made from each scoop sample. One coupon per location was subject to a 100 hour test while the other coupon was subjected to a 200 hour test. This left one full Scoop Sample per location for additional testing as needed.
- L.R. Capstone also performed internal metallurgical examination using field metallography and replication, (FMR).
- Advanced Ultrasonic Backscatter Techniques (AUBT) were used to examine the base metal and weld joints were examined using angle beam spectrum analysis (ABSA).

Test Procedure for Scoop Samples

Figure 1 and 2 show the Scoop Samples that were removed from the vessel OD surface. These were removed using LR Capstone's proprietary Scoop Sampler^{SM}. Depth of the resultant divots were less than the maximum allowable based on local thin area calculations that were previously performed in the 1999 evaluation. Therefore, the excavations were blended to minimize local stress concentrations with no further repairs needed.

It can be seen that a total of eight Scoop Samples were removed from the vessel. Two Scoop Samples were removed from each of four locations; two test coupons were able to be removed from a Scoop Sample. One coupon per location was subjected to a 100 hour test while the other coupon was subjected to a 200 hour test. This left one full Scoop Sample per location for additional testing if needed. Sample locations are given below in Table 1.

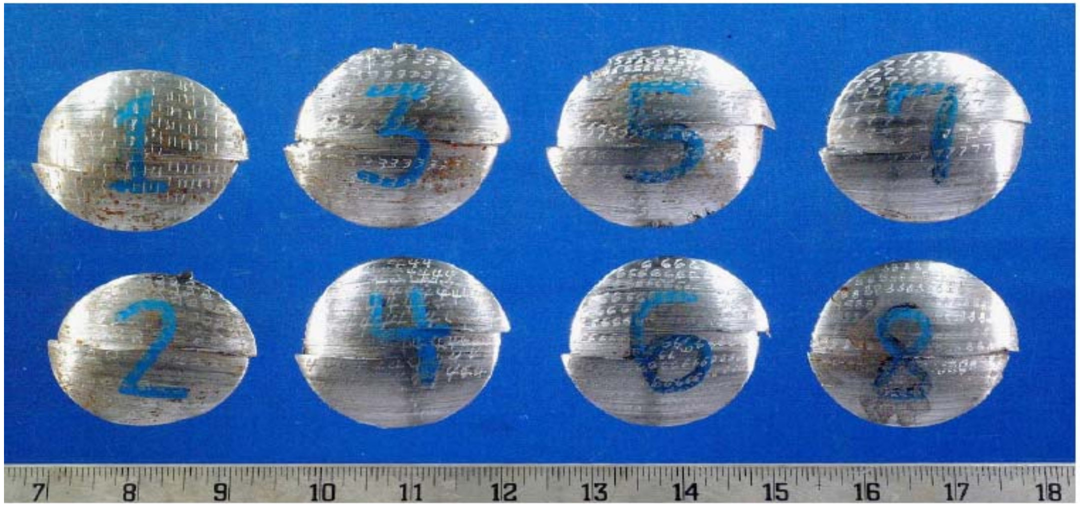
Table 1. Scoop Sample Locations

	Scoop Sample ID
Bottom Head	1 and 2
Bottom Course	3 and 4
Top Course	5 and 6
Top Head	7 and 8

TOTAL

Scoop Samples

Figure 1. OD surfaces of the removed Scoop Samples.



Test Procedure Cont.

The coupons were welded around their perimeter to seal them in place at the end of the test chamber, which had hydrogen inside and argon on the OD. The single side exposure testing was performed by exposing only one side of the coupon to high pressure hydrogen while the argon on the other side was set at a pressure equal to the hydrogen pressure. This balanced pressure approach minimized the potential for a leak or crack of the coupon to hydrogen chamber seal weld. Thermocouples were placed against the test coupon in the hydrogen chamber to monitor temperature during the test. Test temperature was set at 950 degrees F at a hydrogen pressure of 1215 PSIA.

Carbon Steel Reference Sample

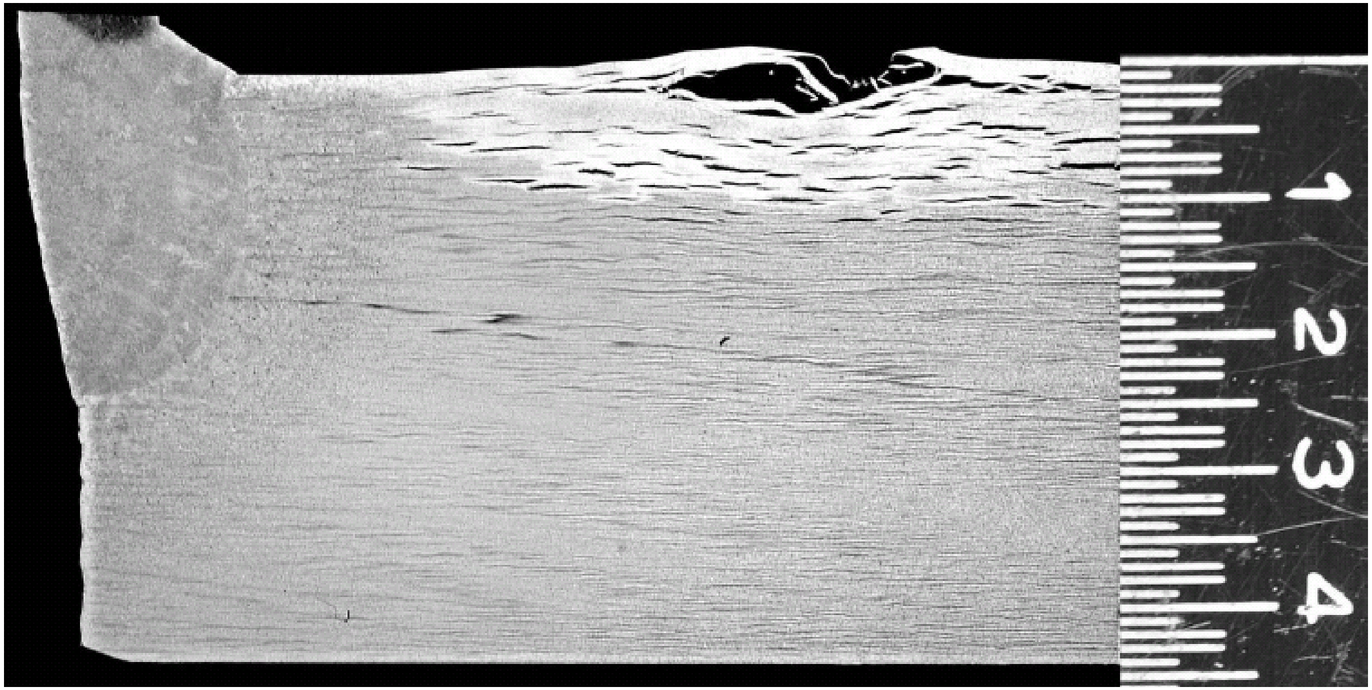


Figure 4: Macroscopic view of a carbon steel reference sample at the accelerated test conditions, 100 hour exposure. Decarburization depth is approximately 0.1" (23% through wall). Depth of cracking was approximately 0.13" (30% through wall). 3% Nital Etch, 6.7X.

Nelson Curve

Included in this figure are the 100 hour incipient damage curves for carbon steel and C- 0.5Mo steel and past and future operating conditions. It can be seen that the test conditions are very severe and if susceptible they should have produced damage in the test coupons.

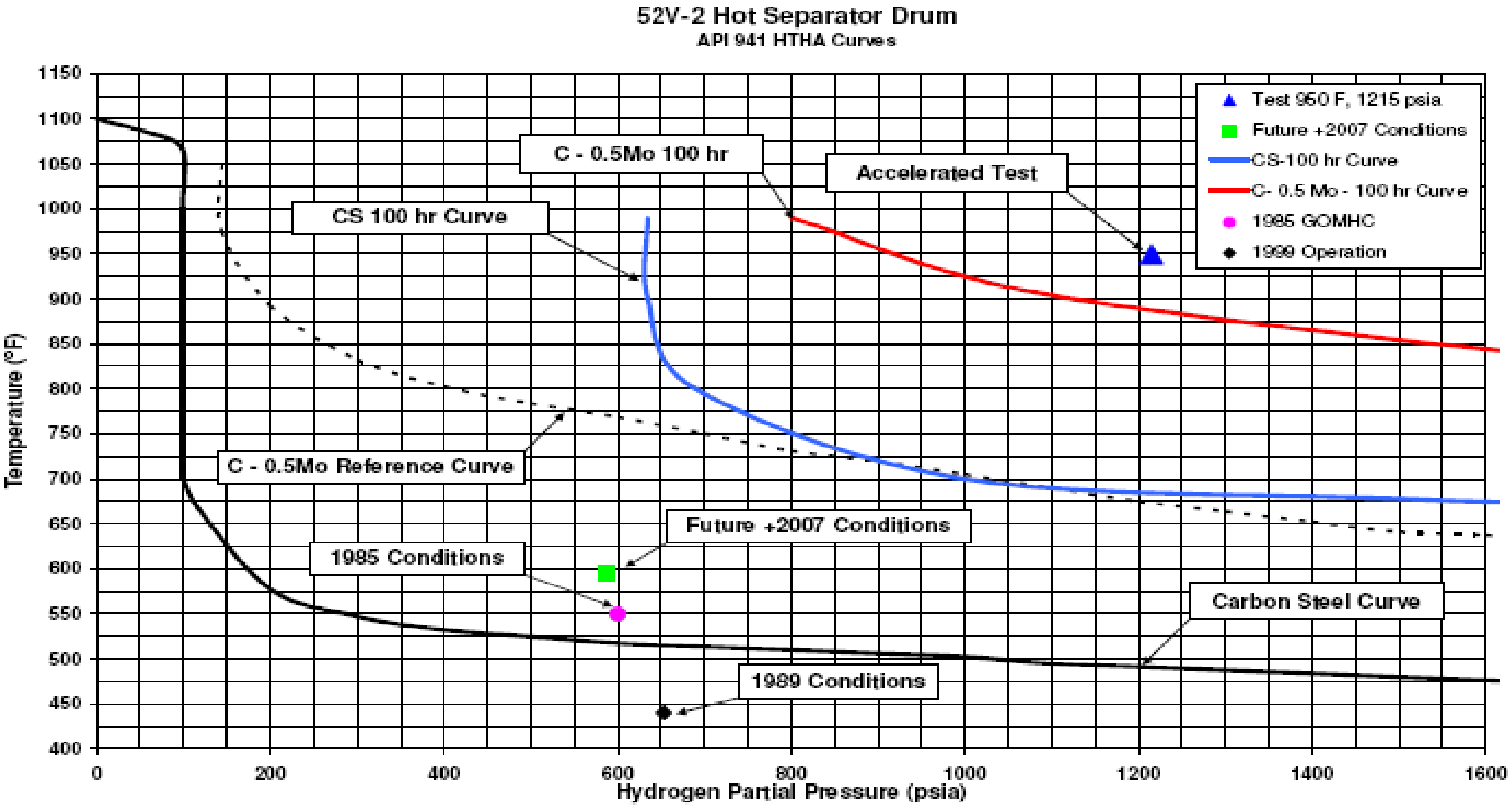


Figure 3: HTHA damage curves from API 941. Past to future operating conditions plus the accelerated test conditions are plotted to show severity of the various operating conditions.

