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Corrosion - Sudden and Unforeseen?


OPERA


29th October 2002


Does corrosion matter?

USA - corrosion costs

 Exploration/production \$1.4billion/year

 Refining \$3.7 billion/year

 1975 = 4.2% GNP

 1999-2001 = 3.2% GNP

(www.costofcorrosion.com)

UK - corrosion costs

 1971 = 3.5% GNP

(DTI Report of the Committee on Corrosion and Protection 1971)

Basics

❗ Most deterioration mechanisms are well understood and predictable if all relevant information is known

❗ Failures appearing as corrosion or fatigue occur frequently

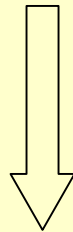
BUT

❗ Nothing ever fails **because** of corrosion

Management Systems

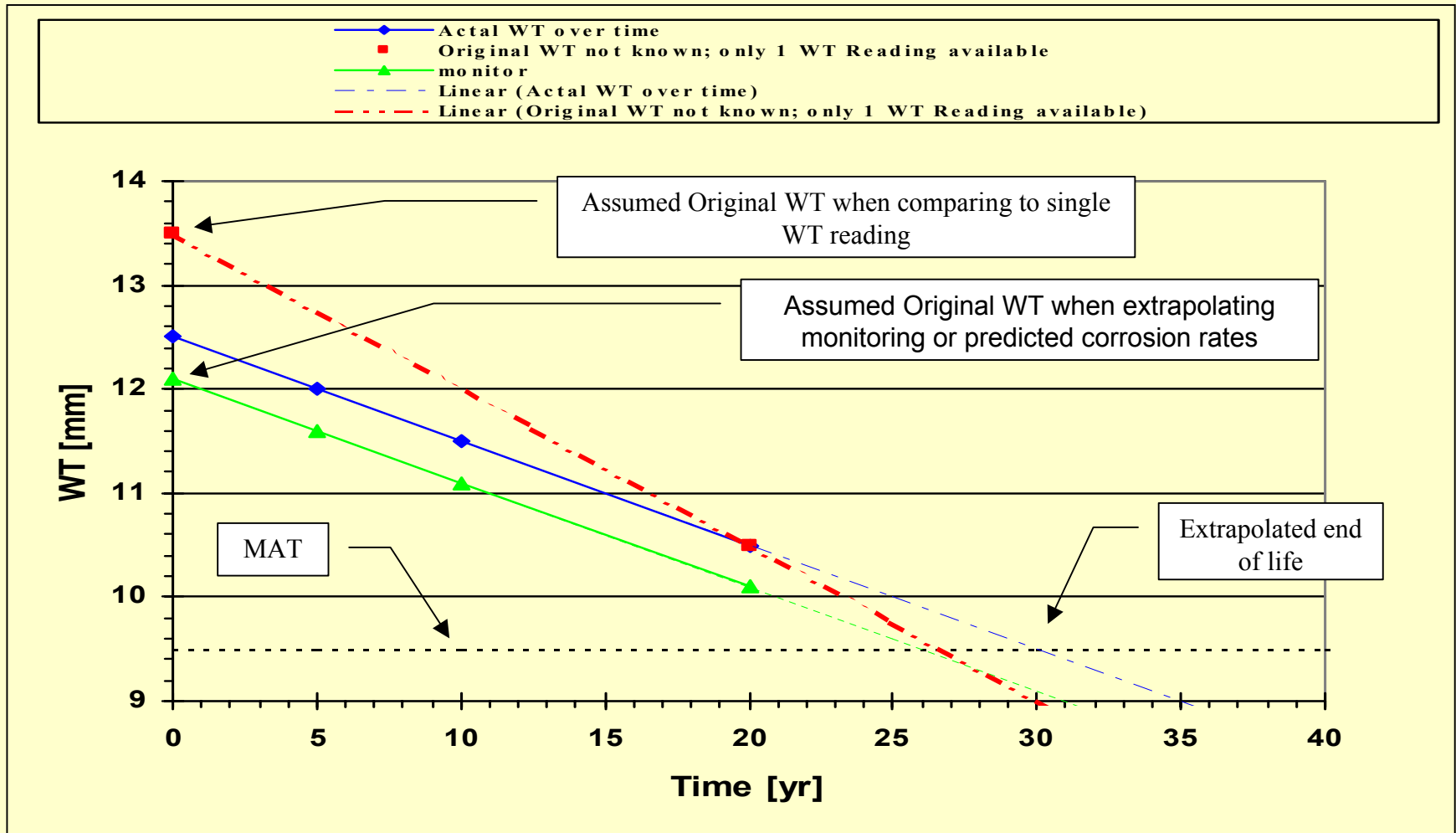
Directive 96/82/EC

‘...analysis of the major accidents reported in the Community indicates that the majority of them are the result of managerial and/or organizational shortcomings...’



COMAH 1999

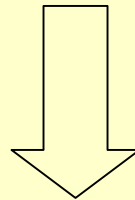
'Simple' corrosion scenario



Sources of Guidance

- ❏ Past history - in house
- ❏ Past history - public domain

Increasing availability of software programmes



More data - less thought?

Cause of failure



‘Corrosion’ incidents are attributable to inadequacies in:

- ❏ design
- ❏ fabrication/construction
- ❏ operation
- ❏ maintenance



All have human/economic elements

Deterioration v fair wear and tear

Possible perception:

-  corrosion, fatigue, etc. develop 'slowly'
-  time is available for damage to be located by inspection and/or remedied by maintenance

Reality

-  Only the anticipated is looked for and/or controlled
-  Failure arises from omission irrespective of speed of initiation/propagation

Time to failure

- ❗ Fatigue, corrosion and corrosion cracking can be rapid particularly when due to diversions
- ❗ Rate of initiation and propagation irrelevant if the damage is not expected and so not looked for

Damage under variable conditions

- ❗ Canada - pipeline - sour gas - failed 'almost immediately'