Pre-Exposure Microscopic View

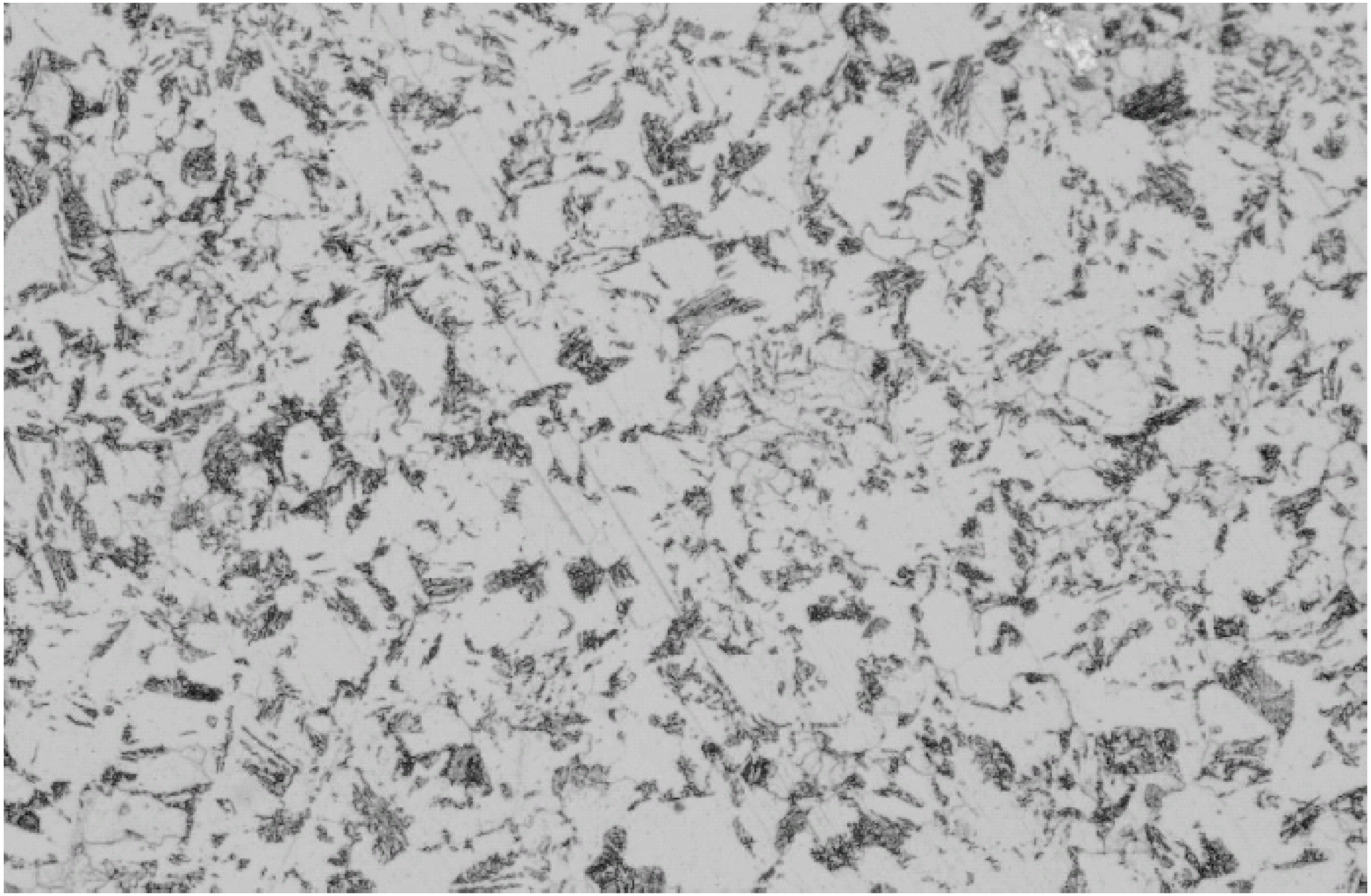


Figure 5. Scoop Sample 6, representative base metal microstructure, pre-exposure. 3% Nital Etch, 400X.

Results:
No evidence of decarburization, methane voids, or microfissuring was found in any of the samples.

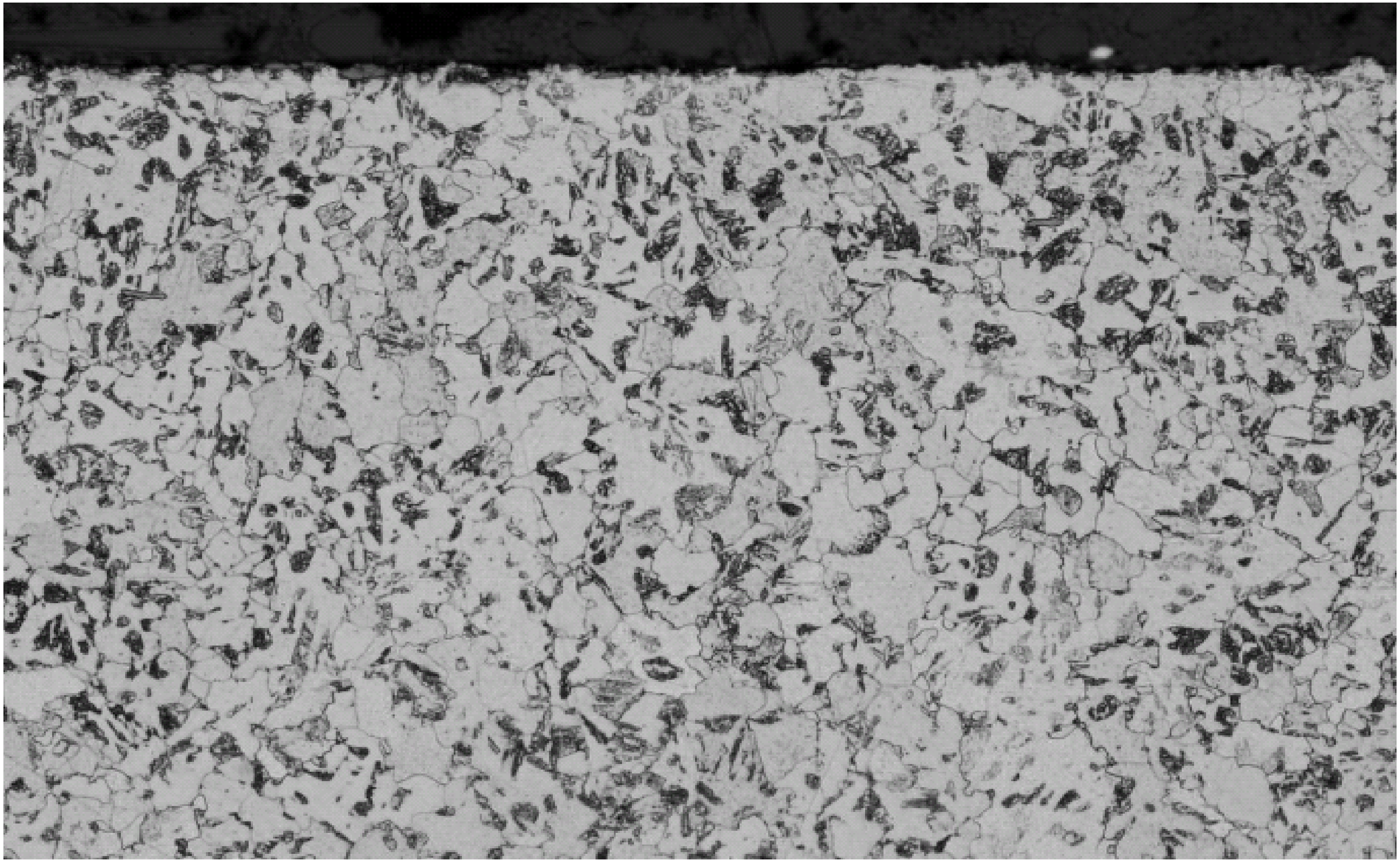


Figure 6: Scoop Sample 1, representative base metal microstructure Test 1. 3% Nital Etch, 400X.

Results cont.
All of the C-0.5 Mo steel materials displayed good resistance to HTHA type of damage.

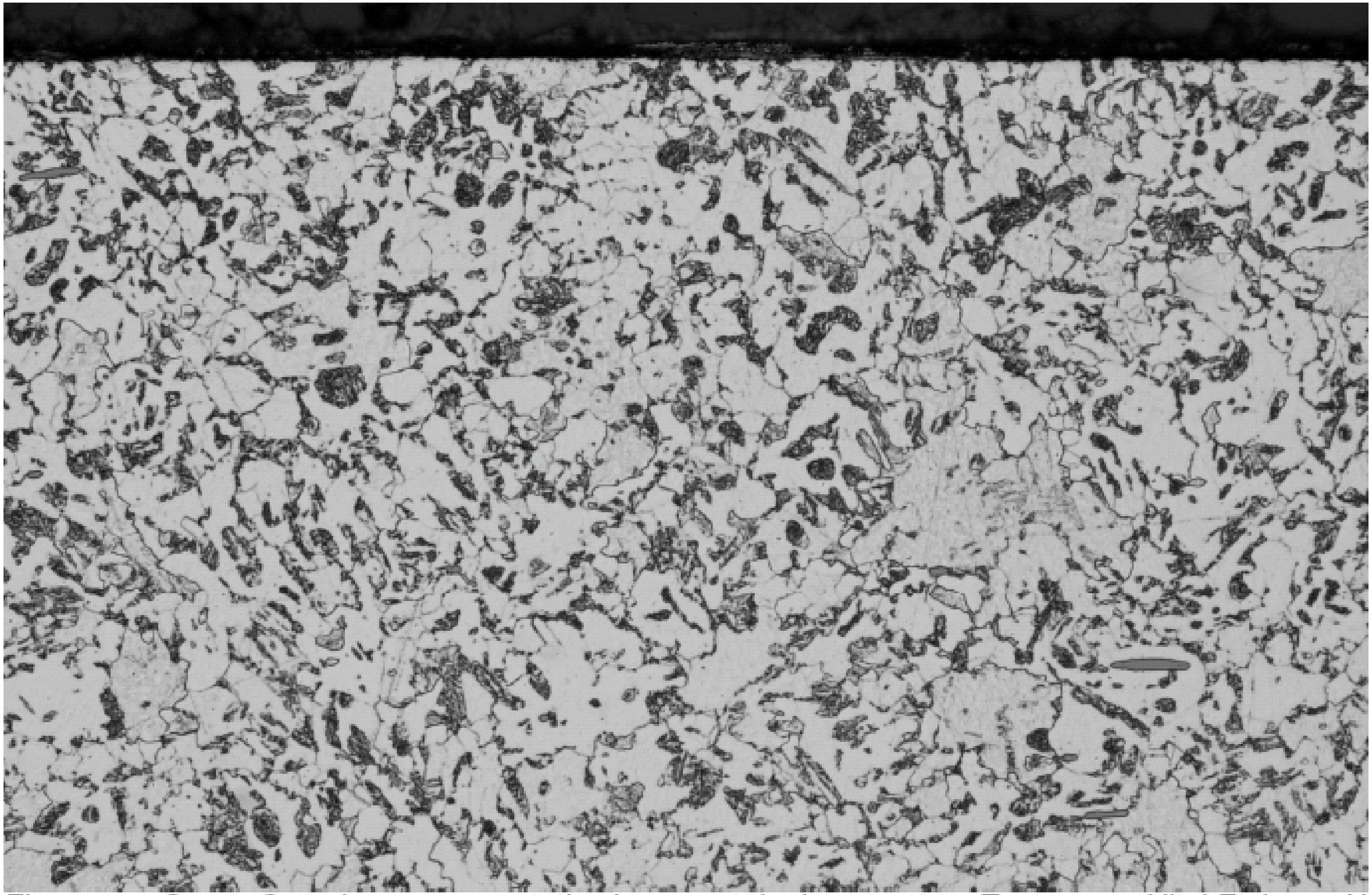


Figure 10: Scoop Sample 1, representative base metal microstructure Test 2. 3% Nital Etch, 400X

DISCUSSION

The test conditions were set approximately 65°F above the 100 hour C - ½ Mo steel incipient damage curve. It also corresponds to the 100 hour incipient damage as predicted using both P_v and P_w calculations. The equations used to calculate P_v is given below and are taken from the API 580 document. Critical values for P_v "worst case" annealed material is low susceptibility at 4.78, medium susceptibile at P_v = 4.87, and a high susceptibility at P_v = 4.95. For "good" normalized material, low susceptibility starts at a P_v of 5.43, a medium susceptibility at P_v of 5.51, and a high susceptibility at P_v of 5.60. Based on published literature and some work by Japanese researchers, the critical value for "good" C - ½ Mo steel base metal is P_v of 5.80.

$$Pv = \log (P_{H2}) + 3.09 \times 10^{-4}\, T (\log t + 14)$$

P_{H2} : Hydrogen partial pressure (kgf/cm²)

t : Total operating time (hr)

T : Operating Temperature (K)

Critical P_V Factors

Materials	High Susceptibility	Medium Susceptibility	Low Susceptibility	Not Susceptible
Carbon Steel	$P_V > 4.70$	$4.61 < P_V \le 4.70$	$4.53 < P_V \le 4.61$	$P_V \le 4.53$
C½ Mo[a] (Annealed)	$P_V > 4.95$	$4.87 < P_V \le 4.95$	$4.78 < P_V \le 4.87$	$P_V \le 4.78$
C½ Mo[a] (Normalized)	$P_V > 5.60$	$5.51 < P_V \le 5.60$	$5.43 < P_V \le 5.51$	$P_V \le 5.43$

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The P_w factor has a similar logarithmic equation with slight differences and is included here for reference, where:

$$P_w = \log t + 3\log P - 9918/T$$

JPVRC revealed in their investigation [5] that the critical values of Pw on HTHA of C-0.5Mo steel were the followings;

For base metal Pwcr = -4.80

For HAZ with PWHT Pwcr = -5.25

For HAZ without PWHT Pwcr = -7.90

The results of the calculated P_v and P_w factors are given in Table 2. The test conditions for Test 1 (102 actual hour test) gave a calculated Pv of 5.81. It can be seen that Test 1 produced conditions that exceeded the critical Pv value of 5.80 and Test 2 exceeded the thresholds by a wide margin for both the P_v and P_w factors yet the test samples did not display any evidence of HTHA damage. Therefore, it is concluded that the 52V-2 Hot Separator Drum has HTHA resistance similar to normalized "good" C - ½ Mo steel.

Table 2. HTHA Test Results w/ P_v and P_w Calculations

	T, °F	P, psia	Hours	Pv	Pw	Years
Test 1 - No Damage	950	1215	102	5.81	-4.86	---
Test 2 - No Damage	950	1215	223	5.89	-4.52	----
50°F SF	645	587	1,283,039	**5.43**	-5.20	146
50°F SF	645	587	1,150,000	5.42	**-5.25**	131
Clad benefit	645	549	1,825,941	**5.43**	-5.13	208
Clad benefit	645	549	1,400,000	5.41	**-5.25**	160

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Clad benefit	645	549	1,825,941	**5.43**	-5.13	208
Clad benefit	645	549	1,400,000	5.41	**-5.25**	160

The value of using P_v and P_w factors is that they can be used to evaluate different sets of operating conditions and make comparisons based on specified hours of service. Using the proposed upper temperature of 595°F plus a 50°F safety factor (645°F) and a hydrogen partial pressure of 587 psia, the drum could operate for 146 years before reaching a low susceptibility for HTHA damage based on a P_v of 5.43.

Based on a medium value susceptibility for P_w = -5.25, the drum could operate for 131 years. While the benefit of the 410 stainless steel cladding on the inside of the drum is not as much as would be given for a 304 stainless steel material, however, it can be seen that at a minimum, the 410 clad provides a fully resistant layer that reduces the hydrogen partial pressure in the C - ½ Mo steel based on the ratio of clad versus base metal thickness. Assuming a 0.109" thick cladding layer and a 1.6" shell, the cladding reduces the hydrogen partial pressure from 587 psia to 549 psia. This is not as significant of a factor at high pressures, but at the operating pressures given, there is an increase in remaining life of approximately 20 - 40%. A less conservative estimate of the pressure reduction associated with the cladding material is prescribed in the API 941 committee Base Resource Document, which indicates a further reduction of hydrogen partial pressure to approximately 352 psia. The remaining life according to this pressure would be on the order of 2000 years.

While the majority of the vessel is clad, there are six locations where the cladding has been removed. The follow-up field metallography and replication (FMR) inspection in March 2007 repeated the examinations at the previous locations. Upon removal of the internal scab plates, the exposed base metal was found to have a thick layer of black scale, presumed to be FeS. No significant wall loss occurred at these locations, in fact, previous grind marks were still visible in the base metal around the perimeter of the clad removal area. Field metallography and the AUBT inspection found no evidence of HTHA damage.

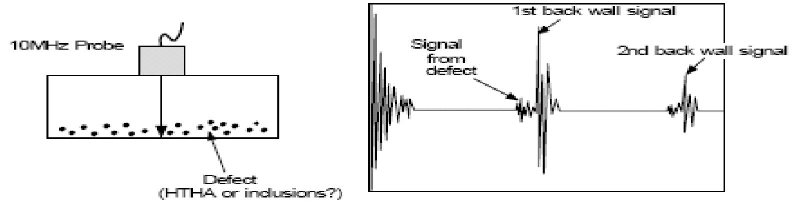
It appears that the scab plates created a stagnant zone where sulfur was able to react with the exposed base metal resulting in a stable FeS scale. It is known that FeS can provide some protection against HTHA damage, as noted in API 941. Therefore, it appears that the scab patches were successful in fostering a stable FeS scale thus avoiding direct hydrogen and base metal contact as would occur if the scab patches did not have a gap in the weld.

Ultrasonic Inspection

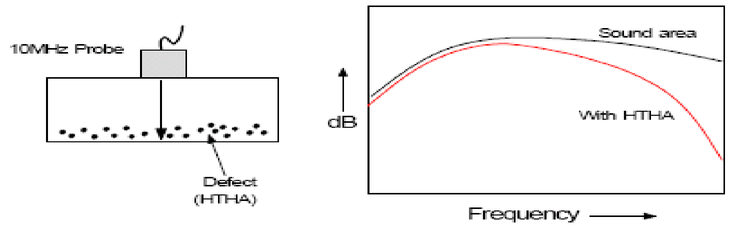
- Seven locations were inspected from the outside and inside surfaces using several techniques at approximately 3” X 3” windows in the insulation.
- From the OD, Advanced Ultrasonic Backscatter Techniques (AUBT) were used to examine the base metal.
- Weld joints were examined using Angle Beam Spectrum Analysis (ABSA)

Explanation for HTHA detection by AUBT

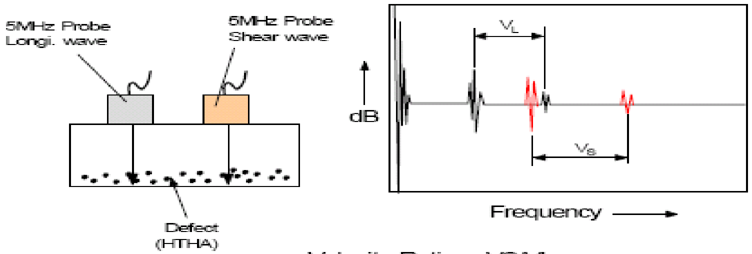
Back-Scattering Technique



Spectrum analysis



Velocity Ratio Technique



Velocity Ratio = VS/VL

VS/VL ≤ 0.55 ----- No HTHA

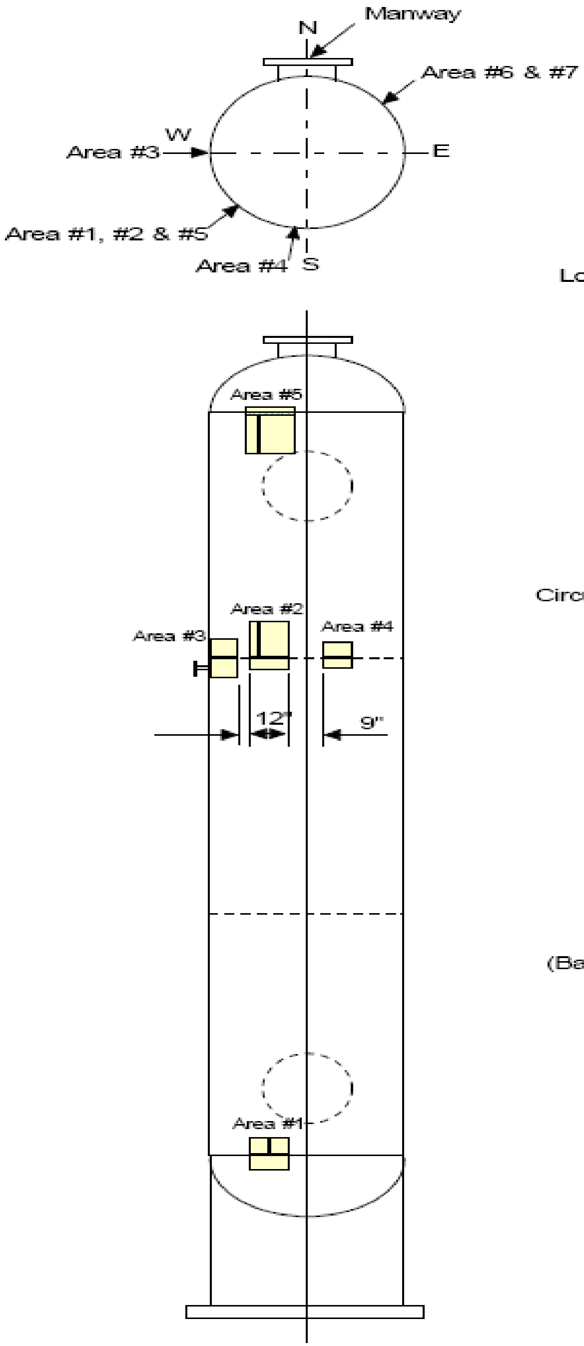
VS/VL > 0.55 ----- HTHA

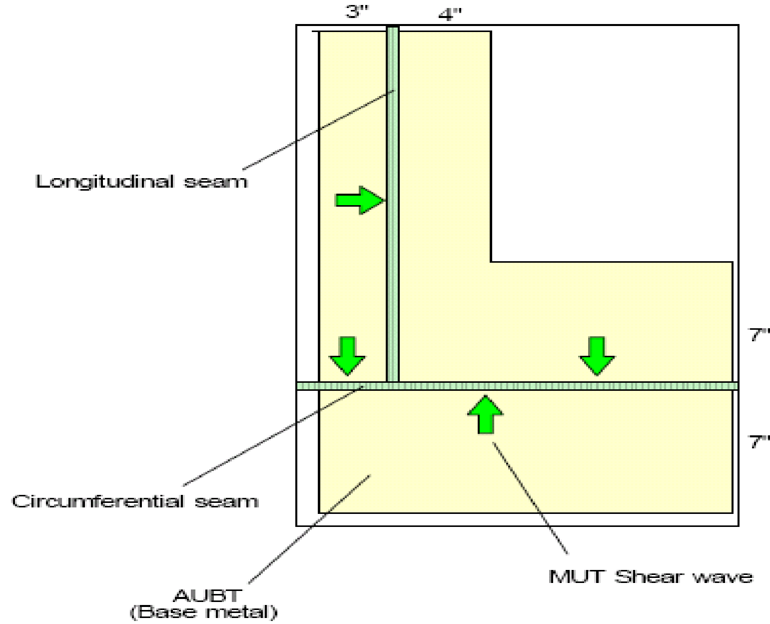
Advanced Ultrasonic Backscatter Technique (AUBT) Inspection

Examination Summary

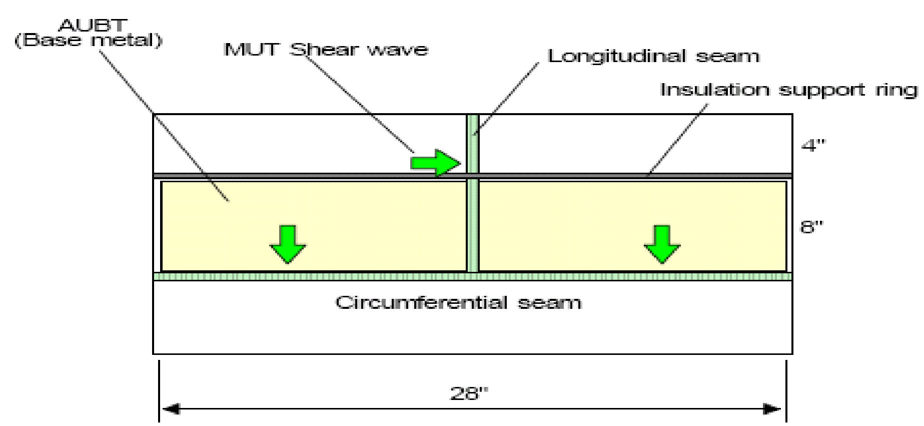
All selected areas of Reactor by the client were performed AUBT for HTHA detection by 0 degree. The inspection was performed to detect backscatter indications in the base metal. Spectrum analysis was applied using the LeCroy system if indication was detected. The probe selected was 0.50" diameter, high frequency (10MHz & 5MHz), and 0 degree to detect small indications such as micro-fisher in the base metal. Also, Angle Beam Spectrum Analysis (ABSA) was applied on the weld seam to detect crack-like indication on the Heat Affected Zone (HAZ) due to HTHA. The probe selected was 0.50" diameter, high frequency (10MHz) 45 & 60 degree shear wave probe. The purpose for this inspection is to locate and evaluate backscatter indications in the base metal, and to determine if these indications are the result of HTHA.