- ❗ Africa - failure at area of turbulence
- ❗ Various - polythionic acid - during shutdowns

Form of failure

- ❏ General corrosion failures rare
- ❏ More commonly local corrosion or cracking
- ❏ Often at sites of local variation in environment or material susceptibility

Sudden and unforeseen

- ❗ the foreseen and knowingly uncertain must be considered at design/materials selection
- ❗ failure is usually unforeseen and appears as a sudden event when the wall is breached
- ❗ it is seldom unforeseeable (at least in retrospect)
- ❗ requires objective assessment to determine what might reasonably have been foreseeable

The Basis of Decisions

 Legislation

 Technical options

 Cost

Statutory Requirements

- 📄 Move to goal setting regulation since early/mid 1990s allowed introduction of risk based systems
- 📄 **Offshore Installations and Wells** (Design and Construction, etc) Regulations 1996 (SI 1996/913).
- 📄 **Pipelines** Safety Regulations 1996 (SI 1996/825).
- 📄 **Pressure Systems** Safety Regulations 2000 (SI 2000/128).

'People must guard against reasonable probabilities, but they are not bound to guard against fantastic possibilities' LORD DUNEDIN, Fardon v Harcourt-Rivington [1932] All ER Rep 81.

Materials

- SI 1996/913 Reg 5(2) The duty holder shall ensure that the installation is composed of **materials which are (a) suitable...** and (b) so far as is reasonably practicable, sufficiently proof against or protected from anything liable to prejudice its integrity.

Reg.16 The well-operator shall ensure that every part of a well is composed of **material which is suitable** for achieving the purposes described in regulation 13(1).

- SI 1996/825 Reg.8 The operator shall ensure that no fluid is conveyed in a pipeline unless it is composed of **materials which are suitable.**
- SI 2000/128 Reg. 4(2) The pressure system or article, as the case may be, shall be properly designed and properly constructed from **suitable material**, so as to prevent danger.