Scan Map



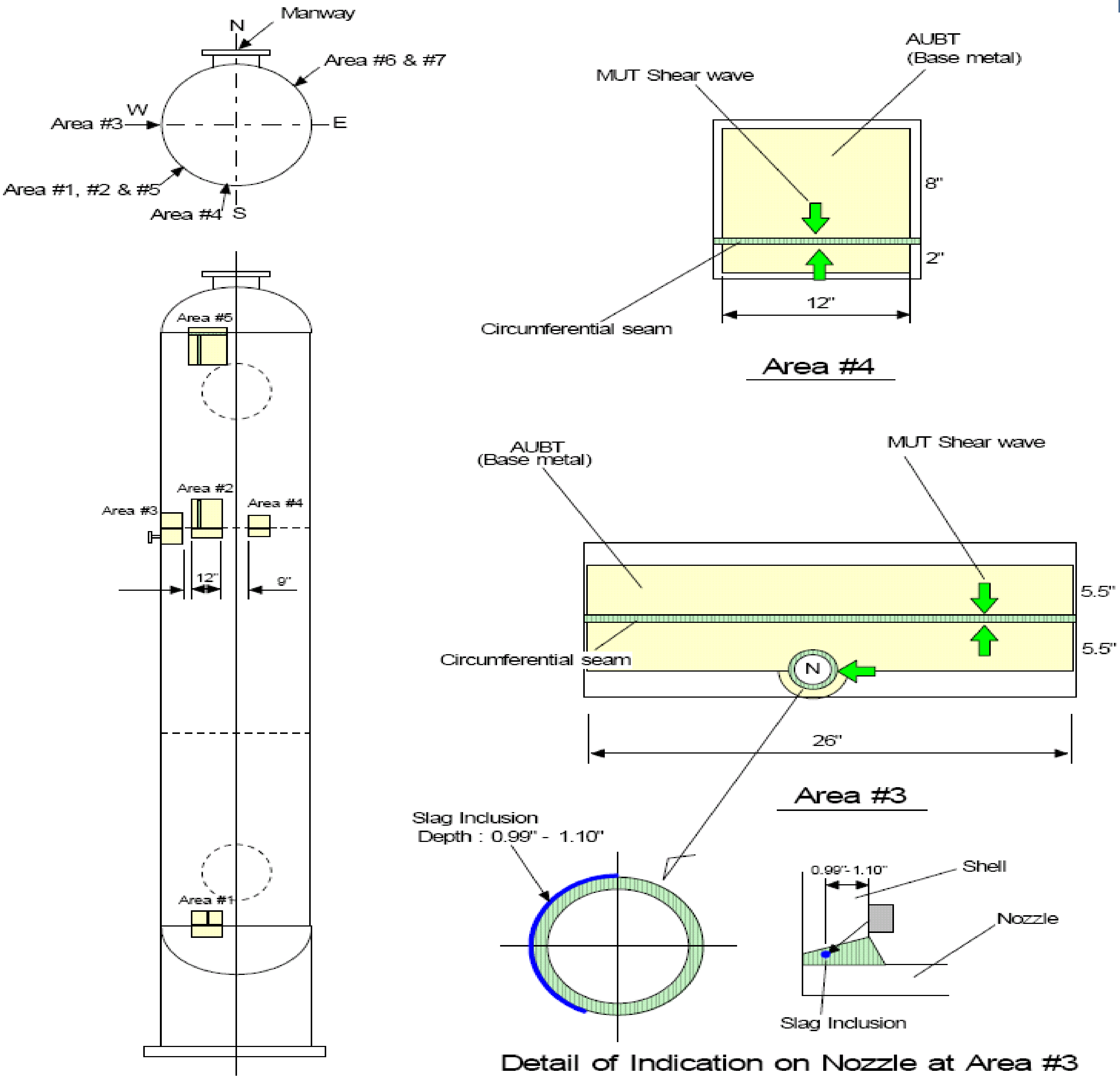


Area #2



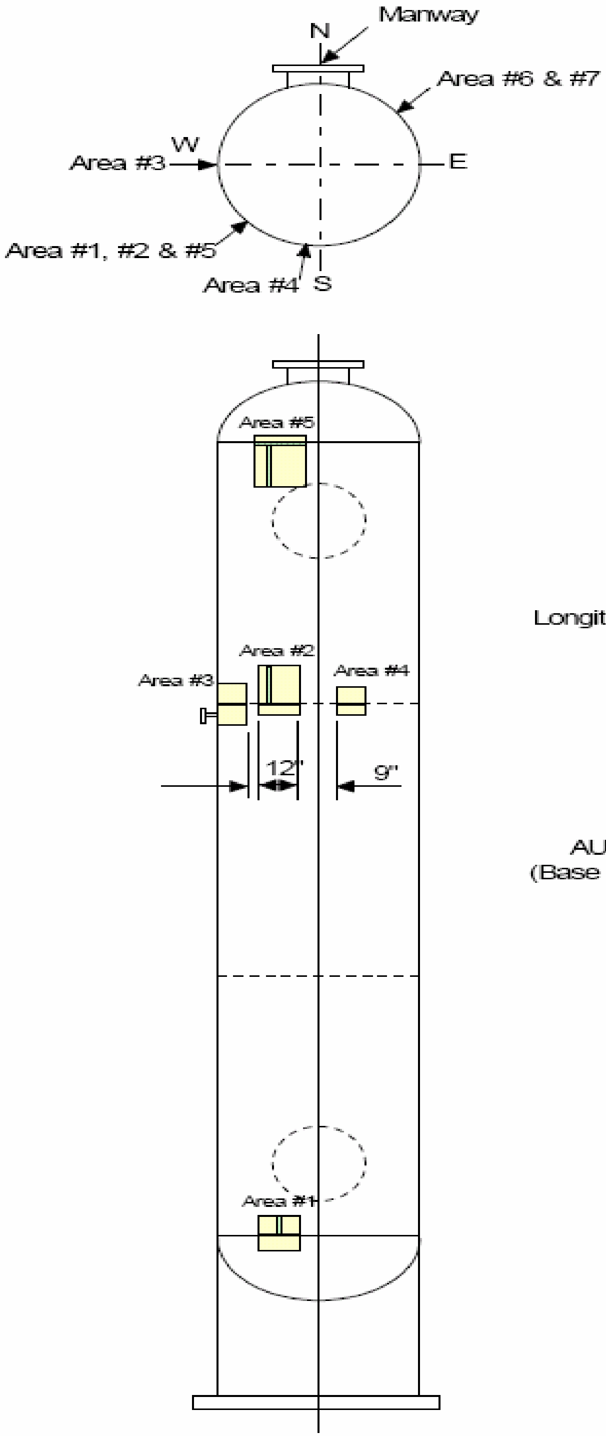
Area #1

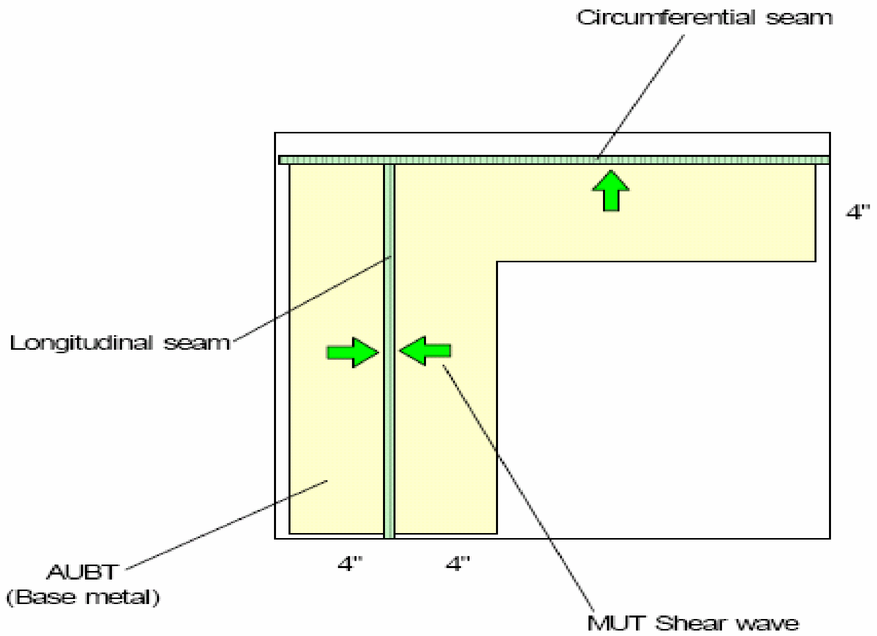
Scan Map



Manway
N
Area #6 & #7
W
Area #3
E
Area #1, #2 & #5
Area #4
S
Area #5
Area #2
Area #3
Area #4
12"
9"
Area #1
AUBT
(Base metal)
MUT Shear wave
8"
2"
12"
Circumferential seam
Area #4
AUBT
(Base metal)
MUT Shear wave
5.5"
5.5"
Circumferential seam
N
26"
Area #3
Slag Inclusion
Depth : 0.99" - 1.10"
0.99"- 1.10"
Shell
Nozzle
Slag Inclusion
Detail of Indication on Nozzle at Area #3