Maintenance

- SI 1996/913 Reg 8. The duty holder shall ensure that **suitable arrangements are in place for maintaining the integrity** of the installation, including suitable arrangements for - (a) periodic assessment of its integrity; and (b) the carrying out of remedial work in the event of damage or deterioration which may prejudice its integrity.
- SI 1996/825 Reg 13. The operator shall ensure that the pipeline is **maintained in an efficient state, in efficient working order and in good repair**.
- SI 2000/128 Reg 12. The user of an installed system and the owner of a mobile system shall ensure that the system is **properly maintained in good repair**, so as to prevent danger.


What are the options?

- ❏ Modify design
- ❏ Materials selection
- ❏ Chemical treatment
- ❏ Coatings
- ❏ Modifying operating environment
- ❏ Inspection/monitoring

Uncertainties

 Few for new assets

but the certainties may change with time
for that same asset

 Change in operation

 Requirement to extend life

Stages of 'Life'

- ❗ Problems and potential solutions change with stage of life
- ❗ Materials options (generally) more restricted later in life
- ❗ Greater reliance on inspection and/or monitoring
- ❗ Possibility that assumptions at design become 'facts' at later review

Prevention by Design

- ❗ Reliance on chemical treatment or inspection and monitoring not usually applied to cracking mechanisms
- ❗ Prevention of cracking primarily achieved by materials selection/testing and design
- ❗ General corrosion more frequently controlled by operational measures

Proving Performance

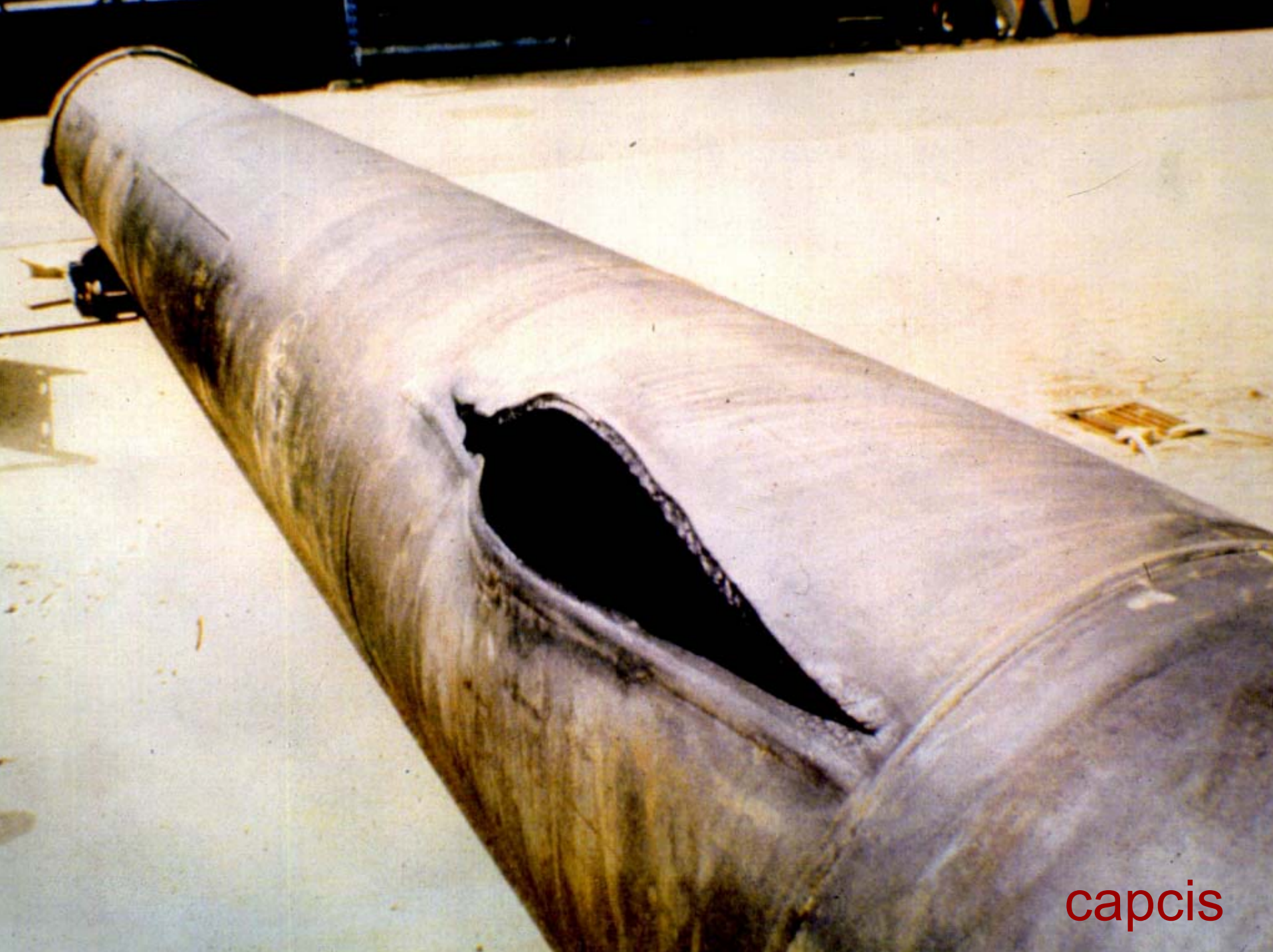
- ❗ Cracking influenced by material condition, residual (fabrication and construction) and operating stresses.
- ❗ Trend towards large scale where uncertainties are recognised