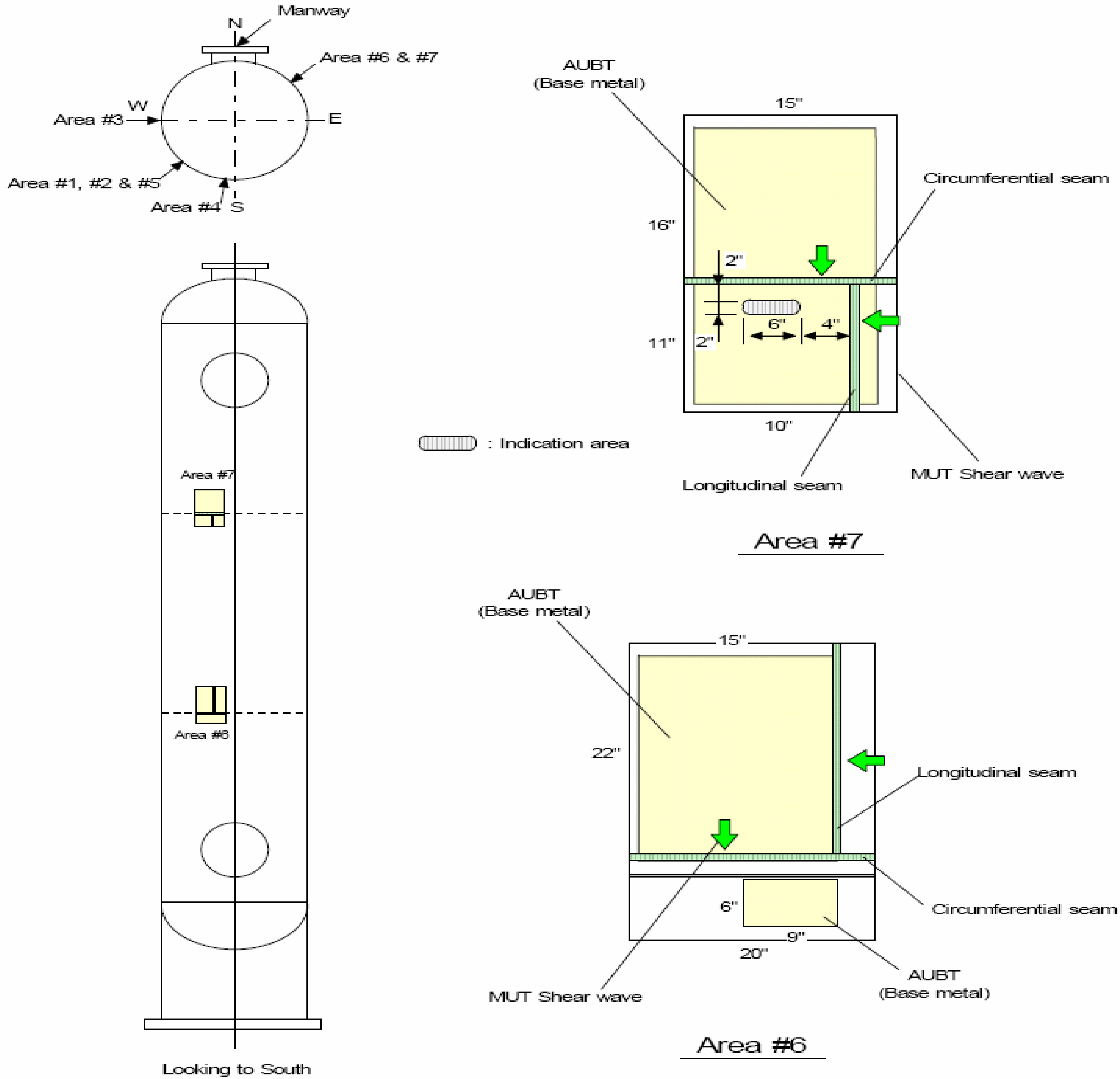
Scan Map





Area #5

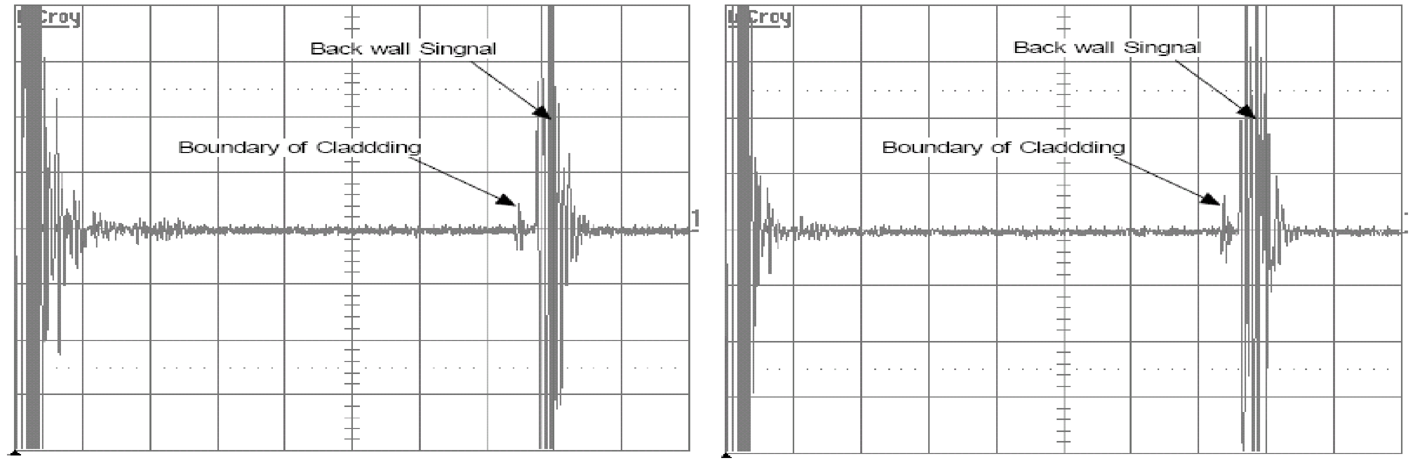
Scan Map



Manway
N
Area #6 & #7
W
Area #3
E
Area #1, #2 & #5
Area #4
S
Area #7
Area #6
Looking to South
: Indication area
AUBT
(Base metal)
15"
16"
2"
11"
2"
6"
4"
10"
Circumferential seam
Longitudinal seam
MUT Shear wave
Area #7
AUBT
(Base metal)
15"
22"
Longitudinal seam
6"
9"
20"
Circumferential seam
MUT Shear wave
AUBT
(Base metal)
Area #6

Typical signal form

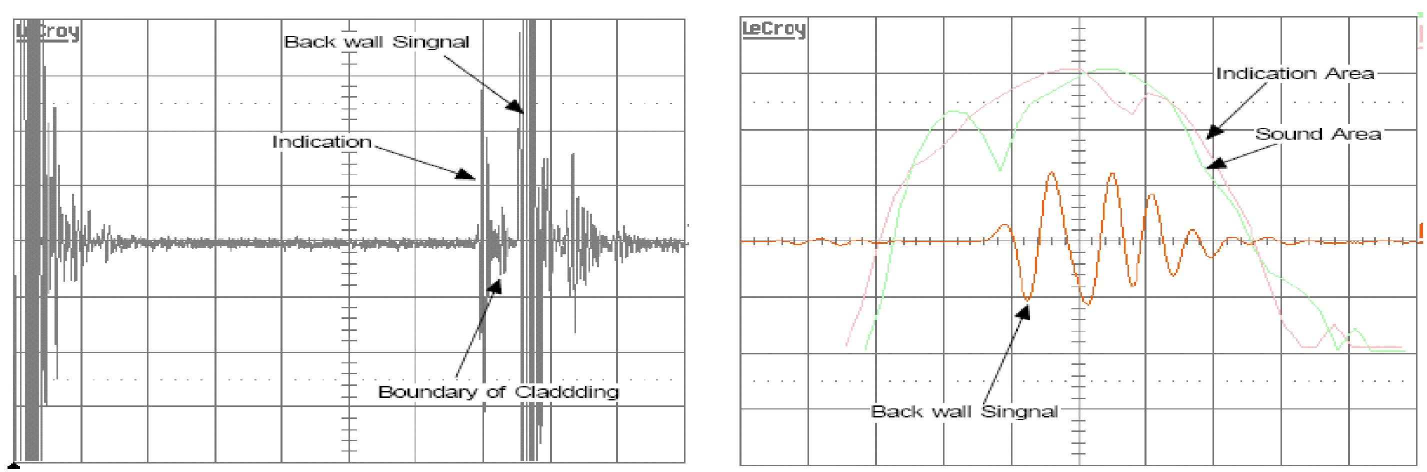
Figure 7 : Typical signal form of Backscatter (Area 5 & 6)



Backscatter Technique

Backscatter Technique

Figure 8 : Typical signal form of Backscatter / Spectrum Analysis (Area 7)



Backscatter Technique

Spectrum Analysis

AUBT Results

The areas inspected were focused on high stress and suspected areas; such as T-cross section on the shell and head. Drawings are included in this report that shows the location of these areas. The AUBT procedure starts by looking for backscatter indications in the base metal by 0 degree. If indications are detected then analysis is performed to determine whether these indications were the result of HTHA.

In according to the results of Backscattering Technique and Spectrum Analysis 0 degree, **no evidence of advanced or micro fissuring due to (HTHA) was detected in the scanned areas of Reactor.** Indications such as inclusions were detected in the base metal on the area #7 of 52V-2 Reactor. These Indications of base metal were not described in this report. Typical signal forms of Backscatter Technique and Spectrum Analysis are shown in Figures 5, 6, 7 & 8.

Also, no crack-like indication was detected on the HAZ using ABSA on the longitudinal weld seam, circumferential weld seam and one nozzle weld. One long slag inclusion was detected on the nozzle weld. The detail of this indication is shown in Figure 2.

TOTAL

Review

- Scoop sampling and testing revealed no evidence of decarburization, methane voids, or microfissuring in any of the samples
- Field Metallography (FMR) – No evidence of HTHA
- Angle Beam Spectrum Analysis (ABSA) – No cracks found
- Advanced Ultrasonic Backscatter Technique (AUBT) – No advanced or microfissuring due to HTHA

Appendix 6

How to use the

EFC WP15 Refinery Cases Web page

Failure cases atlas

CORROSION IN REFINERY INDUSTRY FAILURE ATLAS

CASE HISTORY n° 2 Date

Process : Visbreaking
Equipment: Furnace tube

DATE OF INCIDENT AND/OR INFORMATION: 1990 / refinery inspection team

NATURE OF THE INCIDENT :
Rupture after 23 years at the entry of the fluid in the last box of the furnace

CONSEQUENCES :
Shutdown of the unit

MATERIAL COMPOSITION and REFERENCES
ASTM A335 P5 steel (5% Cr- 0.5%Mo)

PICTURES AND SCHEMES :

ASPECT :
Brittle aspect

MEDIA AND OPERATING CONDITIONS:
460 – 470°C 47 Bars
Distillate (inside) 350/520 TBP 0.2 < TAN < 2.6 mg KOH/g
Fuel gas (outside)

TIME TO DETERIORATION : 23 years

CORROSION IN REFINERY INDUSTRY FAILURE ATLAS

CASE HISTORY n° 2 ANSWER

TYPE OF CORROSION : Naphtenic acid corrosion
API 571 CLASSIFICATION: 5.1.1.7

CAUSES :

Naphthenic acid corrosion due to high molecular acids (T > 420°C) of ASTM A335 P5 steel ?

REMEDY :

Replacement by ASTM 335 P9 steel (9% Cr- 0.5%Mo)

PUBLICATION - TECHNICAL REPORT:

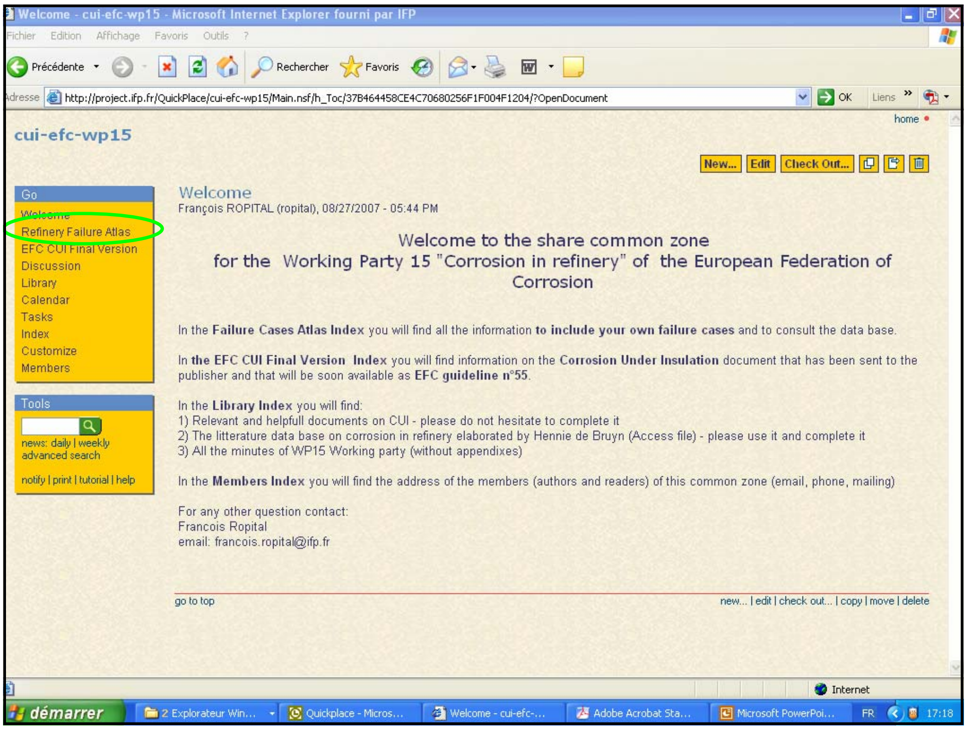
BIBLIOGRAPHIC REFERENCES :

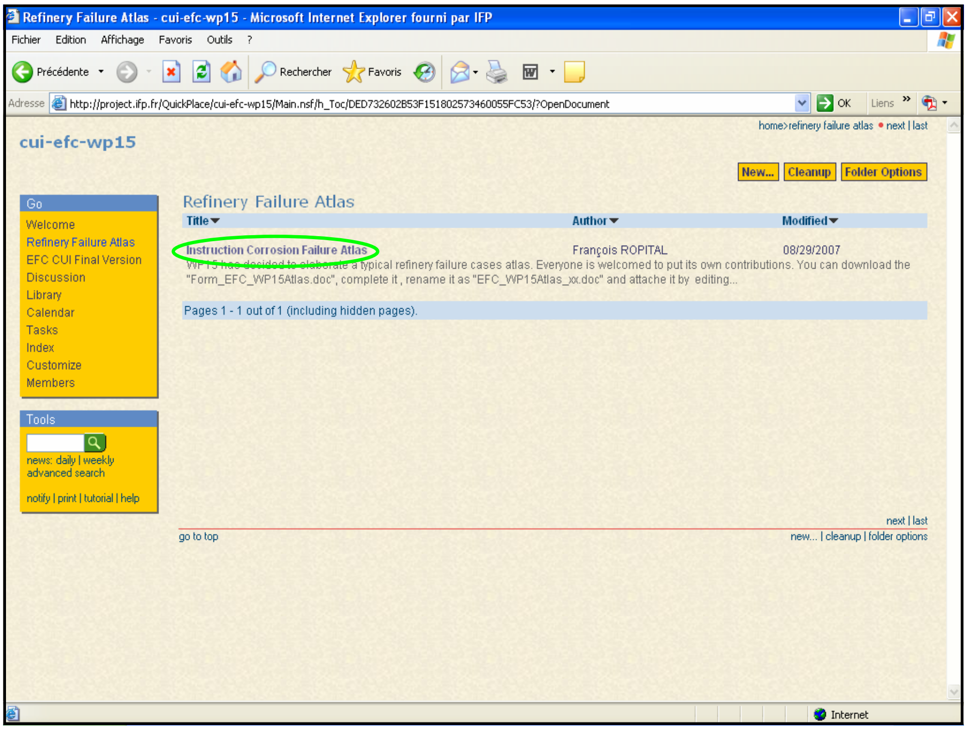
http://project.ifp.fr/cui-efc-wp15

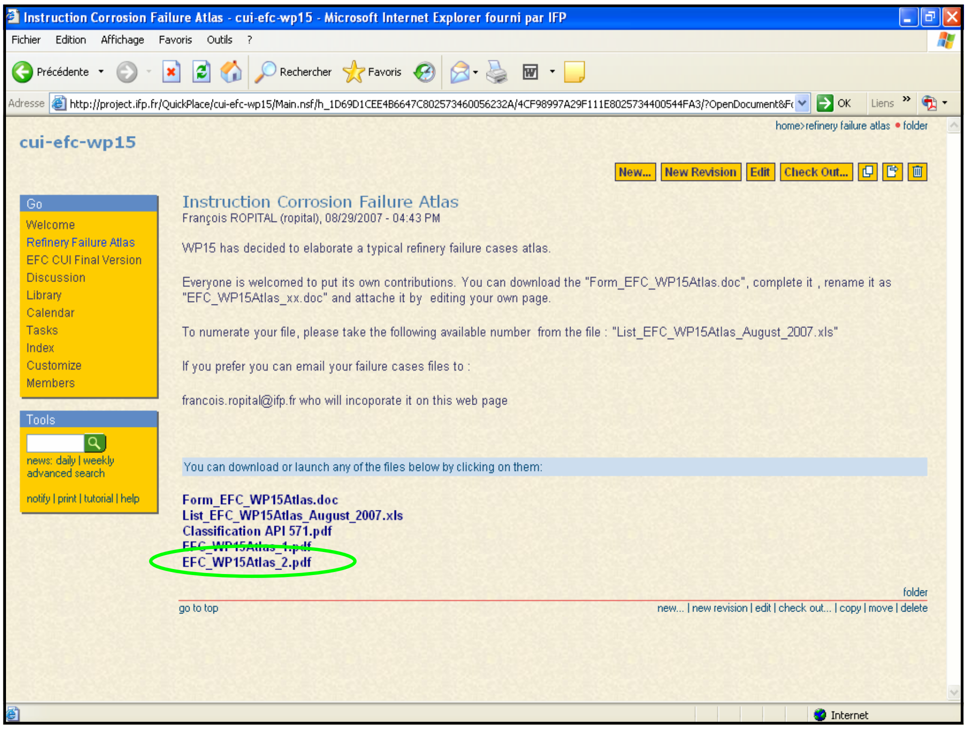
Guide line : how to use the failure case web page available

Failure cases atlas

N° File	Writer	Date	Process	Equipment	Causes	API 571 Classification	Type of material
1	J. Hucinska	2006	Hydrocracking	Reactor	Sulfidation	5.1.1.5	347 SS
2	F. Ropital	29/06/1905	Visbreaking	Furnace	Naphthenic acid corrosion	5.1.1.7	5% Cr steel
3	A.Visgard Nielsen	13/09/2007	Hydrodesulfurizer	Heater	Creep	4.2.8	304 SS
4	F. Ropital	20/12/2007	Continuous Catalytic Reforming	Furnace	Metal dusting	4.4.5	2.25%Cr steel


Welcome - cui-efc-wp15 - Microsoft Internet Explorer fourni par IFP
http://project.ifp.fr/QuickPlace/cui-efc-wp15/Main.nsf/h_Toc/37B464458CE4C70680256F1F004F1204/?OpenDocument
cui-efc-wp15
Go
Welcome
Refinery Failure Atlas
EFC CUI Final Version
Discussion
Library
Calendar
Tasks
Index
Customize
Members
Tools
Welcome
François ROPITAL (ropital), 08/27/2007 - 05:44 PM
Welcome to the share common zone
for the Working Party 15 "Corrosion in refinery" of the European Federation of Corrosion
In the Failure Cases Atlas Index you will find all the information to include your own failure cases and to consult the data base.
In the EFC CUI Final Version Index you will find information on the Corrosion Under Insulation document that has been sent to the publisher and that will be soon available as EFC guideline n°55.
In the Library Index you will find:
1) Relevant and helpfull documents on CUI - please do not hesitate to complete it
2) The litterature data base on corrosion in refinery elaborated by Hennie de Bruyn (Access file) - please use it and complete it
3) All the minutes of WP15 Working party (without appendixes)
In the Members Index you will find the address of the members (authors and readers) of this common zone (email, phone, mailing)
For any other question contact:
Francois Ropital
email: francois.ropital@ifp.fr


Refinery Failure Atlas - cui-efc-wp15 - Microsoft Internet Explorer fourni par IFP
http://project.ifp.fr/QuickPlace/cui-efc-wp15/Main.nsf/h_Toc/DED732602B53F151802573460055FC53/?OpenDocument
cui-efc-wp15
Refinery Failure Atlas
Title Author Modified
Instruction Corrosion Failure Atlas François ROPITAL 08/29/2007
WP15 has decided to elaborate a typical refinery failure cases atlas. Everyone is welcomed to put its own contributions. You can download the "Form_EFC_WP15Atlas.doc", complete it , rename it as "EFC_WP15Atlas_xx.doc" and attache it by editing...
Pages 1 - 1 out of 1 (including hidden pages).


Instruction Corrosion Failure Atlas - cui-efc-wp15 - Microsoft Internet Explorer fourni par IFP
Fichier Edition Affichage Favoris Outils ?
Précédente Rechercher Favoris
Adresse http://project.ifp.fr/QuickPlace/cui-efc-wp15/Main.nsf/h_1D69D1CEE4B6647C802573460056232A/4CF98997A29F111E8025734400544FA3/?OpenDocument&F
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home>refinery failure atlas • folder
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New... New Revision Edit Check Out...
Go
Welcome
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EFC CUI Final Version
Discussion
Library
Calendar
Tasks
Index
Customize
Members
Tools
news: daily | weekly
advanced search
notify | print | tutorial | help
Instruction Corrosion Failure Atlas
François ROPITAL (ropital), 08/29/2007 - 04:43 PM
WP15 has decided to elaborate a typical refinery failure cases atlas.
Everyone is welcomed to put its own contributions. You can download the "Form_EFC_WP15Atlas.doc", complete it , rename it as "EFC_WP15Atlas_xx.doc" and attache it by editing your own page.
To numerate your file, please take the following available number from the file : "List_EFC_WP15Atlas_August_2007.xls"
If you prefer you can email your failure cases files to :
francois.ropital@ifp.fr who will incoporate it on this web page
You can download or launch any of the files below by clicking on them:
Form_EFC_WP15Atlas.doc
List_EFC_WP15Atlas_August_2007.xls
Classification API 571.pdf
EFC_WP15Atlas_1.pdf
EFC_WP15Atlas_2.pdf
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new... | new revision | edit | check out... | copy | move | delete
Internet

Appendix 7

PASCC case in a FCCU

Wim Verstijnen (Shell)