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Materials

- ❏ Big volume items, e.g pipelines; usually a cheaper, less resistant pipe with cathodic protection, coatings, chemical treatment (costs split CAPEX/OPEX)
- ❏ Refineries/chemical process; usually more scope to select more resistant materials for vessels as smaller volume (CAPEX)



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Inspection/Monitoring

- ❗ To confirm assumptions
- ❗ To establish condition
- ❗ To assess remaining life
- ❗ To ensure replacement before failure

BUT

- ❗ Only if significant unknowns are recognised or deterioration is expected

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Known Cracked Condition

- ❗ Unforeseen cracking does not necessarily require immediate replacement
- ❗ Operation possible in a known cracked condition

The potentially neglected

- ❗ Local environmental variations at bends, dead legs, separation and mixing points and restrictions
- ❗ High stresses from geometry, welding
- ❗ Effects of changes in feedstock or operation
- ❗ Failure of protection systems or chemical treatment

Corrosion causes change in legislation?

- An amendment has been proposed to the Pipeline Safety Reg 13 to provide a defence against criminal proceedings in particular circumstances.
- ‘Iron pipelines...and where the proceedings arise from an event involving a failure of a pipe, the operator did not know and could not reasonably be expected to have known that there was a risk to safety concerning the pipe which required immediate attention...’

The Statistics

■ About 23,000 fractures and corrosion failures per year

■ 3 to 4 major incidents per year

(Proposals for amendments to the Pipelines Safety Regulations 1996, HSC 2002)

The Circumstances

- ❏ Was the failure mechanism predictable?
- ❏ The causes of several incidents have been subject to investigation
- ❏ The remedy appears to be based on a reactive risk based replacement regime

- ❏ Was the current situation predictable?
- ❏ What factors led to the current situation?

Causes of failures

- ❗ Inadequate design
 - ❗ Incorrect materials selection or supply
 - ❗ Inappropriate fabrication/construction as specified and/or applied
 - ❗ Operating error
 - ❗ Inadequate monitoring/inspection and/or maintenance
- never corrosion

Why incidents occur

- ❏ What is prevented or controlled (by design, chemical treatment, materials selection) and what is looked for (by inspection and/or design) is what is expected based on assessments.
- ❏ Failures are due to mistakes in assessments, not due to deterioration.

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