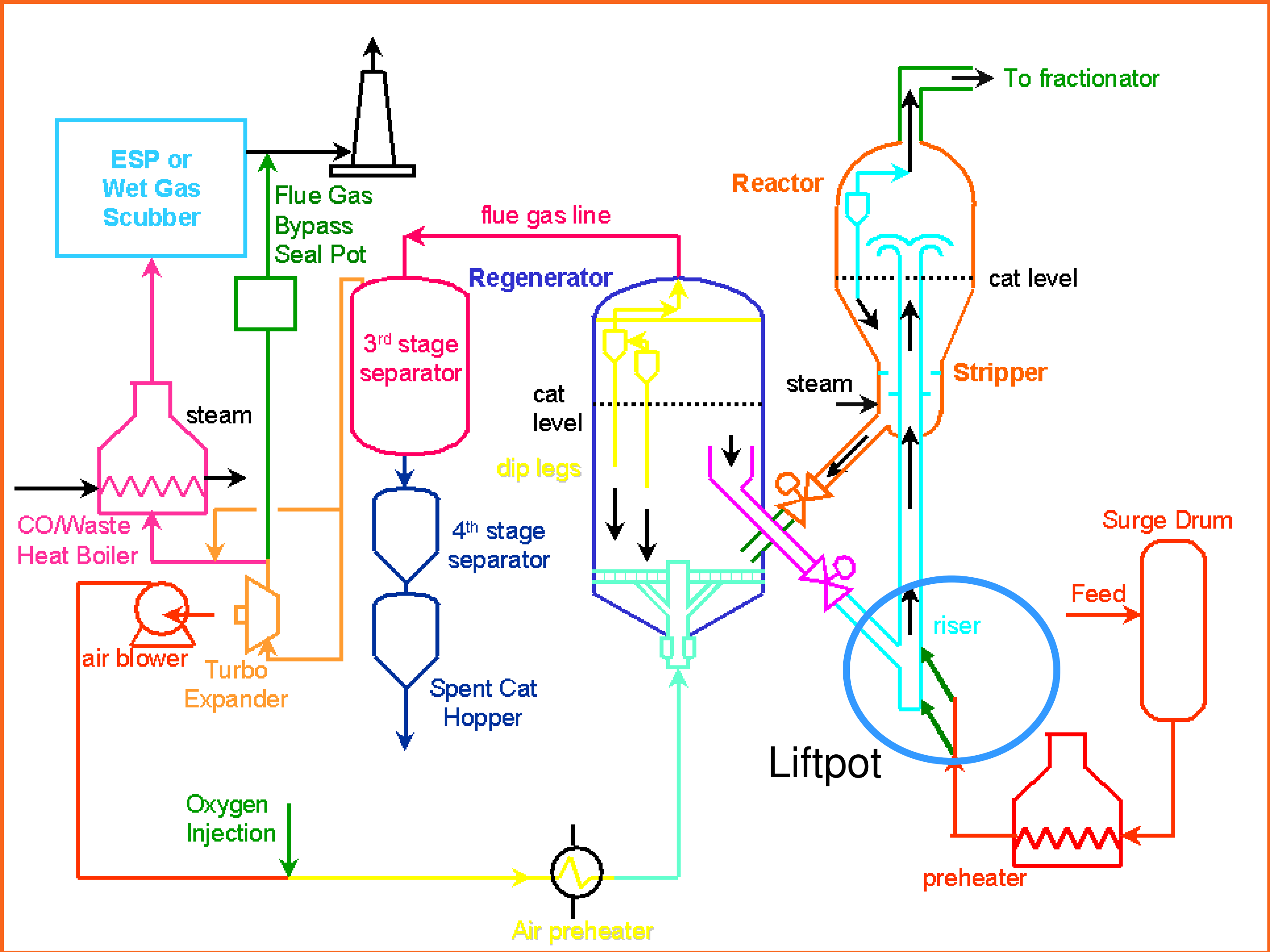
FCCU Liftpot Failure & Repair

Wim Verstijnen

Head Engineering Support

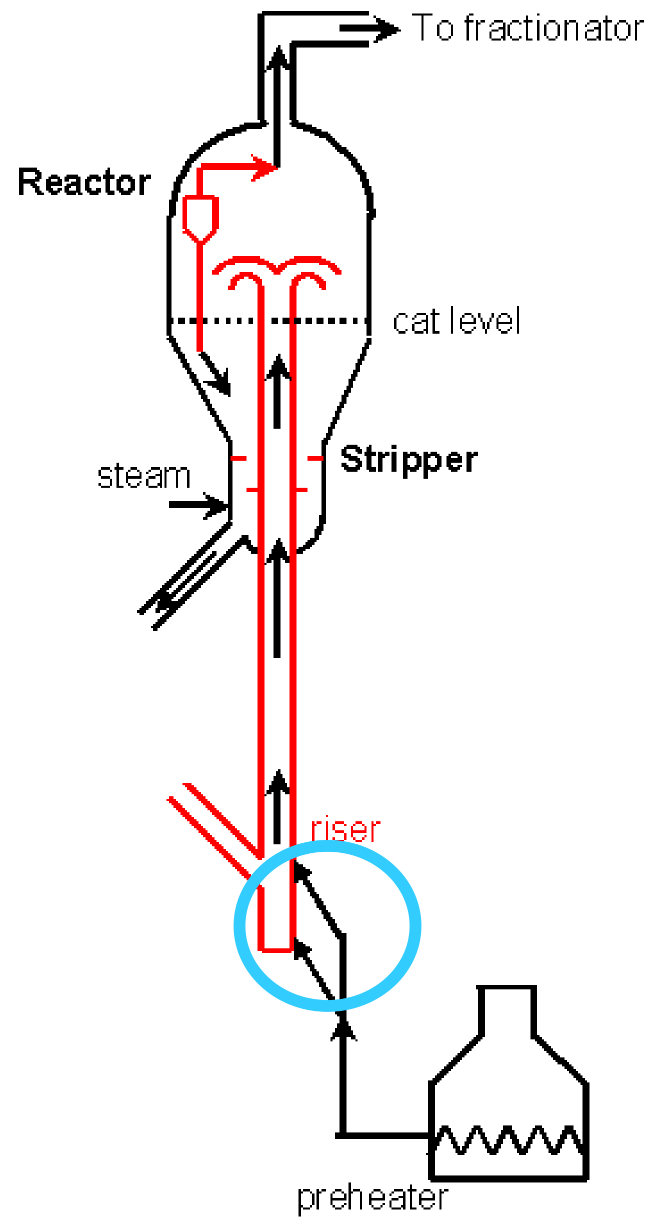
Shell Nederland Raffinaderij
Pernis - Rotterdam

The Process: Catalytic Cracker Unit



Process "Liftpot"

- Feed mixes with Catalyst of 680 degC
- Mix of Feed and Cat "cools" to 520 degC @ 2.5 barg Riser outlet
- Steam ring at bottom of riser liftpot to enhance/assist mixing and transport of catalyst.
- Medium: Oxygen, Air, H2S, Steam/water, Salts(?), Hydrocarbons



Materials

- Reactor liftpot Avesta 253MA (austenitic SS ~ SS 304H)
- Wall thickness head/wall 40mm / 25mm
- Erosion resistant liner of 35 mm.
- Dished end filled with insulating concrete
- Other riser parts SS 304H

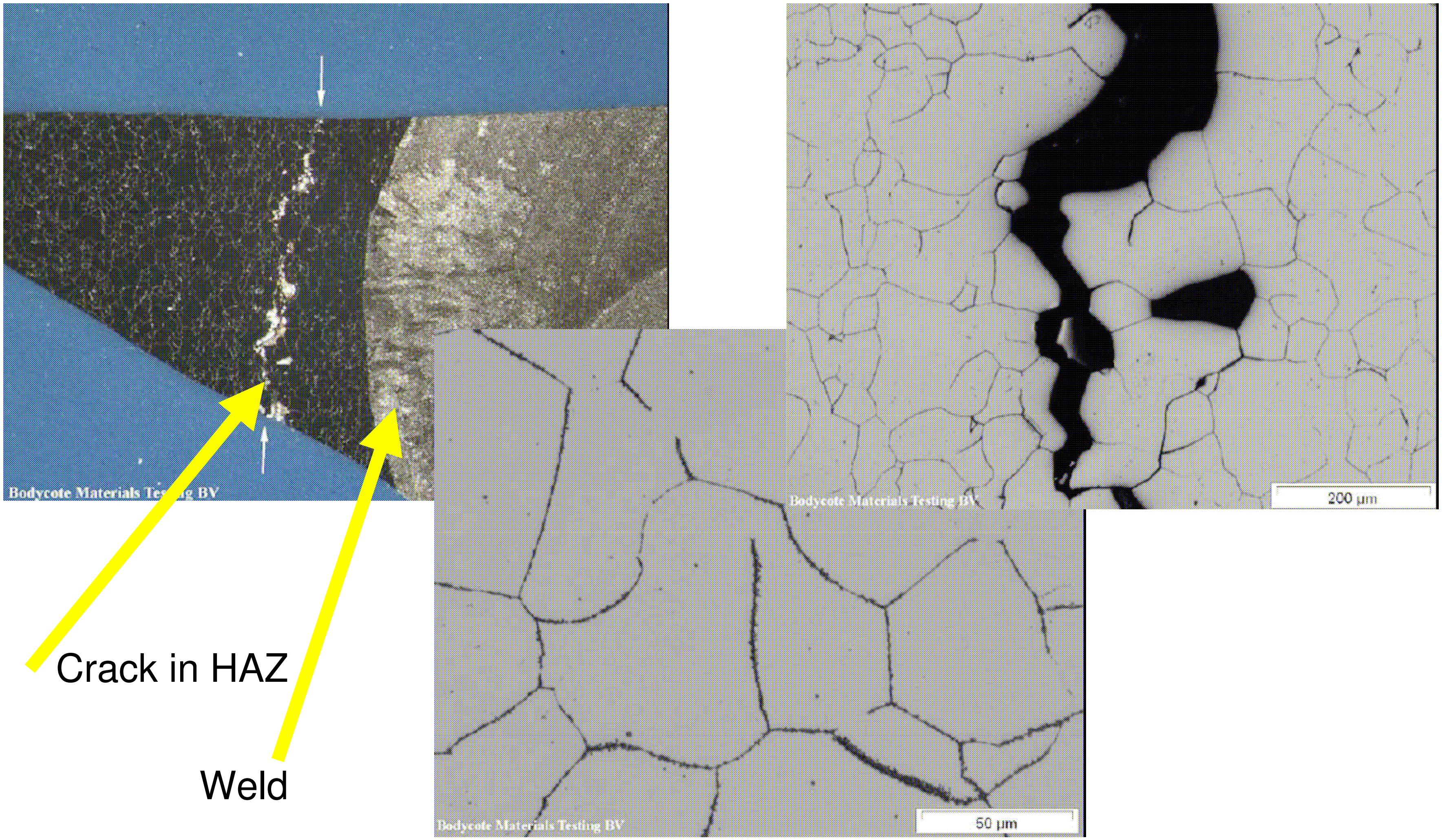
History Liftpot:

- Installed in 1986
- No problems till crack was found

Crack in Liftpot Body

Weld

Metallography of Crack (Boat Sample)



Findings:

- Leakage (Inspection, operations)
- Visual/NDT: Crack in Circumferential weld
- Metallurgical investigation:
  - Sensitized HAZ weld,
  - Inter-crystalline attack in HAZ,
- NDT: Other welds and (plate) material free from cracks

Conclusion:

- Polythionic Stress Corrosion Cracking of sensitized weld area.

Solution Short/Long-term

- Short-term actions:
  - Repair with external reinforcing ring.
- Long-term actions:
  - SCC resistant material
  - Different design

Thank you

Questions?

Appendix 8

Use of fitness for service assessments

Hennie de Bruyn (Borealis Group)

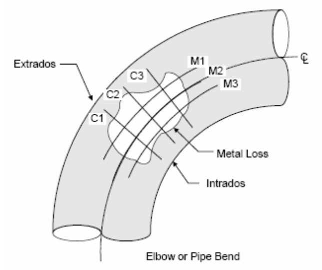
Use of Fitness-for-Service Assessments

Hennie de Bruyn
Chief Engineer Material Technology

BOREALIS
SHAPING the FUTURE with PLASTICS

Introduction

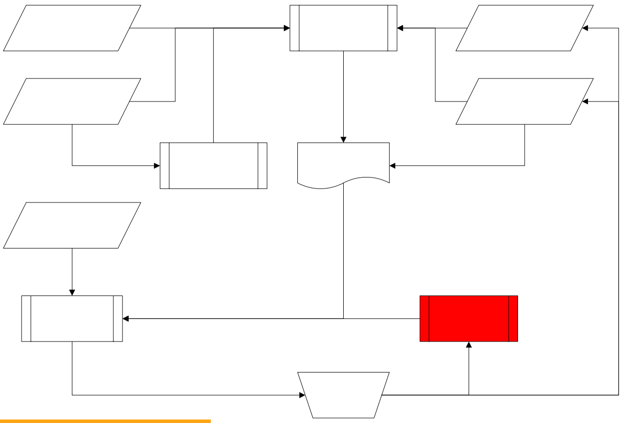
- Inspection results
  - Detect damage / degradation
  - Deviations from original design
  - What now?
    - Do nothing
    - Repair
    - Replace
- Fitness-for-Service (FFS)
  - FFS assessment facilitates the decision-making process



- FFS Definition (API 579-1)
  - FFS assessments are quantative engineering evaluations that are performed to demonstrate the structural integrity of an in-service component containing a flaw or damage

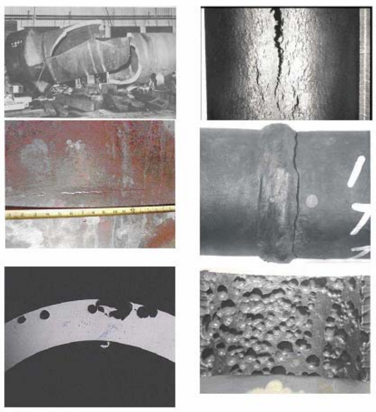
Plant Integrity Management

The Role of FFS



Damage & Degradation

- Brittle fracture
- Metal loss
  - General
  - Localised
  - Pitting
- Hydrogen damage
- Weld misalignment / shell distortions
- Cracking / Plastic collapse
  - Stress corrosion cracking
  - Fatigue
- Creep
- Fire damage / other undesirable events



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build

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Mai
In
Plan

Cracking / Plastic Collapse

FFS methods, procedures & standards

Document	Title	Published by
R6	Assessment of the integrity of structures containing defects	British Energy
BS 7910	Guide to methods for assessing the acceptability of flaws in metallic structures	British Standards Institution
API 579-1 / ASME FFS-1	Fitness For Service	American Petroleum Institute / American Society of Mechanical Engineers
ASME SEC XI	Rules for Inservice Inspection of Nuclear Power Plant Components	American Society of Mechanical Engineers
SINTAP	Structural Integrity Assessment Procedures for European Industry	EU open source
JSME S NA1	Codes for Nuclear Power Generation Facilities - Rules on Fitness-for-Service for Nuclear Power Plants	Japanese Standards Association (JSA)
RSE-M	Rules for in service inspection on nuclear power plant components	AFCEN

Fatigue

FFS methods, procedures & standards

Document	Title	Published by
R6	Assessment of the integrity of structures containing defects	British Energy
BS 7910	Guide to methods for assessing the acceptability of flaws in metallic structures	British Standards Institution
API 579-1 / ASME FFS-1	Fitness For Service	American Petroleum Institute / American Society of Mechanical Engineers
ASME SEC XI	Rules for Inservice Inspection of Nuclear Power Plant Components	American Society of Mechanical Engineers
JSME S NA1	Codes for Nuclear Power Generation Facilities - Rules on Fitness-for-Service for Nuclear Power Plants	Japanese Standards Association (JSA)

Creep

FFS methods, procedures & standards

Document	Title	Published by
R5	Assessment Procedure for the High Temperature Response of Structures	British Energy
BS 7910	Guide to methods for assessing the acceptability of flaws in metallic structures	British Standards Institution
A16	Design and Construction Rules for Mechanical Components of FBR Nuclear Islands	AFCEN
API 579-1 / ASME FFS-1	Fitness For Service: includes now the Materials Properties Council (MPC) Omega method	American Petroleum Institute / American Society of Mechanical Engineers

Thinning / Corrosion / Metal Loss

FFS methods, procedures & standards

Document	Title	Published by
ASME B31G	Manual for Determining the Remaining Strength of Corroded Pipelines	American Society of Mechanical Engineers
DNV RP F-101	Corroded Pipelines	Det Norske Veritas
PDAM	The Pipeline Defect Assessment Manual	Penspen Ltd (UK)
API 579-1 / ASME FFS-1	Fitness For Service	American Petroleum Institute / American Society of Mechanical Engineers

Open questions to EFC WP15

- Is your company using FFS assessments when damage/degradation is detected by inspection?
- What assessment methods/procedures/standards are used?
- Who is responsible to perform assessments in your company?
- Does your company allow inspectors to perform basic assessments?
- Are FFS assessments accepted by your regulating authorities?

Hennie de Bruyn

15 April 2008

Appendix 9

How, when and where to monitor

Dimphy Wilms (Applus[+] RTD)

How, when and where to monitor ?

Dimphy Wilms

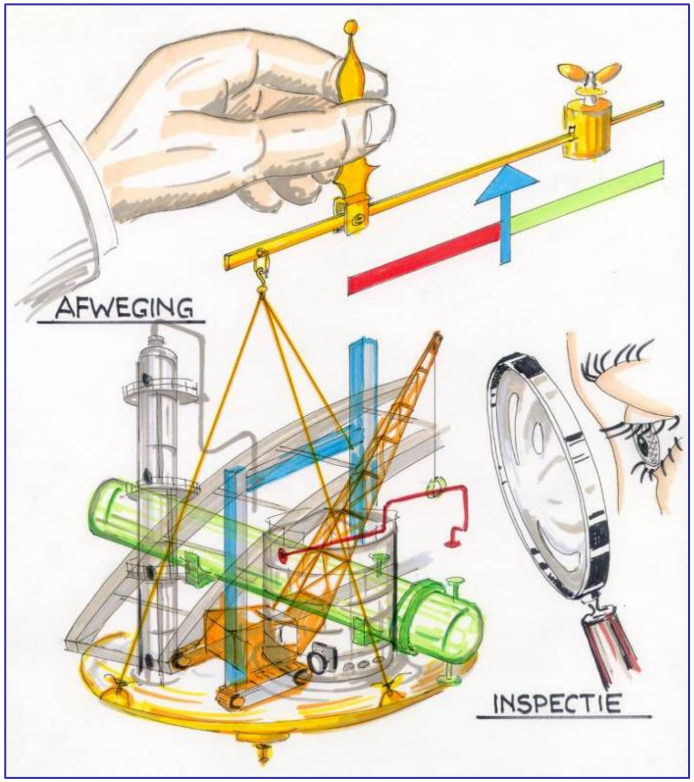
EFC Working Party 15
15 april 2008

Applus RTD
NDT & Inspection

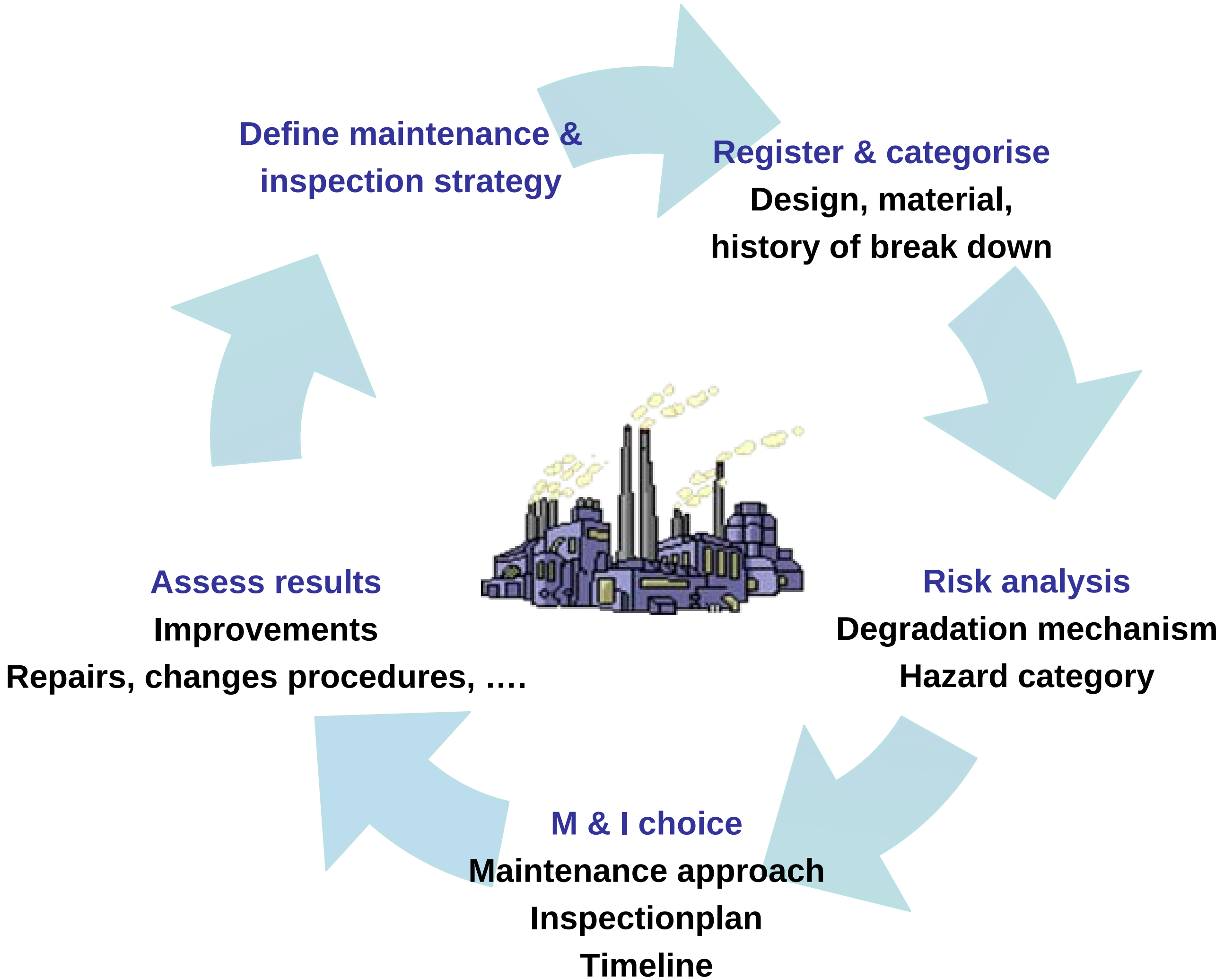
What are you looking for ?

Purpose of inspection

- Maintain the integrity of an asset
- Increase / maintain reliability
- Maintain a safe workplace
- Ensure Fitness for Service
- Do it at the lowest possible cost!



Condensed version of Seveso II



SMART inspections

- Specifically for objects and degradation mechanism
- Minimum impact for operation
- Acceptable according to rules and regulations
- Reliability focused
- Time optimised

How to design a CUI programme ?

Condition of insulation	Wall Temperature: T < -10°C or T > 150°C	Wall Temperature: -10°C< T<60°C or 90°C < T < 150°C	Wall Temperature: 60°C < T < 90°C
Perfect	0	2	4
Good	1	3	5
Reasonable	2	4	6
Bad	3	5	7

Inspection strategy

- Combination of methods
- In line with rules and regulations
- Sampling to be decided
- Inspection effectiveness to be agreed upon
- Non-Intrusive ?
- Screening or Measuring

- *Update database in order to improve*

What technique is the 'right' one ?

- A vessel was inspected by using four different NDT techniques
  - Automated C-scan
  - INCOTEST
  - UT raster
  - Slofec

4 technologieën

Capabilities compared

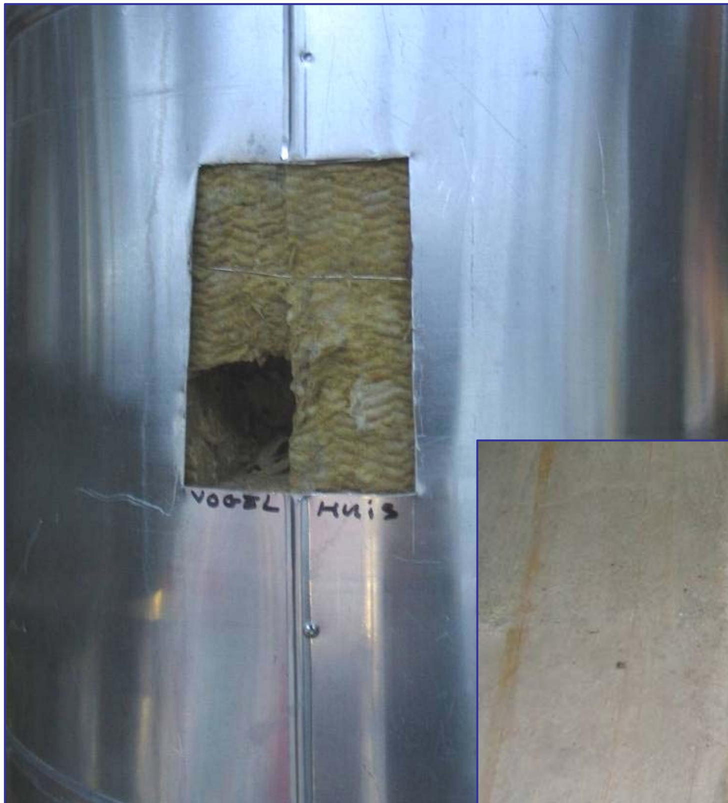
Automated C-scan
- 1 Day
- Insulation removal & surface prep
- Highest resolution
- 100% coverage
- Accurate WT reading

INCOTEST
- 4 hours
- No insulation removal
- Lowest resolution
- 100% coverage
- No absolute WT reading

Manual UT Raster
- 2 Days
- Insulation removal & surface prep
- Medium resolution
- Bad coverage
- Accurate WT reading
- Standard UT set

Slofec
- 2 hours
- Insulation removal only
- High resolution
- 100% coverage
- No absolute WT reading

Never forget the human factor



Never forget the human factor

How, when & where to monitor

- Using the appropriate method(s)
- At a time that is suitable
- At locations that need to be watched
- No system replaces common sense, however it can help you making the right decision